PC MAGAZINE

THE SECRET TO CROWDFUNDING SUCCESS FOR INVENTORS AND BACKERS

HOW BEAMR AND V-NOVA ARE REVOLUTIONIZING 4K VIDEO

CRYPTO WARS

Why the Fight To Encrypt Rages On

DIGITAL EDITION
OCTOBER 2016

SoftGozar.com

PC MAGAZINE

CONTENTS

OCTOBER 2016

COVER STORY

CRYPTO WARS

The fight to encrypt rages on. We talked to luminaries in the field to get the latest intel on this technology.

FEATURES

THE SECRET TO CROWDFUNDING SUCCESS

Some sage advice for both inventors and backers.

HOW BEAMR AND V-NOVA ARE REVOLUTIONIZING 4K VIDEO

4K video is here, and Americans are loving it. So are TV makers.

SoftGozar.com

REVIEWS

CONSUMER ELECTRONICS

Apple iPhone 7 Plus

Motorola Moto 7 Play Droid

Fitbit Charge 2

Microsoft Hololens Development Edition

Apple iPhone 7 Plus

HARDWARE

Asus VivoStick PC (TS10)

Evoluent VerticalMouse C Right Wired

Top 5 Mechanical Keyboards

Wacom Bamboo Folio

Asus VivoStick PC (TS10)

SOFTWARE & APPS

Acronis True Image

No Man's Sky (for PC)

Acronis True Image

SoftGozar.com

WHAT'S NEW NOW

LOOK OUT, GORILLA GLASS: DIAMOND GLASS COULD BE HARDER TO CRACK

This new material could become your phone's best friend.

THE GOOD AND THE TERRIFYING THINGS AT BLACK HAT 2016

The hacker conference is as galvanizing as always.

GOOGLE'S DEEPMIND GIVES ROBOTS A SCARY-ACCURATE NEW VOICE

It's close to human—but not quite there yet.

TOP GEAR

SoftGozar.com

OPINIONS

> **The first issue in which I appeared, August 1986, had my picture on the cover.**

DIGITAL LIFE

SoftGozar.com

DAN COSTA

The Long War on Encryption

A few months back, I used this column to explain why Apple should not have to crack its security measures and unlock a phone for the FBI. The phone belonged to one of the San Bernardino terrorists, and it likely contained information that would be useful to law enforcement. It many ways, this was an ideal test case for the FBI. Popular opinion was mixed, but generally fell on the side of Apple helping out the government, "just this once."

Of course, that isn't how technology works. And the FBI found a way to break the lock anyway, proving that no security system is truly unbreakable. But the broader question remains: Should the government have access to any communication?

In the course of my argument, I said, "This is a big new problem, and it requires a new debate." That isn't entirely accurate. The technology has evolved, but the debate is an old one. The arguments the government made about encrypted iPhones are the same as those made when Phil Zimmerman released PGP (Pretty Good Privacy, an email encryption software package) in 1991. In fact, the debate goes back to the 1970s, at least. And the government's stance is always the same.

Sam Adler-Bell, a policy associate at The Century Foundation, corrected me online and used the following quotes to make his point. All of them are from FBI officials explaining the imminent danger that encryption technologies pose to the American people.

SoftGozar.com

"When changes in technology hinder law enforcement's ability to exercise investigative tools and follow critical leads, we may not be able to root out the child predators hiding in the shadows of the Internet or find and arrest violent criminals who are targeting our neighborhoods."
—FBI Director James Comey, March 2016

"In the ever-changing world of modern communications technologies, however, the FBI and other government agencies are facing a potentially widening gap between our legal authority to intercept electronic communications pursuant to court order and our practical ability to actually intercept those communications. We confront, with increasing frequency, service providers who do not fully comply with court orders in a timely and efficient manner."
—FBI General Counsel Valerie Caproni, February 2011

"Uncrackable encryption will allow drug lords, spies, terrorists and even violent gangs to communicate about their crimes and their conspiracies with impunity. We will lose one of the few remaining vulnerabilities of the worst criminals and terrorists upon which law enforcement depends to successfully investigate and often prevent the worst crimes."
—FBI Director Louis Freeh, July 1997

These make a perfect illustration of the old argument—and it isn't entirely without merit. Yet the scope and scale of pro-encryption arguments have changed dramatically over the years. When the Clipper chip (an encryption device with a built-in backdoor) was pushed forward in the 1990s, it was primarily intended to allow the government to

SoftGozar.com

tap voice calls. Now, there's just a lot more communication that the government wants to track: email, text messages, Snapchats, metadata, location data, and financial transactions. Encryption protects everything from your Google Photos library to your Venmo payments; the technology has become a fundamental part of the infrastructure of the digital world. These days, the encryption battle is just as much about e-commerce and international relations as it is about privacy and security.

As we were closing this issue, Google released Allo, its latest bot-assistant uber-messaging app for Android. It looks promising, but it is already drawing fire from privacy advocates. Edward Snowden tweeted from an undisclosed location in Russia: "What is #Allo? A Google app that records every message you ever send and makes it available to police upon request." Although you can enable an encrypted incognito mode, by default the app will log and store all of your messages. Indefinitely.

We live in a world where every click gets tracked. Our phones continually transmit our location, and we're constantly broadcasting and receiving digital information. Digital trails extend from every decision we make, both online and in real life and persist indefinitely. None of that means we can dismiss the warnings of the FBI, but it offer a new context.

In this month's cover story, Max Eddy dives deep into the roots of the encryption wars. He talks to the some of the creators of public key encryption about what it means and why it matters. And the war continues.

dan_costa@pcmag.com

SoftGozar.com

When the Internet Takes the Wheel

Our September cover story on driverless cars drove a lot of response online. It seems the concept is being met more with skepticism and criticism than enthusiasm by most readers—but not all!

"DRIVERLESS CARS"

What happens when 25 percent or more of the vehicles on the road are autonomous and human drivers along with their unpredictability, slower reflexes and lesser precision become a major problem by causing unnecessary accidents? At some saturation point, human drivers will become a liability as they simply will not be able to function as quickly or precisely as robotic driven cars. Will people in 10 or 15 years be ready to give up driving the car and simply being a passenger?

–bobe123

It's inevitable that companies will want to monetize this technology, and you'll end up with in-dash advertising displays complete with "Press here to go to your nearest McDonald's" style ads. I can't wait for the first news story of someone pressing the "Press here to go to..." button, and the car drives in through the front window of a business.

