PC MAGAZINE

SMART CLOTHES, IMPERFECT FIT

DIGITAL EDITION
JANUARY 2016

PC MAGAZINE

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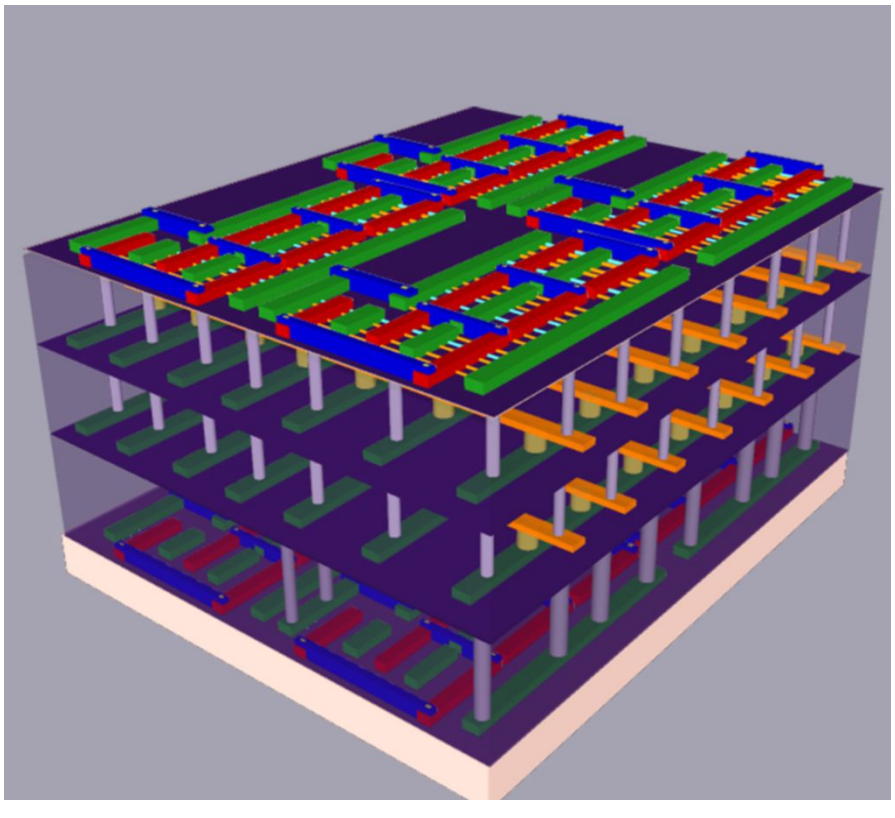

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DAN COSTA

Fit to Be Tried

I'm on the Fitbit bandwagon for the fourth time. I lost one to the laundry, another fell off at an Apple press conference, and the other one—geez, where *is* that one? Anyway, I don't have a good track record with these things, but I'm doing it again with our Editors' Choice–winning Fitbit Surge. The Surge is one of the most advanced trackers on the market, with GPS, a heart rate sensor, and the ability to identify multiple types of exercise. But I didn't get a Fitbit for the hardware. I got it for the software.

There are lots of ways to track your steps these days. Until I splurged on the Surge, I was using an app called Moves on my phone. Of course, it only worked when I had my phone on me, but it gave me a rough idea of how active I'd been on a given day. But once the data was in Moves, it was trapped. I couldn't share it with anyone, and I couldn't see anyone else's progress. Plus, on the infrequent occasions I did make it to the gym, I didn't get any points unless I had my phone knocking around in my pocket. For real fitness tracking, you need a wearable. But for that wearable to be truly useful, it needs great software.

The biggest advantage to Fitbit is that you probably already know someone who's using one. When I connected Fitbit to my Facebook account, it came up with five people actively on the service, including my sister. She's killing me on daily steps, but I do walk more now that there's some vague sense of competition involved. I also found a few coworkers, whom I didn't friend because that's a little weird. Whatever your level of comfort in

> **Whatever your level of comfort in sharing fitness information, study after study proves it's an effective way to change behavior.**

sharing fitness information, study after study proves it's an effective way to change behavior.

The Surge collects a ton of data, but Fitbit's dashboard is what keeps me coming back day after day. That one screen lets me track weight, activity levels, calorie intake, even the quality of sleep I'm getting. Lots of apps do some of this, but few bring it all together in one place as well as Fitbit does.

In this month's cover story, we look at the next frontier of wearables: smart clothes. In the last few years, Jill Duffy has tried every piece of connected clothing she could squeeze herself into—bras, pants, shirts, and more. Some of them are amazing, some of them are disappointing, but, in the end, a lot of them suffer from a common flaw: They just don't fit right. Check out Jill's story before you invest in smart clothes yourself.

Oddly enough, I've had some fitting problems with the Fitbit Surge as well. After three weeks of wearing it almost constantly, I noticed a rash developing on my left wrist. Wearing any piece of metal and plastic on your wrist that much is bound to cause problems. It is what it is. I moved the Surge to my right wrist and the rash went away.

These are still early days for wearables. Eventually, vendors will figure out how to make smart bras that don't chafe and fitness trackers that don't cause rashes. Until then, we're all going to have to make some compromises.

Or wait until the next version. It will be out soon.

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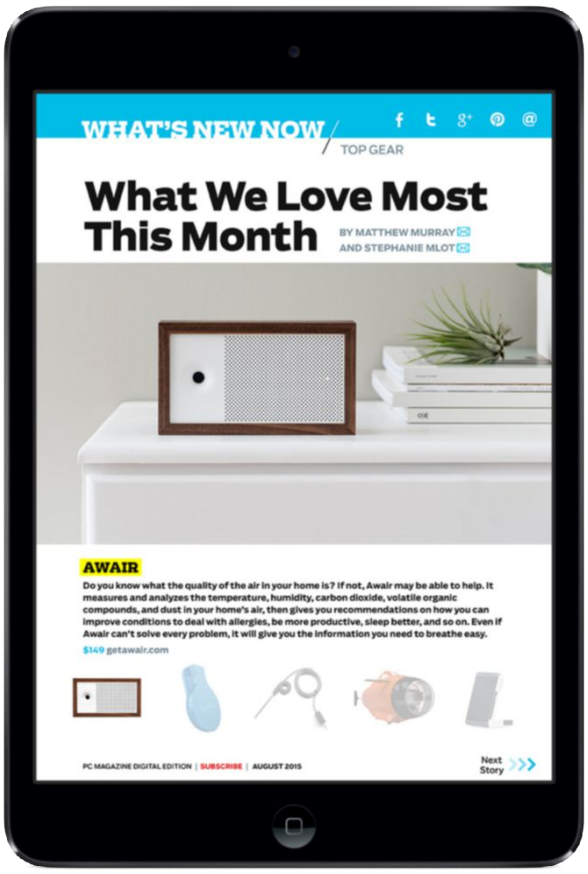
We want your input!



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Tell us what you like and don't like by taking our reader survey by **January 31, 2016**.

Thanks for being a reader of *PC Magazine*.

Happy New Year!

CLICK TO TAKE OUR SURVEY

or visit
https://www.research.net/r/PCMDE0116

What's New Now

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TOP GEAR

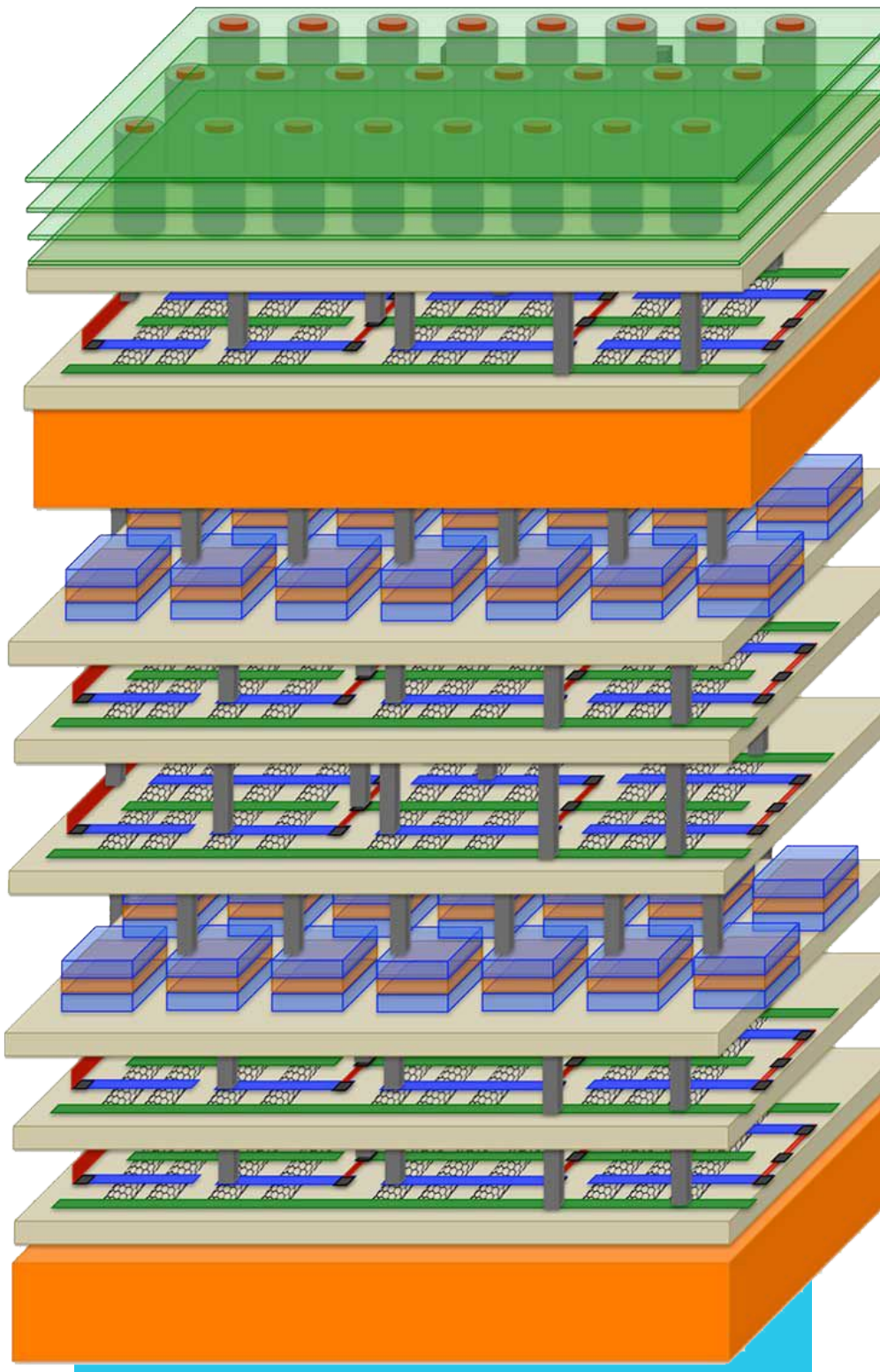
"Skyscraper" Chips Promise Powerful Computing Boost

BY DAMON POETER

A team of researchers led by Stanford's Mohamed M. Sabry Aly, Subhasish Mitra, and H.-S. Philip Wong want to put a "skyscraper" of computer chips in your next PC. The idea is to stack application processors, memory modules, and other components one on top of the other in "a revolutionary new high-rise architecture for computing," according to the Stanford News Service.

Such an "electronic super-device" could power a computer that combines "higher speed with lower energy use [to] outperform conventional approaches by a factor of a thousand," Wong said.

Stacking chips has long been seen as a viable path toward building a more efficient, powerful computing architecture than the current template, which lays out and connects components on a flat board, like "single-story structures in a suburb," as the researchers put it. But building a "skyscraper" of chips has thus far proven difficult using silicon-based integrated circuits (ICs), which are tough to connect reliably in a stacked structure.



MOVIN' ON UP
The new "high-rise" chip design from Stanford researchers could make future computers more powerful and efficient.

Aly, Mitra, Wong, and their colleagues believe they've figured out a way around such issues using "new nano-materials" to construct stacked computer chips in place of traditional silicon ICs. Dubbed Nano-Engineered Computing Systems Technology, or N3XT, the process involves building carbon nanotube transistors (CNTs) in a stacked arrangement. Instead of the relatively limited number of wires in connected stacked silicon chips, an N3XT device could employ "millions of electronic elevators that can move more data over shorter distances than traditional wire, using less energy," per the researchers.

"The process involves building carbon nanotube transistors (CNTs) in a stacked arrangement."

Communication between components in a N3XT system is built in during the actual process of fabrication. Because CNTs can be created at much lower temperatures than silicon-based transistors, it's possible to build components on top of each other, like a processor on a memory module, while maintaining the integrity of those tiny "electronic elevators," the researchers noted. Silicon ICs, on the other hand, have to be fabricated separately from each other and then stacked in "3D" arrangements later, which precludes integrating those interconnects from the get-go.

The team, which has published its findings in a recent special issue of *IEEE Computer* magazine, is also incorporating cooling into its N3XT devices, just as traditional two-dimensional computing architectures must have their thermals kept in check to prevent overheating. Stanford mechanical engineers Kenneth Goodson and Mehdi Asheghi are leading the effort to "incorporate thermal cooling layers" in the stacked chips, according to Stanford News Service.

One major roadblock to the adoption of N3XT or chip-stacking technologies like it? The global semiconductor industry is massively invested in silicon-based process technology, the researchers noted.

"Shifting electronics from a low-rise to a high-rise architecture will demand huge investments from industry," they said.

Still, the incentive to do so is compelling, said N3XT article coauthor Chris Re, a Stanford computer scientist and winner of the MacArthur Foundation "Genius Grant."

"There are huge volumes of data that sit within our reach and are relevant to some of society's most pressing problems, from health care to climate change, but we lack the computational horsepower to bring this data to light and use it," Re said. "As we all hope in the N3XT project, we may have to boost horsepower to solve some of these pressing challenges."

Panasonic Enters the Body Camera Fray

BY SASCHA SEGAN

I'd rather be shot with a Panasonic than a Taser. Wouldn't you?

Driven by recent high-profile police shootings, body cameras are spreading across U.S. police departments. About a third of the 18,000 police forces in the U.S now use body cams, according to a report from B2B seller Insight that was commissioned by the cross-governmental U.S. Communities organization, and President Obama has requested funding for 50,000 more cameras.

Panasonic's brand-new Arbitrator BWC, released on December 1, is a big name stepping into a market dominated by two other firms, VieVu and Taser. Panasonic says that its advantage comes from being an actual maker of cameras and in having an end-to-end system for data management and storage, which Panasonic has been working on for the past decade with its police dashboard camera systems.

The police body cameras aren't just ruggedized GoPros. Although they record optically stabilized 720p video just like a GoPro, the difference really comes in how the footage is handled once it's recorded, said Panasonic video solutions specialist John Cusick. Videos are encrypted in the camera, and every time they're transferred to another device, they're revalidated. Once they're transferred from the camera—either wirelessly, or by dropping them into a charging cradle—they can only be viewed in special software that logs every view and edit action, keeping previous versions intact.

"We're very cognizant of that chain of custody, that integrity," Cusick said. "If it ever gets to court, if it gets challenged, we've done the job of documenting at the bit level the security of the file."

Panasonic also sells a complete system including both body cameras and the more common dash cameras, with footage that can be stored in the same Microsoft Azure–powered government cloud and viewed with the same Windows software.

In the future, body cameras may be combined with facial recognition software, although Panasonic didn't explicitly make the connection. The company showed us—separately, mind you—a facial recognition system called FacePro, which recognizes suspects in real time. It's currently being marketed to companies and universities that want to watch for known thieves or disgruntled employees, but I can see how it could be combined with body cameras down the line.

In the future, body cameras may be combined with facial recognition software.

DATAPOCALYPSE

The proliferation of cameras is making data storage and management a major issue for police departments. In Harrison, New Jersey, cops spend three-fifths of their day looking at and managing digital evidence, Sergeant Dave Doyle of the Harrison Police Department said.

Here's how it works out. Each camera captures about 1GB per hour. (The cameras typically carry 32GB SD cards.) Data retention policies mean that departments need to keep data anywhere from six months to seven years, according to Joe Nigro, digital property custodian for the Harrison PD.

How much data gets recorded depends on department policy. The CEO of VieVu, Steve Ward, said that most officers in the field only record 60-90 minutes of video each day, because they only turn the cameras on when there's an incident.

So a smaller city like Harrison, which may have 15 cops on the streets at any one time, would generate at least 15GB per day, or 5.4TB per year. Doyle said his department is set for local storage right now, but demands are only going to continue to grow, and departments are looking at adopting cloud solutions like Microsoft's.

"The greatest concern of police departments moving forward now are servers, cloud storage, who's going to manage this, and whether we have the proper encryption," Doyle said.

MOST COPS LOVE CAMERAS

At the Panasonic event, Joe Giberson, chief of police for Stafford, NJ, sang the cameras' praises. His department doesn't currently use body cameras, but his officers have dash cams that automatically turn on with a car's alert lights, recording speed, position, and video information.

"I wouldn't have a police car out on the street without this system in it," Giberson said.

This is New Jersey, so it's not like the Stafford Township police officers are without controversy; the department is currently embroiled in a lawsuit over whether the town's mayor used the police as a weapon to intimidate a political opponent. But if anything, that makes Giberson's faith in cameras even more telling—

because he sees it as a way to prove that, most of the time, the cops are right. The dash cams have reduced complaints against his cops, because frivolous complaints are less likely to pop up when people know you have video, and they work wonders in certain circumstances.

"In DUI cases, as soon as a defense attorney sees the video, they're ready to make a deal," Giberson said.

IT'S ALL ABOUT POLICY

But as I asked the cops and Panasonic experts about body cameras making citizens safer, they kept reverting to one phrase: "It's about policy."

They're right, of course. Cameras aren't going to fix departments that have deep-seated anti-accountability cultures, although they can certainly help—as was recently shown with the October shooting of Laquan McDonald in Chicago. In a report about a body camera test in Phoenix, Arizona State University researchers found that officers had "low compliance rates for turning on cameras" and were "concerned that the video might be used against them"—even though complaints against officers who wore the cameras went down by 23 percent, and complaints against officers wearing cameras were less likely to be sustained.

As the cameras get more popular, the momentum among good cops may be enough to overcome departments' fears.

"It's one of the most important tools that an officer, or a police department, can have," Giberson said of his dash cams.

The Quest to Improve Video Game AI

BY JOEL HRUSKA

One of the most common user complaints about gaming is the AI. It's been this way for decades, which doesn't seem to make sense—computers today are vastly more powerful than systems built 30 years ago. We recently sat down with Brad Wardell, CEO of Stardock and the author of the AI in Galactic Civilizations II, about this problem—and how DirectX 12 (DX12) and improved multithreading support offer hope of improvement.

SCALE, COST, AND COMPLEXITY

The first problem, Wardell explained, is that good AI doesn't really sell games. Gamers may value it, but it's not the determining factor in whether people buy a title. At the same time, AI is now tightly coupled to graphics and must be communicated visually. It's no longer enough to tell the player that "the shopkeeper looks frightened"—players want to *see* the shopkeeper's terror.

Virtually all of what we call AI in games relies on scripted sequences, either handwritten or procedurally generated. Bethesda's Radiant AI, for example, uses procedurally generated scripts to create goals and tasks for NPCs, then lets them determine how best to fulfill their needs. The company famously had to tone down how the system functioned in The Elder Scrolls: Oblivion after it became clear its original approach produced unintended consequences. In one case, NPCs addicted to a drug called skooma would buy the drug until they ran out of money, then kill the dealer and steal his supply. Players would arrive to talk to the dealer as part of a quest chain and find he was already dead.

MULTITHREADING AND THE AI-VERSUS-GRAPHICS TUG-OF-WAR

Unlike graphics workloads, which can be easily parallelized and scale well, artificial intelligence processing is difficult to multithread. The job-based systems that many games use for multithreading don't tend to work well for AI processing, Wardell explained, because the AI is constantly asking questions and must receive immediate answers. Job-based systems are designed to launch and process workloads, not facilitate constant communication between the job and the host CPU.

To better understand this, consider interactions between the player and an NPC shop owner. Bethesda games typically offer you the option to steal goods without penalty, provided no one else sees you doing it. This means the game is constantly calculating the shopkeeper's line of sight. If you're trying to sneak around a camp full of bandits, the AI is checking to see how much noise you make and whether the bandits hear it. In both cases, the AI is asking a question and receiving an answer many times a second.

A critical part of the reason why AI doesn't seem to have advanced much is because the overwhelming majority of that compute capability has been devoted to making games prettier, not smarter. Because AI actions and reactions are synched to graphics, AI workloads need to be completed in time for an NPC to react to what's going on in the surrounding world. That means AI processing needs to happen within a time frame of 10 to 20ms—and because AI workloads don't thread well, the AI is probably running on a CPU core that's also handling other tasks. Most games display more than one NPC at a time, so all of their collective AI calculations must be handled simultaneously.

(For the record, audio processing doesn't have the impact on AI calculations that graphics do, but because players now expect titles to be fully voiced, this necessarily limits the unique responses any NPC can deliver.)

RISING FROM ASHES?

Up to now, we've discussed RPG AI, because it's one area where poor AI most sticks out. Wardell's expertise is in real-time-strategy (RTS) and strategy AI, and with Oxide Games' new epic Ashes of the Singularity, the first real DX12 title, we wanted to talk about how RTS AI has evolved, and where it might be headed in the future.

Ashes is an intense RTS game, with large numbers of units on screen simultaneously and plenty of heavy action between ground and flying units. One thing that sets the game apart is that Oxide requires a quad-core CPU to run it—all for purposes of improving AI.

According to Wardell, the basic structure of AI in any RTS to-date is like this:

```
while(true)
{
DoStuff();
DoAI();
DrawStuff();
}
```

"What Ashes does is eliminate the game loop thing entirely," Wardell said. "But this comes with a heavy up-front cost. It's expensive [CPU-wise] to have an asynchronous job system that can answer questions as a job. That cost comes in the form of us having to require four CPU cores as a minimum requirement.

"What we get in return, however," Wardell continued, "is that the AI is asynchronous to the rest of the gameplay so we can ask lots and lots of questions, [such as] "How dangerous is this threat?", "What is their firing range?", "What is my firing range?", "What terrain is nearby?", "What allies do I have nearby?", "Can I ask a nearby unit for help?," [and so on]—and have these answers be provided really fast because we know the user has at least four CPU cores so we can make certain assumptions on response time.

"Eventually, every game will require four CPU cores because of what I've outlined here. Being able to have your job system (which is, by definition, asynchronous) be able to answer questions (which is a synchronous task) in real time means you can [have] much more sophisticated AIs in real time."

DX12 isn't directly intended to improve AI calculations, but distributing workloads across multiple cores reduces overall CPU overhead and gives developers more headroom for other kinds of work.

DO PLAYERS ACTUALLY WANT GOOD AI?

As frustrating as poor AI can be, the alternative may be worse. Imagine playing Skyrim and fighting your way through a dungeon, only to discover that a group of NPC bandits had located and raided the treasure first by following the same clues that you did. Enemies in these games often respond hilariously poorly to stealth-based strategies, quickly forgetting that they're under attack and walking mindlessly over the bodies of stealth-killed compatriots. This scenario could obviously be improved—but a game where guards established realistic choke points and immediately ordered additional patrols might not be much fun, particularly for low-level players.

Games like Bethesda's Dishonored, which implements stealth tactics far more effectively than Skyrim or Fallout, is also a very different title. Levels are self-contained, with far fewer NPCs and no sprawling open world. These trade-offs are not accidental.

Are there players who would relish the chaos of an open-world game in which random bandits could depose rulers and dragons would loot dungeons before you ever reached them? Undoubtedly. I suspect some of them already play Dwarf Fortress. But this kind of freedom makes it impossible for a game to present the player with a coherent narrative. These are the kinds of trade-offs that we won't see resolved anytime soon, as they strike at the inherent difficulty of creating strong narratives while allowing for interactive gameplay rather than any kind of limited resource.

DX12 should give developers more freedom to experiment with better AI simply by giving game engines the option to utilize multithreading more efficiently. We're hoping this yields improvements across the entire game spectrum. We've been stuck with wooden cutouts for a long time now.

DNA as Storage for Mankind's Permanent Record

BY GRAHAM TEMPLETON

In this era of cloud storage and ever-recoverable user accounts, the idea of data just "disappearing" can seem downright odd. The EU has had to pass Right to be Forgotten legislation just to require companies to work to make it possible for data to go away. Yet given the sheer volume of data being generated and made available on the Internet these days, can that trend possibly persist?

Tweets already pass out of easy access through search in just a few weeks' time. The Internet is beginning to buckle under the weight of user-generated video. Can digital storage media progress fast enough to keep up with mankind's ability to generate ones and zeroes?

Perhaps it doesn't have to. In DNA, evolution has come up with a highly specialized form of storage: physically compact and unusually durable. DNA is nature's hard drive, and although it's certainly not perfect, it also has some cool features that beat even the most advanced digital technology. Recent advances could take DNA's abilities in data storage from theory to practice, bringing molecular memory into the mosaic of technologies that let mankind store knowledge outside the brain.

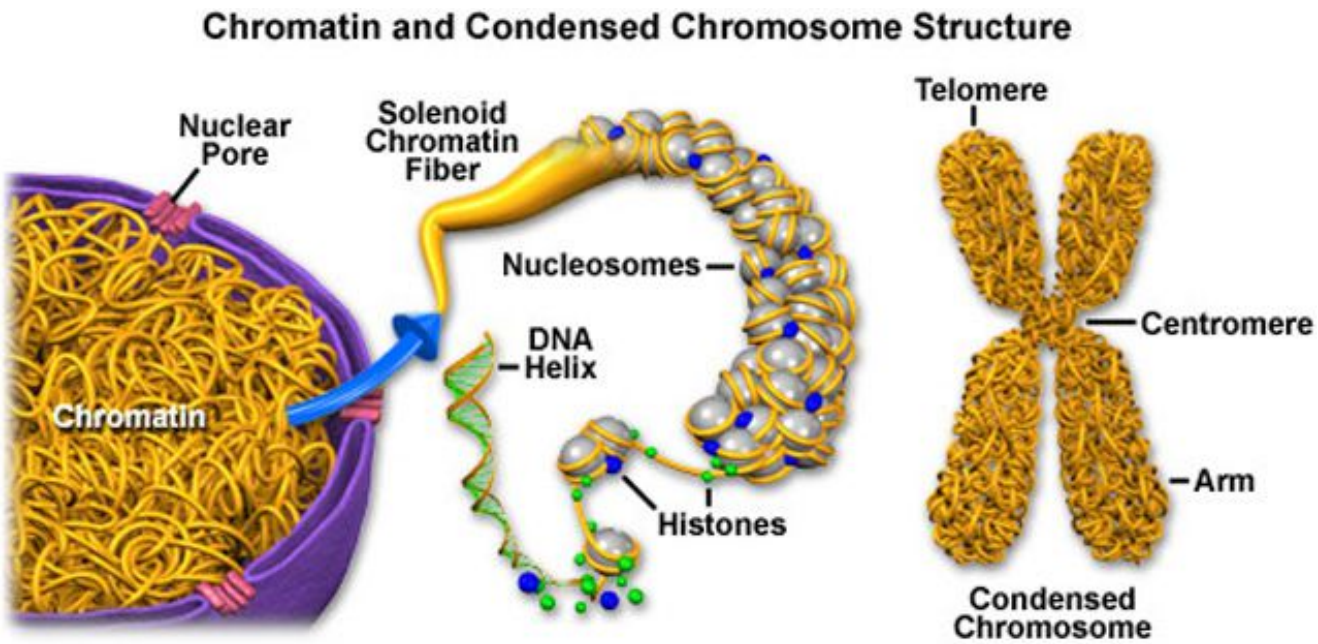
THE DATA "CRISIS"

At the end of the day, it's a good problem to have: From the Internet to genomic sequencing, too many people want to use this new world's rich, innovative features. It's also a potentially debilitating problem that reduces user interest in the Internet, and puts the integrity of potentially important data at risk. If we have so much data to store and we can't afford multiple redundant backups, then eventually power surges and hardware failures will lead to knowledge that fundamentally disappears.

Consider the fact that despite everything we know today—about topics ranging from nuclear fusion to black holes to genetic engineering—we still don't know, and never will know, just what knowledge was lost in the burning of the Library of Alexandria. You can't reinvent the thoughts of ancient people, nor can you rediscover the historical insights of unique documents and ledgers once they've become ash. It might seem trivial now, but if a tweet passes on to be forgotten and never recovered, isn't that an equivalent sort of loss?

The Library of Congress tried to step up and manage the full archive of Twitter posts a few years ago, but at close to half a trillion messages, the project

has stalled and may still never see the light of day. YouTube execs have claimed the video platform is putting up something like 400 new hours of video every minute—a figure that, if accurate, makes it clear why Google has struggled to make the wildly successful business even modestly profitable. With wearables enabling such detailed tracking of personal metrics, this upward trend in data generation is not going to change anytime soon.



DNA can store dizzying amounts of information in an extremely small physical volume, and it has the capacity to last longer than any magnetic or optical signal could ever hope to.

NEXT-GENERATION DATA STORAGE

In its March 2013 issue, *PC Magazine* published an article on an amazing breakthrough in DNA science: Harvard University researchers had managed to store 700TB of information on just a single gram of material. It was an incredible proof of concept, and a reminder of how biology is really just genetic data given form. Yet, in the wake of that discovery, there was a surprising reaction: serious interest. It turns out that long-term storage of a whole lot of data is a more pressing concern than the researchers had anticipated. Since then, they've set up a commercial business based on the idea.