–The Contentious Otter

I noted the absence of two major arguments: criminals and hackers. All the laws in the world will never deter the criminal and if there's a way for them to make an illicit buck they WILL find it. Closely related to that thuggish criminal is the hacker. If there's a way to hack in to one of these AV's, they *will* find it and use it for whatever nefarious purpose they can dream up; even if it's

SoftGozar.com

just to take over the AV to scare the bedunkle out of whatever passenger is present. I guess the author assumes those will won't be a problem; well, we all know about that word!
–jbscpo

Writer Evan Dashevsky's reply:
I assume that hacking and criminality will be major issues to contend with. This is an overview of this emerging technology, and I couldn't possibly go into every issue. I do believe, however, that the benefits to society in making the roads safer and transportation more efficient will far outweigh the occasional issues with hacking.

I actually don't think that there is much danger of a lone hacker causing too much damage. While criminal and mischief hacks do happen with regularity, they very rarely involve the cracking of the security of BIG money digital fortresses like Facebook, Google, or Apple (there have been criminal hacks where individual users have been spear-phished and the like, but not where some kid in his basement has made it into the Facebook servers).

According to the DOT, the age of the average car on US roads is 11.5 years. That statistic alone tells you it will be a very slow process for self driving cars to become a major part of the mix. Even electric vehicles, after many years, are only 0.2 percent of the cars on the road, a factor 100 times smaller than what Tesla was telling everyone in 2010 the percentage would be by 2015.
–Vigilabo_Vigilum

For the drop in driver's licenses and car ownership to be meaningful, it would have to be normalized against the percentage of the population living in urban areas. They are the only areas where car availability (i.e. possession) isn't all but mandatory.
I also think there will be a ton of pushback from municipal law enforcement. AVs will remove most of the minor traffic citation fines that are their livelihood.
–cecil77

"The horse is here to stay, but the automobile is a novelty—a fad." A quote from the president of the Michigan Savings Bank, 1903.
—CapitalistRoader

Ask us a question

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

SoftGozar.com

Look out, Gorilla Glass: Diamond Glass Could Be Harder to Crack

BY RYAN WHITLAM

Hardened glass, such as the near-ubiquitous Corning Gorilla Glass, has made capacitive touchscreens the standard way of interacting with a smartphone. It's constantly improving, too. Gorilla Glass is resistant to scratching, and newer screens won't crack nearly as easily as they have in years past. It doesn't have any bling, though. A company called Akhan Semiconductor says that it's close to releasing a diamond coating for glass that would be even more durable than Gorilla Glass.

A PHONE'S BEST FRIEND?

Your next phone might have a layer of diamond that keeps it from scratching or cracking.

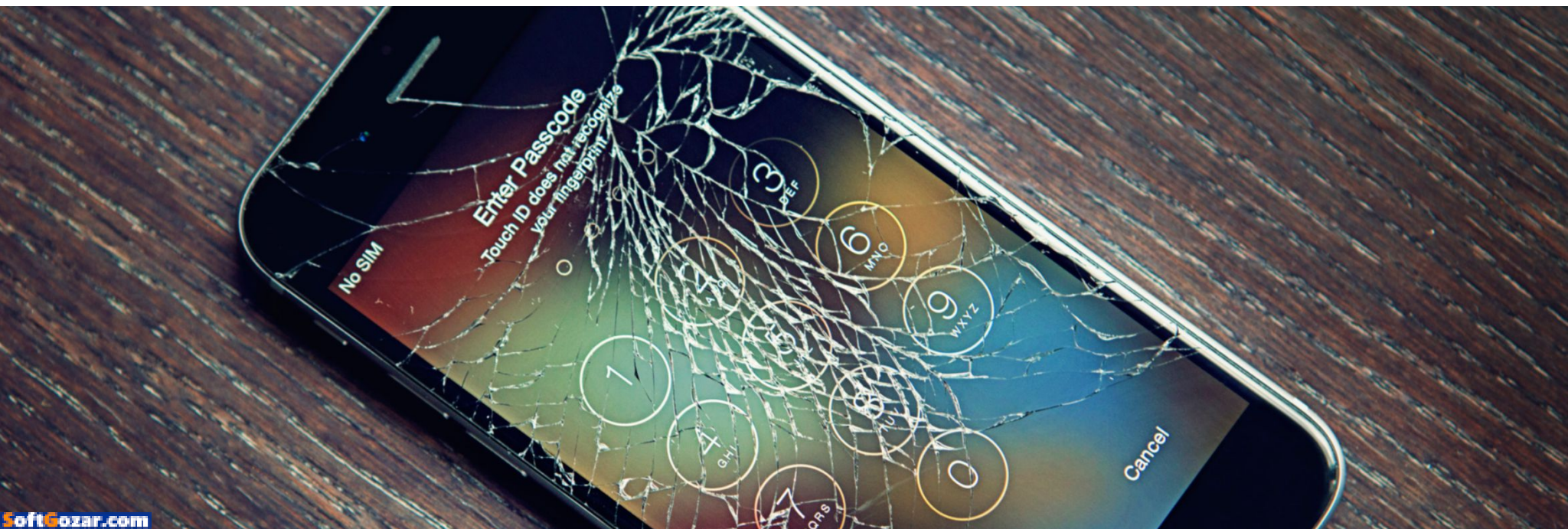
SoftGozar.com

Corning, which recently announced Gorilla Glass 5, makes the glass for nearly every high-end smartphone, including the Samsung Galaxy S7 and Note7. Apple also uses hardened glass from Corning but doesn't like to talk specifics. Akhan Semiconductor says that its Akhan Miraj NCD diamond (that's quite a mouthful) material is four times as crack-resistant and seven times as scratch-proof as Gorilla Glass.

Diamond, the hardest material known, is a natural choice when you want to make something durable. It's not the first place electronics companies looked, though. Sapphire glass has been slowly making its way into mobile devices such as the Apple Watch and a few ruggedized phones. Apple famously wanted to equip the iPhone with a sapphire glass screen several years ago, but the company that was set up to supply that glass, GT Advanced Technologies, was unable to produce it in sufficient volume and eventually went out of business.