The basic appeal is twofold. DNA can store dizzying amounts of information in an extremely small physical volume, and it has the capacity to last longer than any magnetic or optical signal could ever hope to.

The first of these advantages is hard to overstate: DNA can hold a lot of data. That 700TB achievement is astonishing, but it is in no way the limit of what nucleic acids could achieve; in theory, one gram of DNA could hold up to 455 exabytes (EB) of information—more than all the current digital data in the world, by a huge margin. Even if we only ever achieve 1 percent of this theoretical capacity, due to inefficiencies and the necessity of having multiple redundant copies, that's still 4.5EB per gram, the equivalent of 4.5 million 1TB hard drives.

On the other hand, DNA can also be long-lived. This is a bit counterintuitive, as DNA is actually quite fragile and notorious for breaking while you're trying to work with it. DNA isn't durable, given that you have to keep it in fairly peaceful conditions, but it is stable, in that if you do care for it properly it could remain intact for millions of years. Fossilized bone has managed to keep samples safe for tens and even hundreds of thousands of years, so scientists working with high-quality glass and vacuum tubes should be able to come up with something as well.

Making and replicating DNA data has also never been easier, with automated systems for creating a tailored DNA molecule from a digital code, and high-throughput replication techniques that can create thousands of copies in just an hour or two. Credit biological evolution, of course, but also the scientists who have managed to make use of biology's highly specialized solutions.

DNA isn't perfect. It's good for use as a long-term library, but not as an interactive archive to be accessed quickly and often.

DNA'S DOWNSIDE

On the other hand, DNA isn't perfect. It's good for use as a long-term library, but not as an interactive archive to be accessed quickly and often. In the case of a Twitter archive, DNA may be able to keep us from getting into a Library of Alexandria situation, but it couldn't keep the archive searchable. Not only would the sequencing

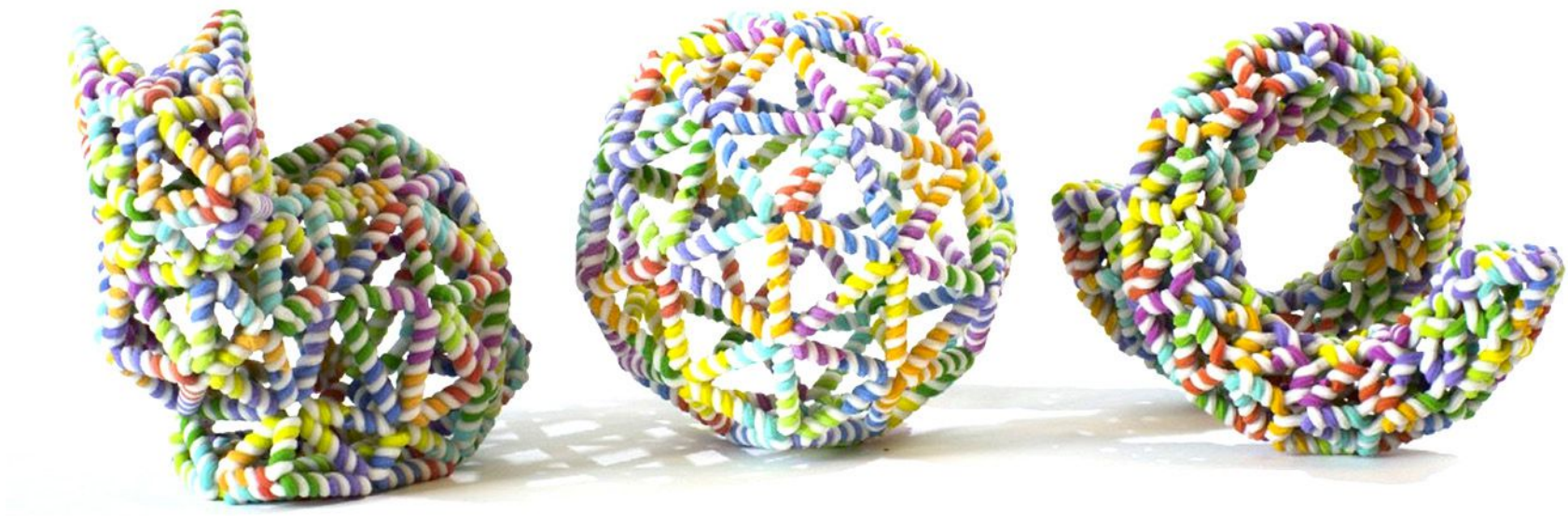
process be too slow for modern users, but the process of reading DNA introduces some small danger to the molecule itself—and the whole point is to keep this data safe. That's why most people are talking about DNA for use as a time capsule.

In addition, it's recently been pointed out that DNA's very facility with data storage could be our undoing—we didn't invent it, after all. There's an almost unimaginable amount of DNA data out there in the biological world, not counting anything extra we derive from analysis of that information, and sequencing more and more of it is becoming mankind's primary source of new, raw data. Even YouTube can't keep up with the biomedical and pure science research sectors in terms of the volume of new data created and in need of storage on a daily basis.

DNA has more than enough storage capacity to fulfill our needs for the near- and mid-term future of data science—but storage isn't the only thing we're interested in doing with data. DNA likely has a part to play in keeping our knowledge and history alive for the coming decades, centuries, and millennia, but you're not going to be running your operating system off of DNA memory anytime soon.

NEW FRONTIERS

In the future, data storage might end up in two distinct technological categories: long-term storage of information with relatively low accessibility, and short-term storage of searchable, easily available data that provides admirable speed but unimpressive permanence. Nonetheless, to the people of the future, it may seem odd that we were ever willing to trust our digital heritage to the transient electrical states of silicon transistors, rather than the hard-nosed reliability of chemistry.



What We Love Most This Month

BY STEPHANIE MLOT

AUTOMATIC ADAPTER

Because not everyone can afford a smart car, Automatic has devised an inexpensive solution. The Adapter plugs into the standard diagnostics port hidden under the dash of most cars built in the last 20 years. Pair that with the companion mobile app and you can view information about your car and driving habits. Automatic also diagnoses your "check engine" light, reminds you to drive more efficiently, and remembers where you parked—because you never do.

$99.95 automatic.com

What We Love Most This Month

BY STEPHANIE MLOT

GRAAVA

Stop spending hours editing your video footage into a 3-minute clip to share on social media. Instead, strap on the Graava camera and let the miniature machine do all the work for you. Using its camera, microphone, accelerometer, GPS, and heart rate monitor, the gadget serves as your eyes and ears, when your eyes and ears can't remember. And it automatically edits up to 3 hours of video down to your set length.

$399 getgraava.com

What We Love Most This Month

BY STEPHANIE MLOT

SOLARPUFF

A nighttime beach picnic is much less romantic when you're shining flashlights in each other's faces. For those moments when candles, glow sticks, and other portable lighting just won't do, unpack a Solarpuff. Designed for durability, flexibility, and water resistance, the solar lamp charges fully in 8 hours of sun, and glows for another 8 to 12 hours. Plus, it squishes into a flat pack to fit into a pocket or purse for easy transportation.

$30 solight-design.com

What We Love Most This Month

BY STEPHANIE MLOT

SWIFTPOINT GT

Sometimes it just takes too much effort to reach out and touch your computer or tablet screen. Maybe it's too far away on your desk, or you're bundled under the blanket and can't get your arm loose. Try the Swiftpoint GT, which combines the intuitive nature of touch screens with the precision of a mouse. With two modes—regular point-and-click and touch gesture—the device can even be used on the surface of your laptop, next to the touchpad.

$149 swiftpoint.com

What We Love Most This Month

BY STEPHANIE MLOT

TRIBY

Sure, you could invest thousands in a smart refrigerator that plays music and receives phone calls. Or you could stay entertained and connected by sticking the Triby to your icebox. Available in four colors (blue, green, gray, and red), the portable device connects to Wi-Fi to sync with the built-in Spotify Connect feature and make hands-free mobile calls. The companion iOS app also lets users doodle and send messages directly to the fridge.

$199 invoxia.com

Opinions

No PC vendor is content to stand still and see this decline continue.

Of Course Trump Could Break the Internet, but Should He?

Sascha Segan is the lead mobile analyst for *PC Magazine*. His commentary has appeared on Fox News, CNBC, CNN, and on radio stations and in newspapers around the world.

The first true social-media-era terrorist organization, Daesh, skips and skims through the Internet, using it to set fires in Paris, San Bernardino, and beyond. It's a terribly difficult strategy to counter, and once again, in his ham-handed way, Donald Trump is opening up an interesting debate with an initially impractical idea to counter it.

Trump's initial statement in the December 15 Republican presidential debate was that "I would certainly be open to closing areas where we are at war with somebody." He later dialed it back to imply more conventional hacking, spying, and cyberwarfare, but of course it opened up the questions of whether we can shut down "their" Internet—and whether we should.

In a fascinating investigation, *Der Spiegel* figured out how Daesh gets its online access: through satellite dishes purchased in Turkey and connected to EU satellite providers. Those dishes all have GPS locators on them, so *Der Spiegel* figured out where they are.

According to the publication, "Many of the satellite dishes are located in Aleppo, Syria's second city, which isn't completely under the control of the terror regime, but other locations of the dishes include Raqqa, the unofficial IS headquarters, al-Bab, Deir al-Zor and along the

Euphrates River into Iraq and the IS-occupied city of Mosul."

The locations of the satellite dishes are known. The ISPs are known. They could be shut down, if these ISPs chose to do so. So why don't they?

There are other, more arcane ways to dump traffic from IP blocks and make ISIS's life difficult. But such solutions, advocated by Trump, Milo Yiannopoulos of Breitbart.com, and others rest on the dangerous assumption that the Internet is "our Internet." To some extent, that's true for now; U.S. companies have an inordinate amount of control over the naming and routing of Internet servers and traffic. But that's an accident of history, and it's not a fixed fact.

The Chinese government has established, essentially, an Internet just for that country, with filters around its borders. We in the English-speaking world seem not to marvel at that daily because China's Internet is in Chinese, we can't read Chinese, and they aren't particularly interested in exporting their homegrown services. But China already broke the Internet, in China.

American influence over the rest of the Internet has been maintained by a quiet agreement that the folks doing it so far have done pretty well, and that breaking it for reasons of national pride or control—unless you're China—is more trouble than it's worth. But as soon as a U.S. president starts unilaterally blacklisting chunks of the Internet, other countries will feel abused and colonized, and they'll break their own Internet. There will be a European Internet, and a Russian Internet, and a Middle Eastern Internet, all with their own policies and their own controls, and there will be no more global market for our U.S. software and services firms—never mind the end of the radical global free speech decade we've been having.

Sascha Segan

Breaking the Internet that way is a one-time-only deal. Daesh could rebuild its connectivity, tapping into the Internet connections in neighboring states and concealing its location more artfully. We would never be able to rebuild our influence, or the overall freedom of the Web.

The *Der Spiegel* article proposes a smarter idea. "Perhaps the companies have full knowledge of who is using their services and are sharing that information with intelligence services. That would mean that intelligence services have been listening in for years, even as IS continued growing in strength."

The Internet is not a one-way path; it's a valuable source of intelligence from which we would be cutting ourselves off. There are forms of cyberwarfare we can conduct without shattering the entire Internet, as well. Targeted viruses can be sent in to cause chaos, the way Stuxnet (a joint Bush-Obama project, if you can believe that) apparently did in Iran.

Cyberwarfare is an invisible and often secret capability. As we fight against an Internet-native enemy, it has to be a core capability—and yet, its successes are often not made public. There's no satellite-viewable carnage, no YouTubed bombings. In other words, you have to trust in the competence of the government that is conducting your cyberwarfare campaign. You have to trust it will be not only aggressive, but more technically competent than its opponents.

One of the top questions for this year's presidential candidates should be: Whom do you trust to do so?

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"There are forms of cyberwarfare we can conduct without shattering the entire Internet."

All Signs Point to Telecommuting

I had a voice over IP (VoIP) conference call with HP recently. When the presentation started, an HP rep quoted some statistics. One was that 40 percent of workers' time is now spent in meetings and on conference calls—with an average 12 minutes at the start of each call spent dialing and debugging to get everybody online.

The end of 2015 brought a fresh crop of work-related statistics and surveys that, taken together, add up to encouraging news for home office fans. According to FlexJobs, an online service for flexible, telecommuting, and freelance work opportunities, we're seeing nothing less than a rejection of the traditional office workspace. A full 76 percent of respondents to a recent FlexJobs survey said that, when they need to get important work done, they avoid the office.

Where do they go instead? Bingo (no, wait, I don't mean they go to play bingo, I mean you guessed it): A home office was a far more popular choice than a coffee shop, library, or conventional office outside of normal work hours. As to why they're more productive at home, roughly three-quarters cited fewer interruptions from colleagues and fewer distractions, and 71 percent listed freedom from office politics and 68 percent reduced stress from commuting.

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With 97 percent of the people surveyed saying a more flexible job would have a positive impact on their quality of life, and four out of five saying they think it would make them healthier, it's not surprising that 82 percent of the respondents said they'd be more loyal to their employers if they had flexible work options. A full 30 percent said they would take a pay cut of 10 to 20 percent in exchange for such options.

Are companies noticing this sentiment? They can't afford not to. From 1995 to 2015, according to Gallup's annual Work and Education poll, the percentage of U.S. workers who say they have telecommuted to their jobs vaulted from 9 to 37 percent.

The overall average is a modest two days per month, increasing to six days among the self-selected group of remote workers. One in four telecommuters (i.e., one in 11 employed Americans) works from home a majority of the time or more than ten days per month.

According to GlobalWorkplaceAnalytics.com, regular work-at-home (among telecommuters, not self-employed individuals) has grown 103 percent since 2005, and 6.5 percent in 2014. The latter is the largest year-over-year increase since before the recession. This means that 3.7 million employees (2.5 percent of the workforce) now work from home at least half of the time.

Half of U.S. jobs, Global adds, are compatible with at least partial telework, and 20 to 25 percent of the workforce telecommutes at least occasionally. Approximately 80 to 90 percent of U.S. workers say they would like to telework at least part time. Global draws a distinction between concentrative work at home and collaborative work at the office, saying the sweet spot or balance between the two seems to be about half time apiece.

Indeed, Fortune 1000 companies are remodeling their offices and their project management practices around the reality of worker mobility. HP says 62 percent of employees work from more than one location. Global says today's office slaves are anything but chained to their desks; in fact, they're away from their desks 50 to 60 percent of the time.

Workers, however, are still leading companies rather than the other way around. Although a study by FlexJobs and WorldatWork found that four-fifths of companies surveyed offer flexible work arrangements, only 37 percent have formal, written policies about them. And only 3 percent quantify return on investment (ROI) by measuring productivity, employee engagement, and performance ratings.

What can you do to get the boss' blessing for telecommuting? Bring in the studies cited here and urge him or her to get with the program. Point out that this year Millennials surpassed Generation X as the largest chunk of the U.S. labor force—and Millennials overwhelmingly desire more flexible work and better work-life balance than their predecessors did.

Chances are, your IT department has already developed (or is working hard to develop) a "bring your own device" (BYOD) strategy to keep up with workers' embrace of tablets and smartphones. And BYOD is a revolving door for a telecommuting plan (I like to say the flip side of BYOD is THYW, for "take home your work").

It's a mix of managerial structure and quantifiable goals with teleworker flexibility that provides peak happiness for bosses and staffers alike. It's not rocket science. It isn't even bingo.

Fortune 1000 companies are remodeling their offices and their project management practices around the reality of mobility.

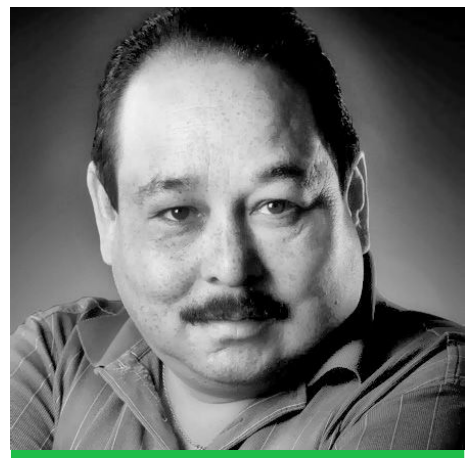
How PC Makers Can Salvage PC Sales

If you follow the PC industry, you know that demand for PCs continues to slide. The numbers aren't yet in for 2015, but most researchers believe that PC sales will have declined at least 5 to 7 percent.

The decline in PC demand has had serious repercussions for the overall PC industry. Over the last five years, there has been significant consolidation. Just in December, Toshiba put its PC business up for sale, meaning another stalwart of the PC industry is getting out of a very tough market. It appears that the only companies with staying power in the PC market will be Lenovo, HP, and Dell mixed, with a lot of white-box PC makers that will go after localized businesses.

Many PC vendors are very concerned about the health of the business and are looking at ways to create stronger demand for PCs going forward. They admit that even the introduction of Windows 10 has not helped grow the market. Although they see enterprise accounts showing more interest in Windows 10 in 2016, the lack of growth in the consumer market suggests that PC sales will still decline about 2 to 3 percent in 2016.

Meanwhile, average prices for consumer PCs range from as low as $129 for a Windows PC with an Atom processor to about $399-$499, with very slim margins. The only good



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news is that the premium market, especially for laptops, has been strong in the enterprise and with high-end consumers, and that has helped those sectors mostly stay in the black when it comes to overall PC sales.

But all the vendors I talk to say that unless they can find a way to make the PC more vital to the computing experience, demand for PCs will continue to slide. No PC vendor is content to stand still and see this decline continue, however. They are all trying to enhance the overall user experience by introducing 3D cameras, speech navigation, better optical experiences, and facial recognition for secure access. They are also working hard to add virtual reality and augmented reality functionality to the PC, and are trying to make the PC itself much more indispensable to their customers.

Current PCs are functional and do what they need to, and hardware designs have made some major strides. But even factoring in Windows 10, with its advanced UI and features like Cortana and Continuum, a PC is still basically a PC. The promise of immersive computing with VR and AR tied to a PC, however, could deliver a richer experience, like the Oculus Rift. If done correctly, it could drive up demand for PCs in the near future.

I realize this is a tall order for those in the PC ecosystem, but if the PC stays like it is now, its decline is assured. If manufacturers have any chance of growing the PC market in the future, I think it will take nothing less than delivering the kind of immersive computing experience that you just can't get anywhere except on a PC.

Reviews

CONSUMER ELECTRONICS

Sonos Play:5

Microsoft Lumia 950 (AT&T, 32GB)

Google Pixel C

Apple iPad Pro

HARDWARE

HP Spectre x2

Acer Predator X4

MakerBot Replicator Mini

SOFTWARE

True Key by Intel Security

Sonos Play:5

$499.95

Top-Quality Wireless Music Starts With Sonos

PC MAGAZINE EDITORS' CHOICE

Sonos is alive and well in 2015, despite attempts on its life from AirPlay (which has seen better days) and Bluetooth (which is enjoying its best days thus far). Sonos thrives because it doesn't just make wireless speakers, it makes an entire wireless speaker ecosystem that functions quite well and, most important, delivers excellent sound. The second-generation Play:5 delivers ferocious power with seriously deep bass (when the mix calls for it) and a solid balance of rich lows and crisp highs. We'd be pleased if this were simply a standalone speaker, but it is part of a larger, non-Bluetooth-equipped, whole. Granted, purchasing this speaker means buying into the Sonos ecosystem, but it's hard to imagine a better-sounding building block for a wireless multi-room system.

DESIGN

Available in black or white models, both of which have black front panels consisting of speaker grilles, the Play:5 has a minimal and sleek look; it seems meant to blend into a setting, not stand out. Measuring 8 by 14.3 by 6 inches (HWD) and weighing 14 pounds, the Play:5 has all its buttons on the top panel: one for Play/Pause and volume controls on either side.

The volume controls are capacitive—each looks more like four tiny pinholes than a button, and it's almost surprising when they work so well. From a visual standpoint, it keeps the top surface looking uncluttered. The volume levels work in conjunction with the master volume levels in the Sonos app. Furthermore, the volume controls act as track navigation tools when you swipe from one to the other. It's a simple, smart design that makes the most of the speaker's surface.

Behind the grille, the Play:5 boasts three tweeters and three midrange drivers that are all driven individually by six class-D digital amplifiers. The back panel, where the power cable plugs in, also houses an Ethernet cable connection (for a direct network connection) and a Join button for connecting the speaker to an already-present Sonos system. There is also a 3.5mm aux input to which the speaker will automatically switch when it detects a signal (though no 3.5mm audio cable is included).

Sonos claims the Play:5 can adjust its audio performance based on the acoustics of the room it's in. There's undoubtedly some digital signal processing going on here, but it's subtle enough that purists likely won't be irked, and it will please everyone else.

The speaker can also be paired with another Play:5 to make a stereo pair, with one acting as the left channel and the other as the right. Sonos even claims the speakers are designed to work in relatively heightened humidity, so you can place the Play:5 in a bathroom and not worry about steam ruining it (the speaker is not water- or splash-proof, however).

Sonos Play:5

PROS Powerful audio performance with seriously deep bass, accurate highs. Easy setup. Expandable to multiple rooms. Can be used as part of a stereo pair.

CONS Pricey. No Bluetooth.

WIRELESS AUDIO

Sonos was one of the first big names in Wi-Fi multi-room audio, and it's stayed committed to the concept. The Play:5 doesn't support Bluetooth; if you want to use the speaker without relying on the 3.5mm auxiliary input, you'll need to use the free Sonos app for Android, iOS, OS X, and Windows, and connect the Play:5 to your home Wi-Fi network. Fortunately, this is a simple process of following a few software prompts and watching the speaker's indicator light.

All music playback is controlled through the app, which, thanks to Sonos' constant development, now supports a startling number of streaming music services. You can listen to music from Amazon Music, Google Play, Pandora, SiriusXM, Spotify, Tidal, and dozens of others. The speaker also supports playing any of your locally stored music from up to 16 different storage devices on your network, and can access more than 100,000 streaming Internet radio stations outside of the different apps. It's a safe bet that, even without Bluetooth as a backup, the Play:5 has you covered for your favorite music sources.

The app handles all of the aforementioned multi-room and multi-speaker setups, including pairing two Play:5 speakers or playing music across multiple rooms. You can have up to 32 Sonos speakers on a single network at a time.

PERFORMANCE

On tracks with intense sub-bass content (we tested The Knife's "Silent Shout"), the Play:5 delivers some serious thunder. Not only can this system get exceptionally loud, but the bass does not distort even at top volumes. That said, things certainly sound a bit more balanced at more moderate, sane listening levels. At a medium-loud volume, the Play:5 produces robust, deep bass. It also still provides a strong sense of bass response even at low volume levels, which is rare.

Bill Callahan's "Drover," a track with less in the way of deep bass content, gives us a better idea of the Play:5's overall sound signature. The system's drivers definitely have the capability to boost the drums to unnaturally hefty levels the way some bass-forward systems tend to do, but instead the drums

sound full and powerful without getting boosted in the deep lows. The Play:5 beautifully highlights the rich presence in the low mids of Callahan's baritone vocals, and complements with a solid presence in the high mids. The guitar strums on "Drover" also benefit from the strong high-mid presence, and from some extra brightness in the highs. This is a slightly sculpted, but balanced, sound signature.

On Jay-Z and Kanye West's "No Church in the Wild," the kick drum loop's attack gets plenty of that high-mid treble edge, retaining its sharp contour so it can slice through the mix. This track highlights what the Play:5 is capable of on deep bass—when the sub-bass synth hits occur, it sounds as if there's a powerful subwoofer in the room. But the Play:5 avoids adding deep bass when it isn't in the mix. And when there is exceptionally powerful deep bass present, as there is on this track, the Play:5 really brings it.

On the opening scene in John Adams' *The Gospel According to the Other Mary*, the higher-register strings, brass, and vocals own the spotlight—they sound crisp and articulate through the Play:5. When there is lower-register instrumentation, it is delivered in a balanced manner, and the occasional sub-bass sound gets the appropriate level of presence in the mix. Absolute purists might find things a bit too boosted in the lows, but most listeners will find the overall mix crisp, rich, and well balanced.

The main reason Sonos has remained relevant is the continuous improvement of its speaker lineup. Simply put, Play speakers sound great. If you're looking for a top-quality wireless speaker, but don't need the multi-zone capability, consider the Bowers & Wilkins Zeppelin Wireless ($699) or the Bang & Olufsen Beolit 15 ($599); for something more affordable, try the Marshall Stanmore ($399) or Audioengine B2 ($299). If you want to start a bit smaller and much less expensive—and also less powerful—Sonos' Play:1 ($199) is a fine choice.

At $500, the Play:5 isn't cheap, but it doesn't sound, look, or behave like a cheap system. Sonically, it's a winner, and from a multi-room home audio standpoint, Sonos still leads the pack.

TIM GIDEON

The First Windows 10 Phone Is Promising But Bug-Laden

Microsoft did it—it finally crammed Windows into a phone. The Lumia 950's Continuum mode is what we've been hoping for from Windows Phone for five years, and it could be a new beginning for Microsoft on mobile devices. But it's only a beginning, and the 97 percent of existing U.S. smartphone owners who are considering coming over from Android or iOS will find that Windows Phone lacks too many of the experiences they're used to—and that it's buggy and has light third-party support.

Microsoft Lumia 950
(AT&T, 32GB)
$598.99

PHYSICAL FEATURES AND HARDWARE

At 5.7 by 2.9 by 0.3 inches, the Lumia 950 fits securely within the middle size range for today's flagship phones.

The phone is plastic, with a matte white back that can be peeled off to reveal nano SIM and microSD card slots, along with a removable battery. The front is mostly a 5.2-inch, 2,560-by-1,440 organic light-emitting diode (OLED) touch screen. It shows rich colors and deep blacks, like all OLEDs, but seems a touch dim when compared with the Galaxy S6's screen. On the bottom, there's a USB Type-C port with fast charging enabled, and the phone also supports wireless charging via the PMA standard.

Although the Lumia 950 is only offered by AT&T, it's compatible with both AT&T and T-Mobile. It has LTE bands

1/2/3/4/5/7/8/12/17/20/28/40, which includes both the primary AT&T and T-Mobile bands, but not AT&T's new speed-enhancing Band 30. On the streets of New York, the phone showed decent AT&T LTE speeds, but strong 3G reception in a weak-signal area. The phone supports HD Voice and voice-over-LTE, but not Wi-Fi calling.

Call quality is good, but falls just short of excellent. The 950's earpiece quality is tops—loud and clear, with no distortion. But my calls from noisy outdoor locations had some scratchiness to them, and the din of background traffic wasn't entirely muted. The speakerphone also sounds a bit thin.

Beyond cellular performance, the Lumia 950 has dual-band 802.11ac Wi-Fi and Bluetooth 4.1. Wi-Fi performance is on par with that of other current flagship phones. The same goes for battery life, at 5 hours, 58 minutes, of continuous video streaming over LTE on the 3,000mAh battery.

Inside the Lumia 950, there's a 1.8GHz Qualcomm Snapdragon 808 processor. Performance is less snappy than I wish it were, especially in Continuum mode. Some of that is due to Windows Mobile's heavy use of animations, but graphics frame rates were low in the standard GFXBench benchmark tests. I got 13.5 frames per second (fps) on screen and 21.7fps off-screen in the T-Rex test, as compared with 59 and 80fps respectively on the iPhone 6s. That could explain why controls in the driving game Asphalt 8 were a little draggy.

WINDOWS 10 MOBILE

The Lumia 950 is the first official U.S. phone to run Windows 10 Mobile out of the box. On the surface, Windows 10 Mobile looks much like Windows Phone 8.1, and that's good. With Live Tiles, Windows has always had the best home screen metaphor in the business, combining the design rigor of Apple's grid with Android's customizability and configurability. The

Microsoft Lumia 950

(AT&T, 32GB)

PROS Excellent desktop Continuum mode. Slick home screen design. High-quality camera (when it works properly).

CONS Very buggy. Missing many big-name apps. Other apps lack features found in their Android and iOS counterparts.

YOU'LL FIND HOME Windows 10 Mobile's Live Tiles give it the best home screen experience of any phone, but right now it's severely hampered by bugs.

People Hub puts Facebook and Twitter updates right in your contact list. The app list, to the right, now starts with the most frequently added apps and a search box, so you can quickly get to what you're looking for.

Instead of a fingerprint scanner, the Lumia 950 offers Windows Hello, which scans your eyes to check your identity. I found it worked in eight out of ten tries, with and without glasses, in different lighting conditions. That's about on par with the Samsung Galaxy S6 fingerprint scanner, but nowhere near as good as fingerprint scanner on the iPhone 6s or the HTC One A9, which have been completely accurate in my tests.

Windows 10's Glance screen borrows one of my favorite features from Motorola phones: the ability to get quick notifications without unlocking the phone. They appear when you pick it up, and then you can decide whether to unlock or not. It's also configurable, so what apps are shown is up to you.

The most important new app in the system is the Microsoft Edge browser, which offers the most desktop-like viewing experience of any mobile browser I've seen (although it still can't handle Flash or Java plug-ins). Complex embedded videos and ads are no problem, as long as they aren't Flash. Unfortunately, like so much else on the platform, Edge is buggy; in Continuum mode, I found that my mouse's scroll wheel only worked some of the time, and the browser simply froze on some multimedia-heavy pages.

Windows Phone fans hate it when I mention the app gap, but it's still there. Maybe you rock out with Amazon Prime or Apple Music elsewhere? Bank with Citi, Chase, or TD Bank? Want to hop on the next bus using Citymapper or Transit App? Watch TV shows from your TiVo, DirecTV, or HBO GO subscriptions? In all these cases, you can on other platforms—but not here.