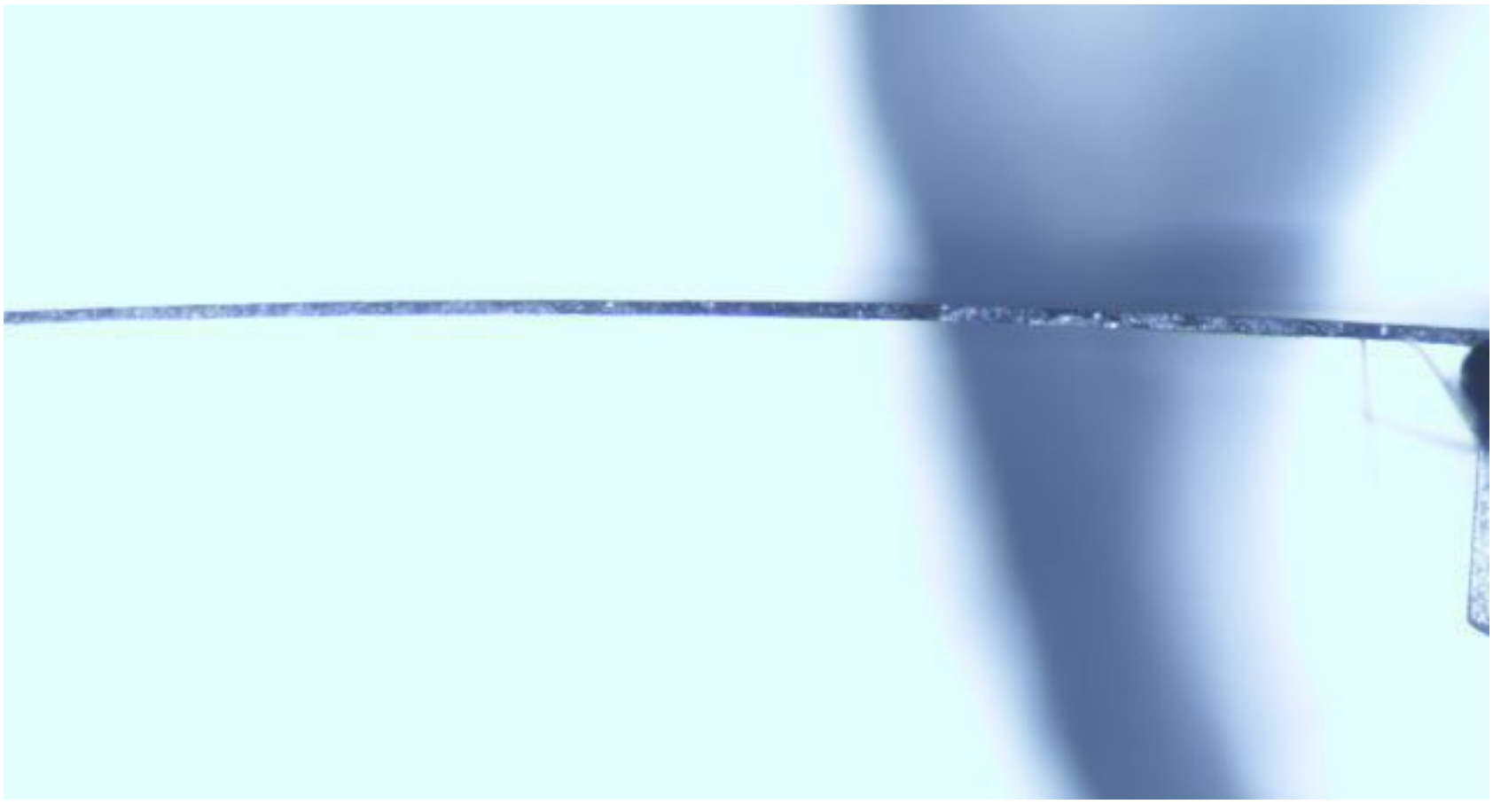
Akhan Semiconductor says that its diamond glass is actually cheaper and easier to produce than sapphire. Scientists have been able to create synthetic diamonds for years, so that's no problem now. What sets the NCD diamond apart is that it's only a very thin layer on top of regular UV glass manufactured by Corning. The company essentially grows the diamond on a glass substrate via an inexpensive process called chemical vapor deposition. The diamond component is 800 times thinner than a Gorilla Glass 5 panel and stronger than a pane of sapphire glass.

> **Akhan says that its diamond glass is actually cheaper and easier to produce than sapphire.**



CRACKING UP
Diamond can shatter, says Akhan, but it hopes to offset that risk by making the panel slightly flexible.

SoftGozar.com



A SLICE OF STRENGTH
This is a magnified side view of the Miraj NCD Diamond on Glass. (Image: Akhan Semiconducter)

That all sounds great, but diamond screens could be challenging to implement for some of the same reasons sapphire hasn't taken off. Because diamond is harder, it won't scratch, but it can shatter. Akhan claims the thinness of the diamond makes up for that, allowing the panel to be slightly flexible. Reflectivity is also an issue with materials such as sapphire and diamond. Again, Akhan says this won't be a problem, because it "tunes" the crystals to lower the index of refraction.

As for when you'll see a Akhan Miraj NCD diamond display, that's up in the air. Akhan Semiconductor thinks it can have the technology to produce the glass at scale within a year, but it's looking for licensing partners to actually do the production. Corning may even bite.

SoftGozar.com

The Good and the Terrifying Things at Black Hat 2016

BY MAX EDDY & NEIL J. RUBENKING

Black Hat is a gathering of security researchers, hackers, and industry that meets in Las Vegas to do three things: outline the latest threats, show how the good guys and the bad guys can be defeated, and launch attacks on the attendees. This year saw plenty of scary things, including car hacks, new ways to steal cash from ATMs, and why smart lightbulbs might not be as safe as we thought. But we also saw lots of reason to hope, including teaching machines to spot dangerous servers, using Dungeons and Dragons to train employees on dealing with security threats, and how Apple handles the security of your iPhone. It was, all told, a pretty mind-bending event.

SoftGozar.com

THE GOOD

Apple announced a bug bounty program at Black Hat (a select handful of researchers can earn up to $200,000 for identifying vulnerabilities in iOS or iCloud). But that was just the last 10 minutes of a presentation by Ivan Krstic, Apple's head of security engineering and architecture. During the other 40 minutes, he offered an unprecedented deep dive into the ways Apple protects users' devices and data, both from malefactors and from itself. (And it involves using an honest-to-God blender.)

APPLE'S IVAN KRSTIC
His group at the company is responsible for end-to-end security of all Apple products. Krstic took the conference stage to talk about security features of HomeKit, AutoUnlock, and iCloud Keychain.

As Internet of Things devices become more popular, security professionals are becoming more concerned. These are, after all, devices with microcomputers connected to networks and fully capable of running code. That's an attacker's dream. The good news is, at least in the case of the Philips Hue system, creating a worm to jump from lightbulb to lightbulb is very difficult. The bad news? It's apparently very simple to trick Hue systems into joining an attacker's network.

Every security training in every business includes the admonition that employees should never click links in emails from unknown sources. And employees continue to be duped into clicking them. Dr. Zinaida Benenson, from the University of Erlangen-Nuremberg, concluded that it's simply not reasonable to expect employees to resist curiosity and other motivations. If you want them to be James Bond, you should put that in the job description and pay them accordingly.

SoftGozar.com

A lot of security research and execution can be mind-numbingly tedious, but new techniques in machine learning might lead to a safer Internet. Researchers detailed their efforts at teaching machines to identify botnet command and control servers, which allow the bad guys to control hundreds of thousands (if not millions) of infected computers. The tool could help keep a lid on such nefarious activity, but it wasn't all heavy research. To conclude their session, researchers demonstrated how machine learning systems could be used to generate a passable Taylor Swift song.

The hotel's network may be fine for a pet-supply conference, but not for Black Hat. The conference has its own, entirely separate network and an impressive Network Operations Center to manage it. Visitors can peer in through the glass wall at the many glowing screens, hacker movies, and long-term security experts in the NOC, which gets packed up in its entirety and moved around the world to each Black Hat conference.

IT security wonks and white-hat hackers just can't get enough of security trainings, but they're not the ones that really need them. The sales staff, HR team, and call center crew don't necessarily understand or appreciate security trainings, and yet businesses really need them to step up their security game. Researcher Tiphaine Romand Latapie suggested reworking security training as a role-playing game. She found that it worked well and produced significant new engagement between the security team and the rest of the staff. Dungeons & Dragons, anyone?

Scam phone calls are a huge problem. IRS scams convince unsuspecting Americans to fork over cash. Password reset scams trick call centers into giving away customer data. Professor Judith Tabron of Hofstra University, who is a forensic linguist, analyzed real scam calls and devised a two-part test to help you spot them. It's a simple and worthwhile technique.

THE FRIGHTENING

Pwnie Express builds devices that monitor network airspace for anything untoward, and it's a good thing, too—the company discovered a massive Man-in-the-Middle attack at Black Hat this year. In this case, a malicious access point changed its SSID in order to fool phones and devices into joining the network, thinking it to be a safe, friendly network the device had seen before. The attackers tricked some 35,000 people. Although the company

SoftGozar.com

was able to spot the attack, the fact that it was so massive is a reminder of how successful these attacks can be.

Last year, Charlie Miller and Chris Valasek presented what many assumed was the pinnacle of their car-hacking careers. They returned this year with even more daring attacks, ones that are able to apply the brakes or nab control of the steering wheel when a car is moving at any speed. Previous attacks could be carried out only when the car is traveling at 5Mph or slower. These new attacks could pose great risk to drivers and will hopefully be swiftly patched by auto manufacturers. For their part, Valasek and Miller said they're done hacking cars, but they encouraged others to follow in their footsteps.

If you watch Mr. Robot, you know that it's possible to infect a victim's computer by strewing USB drives around a parking lot. But does that *really* work? Elie Bursztein, anti-fraud and abuse research lead at Google, presented a two-part talk on the subject. The first part detailed a study that clearly showed it does work (and parking lots work better than hallways). The second part explained, in great detail, exactly how to build a USB drive that would totally take over any computer. Who took notes?

Drones were a hot item last holiday shopping season, and maybe not just for geeks. A presentation showed how the DJI Phantom 4 drone could be used to jam industrial wireless networks, spy on employees, and worse. The trick is that many critical industrial sites use what's called an "air gap" to protect sensitive computers—networks and devices that are isolated from the outside Internet. But small, maneuverable drones can bring the Internet to them instead.

Machine learning is on the cusp of revolutionizing numerous tech industries, and that includes scammers. Researchers at Black Hat demonstrated how machines could also be taught to produce highly effective spear-phishing messages. Their tool determines high-value targets and then scours the victim's tweets to craft a message that's both relevant and irresistibly clickable. The team didn't spread anything malicious with their spam bot, but it's not hard to imagine scammers adopting these techniques.

SoftGozar.com

You expect free Wi-Fi in a hotel, and you may be savvy enough to realize it's not necessarily secure. But in an Airbnb or other short-term rental, security can potentially have the worst security ever. Why? Because prior guests have had physical access to the router, meaning they could totally own it. Jeremy Galloway's talk detailed what a hacker can do (it's bad!), what you can do to stay safe, and what the property owner can do to deter such attacks. It's a problem that's not going away.

In one of the most comprehensive talks at Black Hat, Rapid7's Senior Pentester Weton Hecker demonstrated what might be a new model for fraud. His vision includes a massive network of compromised ATMs, point-of-sale machines (like in grocery stores), and gas pumps. These could steal victim's payment information in real time and then quickly enter them with the help of a motorized PIN-pushing device. The talk ended with an ATM spewing cash and a vision of the future where scammers buy access to a massive real-time network of payment scams.

That wasn't the only presentation at Black Hat to detail attacks on payment systems. Another group of researchers showed off how, with a Raspberry Pi and a little effort, they were able to intercept oodles of personal information from chip card transactions. That's particularly notable not only because chip cards (AKA EMV cards) are considered more secure than magswipe cards but also because the U.S. has just begun rolling out chip cards domestically.

Next year will bring new research, new hacks, and new attacks. But Black Hat 2016 showed that a hacker's work (whether that hacker is white- or black-hatted) is never really done. Now, if you'll excuse us, we're going to shred our credit cards and go off to live in a Faraday Cage in the woods.

SoftGozar.com

Google's DeepMind Gives Robots a Scary-Accurate New Voice

BY AARON KRUMINS

Whatever you may think of the robotic voices foisted upon the world thanks to Google Voice Search and Siri, you're unlikely to mistake them for human voices. The state of the art in computer speech synthesis has been stuck at a fairly low level. But new software called WaveNet, from the brainiacs at DeepMind, is setting a high watermark in the field of speech synthesis and giving AI a voice eerily similar to that of a human.