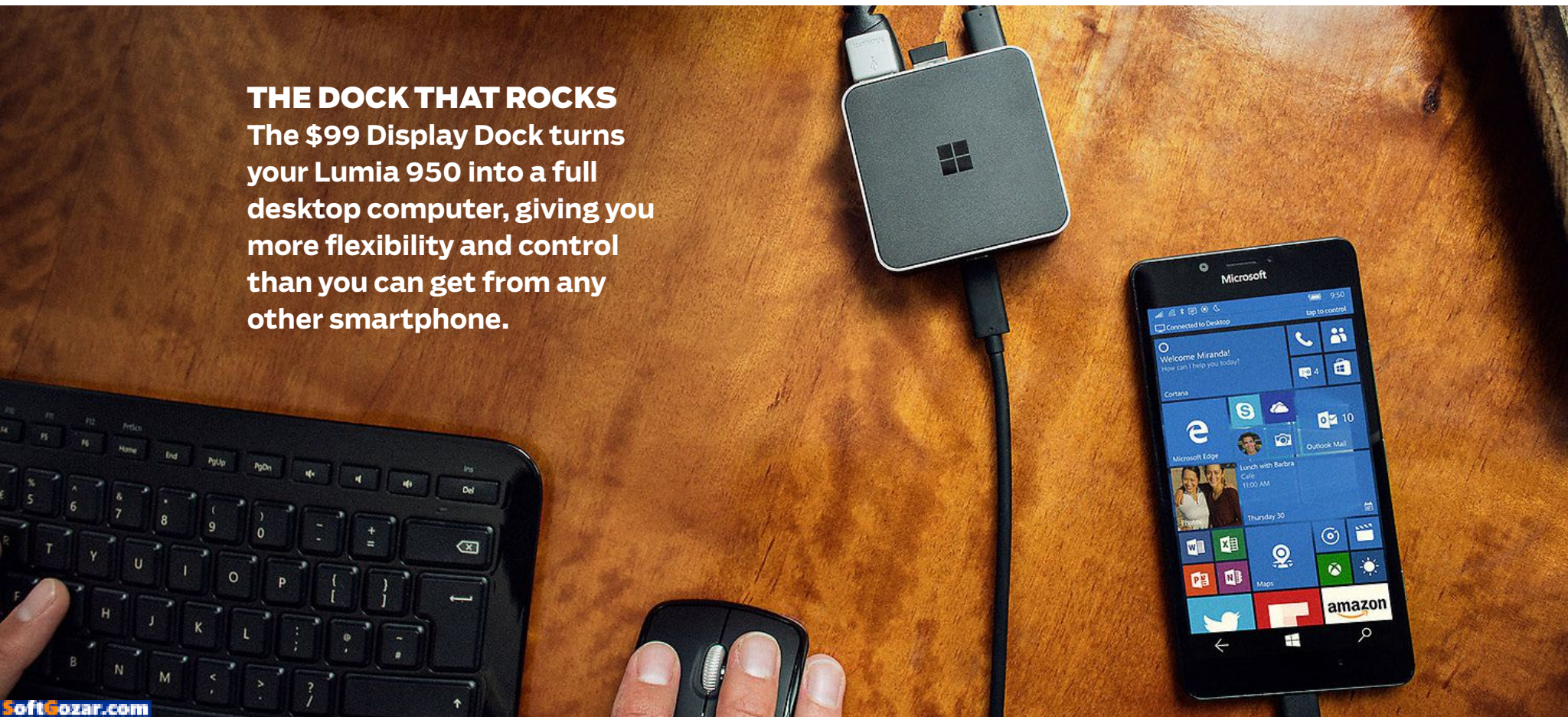
Some popular apps on other platforms get replaced on Windows Phone by rip-off clones, and many Windows Phone implementations of popular services are missing features that have existed for years on other platforms (such as threaded discussions on Facebook). Microsoft says it's improving developer tools by offering easy ways to port iOS (and soon Android) apps to Windows, but Microsoft has been saying this for five years now. It just adds insult to injury that, at this stage of the game, Windows 10 Mobile is so buggy; apps crashed on me constantly. Microsoft has had a good track record for maintenance releases—this is, after all, the company of Patch Tuesday—but c'mon, folks.

CONTINUUM

Ever since the Motorola Atrix in 2011, phone makers have been trying to combine the portability of a mobile phone with the productive ergonomics of a desktop PC. Continuum is the best attempt yet—and the best argument for coming to this party.

Continuum turns the Lumia 950 into a desktop, not a laptop. The key is the $99 Display Dock accessory, which has two USB Type-C ports (one on the front, one on the back), and three traditional USB, DisplayPort, and HDMI ports (all on the back). Hook up a keyboard, mouse, and monitor, and you have a full desktop setup without the wobbly unreliability of Bluetooth peripherals.

Microsoft gets the desktop interface really right, too. There's a Start menu in the lower left, along with icons that show all of your currently active apps so you can flip between them. The Office apps open in full-screen mode, and the mouse support is perfect. It's really like editing on a desktop, at least interface-wise. The only missing piece is that you can't have multiple windows on the screen—not even two, as you can on the iPad Pro.



THE DOCK THAT ROCKS
The $99 Display Dock turns your Lumia 950 into a full desktop computer, giving you more flexibility and control than you can get from any other smartphone.

Continuum's major flaw right now is limited app support. It works with Microsoft's own Office apps and Facebook, but not, say, with Slack or Adobe's PDF viewer. That will change if the Windows 10 platform becomes popular, but with only one phone coming out on only one carrier in the U.S., there's not much of a pull for developers to support this mode. That's a pity.

STORAGE AND MULTIMEDIA

You get the storage you pay for with Windows 10. My 32GB phone had 29.1GB available, and using a microSD card will give you a lot of additional flexibility.

Groove is the new name for Microsoft's music player, and it has a few neat tricks, such as automatically finding artist and album art for your MP3s. If you want to buy music on this phone, you're going through Microsoft, of course: Apple, Google Play, and Amazon's music stores are not available on this platform. You have better choices for streaming, though, with Spotify, Pandora, and Slacker available.

The same goes for video. The only real option other than Microsoft's store is Netflix; Amazon Prime, HBO GO, MGo, Vudu, and other services just aren't offered for Windows Mobile.

Audio through headphones defaults to a flat, treble-heavy sound, but a built-in equalizer can give you some bass boost. To watch videos on a big screen, you can toss them wirelessly using Qualcomm's Miracast technology, or hook up the Display Dock to get an HDMI out.

The Lumia 950 has all the ingredients it needs for killer camera performance. It has a 20-megapixel rear-facing camera with a fixed f/1.9 aperture, Zeiss optics, optical image stabilization, a triple LED natural flash, and a hardware shutter key. Unfortunately, as elsewhere, buggy software mars the experience. When it worked correctly, we took spectacular photos, even when zoomed in—but that was only about half the time. The problem: The 950's autoexposure kept getting confused and messing up the shots. The 5MP selfie

SHOT FOR SHOOTING
Despite strong hardware, the Lumia 950's camera suffers from much of the same bugginess that affects the rest of the phone.

camera on the front doesn't have an LED flash, but it still performs well, capturing detail free from grain and maintaining natural colors. It's as good as the front-facing cameras on the iPhone 6s and the Nexus 6P.

When it comes to video, the Lumia 950 is capable of crisp 2160p (4K) recording at 30fps, but unfortunately, the experience proved as variable as photos—again due to changes in exposure. The optical stabilization system, however, did its job; there was no evidence of jitter when hand-holding the phone, and although there was certainly some movement noticeable when walking, the stabilization system smoothed that motion.

CONCLUSIONS

Using the Lumia 950 in Continuum mode with a big monitor, wired keyboard, and mouse is smoother and easier than even on the iPad Pro, because Microsoft understands—ironically—that when you're in desktop mode, you don't want to have to poke at the screen. But disconnect the phone from your desktop display, and you're stuck as a second-class citizen of the smartphone world. Microsoft Edge and the People Hub set the bar for mobile browsing and for an integrated social contact book. But almost every first- and third-party experience is simply better on an Android or iOS device, even down to Microsoft's own Office apps.

I want to have high hopes for Windows 10 Mobile. It's full of good ideas, Live Tiles and Continuum foremost among them. But there are too many downsides for me to recommend the Lumia 950 to anyone other than die-hard Windows loyalists, who have no better choice at the moment (and, as Microsoft has delayed pushing out updates for at least a couple of months, won't anytime soon). Most smartphone owners will end up turning to more established platforms, and phones like the Samsung Galaxy S6 and the Apple iPhone 6s.

SASCHA SEGAN

Google Pixel C

$499 (32GB)
$599 (64GB)

●●●○○

Google's Ambitious Pixel C Tablet Is Hard to Swallow

Somewhere within Google, a software engineer is screaming. The new Pixel C is supposed to show off what a Google tablet can do, but it reminds me of the disastrous Samsung Nexus 10: a tablet with solid hardware so buggy that I can't believe it was actually released. Beyond bugginess, though, I'm still not comfortable recommending the Pixel C, because it's neither the best Android device nor the best tablet I've tested.

Google's large tablets have always suffered from the fact that many third-party Android apps format poorly on bigger screens. LG and Samsung tablets get around this, in part, by prioritizing multi-window multitasking. Not so the Pixel C, which lacks this critical feature. It's coming in the future, but right now Samsung is doing a much better job of designing an Android tablet experience than Google is. You're betting off buying the Galaxy Tab S2 or switching teams for the iOS-powered Apple iPad Air 2.

PHYSICAL FEATURES AND NETWORKING

Hardware isn't the problem with the Pixel C. It's a good-looking, well-built tablet at 9.53 by 7.05 by 0.27 inches (HWD) and 18 ounces. On the metal back, there's a colorful "lightbar" that shows the battery charge level if it's tapped or knocked, which is a neat feature. Along with the power and volume buttons, the slate has stereo speakers on both sides and a single USB Type-C port. Oddly, the entire back of the tablet is powerfully magnetized; I stuck it to a fridge, a filing cabinet, and an office door.

Google Pixel C

PROS High-end metal body. Good CPU performance. Long battery life.

CONS Extremely buggy. Lags behind other tablets on productivity. Dull cameras.

LOOK, BUT DON'T TOUCH
The Google Pixel C sports high-end hardware and is well designed, but it's held back by its bugs and performance.

The Pixel C's 10.2-inch LCD has a 2,560-by-1,800-pixel resolution for a peculiar (but benign) aspect ratio of the square root of two. Colors are rich if you're looking at the screen face on, and they look natural rather than oversaturated the way they can on many OLED screens. On the other hand, I found the display to be distractingly reflective when the tablet is laid flat on a table.

This might be the only tablet you ever see with Nvidia's Tegra X1 processor, which seems to be Google's way out of Qualcomm's current Snapdragon 810 debacle. The X1 here runs at 1.91GHz and acquits itself competitively on benchmarks. As far as raw processing power goes, it slightly outpaces the Snapdragon 810 but

THE BIGGEST AIN'T THE BEST
The Pixel C's big, high-resolution screen is nice, but the tablet's Tegra X1 chip can't compare with faster CPUS in other tablets.

falls short of the Exynos processors used in the latest Samsung Galaxy phones. Nvidia has its own Maxwell GPU, which gets better graphics frame rates than any other current processor powering an Android device. But alas, the X1 is slain in every possible way by the blazing A9X chip in Apple's iPad Pro.

My travails started when I began to test Wi-Fi performance. The Pixel C has the latest wireless technologies, with dual-band 802.11ac and Bluetooth 4.1. But Wi-Fi speeds were the worst I've seen on a high-end tablet. Even close to a Verizon FiOS router, where an older Samsung Galaxy Tab S consistently got 50 to 60Mbps down, the Pixel C reported 18 to 20Mbps. More than 20 feet away from the router the Pixel C had just 1 to 2Mbps down; the Tab S reported 10Mbps or more. The Pixel C also dropped its Wi-Fi signal over and over again at distances of 25 feet or more. Neither a Tab S, an iPad mini 4, nor several phones had any problems in the same location.

I think this is evidence of software bugs rather than hardware flaws, because the Pixel C reported surprisingly high upload speeds when it could stay connected—often up to several times what it reported in download speeds. That's extremely unusual, and most likely a signal that it's the OS's network stack, and not its network hardware, that's the problem.

On a more positive note, battery life is excellent—but then it should be, given the gigantic 9,000mAh battery. I got 8 hours, 10 minutes, of full-screen video streaming, which puts the Galaxy Tab S2 (5 hours, 11 minutes) to shame. The Pixel C's battery fully recharges within 3 hours using the included fast-charging USB Type-C adapter.

The tablet comes in 32 and 64GB capacities. On my 64GB unit, 52.88GB was available. There's no microSD card slot on the Pixel C, but you can connect a USB Type-C–compatible flash drive.

SOFTWARE AND PERFORMANCE

The Pixel C is Google's flagship tablet, so it will always have the latest Android OS. But the version of Marshmallow on this tablet (Android 6.0.1) was riddled with bugs. One of the biggest was that the tablet regularly dropped touch input, whether I was typing on the on-screen keyboard, or, say, flipping pages in Marvel Unlimited. (My guess is that something in the tablet's firmware is missing initial touch events.)

I kept running into smaller bugs, too. If you try to connect a keyboard to the tablet with Bluetooth off, it asks you to turn Bluetooth on—and doesn't dismiss the dialog box even after it's activated. Or if you upload a bunch of files to Google Drive, when the upload completes, the notification entry starts appearing and disappearing repeatedly from the notification list. That's just the tip of a very buggy iceberg, though they could be related to Android (as we saw similar behavior when we updated a phone to 6.0.1).

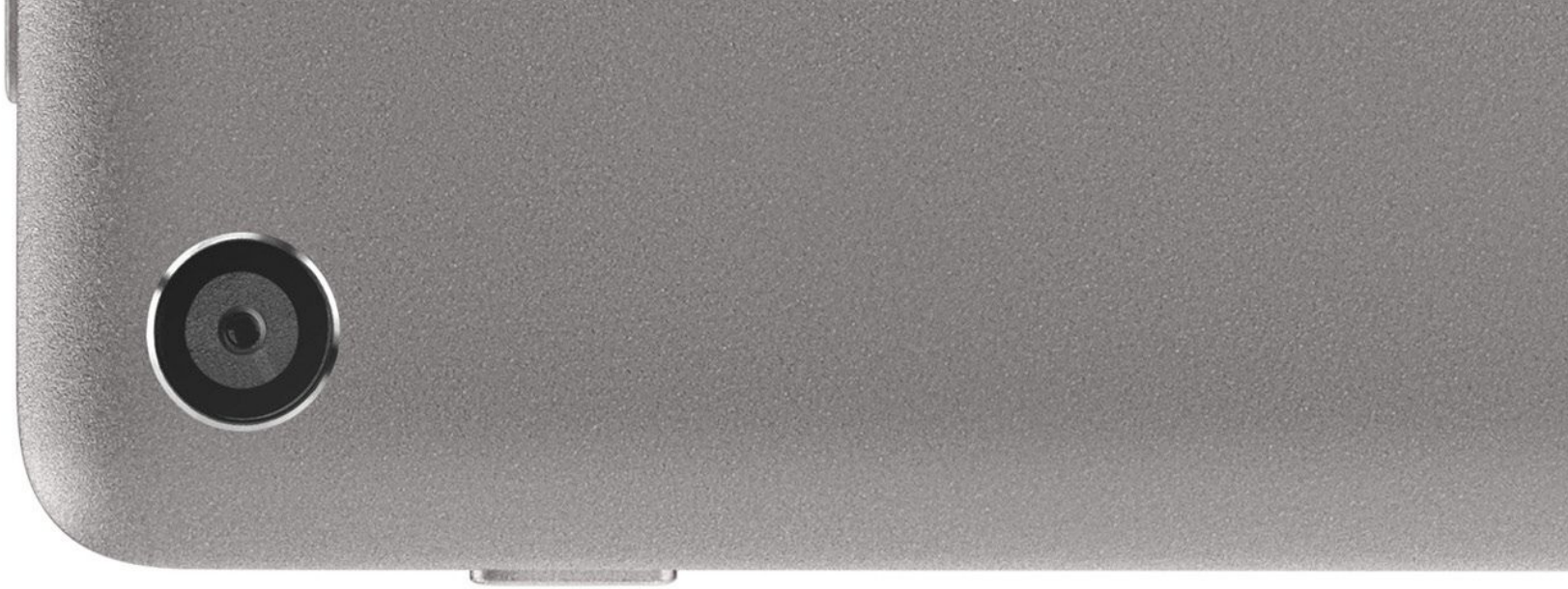
The main problem is that many Android apps aren't designed for large screen use in landscape orientation. Load up Facebook, Twitter, or even Google Docs on a tablet like this, and instead of a smart interface tailored for a big screen, you essentially see the phone interface that's stretched wide with lots of white space on the sides or in the middle. The situation has gotten a bit better with time—Microsoft Word, Evernote, and Autodesk Sketchbook, for instance, all are truly tablet-friendly now. But many big-name apps still lag behind. Google promises that it will bring multi-window capabilities officially with Android N, which will be released in the middle of 2016.

KEYBOARD AND PORTS

The Pixel C's $149 add-on keyboard is not intuitively designed. Initially, it appears to be a flat slab, with roomy, full-size keys that have terrific throw. The keys have better action than those on either the default Microsoft Surface Pro 4 or the Apple iPad Pro Smart keyboards. No pairing is necessary; when the keyboard is attached to the tablet, it's connected. The keyboard's kickstand has a good range of motion between 100 and 135 degrees, unlike the iPad Pro's keyboard, which only has one position.

But attaching and detaching the keyboard can be confusing. To attach it, you pull the tablet and keyboard apart, push the tablet back until it clicks onto a magnet, then pull it forward on its kickstand. To detach it, you pull the tablet forward completely off the keyboard, lay it flat on top of the keyboard, then slide it back. Everything is so highly magnetized that you can't do this on a metal surface, as the keyboard will stick to the metal and the kickstand won't pull up.

I also have mixed feelings about the Pixel C's single USB Type-C port, which is used for both charging and syncing. Attach it to a $20 Aukey hub and it becomes thrillingly powerful: I hooked up a wired keyboard, a mouse, and a flash drive, all of which worked perfectly with no configuration. Mouse support in particular gives Android tablets productivity potential that the iPad Pro can't match, because it means you no longer have to reach up to control the screen by touch. But you only get the one port, which means you can't charge and sync at the same time.



PHOTOGRAPHY

The Pixel C has a main 8-megapixel camera, which is unremarkable. In good light it doesn't show a lot of noise, but there isn't much shadow detail and there's some blur on moving objects. In poor light, things get soft quickly. The main camera captures 1080p video at 30 frames per second (fps) indoors and out, the former at the cost of heavy video noise.

For a tablet, the front-facing 2MP camera is probably more important, because it's how you'll be video chatting. Unfortunately, it has a shallow focal length and a tendency toward both noise and blurriness in anything but the best possible lighting. Video recording tells a better story. Indoors, I got good 30fps video, oddly with less noise than I got on the main camera. Once again, all of this could and should be tuned in firmware.

COMPARISONS AND CONCLUSIONS

It's unfortunate (and more than a little maddening) that Google released the Pixel C with its software in this state. Fortunately, there are much better Android tablets on the market. Samsung's Galaxy Tab S2 series is the best, offering the slimness, speed, stability, and dual-window multitasking that you want from an Android tablet.

Beyond competing with other Android tablets, the Pixel C underscores that the Android tablet ecosystem still isn't competitive enough with iOS or Windows. For productivity, Android is far behind Windows 10 tablets, with its no-compromise Office applications, wide range of different keyboard form factors, and as many open windows as you want. For education and fun, the range of properly formatted, good-looking apps and games on iOS still far outstrips the list of Android apps that properly make use of large tablet real estate. So even if Google fixes the software issues, the Pixel C still might not be the right tablet for you.

SASCHA SEGAN

Real Work Comes to Apple's iPad, But With a High Price

Apple iPad Pro

$799-$1,079

The 12.9-inch Apple iPad Pro looks like a very large tablet, but it's really more like the first iOS laptop. It's easily as powerful as a midrange laptop, and it can do things that other laptops can't. Alas, iOS is both the iPad Pro's triumph and its trial. You can go from zero to productive work in seconds, but if you're used to working on a Mac or PC, you'll quickly run into the tablet's limits: two windows, no easy way to navigate the UI without using your hand, and apps that just aren't as powerful as their desktop equivalents.

Ultimately, the supersize iPad Pro is a love letter to the creative types who have been Apple's most faithful customers. The iPad Pro isn't meant to sit on a desk with a keyboard attached; it's made to be held with Apple's spectacular new stylus, the optional Pencil, in your other hand. Its niche audience will surely adore it, but its very high price prevents us from endorsing it more heartily for everybody else.

PHYSICAL DESIGN AND FEATURES

At 12.0 by 8.68 by 0.27 inches (HWD) and 1.59 pounds, the iPad Pro is obviously taller and wider than all of the 10-inch tablets out there, although it's slimmer and lighter than the Surface Pro 4 (11.5 by 7.93 by 0.33 inches, 1.73 pounds), which I see as its primary competition. I found the iPad Pro easy to carry around, but difficult to use standing up. The 12.9-inch 2,732-by-2,048 display, at 264ppi, looks good at arm's length, and it's

stunningly bright and anti-reflective. The tablet comes in matte silver, gold, or gray finishes.

It's surrounded by a sizable bezel, with the 1.2-megapixel front-facing camera above it and the Home button/fingerprint scanner below it. This camera is designed for video conferencing, and is fairly noisy in low light. The 8MP main camera is on the upper-left corner of the back. There are good reasons for a tablet this huge to have a rear camera: augmented reality, computer vision, scanning, and translation applications all come to mind. So sharp macro performance trumps fast image capture. Macro shots taken with the iPad Pro—the kinds of shooting you'd do to translate text in a book, for instance—are sharp and clear. But in general, focus lock can take about half a second, so you can't just whip out the tablet and shoot instantly. The main camera records 1080p video at 30fps indoors and out, but not 4K video the way the iPhone 6s does.

With four speakers, two on each side of the device in landscape mode and each louder than you'll find on either the iPad Air 2 or the Surface Pro 4, the iPad Pro turns out powerful stereo sound.

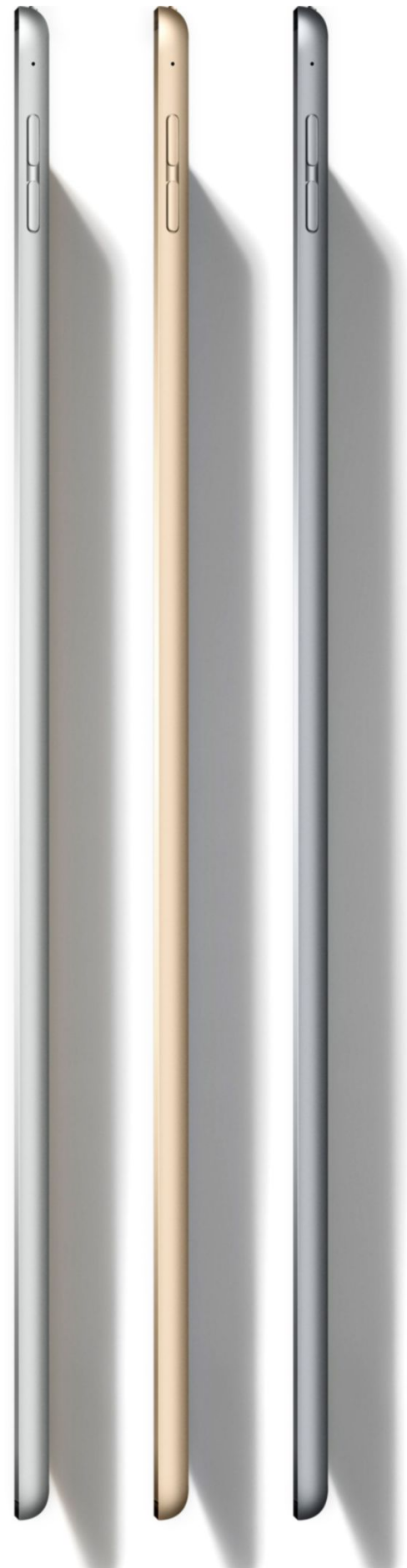
I tested the 128GB iPad Pro, which comes with 113.8GB of free storage. Only go for the lowest-end 32GB model if you intend to do your document and media storage in the cloud; the Microsoft Office app suite comes in a little over 2GB, for example, and a lot of high-end games are around 1GB each nowadays.

Our battery test, which streams a YouTube video at maximum brightness until the screen runs down, tends to privilege devices with power-efficient screens, and the iPad Pro's screen is just brutal on battery life. It lasted a mere 3 hours, 51 minutes, but you can double that by turning down the brightness to half, and I think the Pro—because of its huge size—is more likely than other tablets to be used plugged in. So although the battery life isn't a plus, I'm also not willing to call it a minus. The battery fully charges in a little over 4 hours.

Apple iPad Pro

PROS Laptop-level power. Surprisingly light. Pencil accessory is the best stylus experience on a mainstream tablet.

CONS Very expensive. Touch-centric UI with keyboard is awkward. Apps don't quite complete your workflow.



The Pro had about the same Wi-Fi range as the Air 2, but even better download performance at far distances: 60Mbps down instead of 30Mbps at the edge of Wi-Fi range. In any case, both tablets are terrific when it comes to wireless connectivity. The cellular model has the same banding as the multi-carrier iPhone 6s, including every band used by U.S. carriers except for AT&T's new Band 30. The embedded Apple SIM lets you choose between AT&T, Sprint, and T-Mobile, or get prepaid data through GigSky at the rate of $50 for 1GB. (That's bogus; T-Mobile is offering 5GB for $40, and often less when it's on sale.) The device is unlocked, and will let you install any nano SIM you want. The downside is that you'll pay $1,079 for the only cellular model available, which has 128GB of storage.

Apple's ARM processors have matched the performance of midrange Intel laptop processors.

PERFORMANCE AND ACCESSORIES

It's now clear that Apple's ARM processors have matched the performance of midrange Intel laptop processors, and all that remains is for the software to catch up. The iPad Pro benchmarks like a laptop: specifically, like an early-2015, 1.6GHz MacBook Air.

The iPad Pro scores even better than the MacBook Air on graphics, in fact. Using the GFXBench T-Rex test,

TABLETOP TABLET
The huge 12.9-inch screen on the iPad Pro gives you plenty of room to work, but it takes a real toll on battery life.

both the Pro and most Macs hit the VSync limit of 60 frames per second (fps) on screen. But off-screen, with the resolution normalized to 1080p, the Pro's A9X chip hits 163fps, which I've never seen before on an ARM-based device. That's double the frame rate on the iPhone 6s and the MacBook Air, and equal to the performance of a 2013-era desktop iMac. It's also double the frame rate of the Surface Pro 4, which does 28.4 and 89.4fps on screen and off-screen, respectively.

I was able to open and scroll around large Excel files without a problem, and multitask to my heart's content. But I also feel that the Pro is reaching the limits of iOS. In my standard test exporting a 1-minute file in iMovie, the Pro proved only 10 percent faster than last year's iPad Air 2, even though the processor and GPU are much more powerful. That's a limitation of the software.

Split-window multitasking is one iOS 9 feature that really comes into its own on the iPad Pro. I found myself frequently opening an Evernote sidebar to copy text into my Microsoft Word documents. To multitask, you drag in from the right-hand side of the screen and pick a compatible app. The app automatically snaps to about a third of the screen, but you can drag the split-view window wider to split the screen more evenly.

Attach Apple's $169 Smart Keyboard accessory and the iPad Pro certainly looks like a laptop, or at least like a Surface. Hold down the Command key in any app to see keyboard shortcuts. Start running Word or Excel and you'll be able to do very productive work, until you run into a workbook with macros that won't render on iOS.

But with a keyboard attached, the iPad Pro struggles with iOS's touch-first

design. There's no mouse or trackpad support, so you have to poke at the screen a lot. That's not a good ergonomic setup. Some apps (such as Slack) insist on popping up the software keyboard even when a hardware keyboard is attached.

And you just can't think of the iPad Pro as a general-purpose laptop replacement because so many applications assume desktop technologies. For instance, my daughter's school has an online homework app that, for some reason, doesn't render in mobile Safari. Google Docs doesn't work well on this tablet at all, something Apple says it's working with Google on. The Web, especially the enterprise Web, is also still plumbed with land mines of Flash and Java, and iOS devices can't touch that.