ALMOST HUMAN

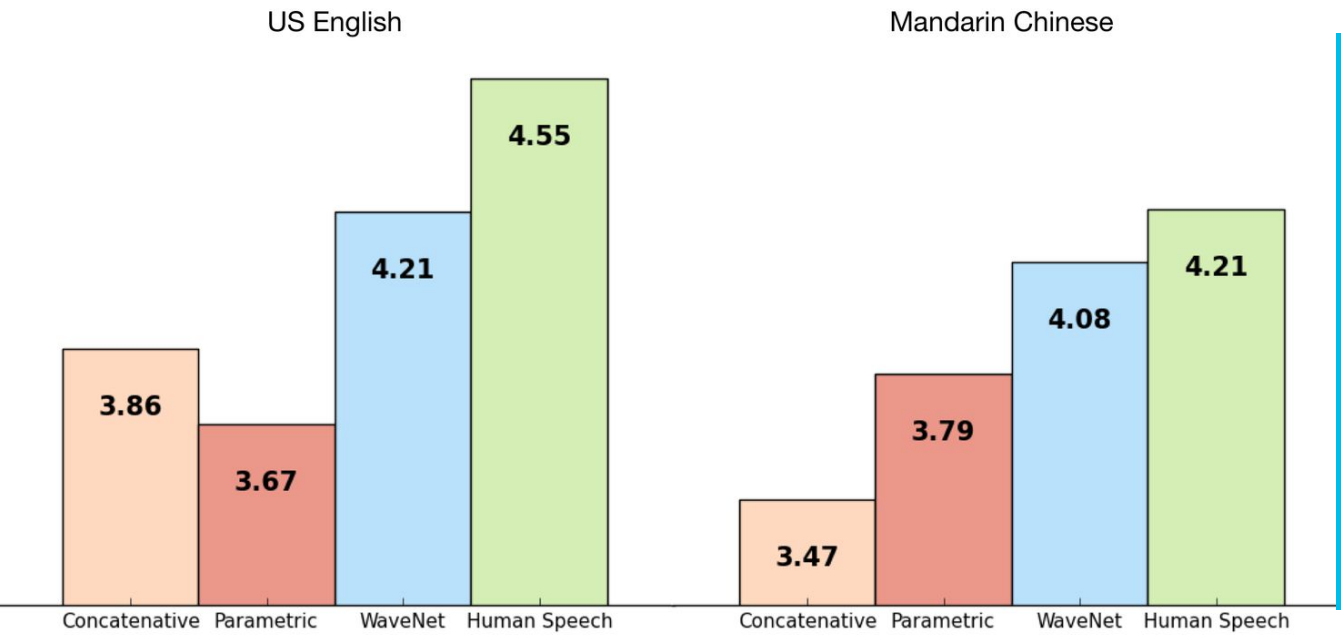
A new artificial neural network is setting high watermarks in the field of speech synthesis and giving robots a voice eerily similar to that of humans.

SoftGozar.com

For years, robotics experts have spoken about something called the “uncanny valley”—the creepy feeling one gets when observing a robot that is too mechanistic to be mistaken for a human but not quite mechanical enough to be distinctly robotic.

Perhaps one reason there has been no parallel concept for robotic speech is that to date, no speech synthesizer was capable of attaining a quality that came close enough to a human as to be disturbingly similar. With DeepMind’s WaveNet, we may be witnessing the emergence of something like an uncanny waveform, a robotic voice close enough to our own as to be distinctly creepy. Or like me, you may just rejoice that finally there’s hope for an ebook reader that doesn’t sound like the re-animated corpse of a 1980’s Commodore computer.

We may be witnessing the emergence of a robotic voice close enough to our own as to be distinctly creepy.



CHINESE AND ENGLISH TEXT TO SPEECH
This graphic shows a side-by-side comparison of text-to-speech methods, including WaveNet, as rated by human listeners.

Image Source: DeepMind

The secret sauce behind this new standard in robotic speech, ironically enough, is artificial intelligence, albeit with a little help from some smart software engineers.

We may as well get used to this state of affairs, as it looks increasingly that advancements made in fields like robotics and AI will be realized with the help of artificial intelligence. While this virtuous feedback loop still includes human intermediaries, a trend toward self-improving AI may be in the offing, along with all the

SoftGozar.com

concomitant existential risks. Regardless, here's a closer look at WaveNet and how artificial intelligence has enabled and is the backbone behind DeepMind's new speech synthesizer.

Most speech synthesizers have been one of two types: concatenative text to speech and parametric text to speech. Concatenative text to speech is the method behind the so-called "high quality" speech synthesizers used by Google Voice and Siri. It provides a more realistic sound by using large audio files of real people's voices, chopped up and reorganized to form whatever word the computer is enunciating. The downside is that it is difficult to color the speech with changes of emotion or emphasis.

The alternative method, parametric speech, uses a rule-based system discovered by applying statistical models to speech patterns. The stilted and robotic-sounding speech synthesizers are mostly of this latter type, since they rely upon the computer to generate the audio signal rather than recordings of real human voices.

The WaveNet system can be thought of as an improvement upon concatenative text to speech in that it employs recordings of real human voices. But instead of chopping them up and reorganizing them in the old way, it uses an artificial neural network to generate synthetic utterances based upon the voices it was trained with. The downside is that this system is computationally intensive. Modeling raw audio typically requires 16,000 samples per second, with each sample being influenced by all the previous ones. This is well beyond the processing power of a typical smartphone, but not unthinkable for GPUs like Nvidia's DGX-1 deep learning supercomputer.

DeepMind has some audio samples posted up on its WaveNet page, if you want to hear what it sounds like. For the time being, while you're unlikely to encounter WaveNet out in the wild, it's not unthinkable that this system will someday power the voice on your ebook reader or a smart home console—that is, if a recursive self-improving AI hasn't obliterated humanity first.

SoftGozar.com

What We Love Most This Month

BY STEPHANIE MLOT

RFID-BLOCKING ACCESSORIES

Whether you tote your license, credit cards, or passport in a back-pocket wallet or shoulder bag, RFID blockers can help to keep your personal data hidden. Access Denied uses proprietary RFID Lock technology to shield in and around all wallet pockets and folds. Similarly, the Lodis laptop bag promises safety for your passport or other identifiable information.

Wallet: $109.96 rfiddenied.com

Handbag: $368.00 lodis.com

SoftGozar.com

What We Love Most This Month

BY STEPHANIE MLOT

MILITARY-GRADE FARADAY BAGS

Faraday cages—named after 19th-century scientist Michael Faraday—are designed to defend against damaging electromagnetic pulses (EMPs). You could, of course, build your own tinfoil enclosures. Or you could pick up Tech Protect's value pack of Faraday bags, complete with one 20-by-30-inch bag, one 8-by-16-inch sack, and two 8-by-8-inch pouches for carrying laptops, gaming systems, video cameras, cell phones, thumb drives, GPS devices, and more.

$34.95 techprotectbag.com





SoftGozar.com

What We Love Most This Month

BY STEPHANIE MLOT

iPHONE PRIVACY BALLISTIC GLASS SCREEN PROTECTOR

Prying eyes are rarely welcome—whether you're playing Candy Crush or writing a sensitive email. Slap on a 4-Way Privacy screen protector, and your handset becomes unreadable to anyone but the you, the user. Tech Armor's six-layer technology resists scratches and meddling thieves.

$15.95 www.techarmor.com

SoftGozar.com

What We Love Most This Month

BY STEPHANIE MLOT

ITOUCHLESS BIO-MATIC FINGERPRINT DOOR LOCK

Worried your spare-key hiding place under the welcome mat won't fool intruders? iTouchless has a simple (albeit pricey) solution. The Bio-Matic weatherproof fingerprint-recognition door lock stores up to 150 prints and 78 pass codes and even comes with two backup keys for emergencies. Available in gold or silver, the lock system provides an extra layer of home security.

$329.95 itouchless.com

SoftGozar.com

What We Love Most This Month

BY STEPHANIE MLOT

KJB CELL PHONE DETECTOR WITH WHITE NOISE GENERATOR

Worried someone is trying to listen to your private conversations? This device ensures your dialogue remains discreet by blocking spies and locating their recording devices, so you can sniff out the snoops: If your phone begins exchanging data with the network, three LEDs flash and an alarm goes off. The credit card-size gadget lasts up to five days per charge.

$285 gadgetsandgear.com





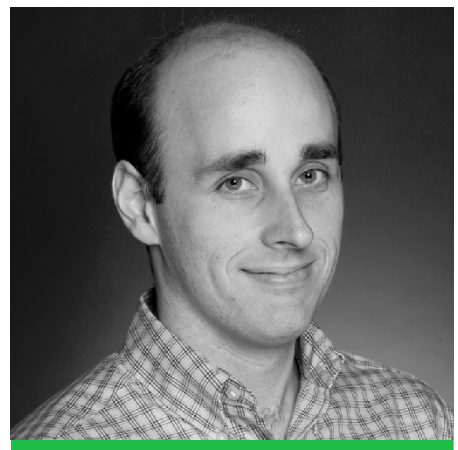
SoftGozar.com

Keeping Perspective in a Changing Tech World

One of the most important things you can have in any field is perspective. Being able to see what the trends are and were, what's a genuine advancement and what's just a fad, and having a clear understanding of what's at stake at any given point—these are skills that will make a significant difference in everything you do. In technology journalism, for example, this amounts to being able to cut through the flimsy promises, false history, and marketing hype that too often substitute for innovation—and focus on what really matters with any given issue or product.

There's a downside to this, as I discovered recently: If you have too much perspective, you can end up losing it.

At the Intel Developer Forum (IDF) in San Francisco in August, the press was buzzing about Intel's new cordless VR headset, code-named Project Alloy, which could indeed signal a fundamental change in the nascent VR market currently ruled by the Oculus Rift and the HTC Vive. But as amazing as Project Alloy looked, and despite its obvious potential, my mind floated to thoughts of what was being lost by Intel not devoting more time at its signature annual event to its 7th Generation Core processing platform (which it debuted instead at the end of August). What does it mean when the chip company, apparently, stops caring about chips?



Matthew Murray, managing editor for hardware at *PC Magazine*, has also edited its software and consumer electronics content and been an editor at *Computer Shopper*.

SoftGozar.com

Cue the perspective. When I first became interested in computers in the 1980s, it was because I loved how raw and frontier-like it all was. With just a few keystrokes, anyone could write an Integer BASIC program to do, er, basic things. Or with a bit more effort, you could dig into a game's code and uncover the secrets that, for whatever reason, you could never manage on your own. (After 30-plus years, I think it's safe—if a little embarrassing—to admit that this is the only way I was able to "win" the original Snooper Troops.) You could pop a video card or a few SIMMs into your computer, noodle away at the CONFIG.SYS file for a few minutes (or hours), and end up with a computer a lot more capable than the one you started with.

As time passed and I began building my own computers from scratch, I developed an even stronger respect and curiosity for what made it all possible. This led to my "enthusiast" years, which comprised, among other things, consulting, working in IT, and eventually landing at *PC Magazine*. It's been an amazing, unusual ride, and one that I've found just as enjoyable as it's been educational. And coming through all that to where we are today, when technology is more integrated into mainstream lives than I ever imagined as a kid—and will only become more so in the years ahead—is undeniably exciting.

Still, it's tough not to feel a tinge of sadness that this thing I grew up with is either going away or changing so much that it will soon be beyond most people's grasp. It's already moved into a pretty deep niche, and when major companies place it further in the background, I find myself worrying about what sort of life it has left. For how many more years will I be able to build my

SoftGozar.com

own computer? For that matter, for how many more years will computers as we know them today even exist?

What can I say? It's hard to abandon your first love. My pulse still skips a beat when I use a powerful new processor for the first time, or plug in an amazing new video card and watch it blow away the last generation's king. That's where my affections lie, because companies like Intel, through their constant innovation and exploration of the possibilities of silicon and dreaming, showed me the magic inherent in it all and made me want to be a part of it at a time no one else did. And there's not a day that I don't wake up at least a little thrilled that I get to be.

But while fretting about what this means for me and the industry and I care about, how Intel and companies like it are transforming what we've come to accept as the status quo, I was reminded that there's another way to look at this. My mom sent me an e-mail with the sentence: "The world you'll be living in is going to be so different from the world your dad and grandma knew, it blows my mind!"

I hate it when she's right.

When my grandmother was born in 1916, there was no real commercial radio. Now we use radios to transmit data, not just audio, wirelessly between computing devices that are small enough to carry in your pocket yet able to connect to the entire knowledge store of humanity. My father was born in 1935, 10 years (to the day) before the Trinity test that heralded the dawn of the Atomic Age, and television was barely a thing—today, I watch almost everything on Hulu and Netflix, anytime I want, without the need for conventional broadcast networks.

My pulse still skips a beat when I use a powerful new processor for the first time, or plug in an amazing new video card and watch it blow away the last generation's king.

SoftGozar.com

My mother's family didn't have a color TV until just a few years before I was born; and I'm old enough to remember when my dad had to use punch cards for his library media job at the local university. High definition, 4K, smartphones, smartwatches—all these things have revolutionized society, brought us closer together, and taken us further than anyone of my parents' and grandparents' generation could have conceived.