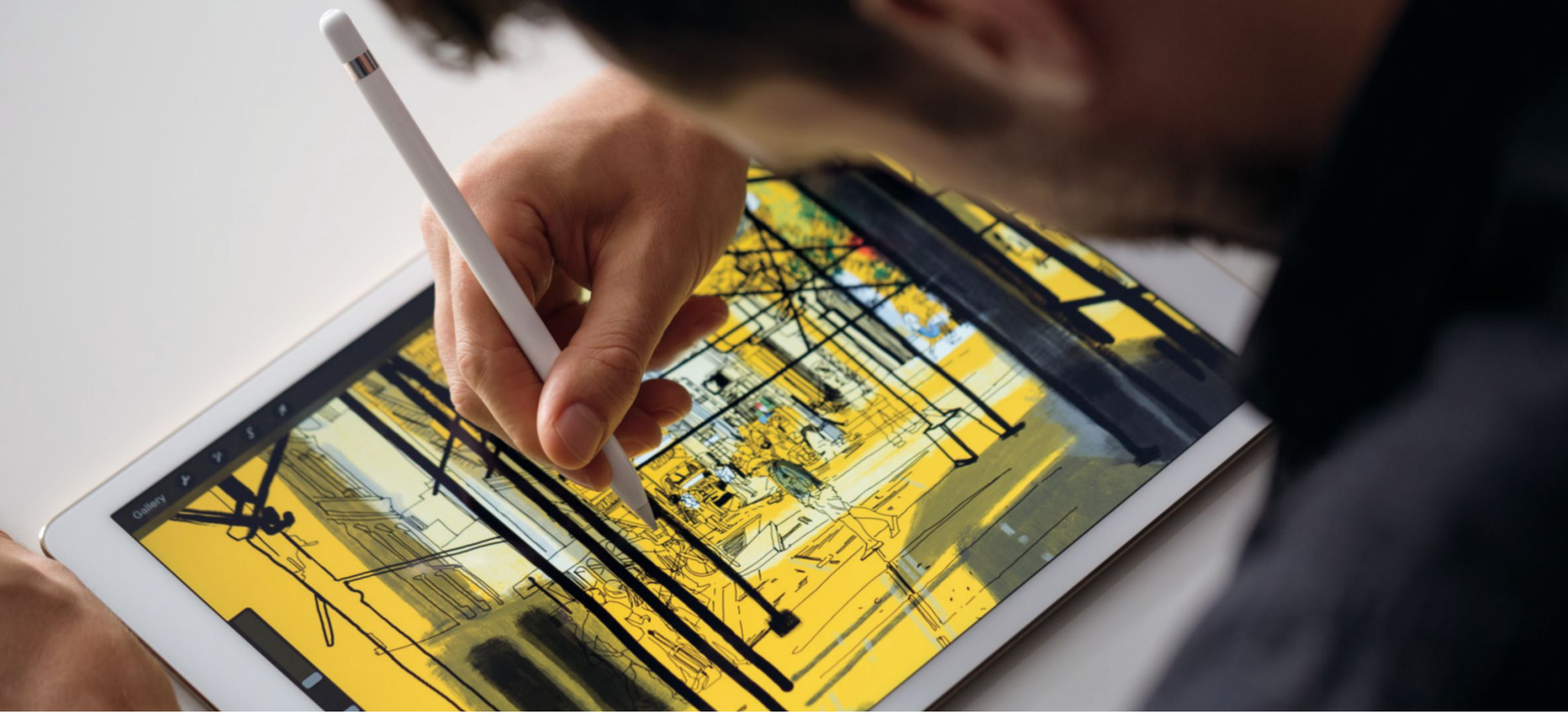
Many people already use iPads as laptop replacements, reveling in their always-on, quick-hit, virus-free nature. The iPad Pro is a step up in that regard. But it doesn't break any real new ground—on its own.

IOS FOR PRO APPLICATIONS

Add a smooth, white, $99 accessory to the iPad Pro, and amazing things start to happen for artists, designers, architects, and other members of Apple's core creative classes. The Pencil feels warm, comfortable, and delightfully well balanced. You charge it with a built-in Lightning connector under a cap on the back end. Apple says the Pencil has 12 hours of charge, and charges enough for 30 minutes of use within 15 seconds.

The Pencil is far superior to hold compared with Microsoft's Surface Pen, which feels lumpy and awkward in contrast. Drawing on the screen has zero lag, and both pressure and angle sensitivity work perfectly. In addition, iOS's bench of pressure-sensitive, high-end creative apps runs deep, with full Adobe and Corel suites available. Although high-end creative apps are available on the Surface Pro 4, their stylus compatibility isn't obvious and sometimes involves driver updates, and the screen has a disturbing amount of give while drawing.

But here's where the iOS dilemma comes up again. Corel's Procreate and



Adobe Draw are terrific apps, but there's a reason Adobe Draw isn't called Illustrator—it just isn't Illustrator. If you're a graphics professional, eventually you're going to want some feature that's in Illustrator but not Draw, and then you're going to have to put the iPad Pro down and use your Mac instead.

And yet, you can't draw on your Wacom Cintiq in a meeting (unless you get the Cintiq Companion 2, which costs far more than the iPad Pro), so there's Apple's genius: The company just created a $1,000 accessory. Now creative professionals need both a Mac and an iPad Pro.

CONCLUSIONS

We've seen iPads before. We've seen keyboard cases. We've even seen styluses. But, as happens so often, Apple has remixed existing elements into something new, driven by design, ease of use, and compelling third-party apps.

But the more pro you get with the Pro, the more you start pushing against the functionality limits of even the most professional iOS apps. That's why the Surface Pro 4 is still our Editors' Choice professional-class slate tablet. It offers the applications pro users expect, with no compromises. Most consumers, meanwhile, will be more than happy with the more manageable iPad Air 2.

The iPad Pro does, however, break the ARM/x86 boundary to create a mobile device with the kind of processing power previously reserved for laptops, and extends Apple's touch-centric interface to officially include keyboards and styluses. The iPad Pro pushes Apple's tablets forward in ways we haven't seen for a few years. Let's see what software developers can do with it.

SASCHA SEGAN

HP Spectre x2

$1,149.99

●●●●○

This Touch-Screen Tablet Is Almost as Good as a Laptop

The HP Spectre x2 will appeal to you if you think a touch-screen tablet is the Windows 10 PC you should be carrying around. It has a speedy but power-efficient Intel Core m7 processor, 4G LTE capability, and it comes with a full-size mechanical keyboard cover. This tablet is lightweight, has a full-HD, In-Plane Switching (IPS) screen, and comes in at less than $1,200. We're not sure that the Spectre x2 is the ultimate PC for everyone, but it's a solid laptop alternative if you need to type often, but still want the portability of the tablet form factor.

DESIGN AND FEATURES

A slate tablet with a detachable keyboard case, the Spectre x2 shares a similar design with the Microsoft Surface Pro 4 and its predecessors. It has a matte silver finish on its back, with a chrome HP logo. A stainless steel, U-shaped kickstand pops out of the back panel when you slide the release on the left side

of the tablet. The kickstand offers a wide range of angles, so you can use it from a seated or standing position, propped on a table, or on your lap. Like the Surface tablets, the kickstand may dig into your leg if you're using it on your lap.

The aluminum-clad Spectre x2 measures 0.31 by 11.93 by 8.23 inches (HWD) and weighs 1.88 pounds alone and 2.72 pounds with its keyboard cover attached. That's a bit heftier than the Microsoft Surface Pro 4, which is 0.33 inch thick and weighs 1.73 pounds sans keyboard. It's a measurable difference, but you're unlikely to notice unless you compare them side by side. The keyboard case adds 0.21 inch to the tablet's thickness (for a total of 0.52 inch), but the depth and width remain the same.

Its included backlit, chiclet-style keyboard cover makes the Spectre x2 a better proposition than the Microsoft Surface Pro 4, which doesn't come with a keyboard, only a stylus. It's also a much prettier keyboard, with an aluminum deck that lends a bit of welcome rigidity. The two-stage magnetic connector on the keyboard helps steady it, and raises the keyboard to a more comfortable angle. All of the signals from the keyboard pass through the magnetic connector, including the power for the lighting.

HP Spectre x2

PROS High-resolution display. Two USB Type-C ports. Good battery life. Includes 4G LTE radio, well-constructed backlit keyboard case.

CONS No HDMI, USB 3.0 ports. Woefully soft speakers.

WHAT'S YOUR ANGLE?

The kickstand on the HP Spectre x2 makes it possible for you to use the system in a wide variety of positions.

The keys themselves have a full 1.5mm keystroke and are mostly full-size, with half-height function keys and a small Delete key the notable exceptions. Using the keyboard is comfortable enough for short sessions in your lap, and for extended sessions on, say, a table at a coffee shop. The one-piece touchpad is wide, so you could theoretically use the system with keyboard and touchpad alone.

Of course, that would nullify the reason for using a tablet in the first place, which is the ten-point touch screen. On the whole, the display is responsive when playing games, manipulating on-screen user interface elements, or simply navigating the Web in the Microsoft Edge browser. Multitouch gestures like pinch-to-zoom and two-finger scrolling work without a hitch in Edge, but not in Google Chrome.

Using the keyboard is comfortable enough for short sessions in your lap.

WHEN BIGGER IS BETTER
Thanks to its unusual 1,920-by-1,280 resolution, the Spectre x2 is easier than some tablets to hold in your hand.

The 12-inch 1,920-by-1,280 screen is taller than most 1080p laptop screens, and matches the 3:2 aspect ratio and native resolution of the entry-level Surface 3; the Surface Pro 4's 12.3-inch screen has a much higher 2,736-by-1,824 resolution. A slate with a 3:2 aspect ratio display is easier to hold in your hand than one with a 16:9 screen, such as the Dell Latitude 13 7000 Series 2-in-1.

The slim frame means there's limited space for ports. There are only two USB Type-C ports and a headset jack on the entire tablet. The AC adapter requires a

USB port for charging, so only port is available while the tablet is plugged in. If you want to use a USB flash drive or an external solid-state drive (SSD), you need to use the included adapter. Likewise, to connect an external display, you'll have to pick up a third-party DisplayPort or HDMI adapter separately. It's not all bad news, however; there's a microSD card slot for additional storage, and 802.11ac Wi-Fi and Bluetooth handle wireless connections.

In addition to Wi-Fi, the Spectre x2 comes with a built-in 4G LTE modem and a Verizon SIM card (though you'll have to sign up for a data plan on your own). At the time of this writing, Verizon's monthly plans run from $20 for 2GB to $710 for 100GB of data. During testing, we were able to view streaming videos, research stories, and work on cloud-based apps over 4G LTE without a hitch. It was just like being connected to Wi-Fi.

Storage comes by way of a 256GB SSD, and there's 8GB of RAM. You get 199GB of free space out of the box, though there are a few apps like Netflix, Snapfish, and Candy Crush Saga that you can uninstall as well. That said, there really aren't too many preloaded apps, which is nice. HP backs the tablet with a one-year standard warranty.

PERFORMANCE

The Spectre x2 is equipped with a Skylake-based Intel Core m7-6Y75 processor with integrated Intel HD Graphics 515. Like Core i7 chips, Core m7 processors are the top-of-the-line, high-performance CPUs. This shows in the Spectre x2's PCMark 8 Work Conventional score of 2,841, which beats tablets equipped with previous-generation Core M processors, such as the Dell Latitude 13 7350 (2,426) and the Toshiba Portege Z20t-B2112 (2,607), and even Core i7–powered laptops like the Lenovo Yoga 900 (2,564).

HOW YOU USB
There are two USB Type-C ports on the Spectre x2, but you'll only have access to one if you're using the system while it's plugged in.

The Spectre x2 finished a little behind the Lenovo Yoga 900 in our multimedia tests, but fared well on the Handbrake (3:17), CineBench (221), and Adobe Photoshop CS6 (4:36) tests. Tablets with the older Core M processors, like the HP Elite x2 1011 G1 and the Lenovo ThinkPad Helix 2nd Gen, scored much lower on the multimedia tests, whereas systems with Intel Core i5 and i7 processors, like the Surface Pro 4 and the Yoga 900, were faster overall. As expected for a tablet with integrated graphics, 3D gaming test results were mediocre. You'll be able to play games with moderate requirements like Diablo III and DOTA 2, but you'll have to dial down the quality settings.

Battery life was very good at 9 hours, 38 minutes, on our rundown test. That will make it possible for you to watch movies and TV shows during a cross-country flight and have power left over. That's less than the Surface Pro 4 (10:19) and the Yoga 900 (10:56) deliver, but more than you get with the Asus Transformer Book T300 Chi (5:54) or the Lenovo Yoga 3 Pro (8:19).

CONCLUSION

The HP Spectre x2, billed as a laptop replacement, has the power and speed to run complex applications, more than 9 hours of battery life, and, unlike the Microsoft Surface Pro 4, it comes with a built-in 4G LTE modem and a keyboard cover. The Surface Pro 4 remains our top pick for high-end slate tablets, given its higher performance, longer battery life, higher-resolution screen, and better legacy connectivity. But if you want to save $150 and avoid paying extra for a keyboard, the Spectre x2 is worth considering.

JOEL SANTO DOMINGO

Acer Predator X34

$1,299

Gaming Graphics Look Great Graded on a Curve

PC MAGAZINE EDITORS' CHOICE

Designed for discerning gamers, the Acer Predator X34 is a stunning 34-inch ultrawide gaming monitor featuring a curved screen and Nvidia's G-Sync anti-tearing technology. It uses an In-Plane Switching (IPS) panel to deliver rich, accurate colors and crisp grayscale reproduction, and its UW-QHD resolution provides outstanding image detail. You only get two video inputs with the X34, but it is loaded with game-friendly features, including aim points, customizable game profiles, and LED lighting effects.

DESIGN AND FEATURES

One look at the X34 tells you that this is not a typical monitor. For starters, the cabinet is huge, measuring 14.8 by 32.2 by 4 inches (HWD). It uses a bezel-free design and has a glossy black finish with a chevron-shaped pattern at the rear

and a Predator logo on the front. The 3,440-by-1,440-resolution panel has a matte antiglare coating, a 21:9 aspect ratio, and a curvature radius of 3,800R. (This means that if you put these monitors edge to edge to create a complete circle, the circle's radius would be 3,800mm, or about 12.5 feet) The 20-pound cabinet is supported by a V-shaped aluminum stand that offers 40 degrees of tilt (5 degrees forward, 35 degrees backward) and 5 inches of height adjustability. There are four VESA mounting holes for use with the included mounting plate, but you'll need to supply your own wall mounting bracket kit.

Embedded in the cabinet is a pair of 7-watt speakers that use DTS Sound technology to deliver robust audio output with a generous helping of bass response. All of the X34's I/O ports are located around back, facing outward. You only get two video inputs with this model (DisplayPort and HDMI), but it is equipped with a five-port USB 3.0 hub (four downstream, one upstream) and a headphone jack.

There are five red function buttons and a Power switch located on the bottom edge of the cabinet, off to the right. The buttons are used to access the settings menus and use on-screen labels that makes navigation easy. They also serve as hot keys for toggling between inputs, selecting one of three-user defined game profiles that let you assign custom image settings for each profile, selecting an overdrive mode (Off, Normal, Extreme) that accelerates pixel response to eliminate motion artifacts, and adjusting speaker volume.

Picture settings include Brightness, Contrast, Adaptive Contrast, Dark Boost, and Low Blue Light. In addition to Gamma and Color Temperature, there are settings for Saturation, which adjusts color brightness, and 6-Axis Color, which lets you fine-tune color quality by adjusting the intensity levels of red, green, blue, cyan, magenta, and yellow. There are five picture presets: User, Standard, Movie, Graphics, and ECO.

Acer Predator X34

PROS Excellent performer. USB hub is integrated. Offers gamer-centric settings, G-Sync support. Cool design.

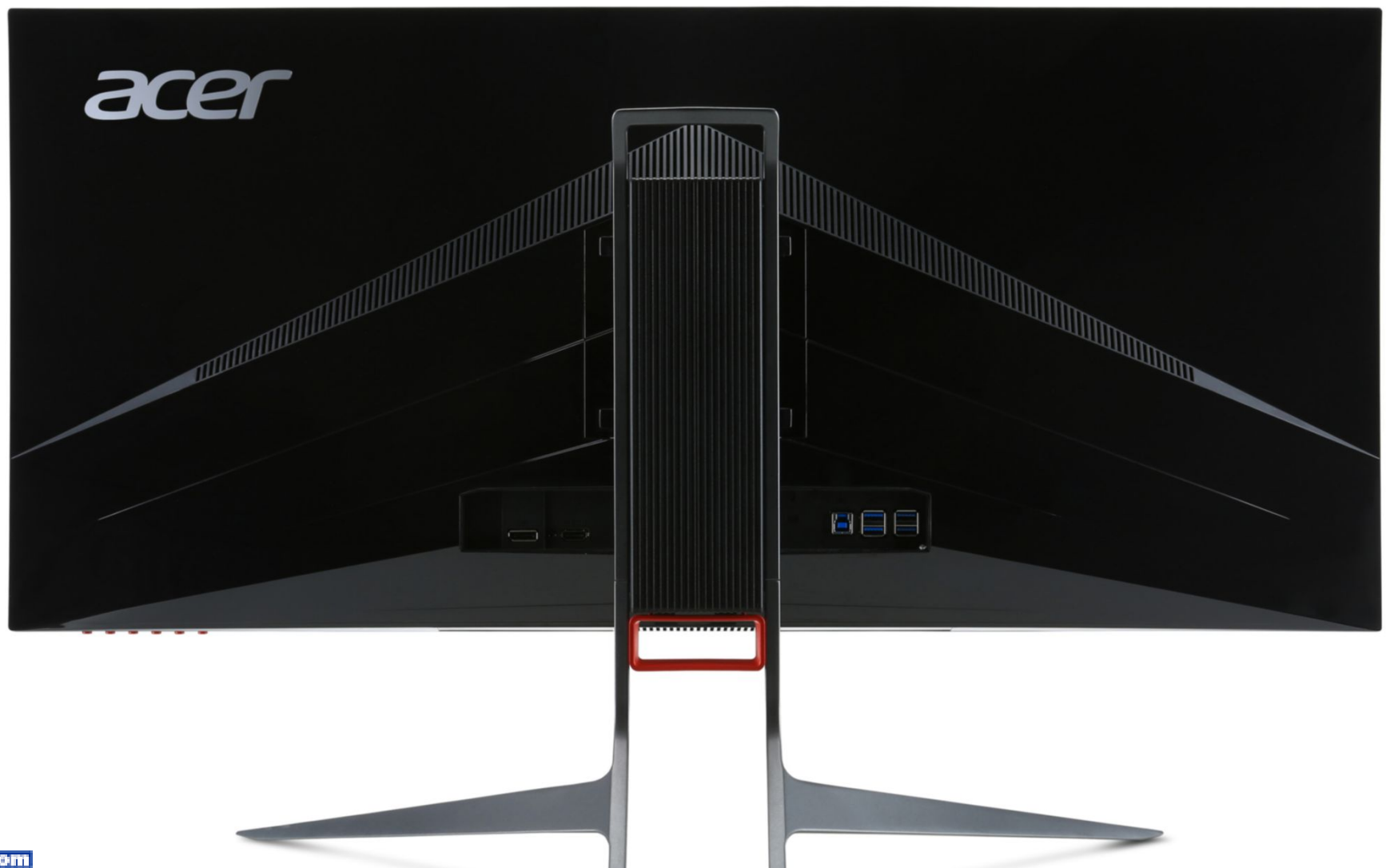
CONS Expensive. Only two video inputs.

Gamers looking to improve their shooting skills will appreciate the X34's Aim Point feature, which offers three aiming targets for use with first-person-shooter (FPS) games. There's also an Ambient Light feature that lets you enable the LED lights embedded in the bottom edge of the cabinet. You can select a color (red, green, blue, white, or orange) or have it change randomly, and you can select a style (fixed, flashing, breathing, and ripple) to suit your mood. Finally, with the Overclock setting you can speed up the monitor's refresh rate to 100Hz (the default is 75Hz), but you'll have to reboot your PC for the change to take effect.

The Predator X34 comes with DisplayPort and HDMI cables, a USB upstream cable, a Quick Start Guide, and the above-mentioned wall mounting plate and screws. It is covered by a three-year warranty on parts, labor, and the backlight.

PERFORMANCE

Color accuracy on the X34 is spot-on. Colors appeared rich and uniform while watching *Captain America: The Winter Soldier* on Blu-ray, and image quality was sharp. Grayscale performance was equally strong; the X34 displayed every shade of gray on the DisplayMate 64-Step Gray-Scale test cleanly, without any clipped whites or crushed blacks. As a result, my test images displayed outstanding highlight and shadow detail. Viewing angles were wide, with no color shifting or loss of luminance. And the curvature made me feel closer to the action than a flat-screen panel and provided a sense of increased peripheral vision while playing Call of Duty: Black Ops III on a Sony PlayStation 4.



The panel's 4ms (gray-to-gray) pixel response kept ghosting artifacts at bay, and the default 75Hz refresh rate provided relatively smooth, blur-free action on my Crysis 3 gaming tests, but I did notice a bit of screen tearing. Enabling G-Sync made the action noticeably more fluid and fixed the tearing problems. The 10.3ms input lag (the time it takes for the monitor to react to a controller command) is short, but not as short as that of the BenQ XL2430T (9.5ms). Regardless, input lag is not an issue.

The X34 drew 49 watts of power in testing while set to Standard mode and 36 watts when set to ECO mode. By way of comparison, the Acer XR341CK consumed 50 watts in Standard mode and 36 watts in ECO mode. The BenQ XR3501 also used 50 watts in Standard mode, but lacks a power-saving mode.

CONCLUSION

If you're looking to pair your high-end gaming system with an equally extreme big-screen ultrawide monitor, look no further than the Acer Predator X34, but prepared to part with a wad of cash. Its 34-inch curved screen brings more depth to your gaming experience than you get from a large, flat-screen model, and it delivers excellent motion handling, color, and grayscale performance. It may cost more than the Acer XR341CK and the BenQ XR3501, but it offers better all-around performance than both and has a higher resolution than the BenQ model. Throw in a pair of rich-sounding speakers, LED lighting effects, and programmable gaming modes, and the Predator X34 well deserves our Editors' Choice for big-screen ultrawide gaming monitors.

JOHN R. DELANEY

A Mini 3D Printer for Small Uses (and Small Users)

MakerBot Replicator Mini

$1,375

The Replicator Mini is the most compact 3D printer from MakerBot yet, and its print area is small, but its print quality essentially matches that of the company's flagship model, the Replicator. It had several glitches and a couple of misprints during testing, but the problems were resolvable. It's easy to set up, and MakerBot's software (whether run from a desktop or a mobile device) is user-friendly. The Mini is a good choice for a school or a 3D printing newbie.

DESIGN AND FEATURES

The all-black Mini is compact, measuring 15 by 11.6 by 12.2 inches (HWD) and weighing 18 pounds. It has a rigid frame, and it's open at the front, on the sides, and on top, permitting easy access to the print bed and easy viewing of prints in progress. A camera in one upper corner of the Mini lets you monitor print jobs from your desktop or mobile device. The Mini has a self-leveling print bed, so you don't have to frequently calibrate the printer to ensure that the extruder is at the proper distance from it.

The Mini's build area is just 3.9 by 3.9 by 4.9 inches, the smallest of any 3D printer we've reviewed, so it's only capable of printing relatively small objects.

In comparison, the Ultimaker 2 Go has a build area of 4.5 by 4.7 by 4.7 inches. Larger still are the build areas of the MakerBot Replicator (5.9 by 7.8 by 9.9 inches) and the LulzBot Mini 3D Printer (6 by 6 by 6.2 inches).

MakerBot's so-called Smart Extruder is exceedingly easy to install or remove, as it's held in place by magnets. One example of its "intelligence" is that it detects when you're out of filament and automatically pauses the print so you don't have to scrap it. It also sends notifications to the MakerBot Desktop software and MakerBot Mobile app. The extruder had minor issues in testing, which I'll discuss below.

The Mini lacks the control panel and display that are so useful on the Replicator, as they let you load and unload filament, preheat the extruder, launch print jobs, and perform other functions. The only control on the front of the Mini is a button that's surrounded by a frame that glows different colors depending on the printer's status. For instance, if it's glowing blue, it's ready to print, and pressing the button will launch (or resume) the print job.

SETUP AND OPERATION

Setting up the Mini is straightforward. Once you unpack it, you install the Smart Extruder by pressing it against the back of the extruder carriage so magnets lock the extruder into place. Then you load a filament spool into a slot in back of the printer, unclip a feeder tube from the side of the slot and snake the filament through it, and reattach the spool. You then peel off the backing of a sheet of blue tape (several are included), affix the tape to the build plate, and slide the build plate into place. You connect the included USB cable to your printer and computer, and then plug the printer in and power it up. You then download, install, and run the MakerBot Desktop software, and complete the setup using the Setup Assistant wizard.

MakerBot Replicator Mini

PROS Safe design for an open-frame printer. Self-leveling build plate. User-friendly software. Prints via USB and Wi-Fi. Can print from desktop, mobile devices. Good overall print quality.

CONS Tiny build area. Relatively expensive filament. Noisy during operation. No display. Misprints, occasional filament jams during testing.

SMART POWER
MakerBot's Smart Extruder is easy to install and has features that take some of the guesswork out of the 3D printing process.

The Replicator Mini uses MakerBot's small (0.5-pound) spools of 1.75mm polylactic acid (PLA) filament, which range in price from $18 (for standard filament) to $25 (for specialty filament, such as neon and translucent. Currently, MakerBot only sells PLA filament for the Replicator Mini. That may change later in 2016, when the company launches a line of composite filaments that mix PLA with non-plastics (namely, limestone, iron, maple, and bronze) and can take on some of the properties of these materials. For instance, a magnet will attract an object printed from iron filament, and you can sand and stain an object made from maple. When the new filament is released, you will probably need to get a new extruder designed to work with it.

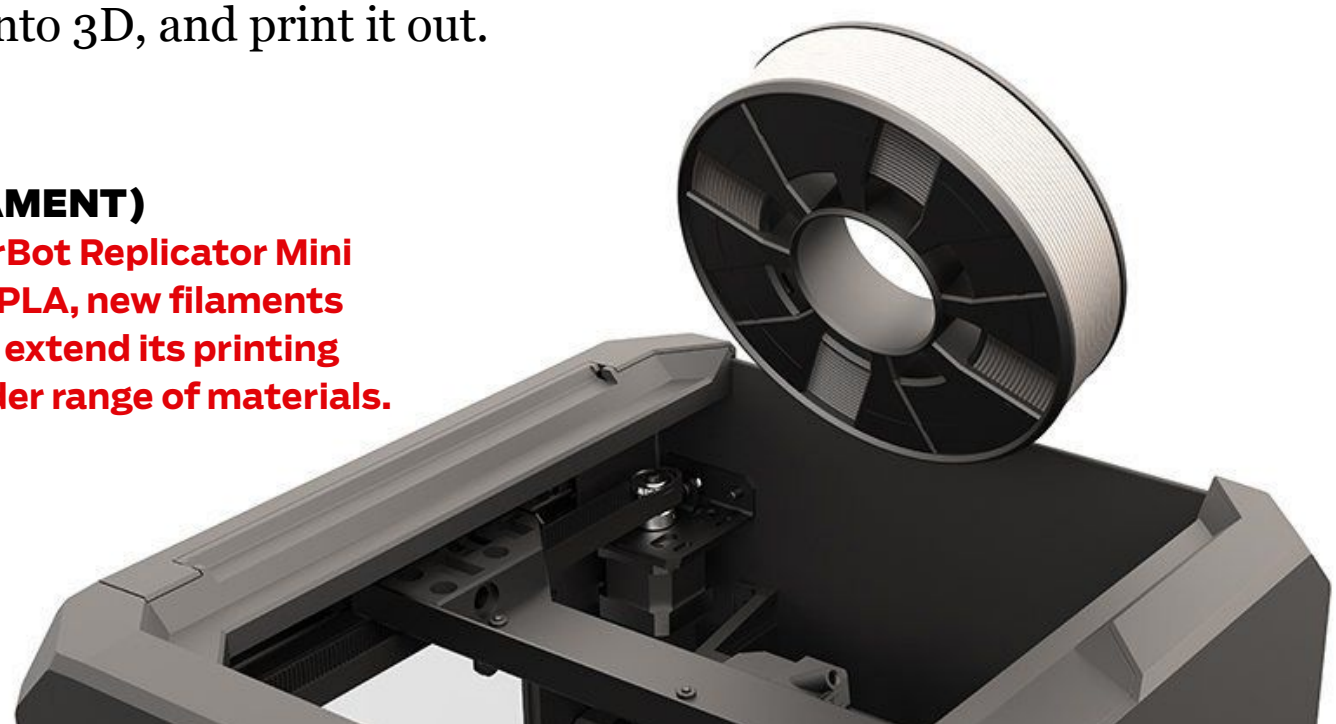
With open-frame printers, there is always a risk that you could get burned by touching the hot extruder, but this risk is minimized with Mini, because the extruder nozzle is hard to reach from the front or top of the printer. This design should keep both adults and children about as safe as is possible with any open-frame printer.

The Mini makes a range of sounds from motors revving to weirdly electronic melodies. It's louder than most 3D printers we've tested; if you buy it, you'll want to find a place for it where it won't disturb others.

You can print to the Mini from a computer over a USB or Wi-Fi connection, as well as over Wi-Fi from an iOS or Android phone or tabloid with the Mobile app installed. This app is the mobile equivalent of Desktop, and I used it to print one of our test objects, which I downloaded from Thingiverse, MakerBot's repository of hundreds of thousands of user-created 3D object files. You can use the app to see the print in progress, or take a snapshot of it, as the Replicator has an onboard camera looking down into the build area from the printer's front-right corner.

A second MakerBot app, PrintShop, lets you create and modify objects from onscreen templates, such as a bracelet, a ring, a vase, a medal, or a block of text. A special function, Shape Maker, lets you photograph a 2D drawing with your iPad, convert it into 3D, and print it out.

TAKE YOUR FIL(AMENT)
Although the MakerBot Replicator Mini currently only uses PLA, new filaments later in the year will extend its printing capabilities to a wider range of materials.



SOFTWARE

MakerBot Desktop lets you load, edit, and print files, save files to a personal library, find new Thingiverse objects to print, and access instructional and troubleshooting videos. As for printing, first you press the Prepare tab in a taskbar near the top of the screen. This brings up a representation of the print bed, which fills the screen. You then pull down the File menu in the screen's upper-left corner and click on "Add to open Windows Explorer." When you click on the 3D file of your choice (in STL or OBJ format), it will load, and you can see it on screen. By pressing icons on the left side of the screen, you can zoom in or out, or move, rotate, or resize the object.