Now we're on the cusp of real virtual reality, which has been the exclusive domain of fantasists and sci-fi authors since my grandmother was born? *Wow*.

My mom's comments did what my own perspective couldn't and renewed my faith that I may be able to participate in creating things that are at least as remarkable, in the years and decades to come. My father and grandmother would have been astonished at the world we're now living in. They would have wanted to make the most of it—and for me to do the same. I owe it to them to try. I'll do my best to keep the perspective that honors the best of what's old but doesn't ignore the wonders yet to come.

I admit, though, I hope I'll still be able to build a computer once in a while. But if I can't, there's an excellent chance that what I will be able to build will be even better.

"I'll do my best to keep the perspective that honors the best of what's old but doesn't ignore the wonders yet to come."

matthew_murray@pcmag.com

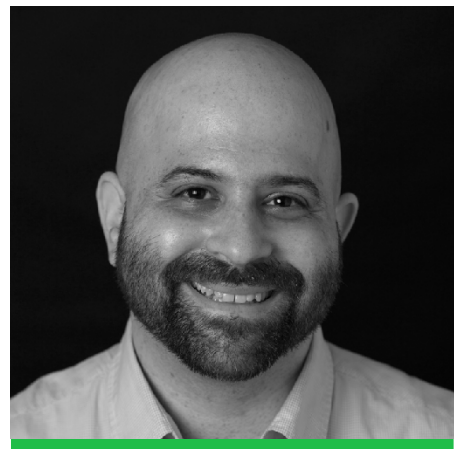
SoftGozar.com

Here's Why Uber Is Pursuing Robo-Taxis

Uber recently took a giant step closer toward the inevitable: The company started picking up passengers with self-driving robotic taxis in Pittsburgh. While the limited tests include human minders in the front seat ready to take the wheel should the need arise, these hominid babysitters are only a stopgap on the way to fully automated vehicles. To be sure, a fully automated fleet is exactly the goal Uber has in mind.

In a way, riding with Uber is already an automated digital process: You order up a ride via a smartphone app, which feeds the request to Uber's servers and pairs you with a nearby driver whose progress and proximity can be monitored live on your device. Once you're picked up, the driver might use an app like Google Maps or Waze to choose the quickest route and provide turn-by-turn directions. Payment takes place digitally and seamlessly—you don't need to talk to or even acknowledge the driver in any way. (You know, if you want to be a jerk.)

Replacing the human driver with a machine simply removes the most expensive ingredient from the process. Though Uber has only recently flirted with profitability in the U.S., the massive investments the company has made in self-driving technology holds the potential of huge future rewards. Presently, 75 cents of every dollar Uber makes goes to the human driver. A robot



Evan Dashevsky, a features editor for *PC Magazine*, has been writing about tech since 2010 for such publications as *PC World*, TechHive, ExtremeTech, and Digital Times.

Evan Dashevsky

SoftGozar.com

chauffeur, on the other hand, will never demand a salary, let alone annoying things like benefits, sick time, and sleep.

I'm not sure if this pivot toward automation was part of the company's original business plan when it was founded in 2009, but it's one that Uber has placed at the heart of its future endeavors. This pursuit included a 2015 talent-poaching spree that decimated Carnegie Mellon University's robotics lab (and explains why so many of the company's self-driving vehicle pursuits have centered in the Steel City).

It's also worth noting another recent program that Uber introduced: a half-billion-dollar initiative to create its own digital maps. That's a lot of money, particularly for a private company that hasn't yet demonstrated sustained profitability. Why would it make this huge investment when there are plenty of digital mapping services already available? To me, the answer seems obvious. Uber doesn't want to be a service that leeches off the infrastructure of others; it wants to be its very own platform.

A number of legal and liability issues still need to be worked out, but the first company to crack the robo-taxi code will be at the core of a whole new digital platform for transportation—like what Windows is for PCs or iOS is for mobile.

Uber is not alone in pursuit of this dream. Millions of dollars are being funneled into self-driving technology tech titans such as Apple and Google but also by all the big auto players around the globe (except Porsche—it's intent on keeping its cars the vinyl albums of transportation).

Building a whole new Road OS (for lack of a better term) is only something that a large company can do at this point. It takes bleeding-edge hardware and advanced software. That isn't

SoftGozar.com

cheap. While money can be made from transporting people around cities, just as much can be made by selling access to your platform.

Think of the multiple ways the masters of today's major platforms make their fortunes. Amazon gets money from Prime subscriptions plus a cut of each product sold, and Apple sells hardware plus a cut of each app sold. Likewise, a future Road OS will make money through direct sales to the public, but it will also surely be of interest to marketers and other industries with a need to move people and goods around.

You could imagine future sales pitches along the lines of, "Hey, Dominos, want to deliver pies sans expensive human drivers? I guess you could develop your own self-driving cars and maps and algorithms OR you could lease ours for a small fee." Or perhaps, "Hey, Starbucks, wouldn't you love an ad for your store to come up on a screen in front of the passengers every time one of your stores was nearby?"

Uber has some competition. Ford, the original Big Auto, has promised to release fully automated robo-taxis by 2021. Even Tesla envisions its EV owners having the option to contribute their self-driving cars to Tesla's robo-taxi fleet when they're not using them.

If you find the idea of self-driving cars icky or weird, that's almost irrelevant. You'll get over it. This is a thing that is happening. Self-driving technology will be the most disruptive technology of the decade to come. The only question is, which company will be the first to get it right?

"Uber doesn't want to simply be a service that leeches off the infrastructure of others; it wants to be its very own platform."

evan_dashevsky@pcmag.com

SoftGozar.com

Tech Innovation Slump? Not So Fast

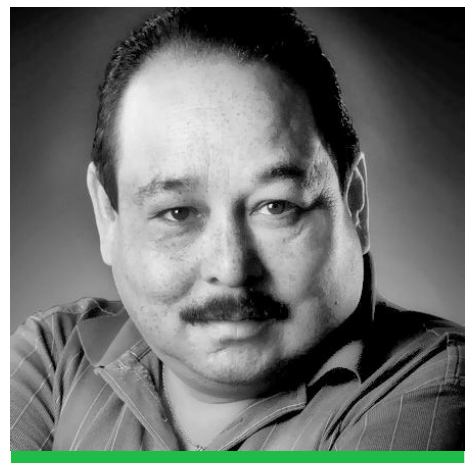
Silicon Valley's biggest tech firms are bursting at the seams. Apple's spaceship campus is nearing completion, but the company recently purchased property in San Jose and is reportedly eyeing more property north of its newest campus in Cupertino. Google and Facebook are looking to expand, and every week I hear of a company that needs more space to house a growing tech staff.