At the screen's upper right are a line of tabs. The Settings tab opens a dialog box that lets you choose between low (300-micron), standard (200-micron), and high (100-micron) resolutions and add a raft or supports. You can open a Custom menu that lets you change printing speed, extruder temperature, amount of infill, and more. The Export to File tab lets you save a file in MakerBot's .thing format to a USB key (or other drive) for printing out. In the screen's upper-right corner is the Print tab, from which you launch your print, provided your computer is connected.

PRINTING

I printed ten test objects with the Mini, over both USB and Wi-Fi. Overall, print quality was very good, on par with the Replicator's, although I experienced several misprints with the Mini, compared with only one with the Replicator. In a couple of cases I encountered a "filament jam" error I had to fix by unloading, snipping, and reloading the filament; one time, this resulted in a partial gap in the layering at the point of the jam, which effectively ruined the print. In another case, the extruder continued to trace its programmed pattern even though no filament was flowing.

HEY, GOOD-LOOKING
Despite some misprints, the Replicator Mini's print quality is on par with that of its much larger sibling, the Replicator.

A REPLICATOR FOR EVERY USER
A range of printer sizes lets you find exactly the Replicator that's right for you. (The Mini, unsurprisingly, is the smallest.)

I experienced a couple of other extruder-related issues with the Mini. For a while, the extruder was balky and steadfastly refused to extrude, although there was no error message, and the only way to fix this was by replacing the filament spool. Also, a couple of times I received the message that the extruder was unseated. That one was easy enough to fix; I removed the extruder and let the magnets snap it back into place.

All the printing issues I encountered were resolvable, but printing wasn't the smooth, problem-free experience I had when testing the LulzBot Mini. That printer produced my dozen or so test objects without any misprints or errors, can print with a variety of filament types, and was a cinch to set up and operate as well.

CONCLUSION

According to MakerBot, the Replicator Mini is geared largely to educators. Its relatively low price makes it budget-friendly for schools, and it's a good platform for students to learn the ropes of 3D printing. Both it and its software are easy to use, too. Although there were some glitches and misprints in my testing, operation for the most part was smooth, and print quality was very similar to the Replicator's, though the Mini's build area is much smaller. In testing, it lacked the flawless operation of the comparably priced LulzBot Mini, but that won't matter for the young and first-time users at whom it's aimed.

TONY HOFFMAN

True Key by Intel Security

$19.99 per year

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Could Intel's Security App Spell the End of Passwords?

Do you use a password manager? If not, chances are good you're recycling the same handful of lame passwords for all your secure websites, and that's a problem. A breach at one site (or a good guess by a wannabe hacker) could expose all of your supposedly secure logins. True Key by Intel Security aims to do more than just manage your passwords, though. In the end, Intel hopes to eliminate passwords altogether.

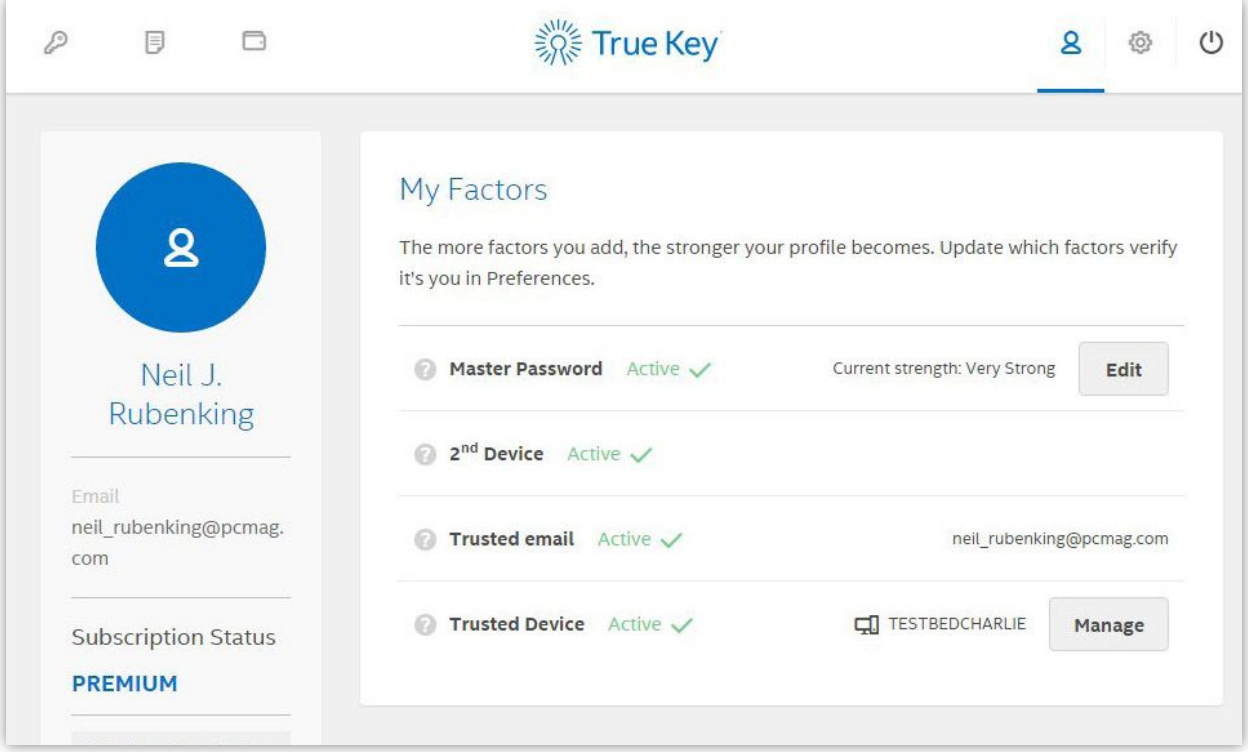
You can set up a True Key account for free and use it on all of your Windows, Mac, iOS, and Android devices. But if you want to store more than 15 sets of login credentials, you'll have to spring for the $19.99-per-year subscription. Users of McAfee Internet Security automatically get the equivalent of a True Key premium subscription; Total Protection and LiveSafe each come with five True Key subscriptions, so up to five family members can protect their devices with their own subscriptions.

IS IT REALLY YOU?

Like virtually every password manager, True Key asks you to define a master password when you create a new account. But it doesn't stop there. Depending on your device, you can add a wide range of other authentication factors.

The email address that's associated with your account can function as an authentication factor. True Key sends a message to that account, you click a link, and the app is unlocked. In addition, once you successfully log on to a new device, you can define that device as trusted. The fact that you're logging in from a trusted device serves as partial proof of your identity.

Once you've installed True Key on a mobile device, you can use that device as a second layer of authentication. When you try to log in, True Key sends a notification to that second device. Swipe the notification and you've authenticated yourself.



It gets better. If the device you're using has a forward-facing camera or a fingerprint reader, you can use them for authentication. In testing, I found that True Key wouldn't recognize my face until I removed my glasses. On the plus side, it had no trouble authenticating me on an iPad and a Windows laptop after I set up facial recognition on an Android device.

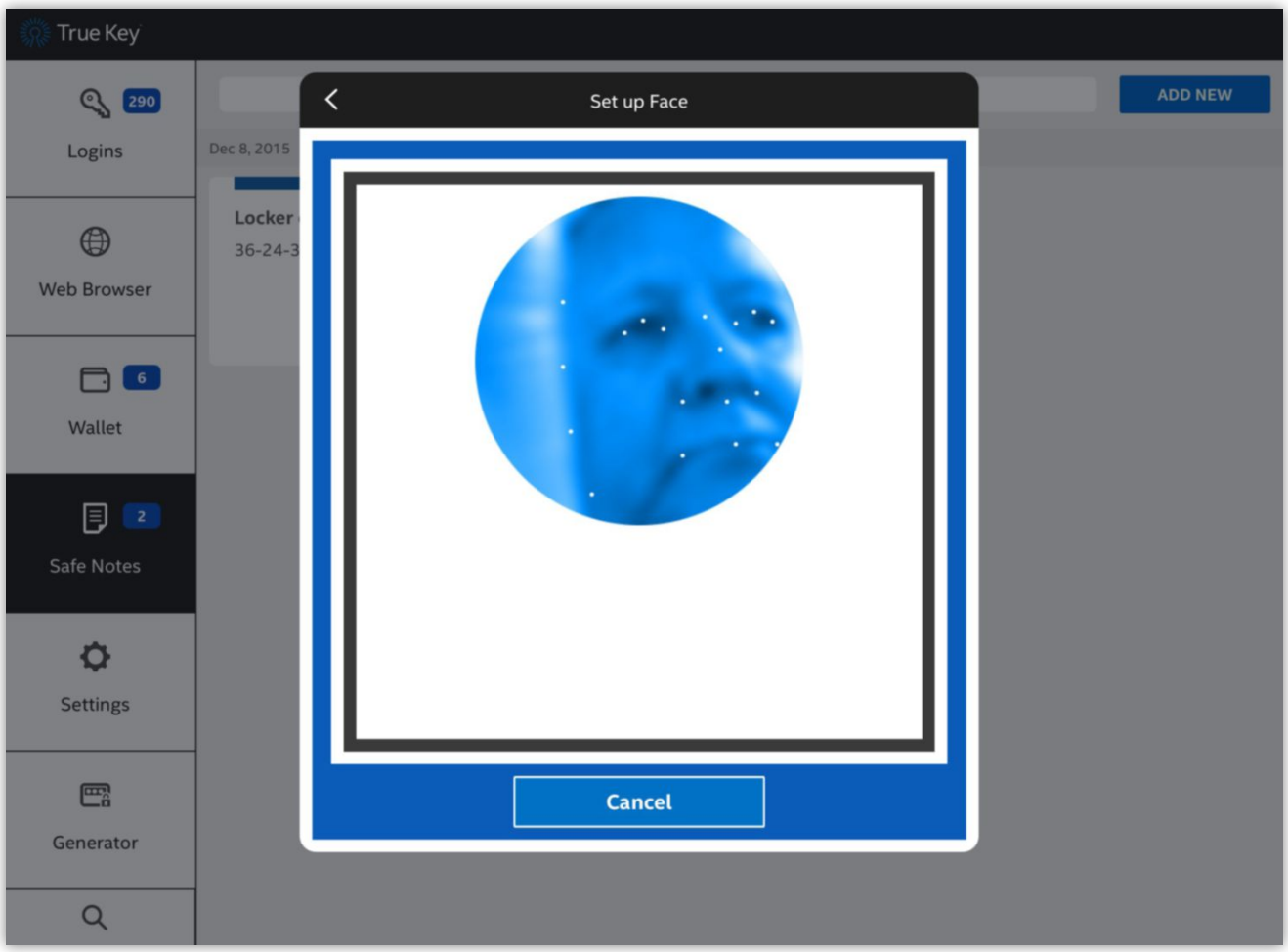
True Key by Intel Security

PROS Syncs data across Windows, Mac, Android, iOS. Comprehensive multifactor authentication. Can import passwords from browsers, competitors. Facial recognition login for Windows. Can reset master password.

CONS Doesn't handle oddball logins. Can't fill in Web forms using saved personal data. No actionable security report, password sharing.

IDENTIFY YOURSELF
True Key by Intel Security can use many different factors for authenticating your identity.

In the movies, secret agents typically fool facial recognition systems using a photo of the victim. I couldn't actually get True Key to accept a photo of me for authentication. But if you're really concerned this might happen, you can enable enhanced facial recognition, which requires you to turn your head from side to side.



True Key's multifactor authentication means that you can reset a forgotten master password, as long as you can prove your identity using other factors.

You don't have to invoke these multiple layers of protection unless you want to. At the Basic security level, you can choose to just rely on the master password, along with the default factor of logging in from a trusted device. You can replace the master password with facial or fingerprint recognition on devices that support those. At the Advanced security level, you need two factors besides a trusted device. For mobile devices, these can be any two of master password, face, and fingerprint. On a desktop, you can choose master password and second device. By digging into your authentication factor profile, you can add trusted email.

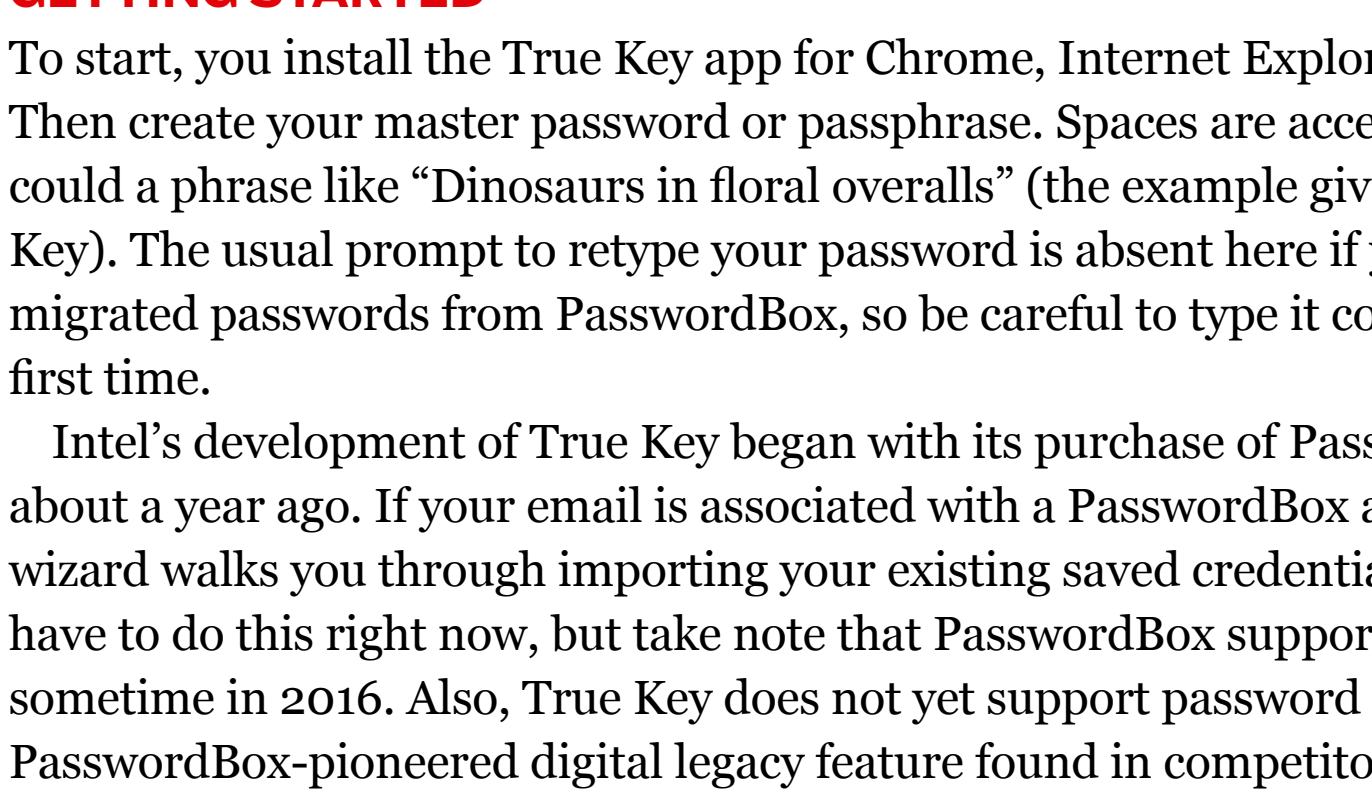
Just about every password manager warns that if you forget your master password, your data is unrecoverable. This does mean that the vendor can't access your data, but people do forget! True Key's multifactor authentication means that you can reset a forgotten master password, as long as you can prove your identity using other factors. That's impressive!

GETTING STARTED

To start, you install the True Key app for Chrome, Internet Explorer, or Firefox. Then create your master password or passphrase. Spaces are acceptable, so you could a phrase like “Dinosaurs in floral overalls” (the example given by True Key). The usual prompt to retype your password is absent here if you’ve migrated passwords from PasswordBox, so be careful to type it correctly the first time.

Intel’s development of True Key began with its purchase of PasswordBox about a year ago. If your email is associated with a PasswordBox account, a wizard walks you through importing your existing saved credentials. You don’t have to do this right now, but take note that PasswordBox support will end sometime in 2016. Also, True Key does not yet support password sharing or the PasswordBox-pioneered digital legacy feature found in competitors like Dashlane and LogMeOnce Password Management Suite Premium.

True Key can import passwords stored in Chrome and Internet Explorer. When it does so, it erases the insecure browser-stored passwords and turns off password capture. It can also import from Dashlane, LastPass, and McAfee’s SafeKey utility, all without exporting a dangerously insecure plain-text copy of those passwords. Note that although the free edition can only save 15 passwords, there’s no limit to the number that can be imported. Just don’t try to save any new ones once you’re past the basic 15.



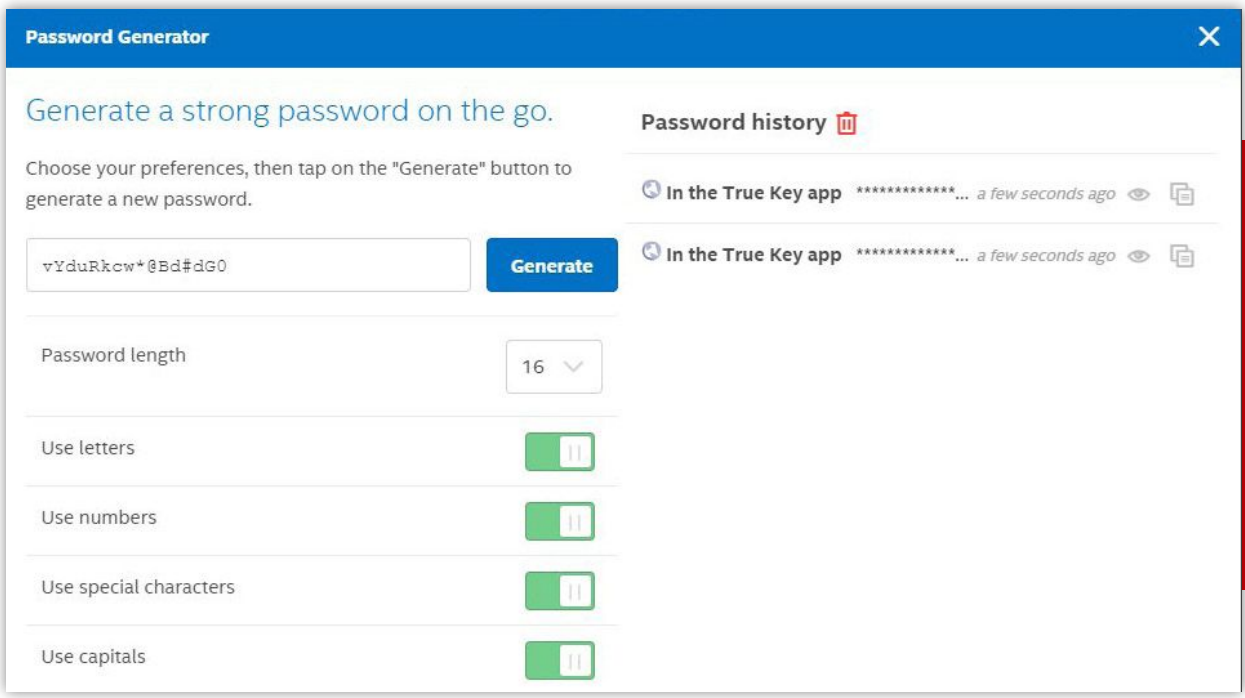
OF GREAT IMPORT
True Key can import passwords from your browsers and a few competing products. Then it deletes them from the original program for an extra measure of security.

PASSWORD CAPTURE AND REPLAY

When you set up a new account, True Key offers a collection of popular sites and invites you to save your credentials for those. I found it simpler to just log

in to secure sites using a supported browser and let True Key capture my credentials. If the site you're visiting uses an unusual login page, one not recognized by True Key, you're out of luck. True Key won't capture all data fields on demand the way Sticky Password Premium, RoboForm Everywhere LastPass, and a few others do. When you revisit a site that has saved credentials, True Key fills them in for you. If you've saved multiple credentials for the site, it offers them all in menu form.

True Key's password generator springs into action automatically when you're creating a new account or changing your password. I was pleased to find that by default it creates 16-character passwords using all character sets.



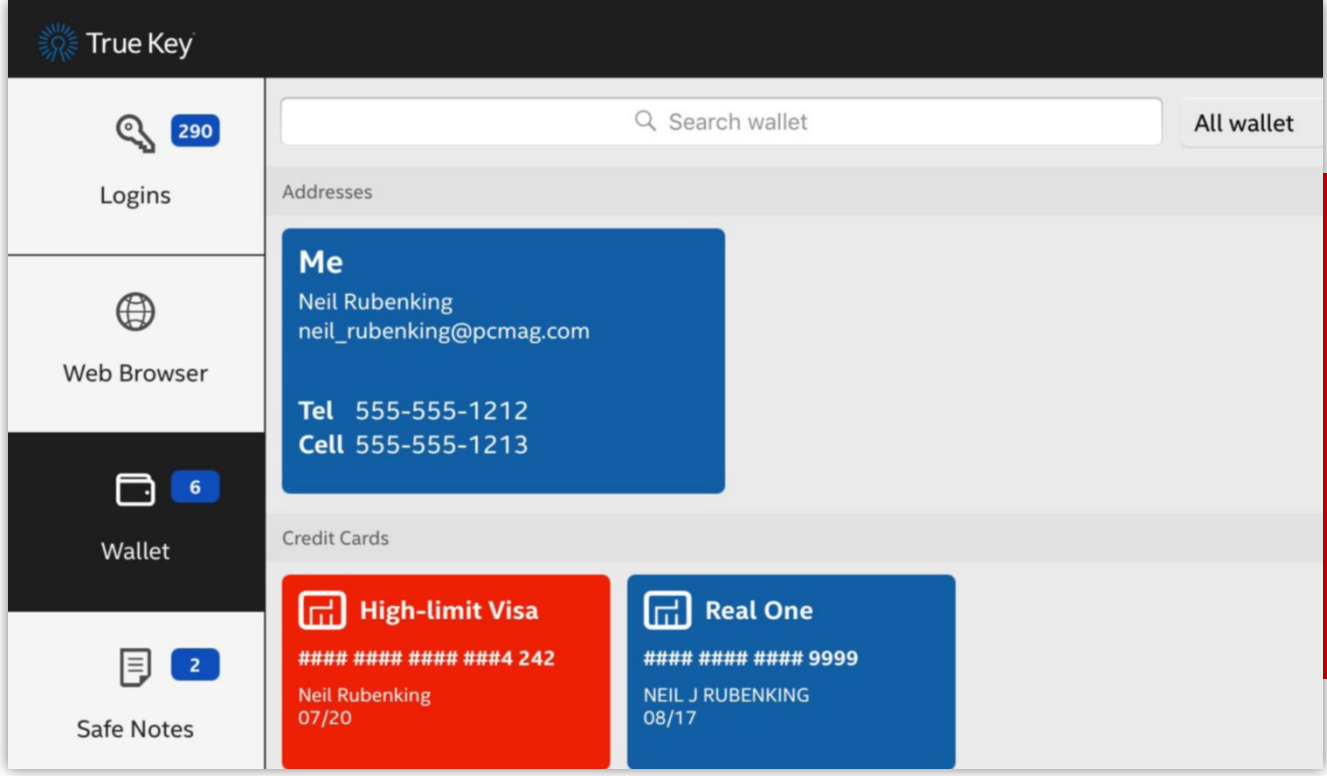
NEXT-GEN GENERATION
By default, True Key generates strong 16-character passwords using all the available character sets.

Clicking the browser toolbar button for LastPass gives you access to a menu of available logins, arranged into submenus if you've organized your passwords into folders. This kind of browser-button menu is fairly common. True Key works a bit differently. To start, it doesn't include folders, groups, tags, or any other sort of organization. Clicking the True Key browser toolbar button simply opens the app—from here, you can click any saved login to go and log in to the site. You can also set True Key's Launch Pad page as your browser homepage.

WALLET AND SECURE NOTES

True Key can store six kinds of wallet items: addresses, credit card numbers, driver's licenses, memberships, passports, and Social Security numbers. Each item type gets its own data entry form containing relevant fields, and you can flag each item with any of six colors.

Your wallet items sync across all your devices, but that's all they do. True Key doesn't currently fill in forms the way many password managers do; that feature is on the roadmap for next year.



WHAT'S IN YOUR WALLET?
You can store credit cards, drivers' licenses, passports, and more in True Key's wallet, though it can't yet use the data to fill in forms.

Secure notes are similar to wallet items, but without the specific structure of, say, credit card details. Enter a title for the note and any text you like, and you're done. You can search your notes or wallet items, or browse the entire collection. Wallet items appear as cards with the selected background color, organized by type. You can view secure notes alphabetically or by creation date.

PLATFORM-SPECIFIC FEATURES

True Key's Android edition has the ability to manage passwords for apps, not just websites. That feature isn't present in the Windows, Mac, or iOS editions. On an iOS device, True Key explains how you can enable password replay in Safari. As with LastPass, Dashlane, and others, you do so by clicking the Share icon, tapping More, and sliding a switch to enable True Key. When you're ready to log in to a site, you simply tap Share and tap True Key. Both mobile editions come with a built-in browser. Using this browser, you can tap any saved website to navigate there and log in.

Forward-facing cameras aren't ubiquitous on Windows boxes. But if you do have one, you can use True Key to enable unlocking Windows with your face.

A WORTHY CONTENDER

True Key is a work in progress; it's evolved quite a bit in the last few months, and more additions are planned for 2016. But even now, it does the basic tasks you'd expect of a password manager, and its multifactor authentication options are unparalleled. You should keep your eye on it, but for now, our Editors' Choice password managers, LastPass, Dashlane, and Sticky Password Premium, have more to offer.

NEIL J. RUBENKING

Features

SMART CLOTHES, IMPERFECT FIT

THE TECH OF THE YEAR(AHEAD)

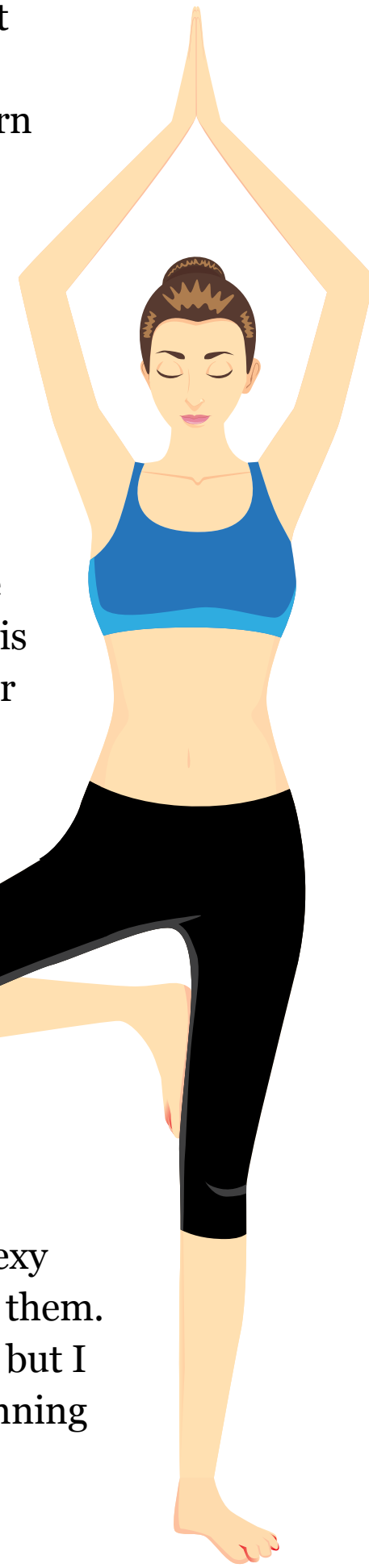
SMART CLOTHES, IMPERFECT FIT

SMART CLOTHES PROMISE BETTER FITNESS TRACKING AND MORE FEEDBACK ABOUT YOUR DAILY HEALTH HABITS AND WORKOUTS. BUT ESPECIALLY FOR WOMEN, THEY NEED ALTERATIONS.

BY JILL DUFFY

Imagine a bra that reads your heart rate, pants that monitor your workout, and socks that help you run in better form. Smart clothing, or clothes embedded with sensors that give real-time feedback about our bodies and health, is one of the most promising categories of consumer technology today, at least conceptually speaking. In reality, however, smart clothes are way off the mark.

For the past two years, I've worn, tested, and written about a wide variety of smart clothing, and I'm torn as to whether most of it ever will succeed in the marketplace. On one hand, I am enthusiastic about how smart clothes could change our health and improve our lives. When compared with activity trackers, which are typically worn around the wrist, smart clothes make a lot of sense. Why buy a wristband that only does one thing when you can get the same function out of the sports bra that you were going to wear anyway?



On the other hand, most of the clothes are terrible. By that, I mean that most of the clothes aren't hitting the bar in terms of being clothing I want to wear. The fit is off. Nothing is stylish. And forget about choosing colors or patterns. In short, they're bad women's wear. Even from a user experience perspective on the technology side, the feedback they provide is rarely, if ever, positive. Smart clothes only give you raw data or tell you what you're doing wrong.

Women have a fraught relationship with fashion. The right clothes can boost a woman's self-esteem, but the way clothes are advertised and marketed feeds women's insecurities about their bodies. What's wrong with you that you don't fit the size and cut of these clothes? Think for a moment about that existing and complicated relationship between a woman and her clothes, and now add sensors that literally judge her body all day long.

Hearing about what smart clothes can do and seeing their sexy advertisements don't actually convey what it feels like to wear them. I can't speak for every woman or every smart clothing wearer, but I can share some of the mixed emotions I experienced while running around in a smart bra, shirt, pair of pants, and socks.

THE BRA

SENSORIA SPORTS BRA
$139 WITH HEART RATE MONITOR

My first experience with smart clothing was the Sensoria Sports Bra. It looks like a typical sports bra but it has special conductive thread woven into the lower band that measures heart rate. Two snaps in the lower center hold a heart rate–monitoring device, which transmits data wirelessly to a workout app.

A sports bra is the most logical piece of clothing to make smarter. Seeing as women are going to wear a sports bra when they work out anyway, shouldn't it do double-duty? Chest-strap heart rate sensors must be tight around the rib cage and damp to work properly, and a sports bra is already snug where it needs to be and usually a little bit sweaty. I was gung-ho for smart sports bras.

I measured myself and should have fit a size small, but it was so tight around my armpits that I upgraded to a size medium, which wasn't much better. My back also felt restricted where a large expanse of compression fabric needlessly hugged my skin. Was the bra poorly designed, or was I misshapen? Either way, I was reminded of how badly the bra fit every time I inhaled deeply.

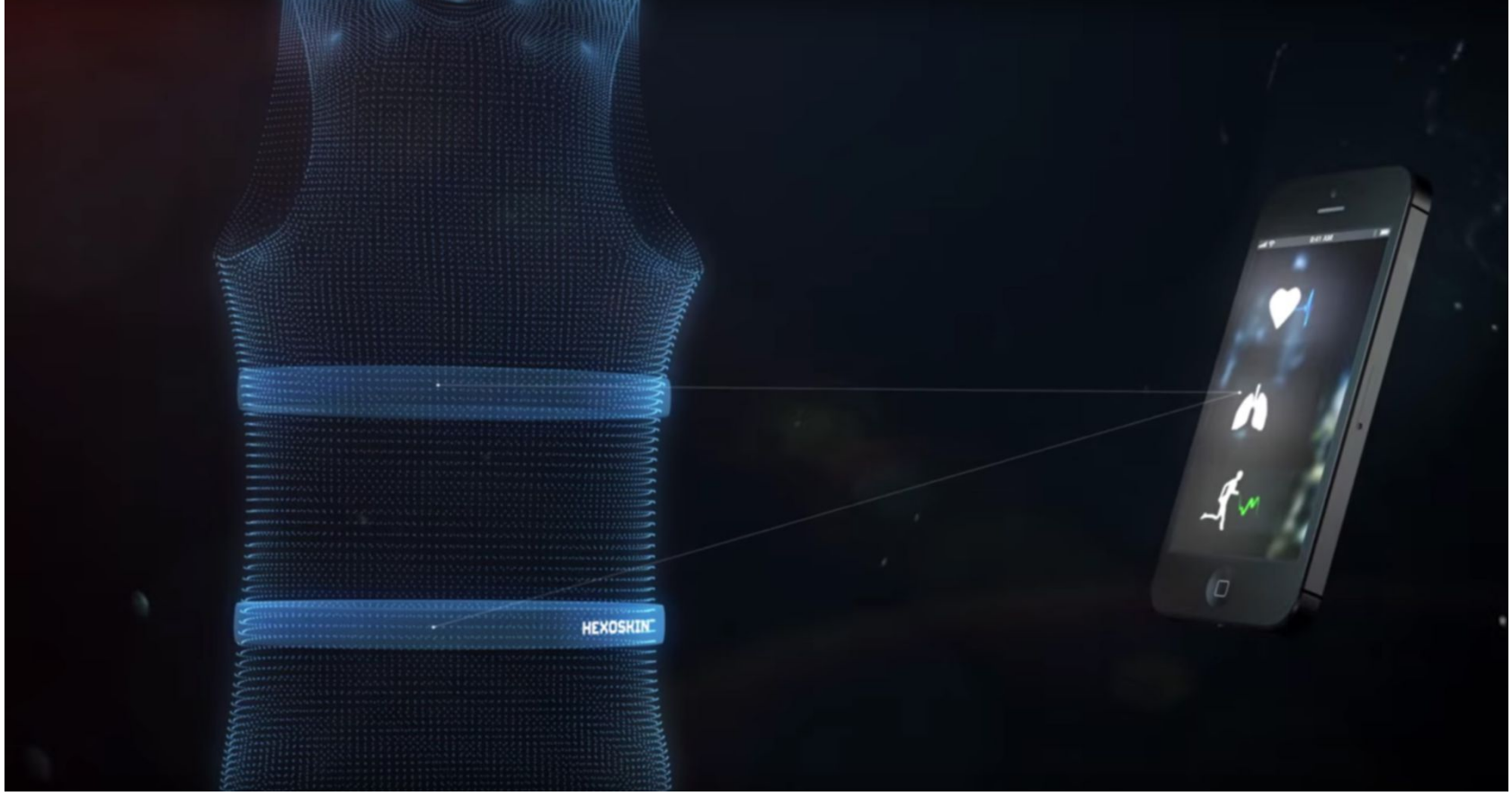
Since I first tried the Sensoria bra two years ago, the company has improved the cut and sizing, and gotten rid of an ugly green logo that used to be on the front. Unfortunately, the bra still only comes in all-black. Although men might assume that women don't care how their sports bras look, considering that they're usually hidden until a shirt, it's just not true.

Around the same time that the Sensoria bra made its debut, Adidas, partnering with Numetrix, released a similar bra, the miCoach Seamless Sports Bra ($54.95). It costs so much less than the Sensoria bra because it doesn't include the heart rate monitoring device. Buying one separately costs about $60. The Adidas miCoach bra is, regrettably, an ordinary sports bra by all other standards, but at least it comes in a few different colors: white, black, red, berry blast, and electric blue. The company lululemon, which has a much stronger track record making fashionable activewear that also fits women's bodies, also took a stab at a smart sports bra, but it is no longer on the market.

THE SHIRT

HEXOSKIN

$399



Not long after I peeled off the sports bra, an expensive smart shirt arrived for me to try. Hexoskin's shirt was also all-black (sigh), but much more complicated than the bra. It measures heart rate, steps, and breathing, and it even has a function for tracking sleep, although I couldn't imagine wearing it to bed.

I flipped the shirt inside out and noticed a built-in sports bra and a number of sensors around the chest and waist. I pulled the shirt over my head and looked down to see no support for the bra whatsoever. Additionally, because the sensors needed to make contact with my skin, I couldn't put my own bra underneath to make up for it. Fail.

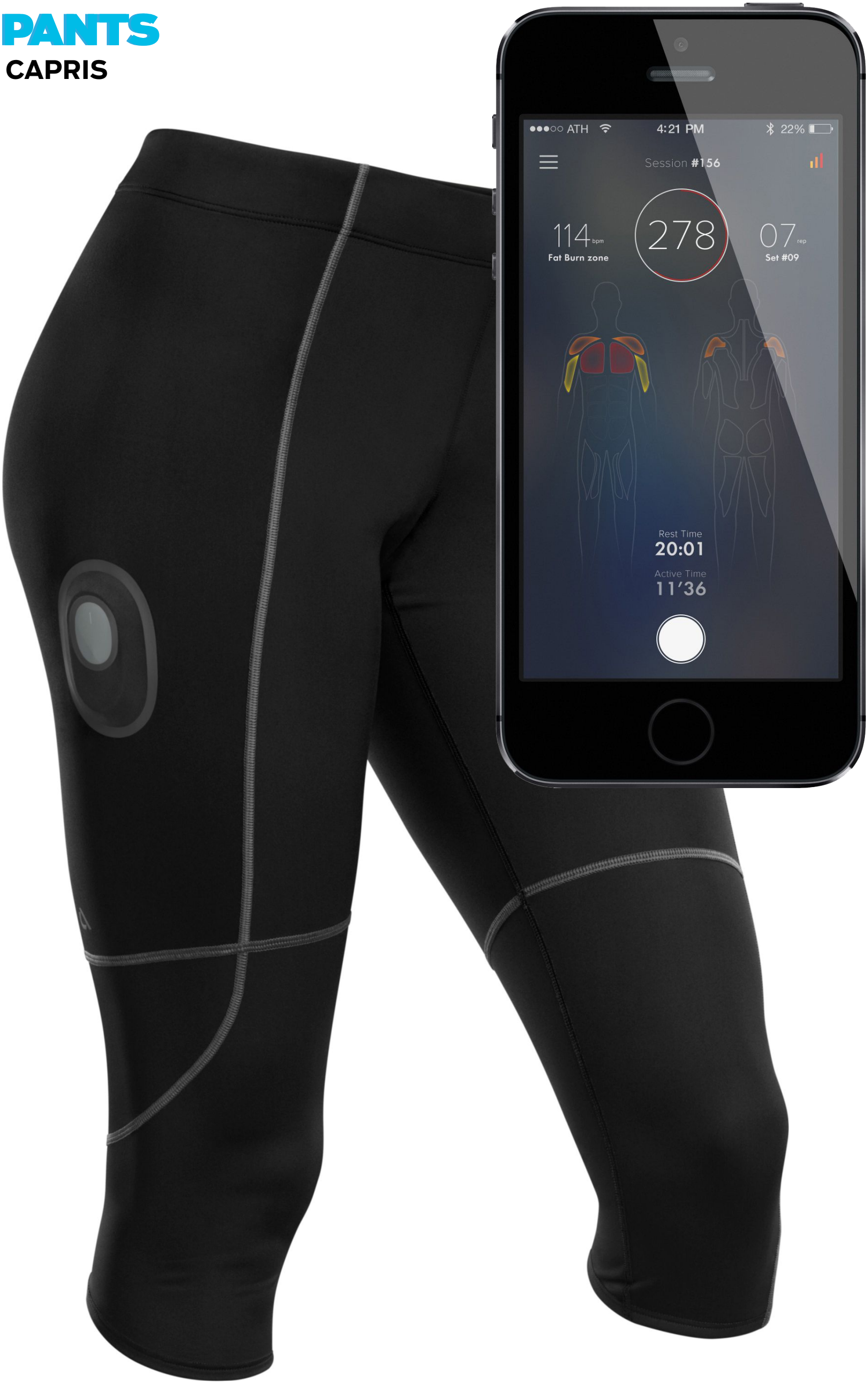
Altogether, the Hexoskin shirt was a lot more trouble than it was worth. Fit aside, the device itself didn't seem as futuristic as I imagined smart clothes should be. I had to charge a little data-transmitting device and then plug it into a cable inside the shirt, physical wires in a "wireless" world.

Plus, to this day, I have never figured out what the LEDs on the transmitter pack mean when they flash.

THE PANTS

ATHOS CAPRIS

$348



By the time I shimmied my way into a pair of Athos' smart pants, I was becoming skeptical about the utility of smart clothes. The pants proved me wrong, in both how well they fit and in the kind of information they delivered.

These all-black (sigh again) capris for women or bicycle shorts for men have electromyography sensors, which are the most intriguing and useful technology I've encountered in smart clothes. They measure electrical activity produced by skeletal muscles—in other words, they tell you how hard your muscles are working. The sensors track the glutes, inner and outer quadriceps, and hamstrings, as well as your heart rate. On the inside of the pants I could see the sensors, which looked like nothing more than patches of thicker fabric. There were no wires or cords like the ones I'd seen in the Hexoskin shirt. The data is sent to a core that snaps into the pants on one side and relays the collected data to a Bluetooth-connected mobile app.

I climbed stairs, lunged, squatted, kicked my legs, and even pedaled on a stationary bike. During my workout, the app showed me in real time how hard my muscles were working and whether I favored one side of my body over the other. That's the kind of detailed, high-tech output I expect from smart clothes, because it let me make changes when I needed to. Because the feedback they give is both objective and actionable, the pants are more like a coach than a data collector, and working out with them is kind of exhilarating.

Athos also sells shirts that measure muscle activity and are equally well-fitted. But I can't say I recommend the shirt unless you have the abs of a swimsuit model; the one I tried on found every possible fold around my tummy and rode up until my skin was exposed. The outfit was so form-fitting, I looked as if I was suiting up for a motion-capture session, only without the ball markers. The pants still felt good, and the upper half of the shirt was supportive, as compression clothes should be, but the whole ensemble was a bit much.

THE SOCKS

SENSORIA FITNESS SOCKS

$179.99

Last spring, I trained for and completed my first half marathon, and before I ran those 13.1 miles, I learned a lot about my running form thanks to a pair of smart socks from Sensoria, the same company that makes the smart sports bras. Similar to the Athos pants, the socks gave me actional feedback in real time—but they gave me too much feedback.

Pressure-sensitive thread is knitted into the socks' fabric, as is conductive fiber that transmits information to a Bluetooth-enabled ankle cuff. The socks read pressure under your feet, which means they can tell if you're heel-striking or running on the balls of your feet as you should. Proper running form prevents injuries. The ankle cuff, which attaches to a row of embedded magnetic studs at the top of the sock, contains motion sensors that also track running speed and distance. A companion app pulls all the data together to make sense of it.

Before running in the socks, which are the thickest and most plush I've ever worn, I used the app to customize the desired landing point on my foot as well as my preferred cadence. Then I popped in some earbuds and set out with a metronome feature enabled. Tick, tick, tick. I ran to this rhythm I had programmed. Pretty soon, an automated voice yelled at me that I was not landing on the ball of my foot, and that I should correct my form or take a break. I corrected my form, but a few minutes later, the same automated lady yelled at me again, with the same exact speech. The sixth time she yelled at me, I'd had it.

See, I'm not a great runner, and a few words of encouragement mixed in with all the negative feedback would have gone a long way. The feedback was admittedly correct. I *was* running improperly. But I was tired of hearing it. In the end, the socks were just too comfortable to give up.

THE IMPORTANCE OF ACTIVEWEAR

Most of the smart clothing I've worn falls into the fitness apparel category, which is single-handedly the most important category of clothing by sales. In 2014, sales growth of activewear exceeded that of the entire apparel market, according to NPD, and women are the primary purchasers. For smart clothing to succeed, it needs to be one with this flourishing market, which means it has to appeal to women. Sadly, a few smart clothing lines, such as the OMsignal Up & Running Kit and the Ralph Lauren PoloTech Smart Shirt, don't even have options for women, though OMsignal claims to have a late-stage prototype of a smart sports bra in the works. The company was founded in 2011 and this bra, five years later, would be its first item for women.

"From a style and fashion perspective, if you look at the players in the market that have had phenomenal growth, you see products that are designed for a woman's body and are in line with the fashion trends," said Shaz Kahng, chief marketing officer for OMsignal, a technology company that partners with fashion brands to make smart clothing. OMsignal is one of the companies with a smart clothing line that currently leaves out womenswear entirely. Perhaps that's one reason Kahng was brought into OMsignal in late 2015.

Kahng is no newcomer to the fitness apparel world. She is a former business director for Nike and was president of Lucy Activewear for nearly two years. She unabashedly told me a story that exemplifies how the female perspective just isn't taken into account in developing activewear. "At Nike, when I was there, they wanted to create the best sports bra ever," she said. The company sunk a lot of time and money into studies and tests that would inform the bra's construction. But in the end, "it was designed by men, and it didn't fit properly," Kahng said. "It was extremely difficult to fasten, and it was priced at $80. So, you have a product that's not great, and it's the most expensive bra on the market."

For women, fit, form, and function matter, but so does style. Kahng agrees that even when women wear a top over their sports bra, "it has to look cute." Other details, such as whether the fabric is

RALPH LAUREN POLOTECH SMART SHIRT
$295

breathable and whether the size is adjustable (straps with sliders, snaps, hooks—this isn't rocket surgery), matter as well. Women have set a high bar for athletic wear, and as consumers, they are intolerant of products that fall short.

A similar lack of understanding of women's bodies has been a problem in the smartwatch category, too. The original Pebble smartwatch looked enormous on me, and I happen to have large wrists. There's really no mistaking the LG G Watch R as a man's wristwatch. And when a petite friend of mine put on the smallest-size Microsoft Band, she looked as though she was wearing handcuffs.

What message does it send when new wearable devices are made only for men? Including the female perspective in development, design, and marketing is less a matter of gender imbalance in the industry (a perpetual problem in its own right) and more related to researching the demographics of the prospective market. Smart clothing makers need to embrace women as their primary customers and support them as early adopters. Smart clothes needs to be as good at being clothes as they are at being smart, and to do that, they need to be made for women.

What message does it send when new wearable devices are made only for men?

HOW DOES YOUR CLOTHING TALK TO YOU?

Smart clothing is meant to empower us by giving us more data about ourselves. As a woman who has worn smart clothing, however, my experience is that it comes with a hyperawareness of being critiqued, made worse by the fact that much of it is ill-fitting, poorly designed, or just plain ugly.

If the purpose of smart clothing, at least at this stage in its development, is to help us live better through improving the quality of workouts and our health over the long term, then the message from the clothes needs to encourage positive behavior. The clothes themselves have to make us feel good.

In time, the purpose of smart clothes will undoubtedly stretch well beyond pumping iron and running faster. Davide Vigano, cofounder of Sensoria, told me his company partners with medical groups to find new uses for the pressure-sensitive thread found in Sensoria's running socks. For example, when a diabetic patient has a skin graft on the foot (usually to prevent an amputation), the patient is not supposed to walk on the area for a few days. But because diabetics often have reduced sensitivity in their extremities, it's hard for them to remember to stay off their feet, and many end up getting an amputation later regardless, which is both traumatic and expensive. A pressure-sensitive bandage could help remind the patient to stay off the treated foot by monitoring post-op behavior.

But even in the case of medical use, we have to want to wear smart clothes. The experience needs to be positive.

"The philosophy has to be more of a coach and a helper than a judge," said Kahng. "I was just in a meeting, and a woman was saying, 'I feel judged every day. I feel like I have to be perfect every day.' Women will take care of everyone else around them and take care of themselves last. The message with smart clothing is you have to take care of yourself first because you can't help anyone else if you're not in a healthy state."

From my trials with smart clothing, I absolutely see the need to include positive feedback and encouragement to counter-balance all the negative feedback and raw data. More important, women have to be a part of the creation and selling of smart clothes, from their initial design and development to beta testing to marketing the final product. The clothes need to be stylish, fitted for real bodies, comfortable, and affordable. Unless women are purposefully included in every step, the smart clothing movement will never get off the ground.

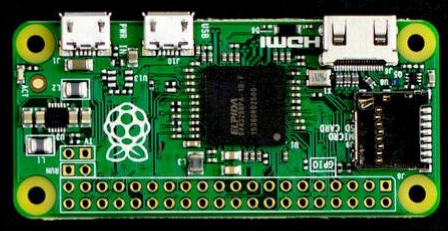
"We have to want to wear smart clothes. The experience needs to be positive."

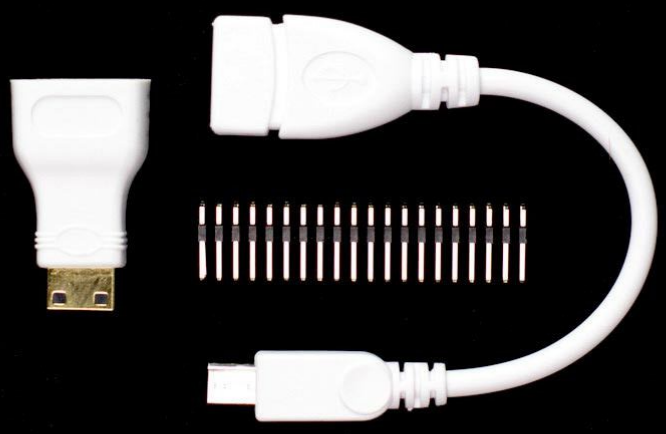
THE TECH OF THE YEAR (AHEAD)

Want to know what the future holds for technology? You need to look back as you look forward, because the most important products frequently come from technological breakthroughs we didn't even know were happening. Here's our glimpse at the advancements from 2015 that are most likely to shape the technology landscape in 2016—and beyond.

BY ERIC GRIFFITH AND MATTHEW MURRAY

TINY PCS





Anyone who's built a desktop PC knows that the engineering that goes into making something smaller—even a laptop—is pretty incredible. Recent "desktop" systems have reduced down to the size of a book, and the manufacturers are showing no signs of stopping. In fact, they've even begun cramming entire PCs into enclosures the size of a USB thumb drive. Just stick them into a port on a compatible monitor or HDTV, wirelessly connect an input device or two, and you have your entire on-the-go PC.

This innovation caught on in a big way in 2015, when systems like the Asus Chromebit (running Chrome OS) and the Intel Compute Stick (running Windows) made their biggest splashes to date—even if the technology behind them means they don't come cheap. The most stunning achievement heading into 2016 is the Raspberry Pi Zero, a pint-size version of the already-minuscule Raspberry Pi that measures 65 by 30 by 5mm. It's made more for enthusiasts than people trying to get work done, but the board, complete with processor and memory, costs only *$5*. We're not that far off from a future in which every room in the house contains a tiny $1 PC running Windows (okay, maybe Linux).

REAL-LIFE HOVERBOARDS

Hoverboards were squawked about all through 2015, in particular during October, when we finally reached the date pegged as "the future" in *Back to the Future Part II*, the film that made us all want hoverboards for ourselves. Sadly, an entire wave of devices with wheels has tried to steal the "hoverboard" moniker. Some are mono-wheeled, but more ubiquitous are the fire-prone two-wheeled balance boards that perform like a Segway without handlebars.

But real hoverboards could be on the horizon! The Hendo 2.0 from Arx Pax is a Kickstarter-backed endeavor that uses magnetic fields. And the Lexus Slide (yes, from the car maker) is a bamboo-and-carbon-fiber board that hovers off the concrete (though it's concrete over steel in a specially made park, so the magnets can work). Lexus used superconductors to get a different kind of magnetic field—the kind used by maglev monorail trains. The fact that it uses liquid nitrogen inside to keep the superconductors at -321º F—causing the Slide to emit smoke-like vapor—makes it look even cooler.

When will we see the Slide on shelves? Probably never—it was more marketing ploy than actual product. But someone will get this right someday. Then we as a society must rebuild all the sidewalks and streets in the nation with steel so the real hoverboards can work.

WHITE LASER BEAM

Lasers typically come in one color at a time; you've seen red, green, and maybe blue. It took a team of researchers at Arizona State University to combine all of those colors to get to a holy grail of sorts: a white laser. It might not seem like much—it's not going to slice through James Bond any more quickly than a red laser could—but it does put lasers a step closer to becoming a potential light source, one that could replace the LED. Laser-powered screens could be in the future, and with them we'd get brighter, more intense, and more accurate displays, with 70 percent more colors available. It may also lead to "Li-Fi"—like Wi-Fi, but using light for communications instead of radio. Li-Fi is already in development, but a white laser could provide even faster throughput. We're years away from that level of efficiency, but the white laser is the first step to the TV and communication you may have in a decade.

PERSONAL MOBILE BROADCASTING

Maybe no one was looking at a way to make video blogging even more immediate, but they got it when Meerkat and, soon after, Periscope debuted last year. These apps bring personal broadcasts (aka social live streaming) to anyone with a smartphone: Instantly share what you're doing with your followers on the Internet, because you're simply that interesting. Both apps used Twitter as a way for people to connect—one of them with a little more legitimacy, as Twitter owns Periscope. Even Facebook is getting in on the act soon.

Personal broadcasting creates a new way for anyone—citizens, journalists, what have you—to connect via video to an audience and get feedback in real time. So far viewing has been limited to the initial live broadcast and 24 hours after; Facebook Live will add permanent storage of broadcasts for later viewing, because it has the server space to make that happen. None of this is necessarily new, but the move to make it ultra-simple on mobile devices is poised to democratize live video in a way we never had when broadcasters needed special equipment.

WIRELESS POWER TRANSFER

Whatever you call it—WPT, wireless energy transmission, radio frequency charging—it boils down to powering devices without needing wires to run the device or charge the battery. It's been theoretical since at least 2006, but some major strides were made in 2015. Researchers in the Netherlands created a microscopic temperature sensor that charges on radio waves (albeit an inch from the source of the waves); and, closer to home, students at the University of Washington in Seattle worked with Sensor Systems Lab to create Power Wi-Fi, a system by which modified routers output a constant energy stream on the radio that modified temperature sensors and cameras use as their energy source. These advancements suggest that your home router could someday be all you need to charge your phone, laptop, or who knows what else—assuming enough power can ever be generated. The Power Wi-Fi managed only enough juice to snap one surveillance picture after 35 minutes. Still, it's a start.

SUPERHYDROPHOBIC COATINGS

Here's one of the ways that Wikipedia defines hydrophobicity: creating "recessed areas on a surface whose wetting expends more energy than bridging the recesses expends." Not too many products, especially electronics, have embraced this process yet. They should. Until then, superhydrophobic coatings for electronics—specifically smartphones—have arrived for do-it-yourself application.

If you've seen the NeverWet spray at a big-box store, you know the gist: Apply the spray and let it dry, and the surface becomes resistant to water (if perhaps not completely waterproof). Products like Nanostate's Flash Flood and Impervious Invisible Waterproofing are all about nanotechnology: microscopic objects adhering to the device to help repel liquid. Each has you treat the outside of your phone or tablet similarly, rubbing in the product then letting the device "cure" for 24 hours. Tests by no less than Yachting World found both products very effective for protecting a phone against splashes, even water poured right on the screen. It's no guarantee for full submersion protection—but can't hurt. If future smartphone makers start using the nanoparticle coating inside as well as out, we could all get fully waterproof electronics in our pockets that involve more than simply some extra rubber gaskets for protection.

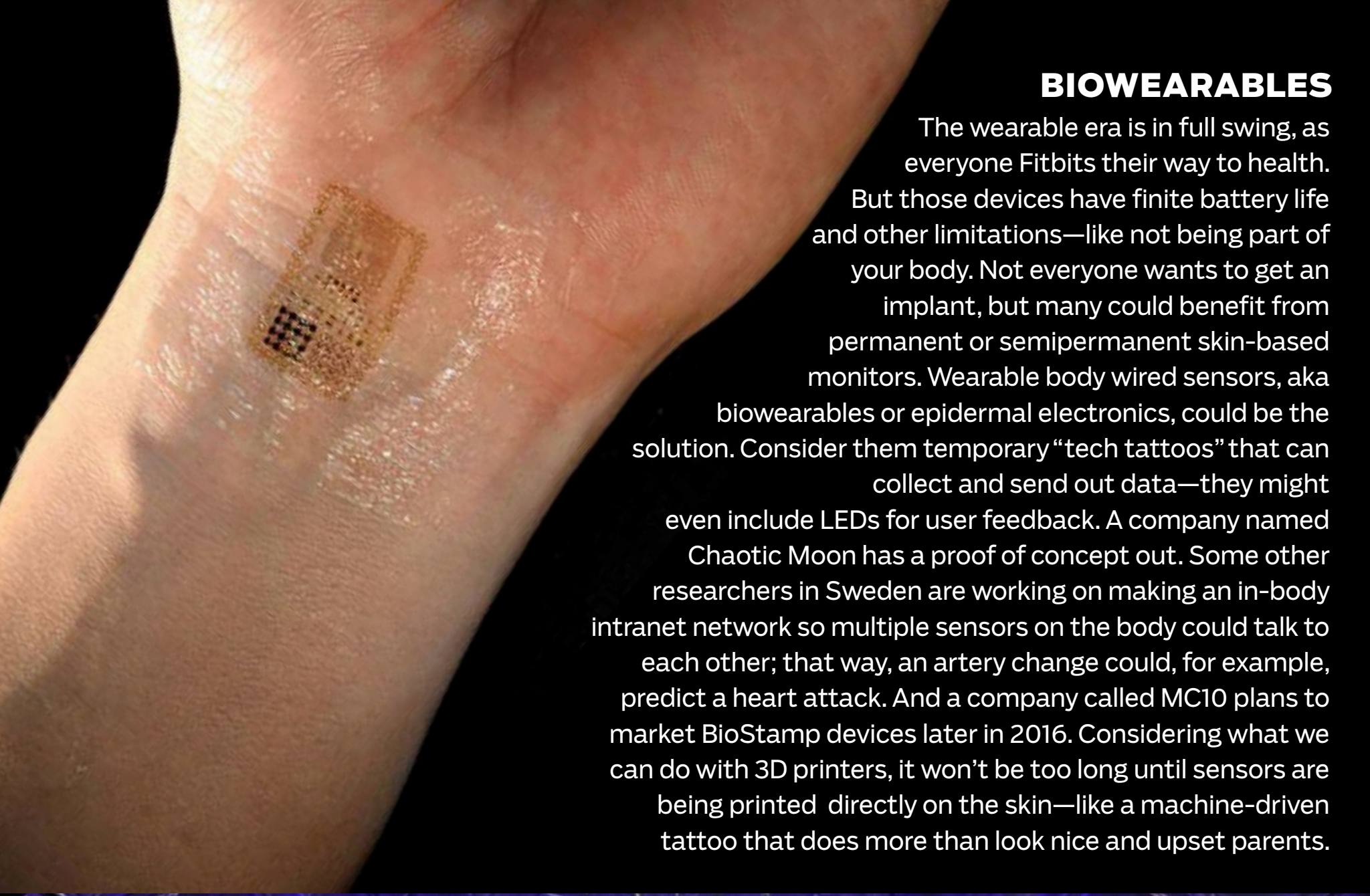
AUGMENTED REALITY 3D

Virtual reality has to be 3D to feel real (that's what Oculus Rift wants to do). But augmented reality—an overlay of data on top of what we see every day—typically settles for making it appear that you're inside of the Terminator, or Iron Man's armor. Some big names are combining the two, creating next-generation 3D augmented reality that's perfect for gaming—whether building blocks in the living room or fighting monsters on the street. Magic Leap, with its solution mixing stereoscopic 3D with projected images, has an investment from Google of more than half a billion dollars. Microsoft announced its own plans last CES, then showed off the HoloLens at the Windows 10 release; Asus is reportedly considering developing its own third-party HoloLens. Microsoft wants to go beyond games and create holography that can work in everyday life, in everything from design to communication. Whoever comes to market first may change how we look at the world, 3D, and reality—again.

HOME BATTERIES

When Elon Musk, our real-life Tony Stark (minus the munitions and armor and goatee), unveils something new, it's usually worth checking out. The PowerWall is a home-oriented rechargeable lithium ion battery like the one Musk's Tesla car uses. There are two models, one like a backup generator, another for daily cycle use. With minimal needs (or multiple PowerWalls installed), the 210-pound wall-mounted battery beauties have the potential to take a household off the grid entirely (assuming those in the household can afford the price of $7,000, which includes installation, that is).

The Powerwall is already sold out through most of 2016, unless you live in a location where a utility company is getting them for you, as California's SolarCity, Vermont's Green Mountain Power, and Australia's SunEdison are doing. Criticisms that the PowerWall is for the rich—it could cost more than double per kilowatt hour for electricity this way as-is—may be valid, but as the technology improves, so too shall the economics, and the benefits for many. Other vendors are stepping into the field, including Mercedes-Benz and China's BYD Auto—because, of course, the home battery can charge electric cars, too.



BIOWEARABLES

The wearable era is in full swing, as everyone Fitbits their way to health. But those devices have finite battery life and other limitations—like not being part of your body. Not everyone wants to get an implant, but many could benefit from permanent or semipermanent skin-based monitors. Wearable body wired sensors, aka biowearables or epidermal electronics, could be the solution. Consider them temporary "tech tattoos" that can collect and send out data—they might even include LEDs for user feedback. A company named Chaotic Moon has a proof of concept out. Some other researchers in Sweden are working on making an in-body intranet network so multiple sensors on the body could talk to each other; that way, an artery change could, for example, predict a heart attack. And a company called MC10 plans to market BioStamp devices later in 2016. Considering what we can do with 3D printers, it won't be too long until sensors are being printed directly on the skin—like a machine-driven tattoo that does more than look nice and upset parents.

CONTINUOUS LIQUID 3D PRINTING

Complex 3D printing jobs can take hours, as millimeter after millimeter of material is laid down to create an object. (And even simple projects can suck up a fair amount of time.) CLIP, short for "continuous liquid interface production" could reduce that time to minutes. It "grows" solid constructs out of a liquid bath. The researchers at UNC–Chapel Hill who developed the photochemical process have already taken the next natural step and created a startup called Carbon3D, which has already landed $100 million in funding led by (who else?) Google Ventures. Carbon3D has already cut deals with companies like Ford, which would suggest it's only a matter of time before this super-fast 3D printing technique is used everywhere.

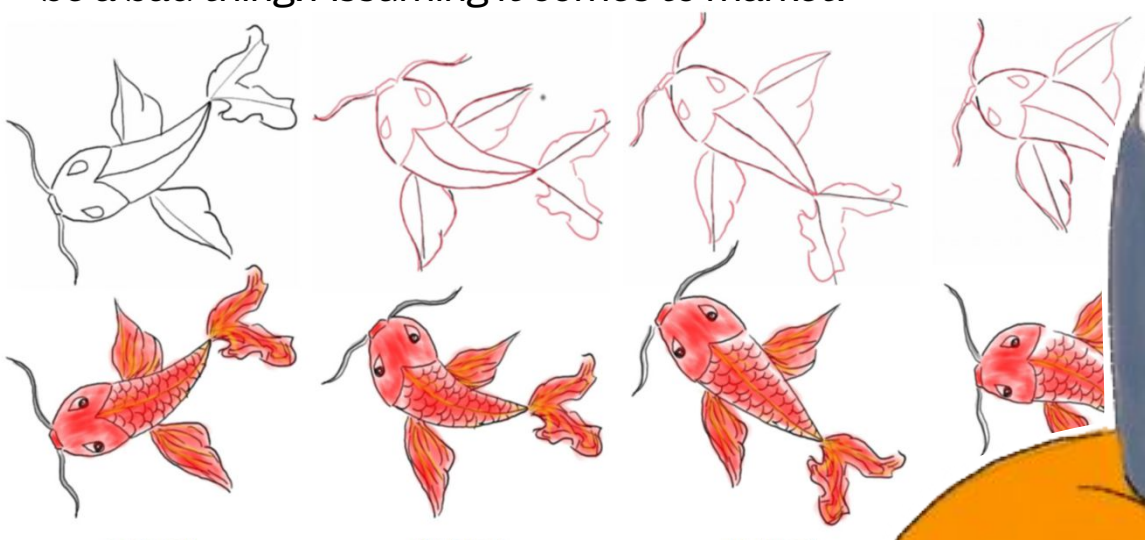
Photo credit: Mark Shwartz, Precourt Institute for Energy, Stanford University

FAST, SAFE, FLEXIBLE ALUMINUM BATTERIES

Trying to use aluminum for a battery is nothing new, but in 2015 Stanford University researchers hit on a combo that could work to replace the rechargeable lithium ion batteries that power toys, laptops, phones, watches, and just about every other type of tech we use today. The major upsides of aluminum battery technology are many: it's flexible (that's good for wearables), it's inexpensive, it's safe (drill through it while running and it won't catch fire), it's fast (charging a phone in a minute), and, maybe best of all, it can handle about 7,500 charges—about 7.5 times more than lithium ion, which starts to lose capacity after 1,000. Even the 2 volts it holds is stronger than typical 1.5-volt alkaline batteries you buy off the shelf, but that's half of what lithium batteries can do. Thus, it still needs work. The cathode material needs to be perfected—currently in use is graphite, which thankfully doesn't disintegrate the way cathodes used in previous aluminum batteries did. No matter what, it holds a lot of promise.

AUTOCOMPLETE FOR ANIMATORS

Microsoft Research, with the University of Hong Kong and the University of Tokyo, unveiled autocomplete hand-drawn animations at Siggraph Asia in October. It's a software tool that lets you draw a complete picture, then start a new cell with one line—and it autocompletes the drawing for you, saving time as you make the subtle changes needed for animating the art into life. It replicates the line art and the colors used, and even senses patterns the animator has begun to draw (like the scales on a fish). This is a niche product, even among animators these days, because who hand-draws each frame of a cartoon anymore? But everything in Hollywood (and beyond) gets planned with not only storyboards, but full "animatics" to preview the action. The program could also create a resurgence in the classic hand-drawn animation world, and that wouldn't be a bad thing. Assuming it comes to market.



GIMBALL DRONE PROTECTOR

There are thousands of hours of video online that depict one fascinating action that happens over and over every single day: drones flying into stuff and falling to their doom. Usually the footage is from the drone's perspective. Flyability in Switzerland has a solution to protect drones: a collision-tolerant flying cage. Inspired by seeing drone after drone go down while trying to help with search-and-rescue efforts at the Fukushima nuclear disaster, the graduate students who eventually founded Flyability created the insect-inspired, carbon-fiber roll-cage to absorb all impact. It's already won awards; Flyability took home a cool million dollars in the "UAE Drones for Good Award" competition this year. The current Gimball can fly for 10 minutes on one battery charge, while carrying a 1,280-by-1,080 5-megapixal camera. Prototypes have just begun shipping.

TZOA ENVIRO-TRACKER

TZOA (pronounced "zoa") is one of those things that makes your smartphone that much more like a *Star Trek* tricorder. It's a wearable sensor that doesn't monitor your body, but rather the environment around you—specifically the particulate matter in the air. It talks to your smartphone and a related app via Bluetooth, providing info on course particulates such as mold, dust, or pollen, as well as tiny respirable particles like smoke, exhaust, and other fumes. It'll help you figure out the best places to go and breathe, or how the air is in your home or office. The GPS and maps on your smartphone will generate a map of the safest place to avoid pollutants. The data gets shared to TZOA so the company can build crowdsourced maps of where the air is good or bad, but you get unlimited free access to your own data.

GET ORGANIZED

Start 2016
More Organized

EDUCATION

Learn to Code

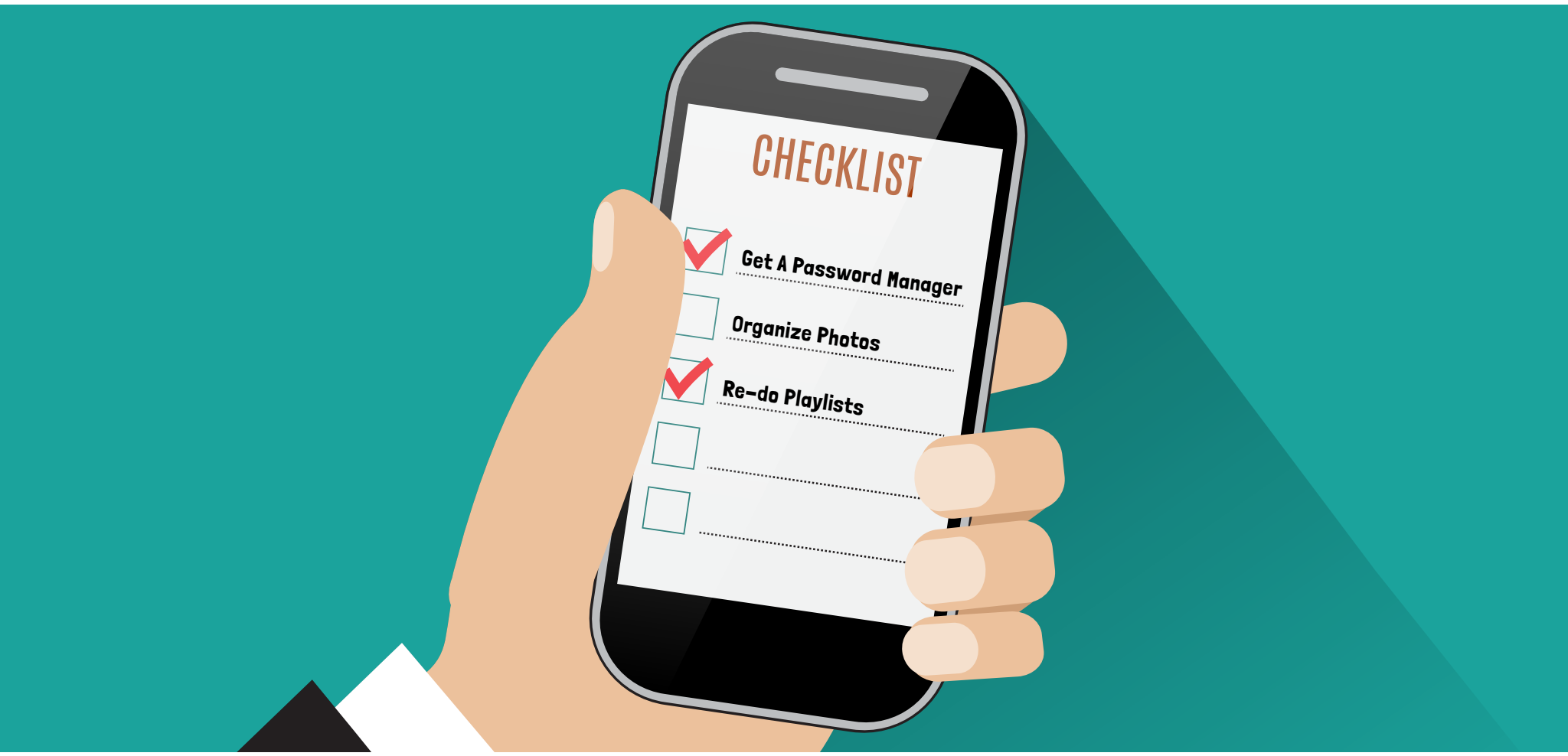
CONNECTED TRAVELER

Earn Airline Miles,
Points While You Roam

Digital Life

Start 2016 More Organized

BY JILL DUFFY



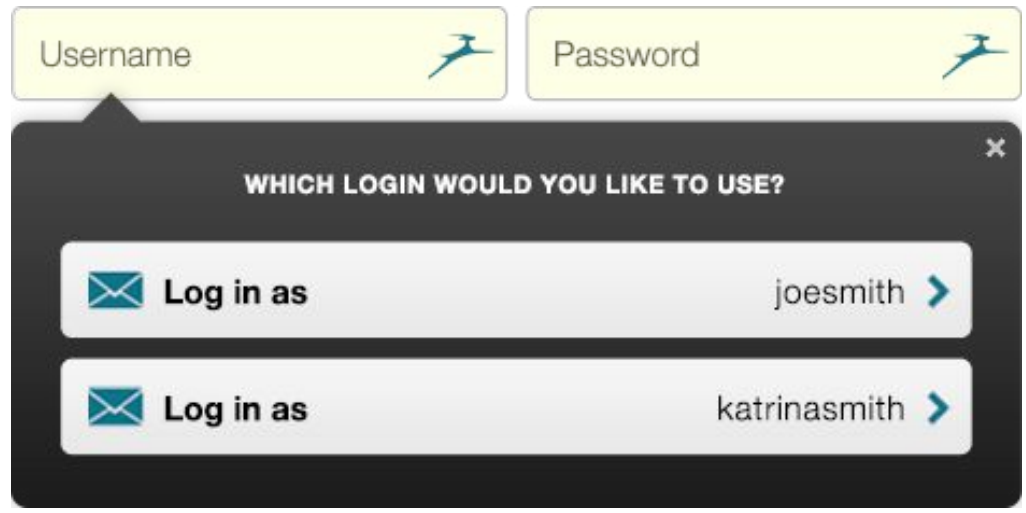
Around the end of one year and the beginning of the next, many people get (and take) a little extra time off, which makes it a perfect opportunity to tackle cleanup and reorganization projects big and small. Use this time wisely! Take on projects that you wouldn't normally do because they require at least an hour of focused attention, and that bring you real value. Make sure to prioritize. Here are some of the most important things you can do to start off your year right.

1. CLEAN UP YOUR PASSWORDS

Whenever anyone asks me for my number-one tech tip, I say, "Get a password manager." To me, it's even more important than backing up your files. A password manager is your key to greater online safety and security.

There are half a dozen excellent password managers, and a few of them have a free level of service, so you can try out a few and decide which one you like best. (We recommend Dashlane and LastPass.)

People who don't use a password manager sometimes misunderstand what it does. It creates unique passwords for all the online accounts you use, it remembers those passwords for you, and it types them for you in a secure way.



So find a password manager you like and try it out for an hour. As you sign in to various online accounts, everything from Facebook to your bank, the password manager will start to collect and analyze your logins and passwords. Pretty soon, the app will help you identify passwords that you need to change—and you should do just that.

2. SET UP A BACKUP SERVICE

A backup service is like insurance for your digital data. Find a reliable backup service. Spend a little time reading reviews to make sure it will work well for your situation. *PC Magazine*'s top three picks are IDrive, CrashPlan, and SOS Online Backup.

Once you pick a service, make sure you understand how it works and how often it will back up your files. While setting it up, take the time to customize all the settings and options to your needs. Then let it run. Your first backup may take a few hours. When it's finished, test it. Use a different computer or a mobile phone, and see if you can retrieve a file from your backup set. Did it work as you expected?

3. RUN A TUNE-UP UTILITY

If it's been a while since you last gave your computer a tune-up (or if you've never done one), now's the time to do it. Our favorite paid tune-up utility is Iolo System Mechanic; SlimWare Utilities SlimCleaner Free is the best free option.

Take a few minutes to read through the instructions, or watch a video tutorial so you understand exactly what will be cleaned up and tuned up before you run the tool. Then execute your tune-up. As when you run a backup for the first time, the first time you do a tune-up it might take a long time.

4. SWEEP YOUR INBOX

Your email inbox is a mess. I know it. You know it. So what are you going to do about it?

I have a simple trick that's perfect for doing right around the New Year: Sweep your inbox. Move all your old messages to a dedicated folder.

Here's how to do it: Create a folder called 2015. Sort your messages by date and select all that are from 2015 (or if you're handy with rules in your email program, do it that way). Drag them into the 2015 folder. Repeat with previous years if necessary.

Notice that you don't have to delete or archive any of your mail. Just sweep it out of sight. You can tend to those old message whenever you want, or even pull a few essential ones that you're "really, really" going to answer any day now back into the inbox. The point is that you've created a blank slate, and that will make you feel much better about email.

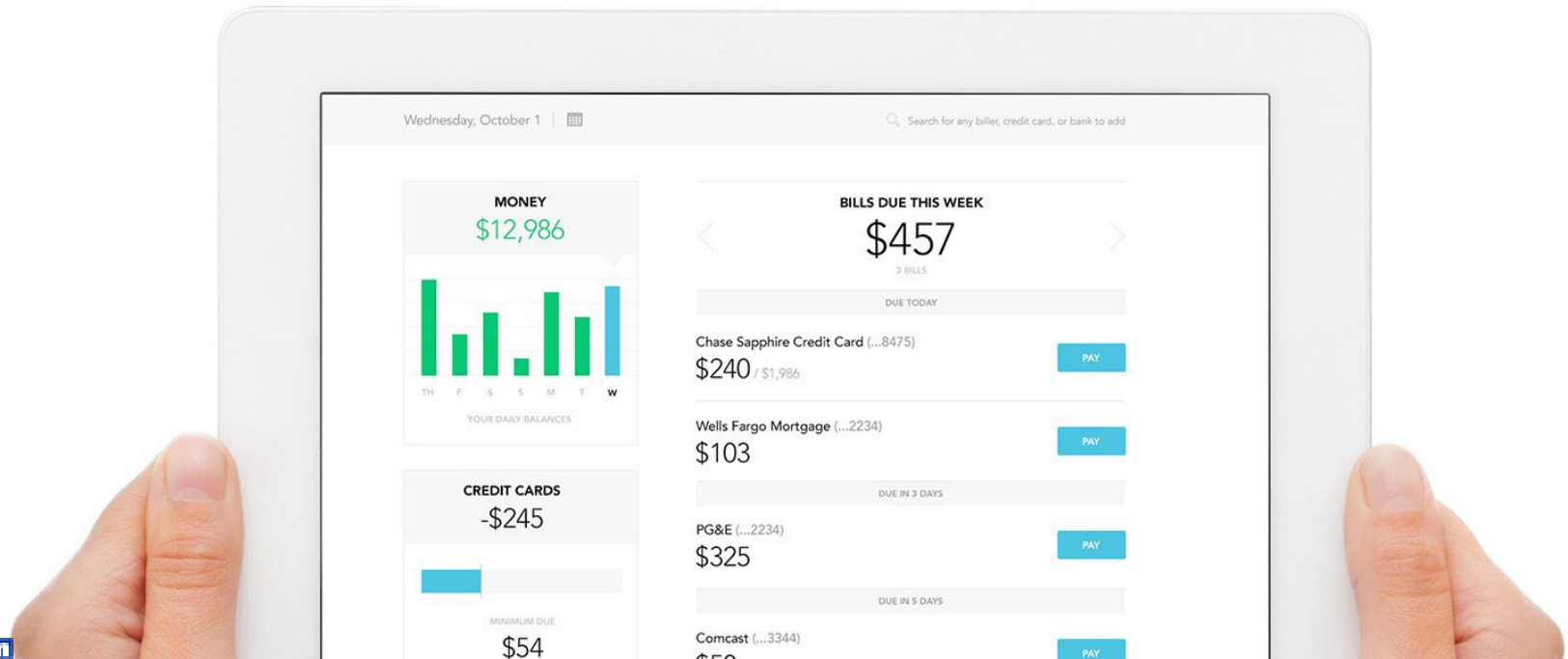
As new email trickles in, unsubscribe from junk and consolidate gray mail (newsletters, coupons, and daily deal messages you opted in to but often don't want) using Unroll.me. This handy service consolidates gray mail so you can scan all the messages en masse without each one eating up space in your inbox.

5. GET A HANDLE ON YOUR FINANCES

Is one of your New Year's resolutions to get on top of your finances? Start by signing up for Mint. Depending on how many financial accounts you have, getting started could take half an hour or more, but it's well worth doing.

The beauty of Mint is that it looks at the history of how you've spent your money and what income you've earned, meaning the day you set it up you can already start to assess your financial situation. With many other budgeting and expense-tracking tools, the day you set up is day zero, meaning you only start collecting data from that point onward.

Mint suggests ways to save money, services with better interest rates than you're currently getting, and a few simple budgeting tools. I also love that it can be used in a set-it-and-forget-it way. You can establish a Mint account now, do absolutely nothing with it for weeks or months, and it will still have valuable, relevant, and up-to-date information the next time you log in.



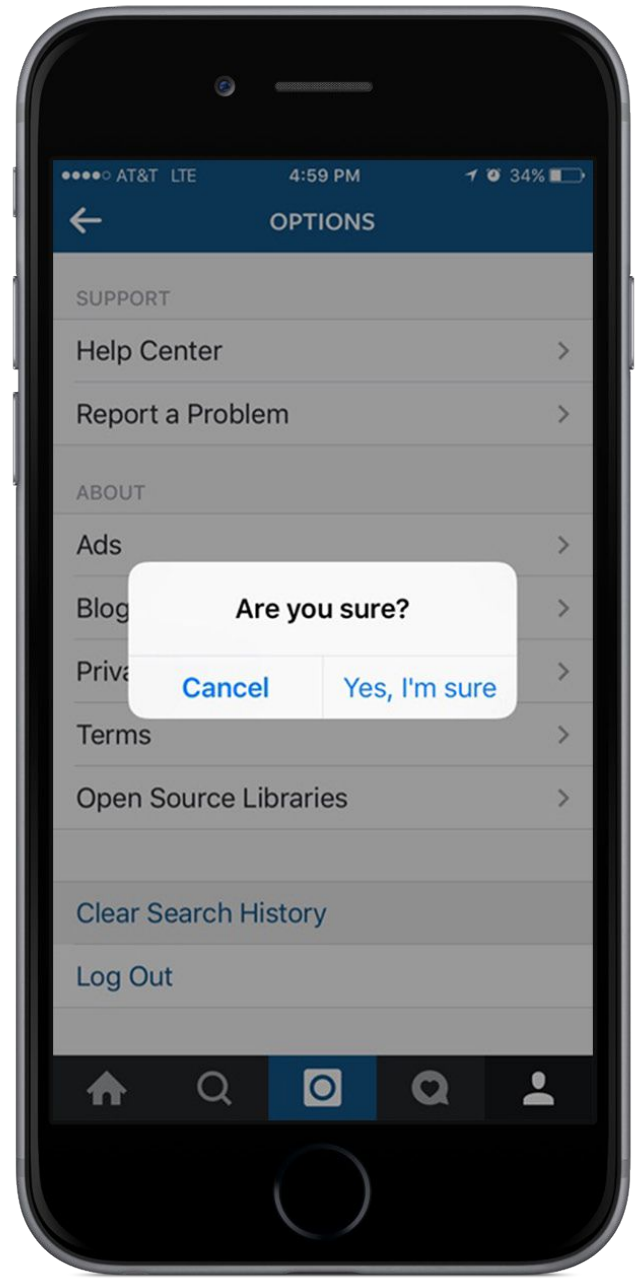
6. CLEAN UP YOUR PHONE

Ready? Set. Clean up your phone! So many people put off this task, but it really doesn't take that long to do.

Start by changing your password, passphrase, or secret drawing. Next, add an emergency contact to your lock screen. Those two steps are the most important ones.

Now it's time to free up space. Start by offloading photos and videos. Move them to a cloud syncing or backup service; that way, you can still see the pictures on your phone, but they don't take up space. Smart, right?

Analyze what else is taking up space needlessly by looking in the settings. You might find old audiobooks, podcasts, PDFs, music that you no longer like, and other junk that's ripe for the trash. Finally, dump your mobile browser's cache, delete old text messages (the ones with videos and images can take up excessive space), clear your Instagram search history, and wipe your WhatsApp archives.



7. CONSOLIDATE YOUR PHOTOS

Whenever I give advice about how to organize photos, I say, "Look forward, not backward. You can deal with the backlog of photos another time." Well, now's that time.

Cleaning up old photo files is a time-consuming pain in the tuchus. How do you do it efficiently? As with many organization projects, tackle the most important stuff first. What photos are most important to you? Maybe they're family portraits and baby pictures. Great. Focus on naming them, tagging them, sorting them into albums or folders, and consolidating them into one place where you keep (or will keep from now on) all your photos. And make sure to back them up!

What if you also have a box of old printed photos you need to deal with? You can scan and digitize them, but I'd recommend treating that as a separate job from cleaning up digital photo files. Compartmentalize these tasks, and they'll be much more manageable.

8. UPDATE YOUR LINKEDIN ACCOUNT AND RESUME

At least once a year, every career-minded person should update his or her resume and LinkedIn profile.

On LinkedIn, update your profile picture with an image of yourself that's appropriate for your industry, bearing in mind that some sectors appreciate seeing personality, style, and charisma, and others really do not. Add achievements, skills you've learned, and new bullet points that illustrate successes and new responsibilities you've earned in the past 12 months.

As for your resume, I believe you should custom-make one for every job application—but it helps to keep an updated skeleton resume on hand that you can treat as a template. Get the basics down on paper, make it excessively long, and plan to trim it and customize it every time you need to spit out a resume.

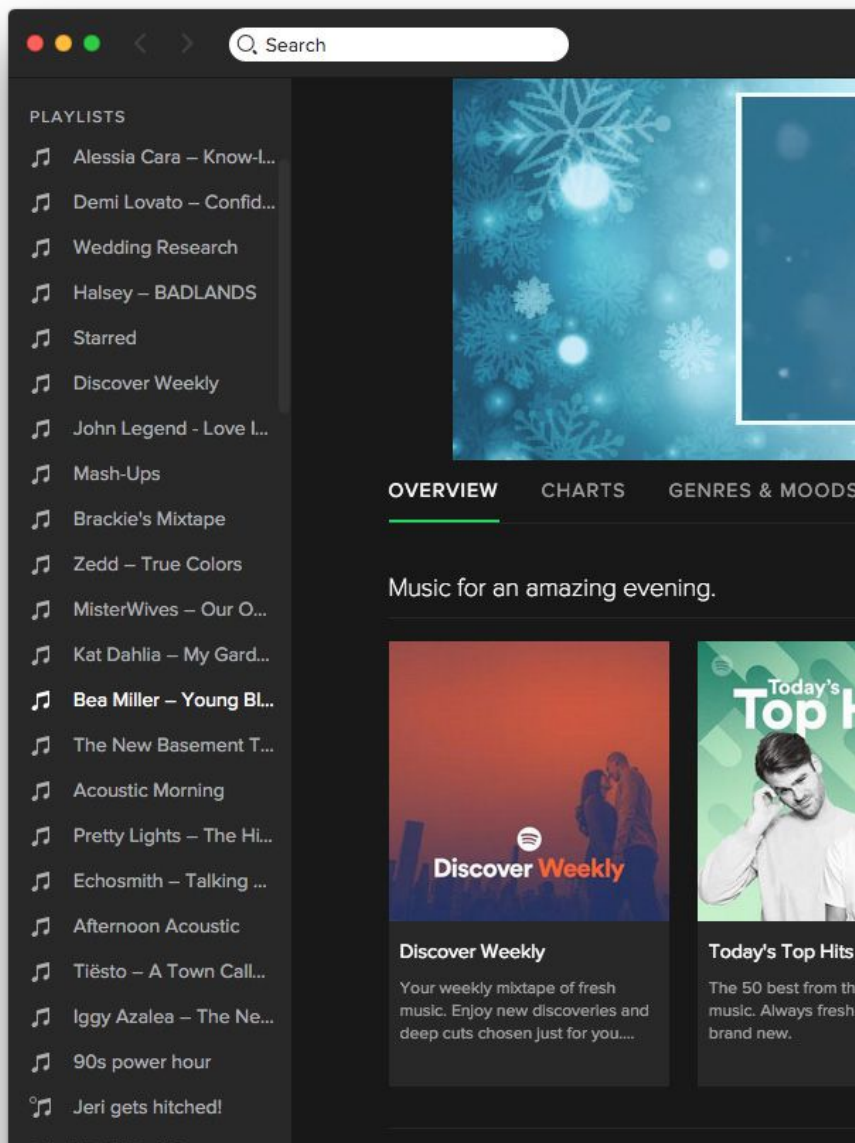
9. CHECK YOUR FACEBOOK AND GOOGLE SECURITY SETTINGS

Has it been too long since you reviewed your Facebook privacy settings or what apps you've authorized through your Google Account? Reviewing your privacy options and other customizations is an excellent thing to do when the calendar switches over. Did you know, for example, that you can block ads on Facebook simply by disabling a few settings? If not, then it's time for a security and privacy checkup.

With Facebook and Google, I recommend accessing the sites from a computer's Web browser rather than a mobile device because of the way the settings are laid out. It's much faster.

10. RENEW YOUR PLAYLISTS

No matter what music service or podcast-catching app you use, the New Year is an ideal time to take stock of what you have and rearrange it how you want. You might decide to clean up iTunes, tidy up your Spotify playlists, or unsubscribe from podcasts that no longer release new episodes. Maybe you've made a resolution to work out more, in which case you could spend a little time putting together a workout playlist. On an average day, this chore might seem like a poor use of your time, but when you have a few hours to kill during the winter holidays, it's just right.



Learn to Code

BY JORDAN MINOR

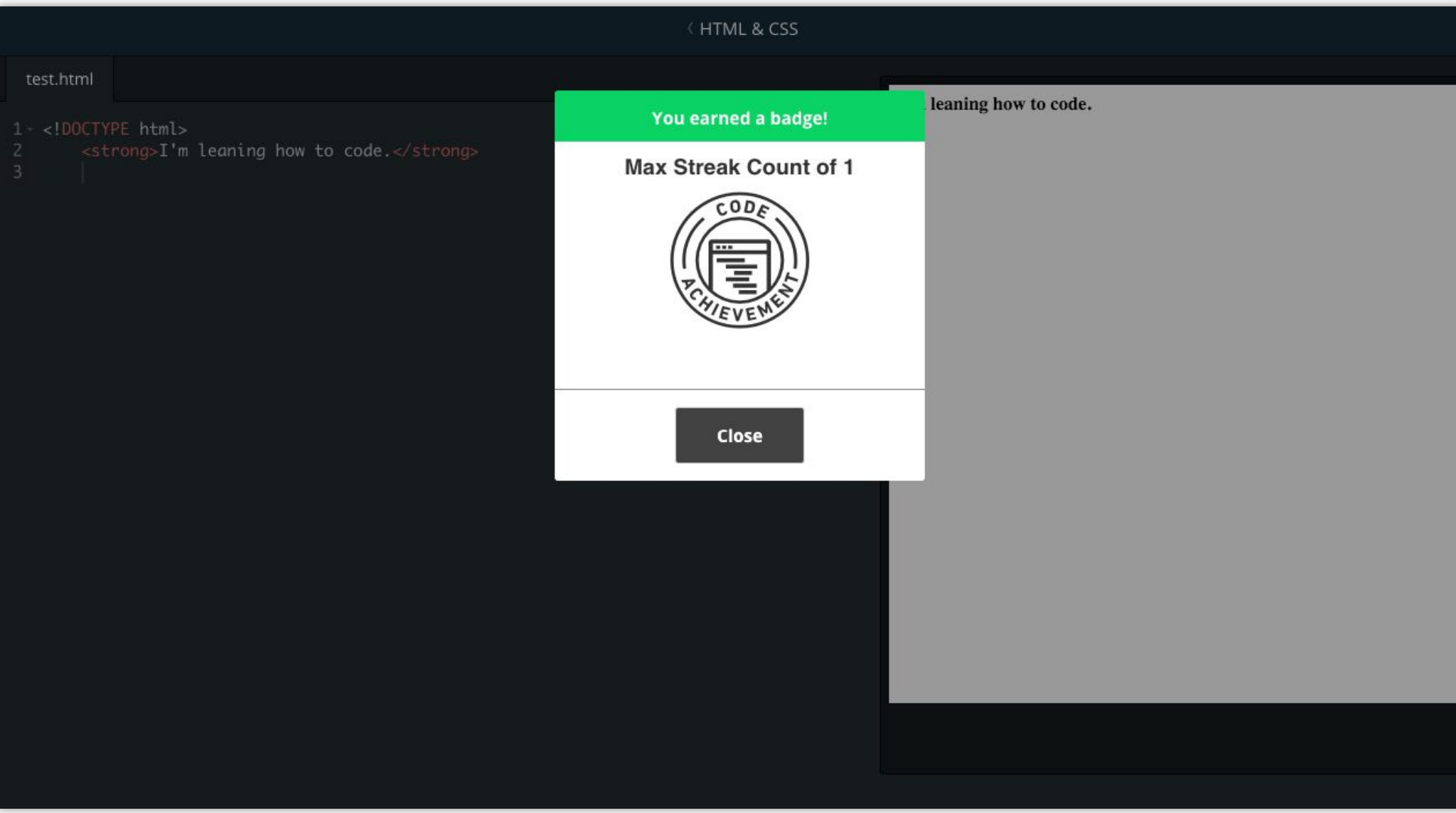
Coding is a critical skill these days, whether you're building a personal website, assembling a professional portfolio, or striving for a promotion at work. Learning to code can be a lonely, confusing, and tedious process, but online learning programs have sprung up to make coding education accessible to everyone, even those with absolutely no experience or knowledge. Here's how to find the best online coding class for you or the children in your life.

LOOK AT THE PRICE TAG

Price is always a concern, no matter what you're buying. There are subscription-based programs such as Treehouse, Infinite Skills, CodeHS, Code School, and Learnable, which offer access to all classes in the course catalog for a monthly or annual fee. Check to see if the program lets you pause your membership, which is helpful if you want to save your progress without racking up fees while you're away on a trip or too busy to access the classes.

The à la carte model, such as that offered by Code Avengers, makes sense if you would rather just pay per course. Courses at Code Avengers start at $21 each, but many of the introductory classes are offered for free. You can also pay one price to access all of the courses in the catalog. When you pay for a quality coding program, you gain access to a library of classes that's bigger, more complex, better produced, and more geared toward professionals than you'll get with free offerings. It's a valuable investment.

Lynda.com and Udemy feature classes on every topic under the sun, and there are more than enough coding options to make a subscription or individual purchase worthwhile. But if all you care about is coding, you might be better served by a program specifically tailored to your needs, especially if you're willing to pay.



Codecademy, on the other hand, offers all of its courses and materials for free, along with built-in tools for writing and testing coding skills. Google also offers two courses for developers with some coding experience as part of Google for Education, but you'll have to set up your free tools separately. And programs like Free Code Camp, Crunchzilla, Dash, and Khan Academy all carve out their own niche in the free landscape, too. Paid classes generally offer more in the way of course depth, breadth, and presentation, but if you're determined and resourceful, you may find that free classes are sufficient.

VARIETY OF COURSES

Another thing to consider is how many courses are offered and the variety of topics that are covered. Some offer straight HTML, CSS, and other Web technologies, whereas others offer classes in advanced languages like Python and C++, mobile app and video game development, and working with APIs. In terms of the sheer number of courses, paid classes usually have the edge over free ones. But a huge library can be overwhelming, so starting off with a smaller, more focused program is also a good option.

Course format is worth paying attention to as well. All you really need to code is a functional text editor, something all of these programs feature. Depending on your learning style, you might appreciate the more polished video tutorials of services like Khan Academy and CodeHS.

EASE OF GETTING STARTED

If you're a beginner, you need a program that's easy to dive into and keep up with as the material becomes more complex. You'll also need encouragement to keep you going. Most of these services offer badges or other rewards when you hit milestones, and show your progress on your dashboard. The best services offer quizzes and challenges so you can test your skills. Testing isn't just for beginners—even experienced programmers want feedback on how they're doing. Newer programs also like to treat progress like a game, rewarding students with shiny badges as they level up their skills. Just don't expect to find these features in all programs.

Those who are serious about pursuing coding as a career, however, will eventually need to ditch the easy stuff and take on more challenging material. Free programs like Crunchzilla tend to be somewhat limited, so consider switching to a paid program like Code School to continue your education. Free Code Camp will even let you take the knowledge you've learned and use it to help a real-life nonprofit organization.

SOMETHING FOR THE KIDS

If you're a parent or teacher, getting kids to code also makes sense. Programming teaches kids to think logically, develops problem solving skills, and improves how they interact with technology. And it can prepare them for the workforce of tomorrow. CodeHS has special features educators can use in the classroom and a wonderful sandbox mode that students can use to express their coding creativity. Other programs like Code Combat, Hopscotch, Scratch, Move the Turtle, and Daisy the Dinosaur treat coding more like a video game, so kids will definitely stay interested. Coding is just another way to make cool things they can show off, which means kids of any age can learn to code.

HELP AND SUPPORT

Finally, you need help when you get stuck on an exercise or a quiz. We like services such as Treehouse and Codecademy, which offer active student forums to help you work through problems and get a second eye on long blocks of code. Support for bugs and website problems, which most of these services offer in some way, is also key. Some communities will encourage you to create a GitHub account so you can easily collaborate on code with fellow students. Lynda and Khan are excellent generalist services, but they can't offer this level of coding-specific help and support.

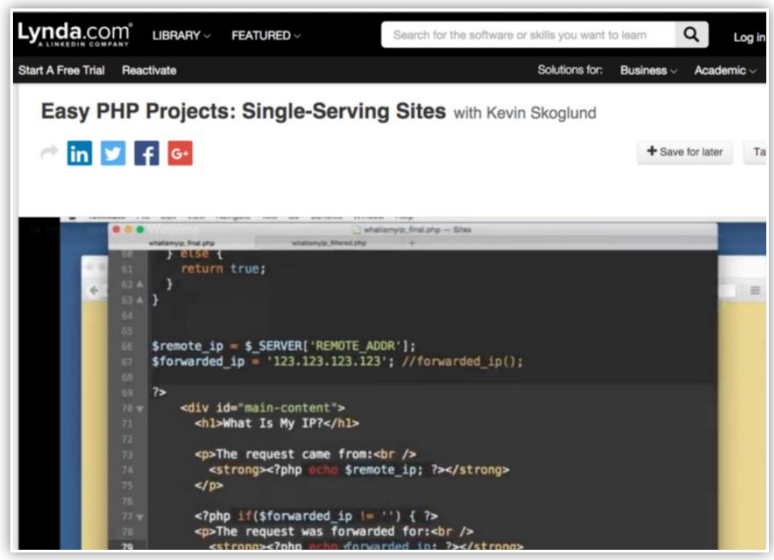
All of these considerations depend on your level of skill. You may not need a lot of hand-holding, in which case you can download ebooks and teach yourself by signing up with Learnable, or you can dive right into a new language with Google for Education. Most beginners will feel more comfortable with services like Dash that start at the basics and test your knowledge as you progress through the course material. Luckily all of these services offer a free or low-cost trial; some even offer completely free coursework.

OUR FAVORITE CODING SERVICES FOR ADULTS

Lynda.com

●●●●◐ EC $25 per month

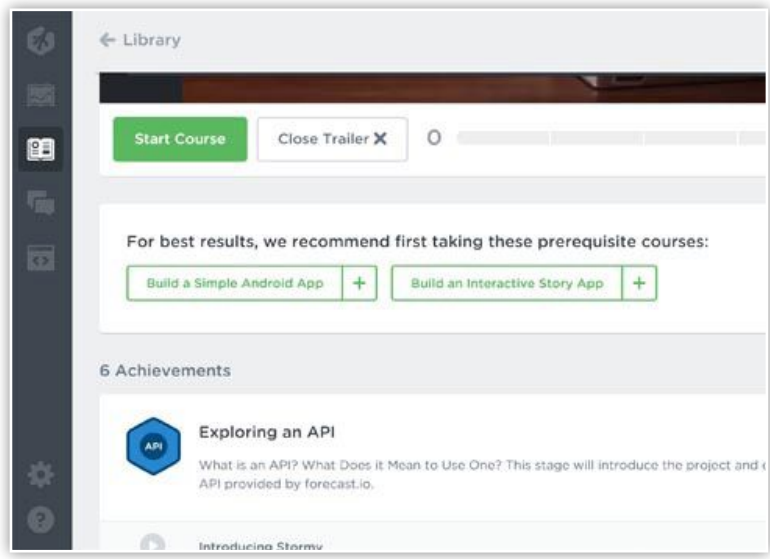
Lynda.com features a variety of courses for those trying to pick up new coding skills. Hundreds of courses and tens of thousands of video tutorials cover Web development and design topics for both beginners and experts. When you need training fast (and are willing to pay for it), Lynda.com is by far the best place to go.



Treehouse

●●●●○ Starts at $25 per month

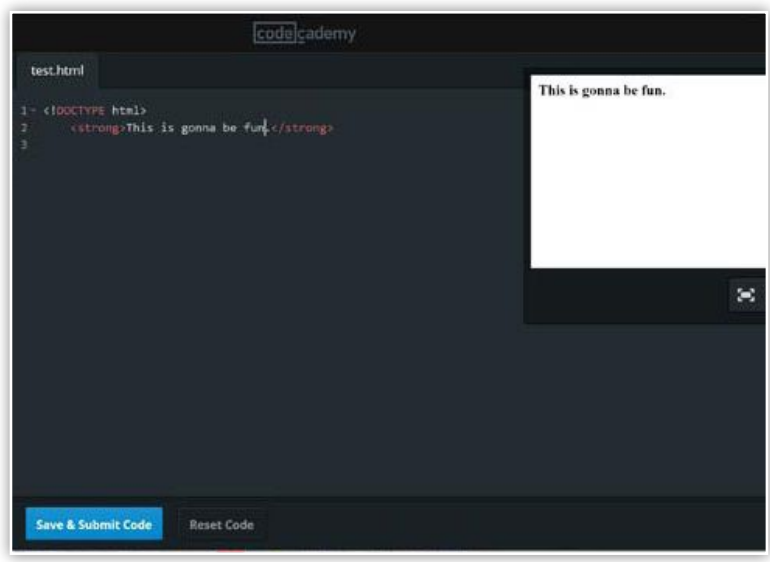
Fun and easy-to-use Treehouse is terrific for newbies, with engaging lessons and challenges, plus an extensive forum for those times you need a helping hand. The website also couldn't be simpler to use, and built-in tools make it easy to follow along.



Codecademy

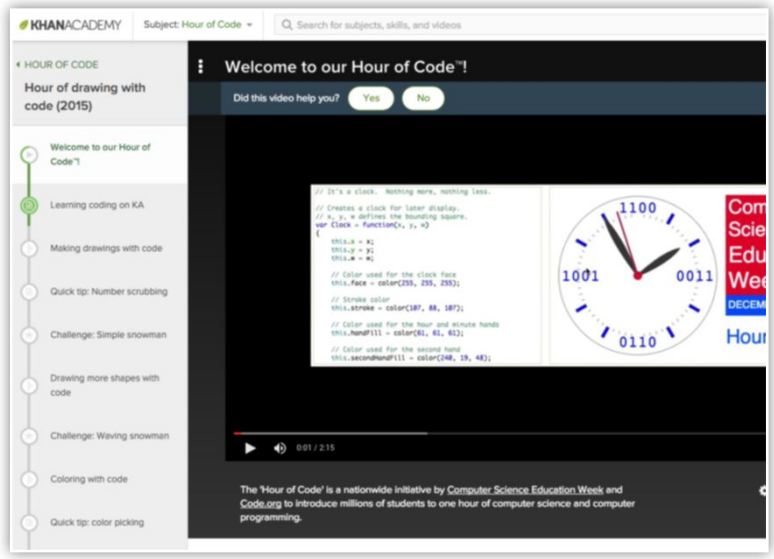
●●●●○ EC Free

The Web-based Codecademy is lots of fun, often feeling more like a game than a classroom, and gives you lots of help along the way. As long as you don't need videos, it's a terrific free choice.



Khan Academy

●●●●○ EC Free



Khan Academy's programming classes teach you languages like HTML, CSS, and JavaScript, for creating websites or designing games, and computer science lessons cover important topics like data encryption and information theory. The Hour of Code tutorials are especially convenient, as they boil down lessons into easily digestible 1-hour chunks.

OUR FAVORITE CODING SERVICES FOR KIDS

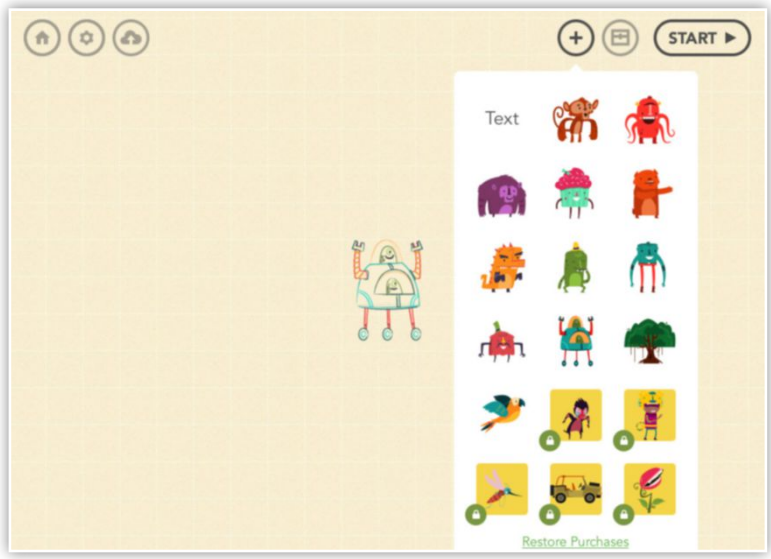
Scratch

●●●●◐ EC Free

Kids can use Scratch, a full-blown Web application (which can also be installed locally on Windows machines), to create elaborate programs. Elements such as variables, conditions, and loops appear as puzzle pieces that can be snapped together to write code. Kids can share their creations with anyone and check out others', too. Your child's imagination is the only limit on what he or she can build.

Hopscotch (for iPad)

●●●●○ EC Free



Teaching programming can be tricky, but the Hopscotch iPad app smooths the way with its kid-friendly interface and pre-built blocks. It's simple enough that most kids will probably get into it right away, but it allows for enough experimentation that they'll still learn a lot. And unlike many other coding apps, Hopscotch is open-ended and encourages children to come up with their own projects.

Earn Airline Miles, Points While You Roam

BY SASCHA SEGAN

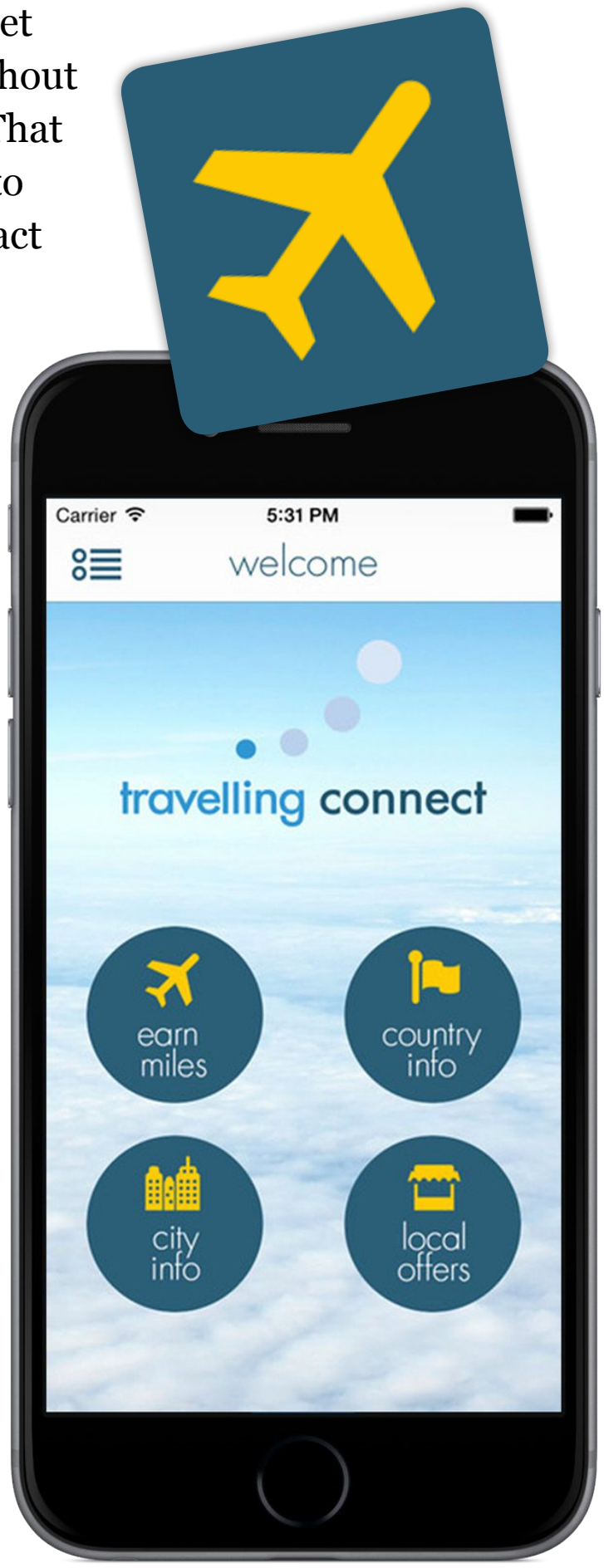
As U.S. cell phone carriers' roaming deals get better, it's easier to just head overseas without worrying about getting a local SIM card. That goes double for business travelers, who may want to keep their U.S. phone numbers so people can contact them. And it goes triple for people with T-Mobile's Simple Global plan, which offers low-cost roaming in 140 countries and territories.

A really unusual app, Travelling Connect, lets you reap frequent-flier miles and hotel points for making calls while you're abroad. It's simple to use and it works (to some extent) with all four major U.S. carriers, although the countries and programs it supports are pretty limited. Still, it's free miles.

Travelling Connect works with American Airlines AAdvantage miles and the hotel points schemes from Hilton, Intercontinental, and Marriott, as well as a bunch of foreign miles programs U.S. travelers are unlikely to focus on.

The app isn't new, but I haven't seen many people writing about it. That's probably because its 25 countries don't involve any of the prime tourist zones that most Americans go to—there's no Canada or Mexico, and almost nowhere in Europe. Travelling Connect says it's working on getting more Caribbean and Latin American partners, but didn't say anything about Europe.

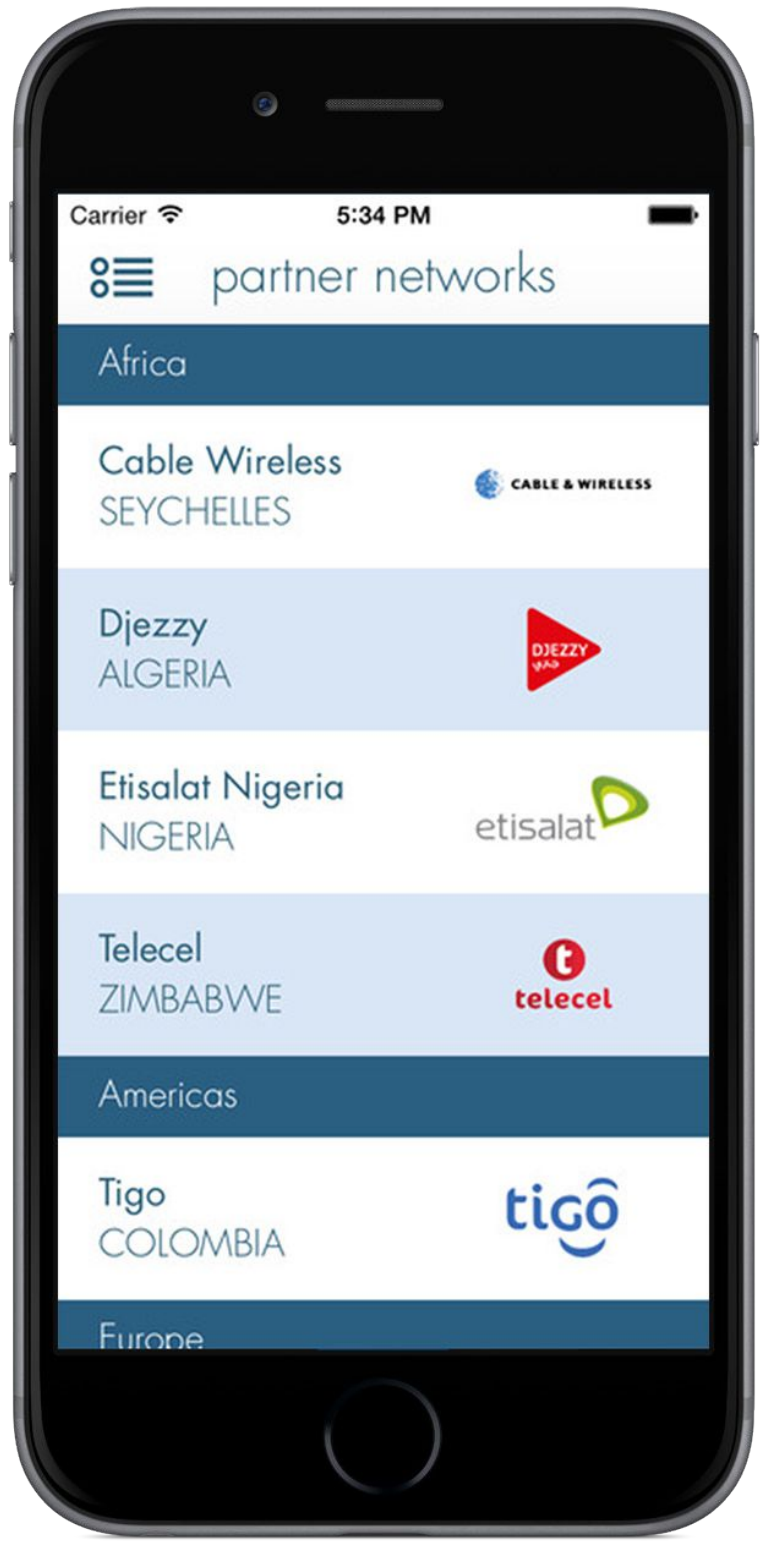
The service covers Hong Kong, Japan, India, and South Korea, as well as Turkey, Dubai, and



Thailand, so there are some places you might go. To use it, download the app and sign up with your frequent-flier or points account. Then, when you're in your destination country, use your phone's "Mobile Networks" setting to manually force your phone onto Travelling Connect's partner network.

That's the one downside: Normally, your roaming phone will latch on to whatever network in a destination is strongest. If you want those sweet, sweet miles, you need to use one specific carrier in each country.

That could be a problem for some American travelers. Although Travelling Connect says it has about 10,000 U.S.-based customers (a little less than 5 percent of its total), Sprint tells me that if you're using its Sprint Open World or Global Roaming plans, you may be stuck with one specific roaming partner in each country and be unable to switch, so you'll have to get lucky.



T-Mobile's Simple Global roaming may be more flexible. The company didn't confirm this, but when I've traveled to Spain, Germany, and South Korea with Simple Global, I've been able to switch between roaming carriers by hand. AT&T and Verizon also generally let you switch between roaming partners.

If you can successfully switch to a Travelling Connect partner, you'll then get miles either for minutes of voice calling, megabytes of data usage, or SMS messages sent. Realistically, finding countries where data becomes miles is the best way to maximize this app. If you use a 300MB AT&T data pass in Dubai, for instance, you can reap 600 AA miles. That isn't bad, especially if you're the kind of mile-hound who's also pulling various credit-card and online-shopping-mall tricks.

Travelling Connect can be used with any mobile platform, the company says. It has dedicated iOS and Android apps, but people on Windows Phone or BlackBerry can sign up on Travelling Connect's website and still get miles if they use the appropriate networks.

JOHN C. DVORAK

Buckling Under the Weight of Search

When you think about Google, Bing, and the future of search, you have to wonder if the mechanism can really survive much longer. Search is ridiculous.

A search system like Google essentially caches the entire Internet into massive server farms around the world, where they are indexed and used as targets for finding specific information. This seemed like a good idea a decade ago, but the enormity of the stored data now strains entire power grids. Server farms are ideally built next to massive hydroelectric plants just to operate.

And all this just so I can find a "needle in a haystack" reference.

The amount of data on the Internet tends to languish forever on active servers run by companies that cannot afford the time to find and delete old garbage. Search engine providers instead buy more storage and leave everything active. This is what they mean when they say that "once it's on the Internet, it's on forever."

Every so often, a large "site of sites," such as Geocities, shutters and removes scads of marginal little sites. But even that content is stored someplace to be passed around at a later date. The entire Geocities archive was released to the public as a 652GB file, and can be found on some BitTorrent indexes. Although not technically on the Internet, it's still out there.

The point is that Google and Bing and anyone else who wants to play this game have to cache a lot of data. But why should Google *and* Bing *and* others have to duplicate the Internet over and

over? A joint venture would be the way: The different companies band together to collect the information, then they all run their own search algorithms on the data pile. Of course, that would probably be illegal for competitive reasons, thus leaving the current mess intact.

There is currently no reasonable solution to this modern and developing Tower of Babel. Everything needs to change regarding how things are posted on the Internet.

Unless protocols are developed that force every page to be self-indexing, self-categorizing, and self-sorting, this chaos will remain. Search results will deteriorate. I already go to regional Google centers such as Google.fr (for France) to get proper results for certain searches that never come up on regular searches using Google.com.

One hugely disappointing development was the constant emergence and disappearance of new search technologies. Yahoo bought a slew of them and did nothing with them. Others, like Fast from Scandinavia, showed a lot of promise as the engineers involved toyed with new ways of looking at data stores.

Eventually, with new ideas squashed by mergers and acquisitions, the Google brute force approach prevailed. But the model is old and tired and barely works.

Facebook was supposed to develop a Google killer with a so-called social search that would find desired pages through some sort of social networking scheme. The idea scared Google into creating Google+, but nothing major has happened except an apparent downturn in search activity overall. As reported in Quartz and elsewhere, search queries have actually peaked and may be on the decline.

> **Facebook is the new and improved AOL. It's for people who don't want to get all confused by the crazy Internet.**

This may have more to do with the nature of modern computer users. They gravitate toward a closed proprietary system (Facebook) where there is structure. Unfortunately, along with this comes a stream of never-ending—albeit controlled—information and entertainment. The dulling effect this has on the individual is similar to that the original AOL (with its keyword meme) had.

I've always said that Facebook is the new and improved AOL. It's for people who don't want to get all confused by the crazy Internet. It's Internet enough for them.

If you survey many Facebook users, you'll find that a majority of them cannot, in fact, do any sort of complex Google search. Google is not about to go out of business anytime soon, but the company is aware of what looks to me like a sea change.

With a now mildly dwindling user base that could easily become a massively dwindling user base, how can Google rationalize building out more and more massive data centers to account for the still-growing Internet?

If these trends are real, the answer is that they cannot keep doing this.

Then what happens? Massive search deterioration, that's what.

Once you can't find anything at all on the Internet, then maybe the entire structure will be forced to change. It can't happen soon enough.

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