So one has to wonder whether they know something we don't. Are we about to enter a strong growth cycle?

At Creative Strategies, we've spent a lot of time researching this question, and I believe we've identified several indicators that the technology industry is poised for a major upswing in the next five to 10 years.

The biggest thing I see coming is 5G. Every major telecom company, as well as chip makers including Qualcomm and Intel, are betting their futures on 5G networks and the devices that will take advantage of it. The amount of money being spent on this buildout will be staggering, and that means more tech jobs and growth not only in Silicon Valley but all over the world. Once a mesh of broadband wireless networks becomes available, the Internet of Things (IoT) will really take hold.

A recent Business Insider report estimated that IoT investment will hit $6 trillion over the next five years, with 24 billion IoT devices installed by



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

SoftGozar.com

2020. Close to $3 trillion will be spent on application development, device hardware, system integration, data storage, security and connectivity between now and 2020. If that's true, you can see why Apple, Facebook, Google, Intel, Qualcomm, and many other tech companies are prepping for explosive growth.

But the IoT is not just for the home; cars and city infrastructure stand to benefit, too. We are already seeing major moves to put sensors and wireless cameras in light poles, streets, and buildings. While these will be important for city management and services, they will also be critical for use by autonomous vehicles. These costly infrastructure buildouts will take time and demand the help of many engineers and specialty personnel.

Another growth area will be data centers, from data mining to data analytic skills and data-specific engineers. Right now, almost every company is in need of more staff to deal with these disciplines, especially data analysis. Each day, these companies collect terabytes or petabytes of data that needs to be searched, analyzed, and used to enhance the ability to create products and services.

All these connected devices, however, will need to be secure. In years past, my career advice has been to become an IT professional or engineer. Now my answer is to become a security expert. This area will only grow as hackers and rogue nations try to steal identifies, state secrets, and intellectual property.

Don't forget about virtual and augmented reality, or more likely a mix of the two. There is no doubt that VR and AR will revolutionize the computing experience and offer new ways to interact with technology. It's still early days, but

SoftGozar.com

this sector will bring new jobs and new levels of innovation.

Finally, keep an eye on the digitization of the health market and how trackers and smartwatches will link patients to health professionals. At every level of the healthcare system, digital technology will be an important tool for diagnoses, records, and disease prevention.

As someone who has tracked the tech market for the last 35 years, I am excited about what's to come. Clearly, the country's top tech firms are getting ready for the next great era in technology.

tim_bajarin@pcmag.com

Major telecom company, as well as chip makers including Qualcomm and Intel, are betting their futures on 5G.

SoftGozar.com

Great Features Make the iPhone 7 Plus a Winner

PC MAGAZINE EDITORS' CHOICE

For the first time, we're recommending the big iPhone—in this case, the iPhone 7 Plus—as the one to get this year. Apple's two new phones, the iPhone 7 and the iPhone 7 Plus, offer mostly stepwise improvements over last year's models. Older iPhone owners will probably most appreciate the significant improvement in battery life. There's a cost beyond the price of the phone, as you're going to struggle for a few months as an early adopter of the headphone-jack-less lifestyle. But the iPhone 7 Plus brings enough benefits and improvements to the table to make it worthwhile. It's our new Editors' Choice.

Apple iPhone 7 Plus

$769.99

SoftGozar.com

DESIGN

The iPhone 7 Plus is exactly the size of last year's iPhone 6s Plus, at 6.23 by 3.07 by 0.29 inches (HWD). But it's a little bit lighter, at 6.63 ounces compared with 6.77. It may not fit into the same cases, however, because the dual rear cameras require a larger cutout. The phone is still kind of a surfboard and doesn't fit into my pocket or the phone strap on my backpack. But that's the case with most phablets, other than the sadly doomed Galaxy Note 7 (0.30 inches wide).

The main visual changes are a larger camera bump on the back for the dual 12MP rear cameras and the lack of a headphone jack on the bottom, replaced by a grille for the barometer vent. The Taptic home button looks the same as last year's, but it's virtual rather than a physical button.

Whether you think the Taptic home button is weird depends entirely on whether you've used phones other than iPhones. As I spend most of my year with non-iPhones, I find it completely normal to use: It feels like a home button. It responds quickly, and you can even tune the haptic response (which is essentially a

Apple iPhone 7 Plus

PROS Dual cameras. Lots of memory and storage. Water-resistant design. Faster on all performance measures, with better battery life, than last year's iPhones. iOS still leads on high-quality games and creative apps.

CONS No headphone jack, and not a lot of Lightning-compatible headphones yet. Not all models are compatible with all carriers.

BRAND-NEW HOME BUTTON
The new Taptic home button is a virtual button, which you get used to quickly.

SoftGozar.com

vibration) to your tastes. The new haptic engine also helps enhance gaming, offering a range of stuttering and buzzing responses to screen taps in general.

Phones are fashion objects, and two new colors join the iPhone array this year. Jet Black, which is glossy but very grippy, is gorgeous. It's also the world's worst fingerprint magnet. Our Jet Black review unit was impossible to keep pristine—it practically picks up fingerprints out of the air. Matte Black is the less frustrating (and arguably more attractive) finish. It's far more resistant to scratches and fingerprints, and has a premium feel. Gold, Rose Gold, and Silver options are also available.

The phones are also now water-resistant: IP67 certification means you can dunk one in shallow water for half an hour. That doesn't mean you should take it swimming—just that you don't have to worry about dropping it in the sink. I submerged both iPhones in a bowl of water for half an hour with no problems. You can't do that with the iPhone 6s, although you can with the Samsung Galaxy S7 Edge. Apple recommends that you let the Lightning port dry out for five hours after getting it wet before plugging it in again, to prevent short circuits.

GREAT FEATURES OF THE IPHONE 7
They include water resistance, longer battery life, and more powerful gaming.

SoftGozar.com

DISPLAY

Superficially, the iPhone 7 Plus's 5.5-inch, 1,920-by-1,080 screen looks just like last year's model. Apple says it's 25 percent brighter and displays better colors, but I just can't see the difference in any normal circumstances. The screen also still pales (often literally) against the rich color and precise text on Samsung's latest AMOLED displays.

But this is another area where lab tests tell a different story than our eyes. Raymond Soneira of DisplayMate Labs says the screen is brighter and less reflective than previous iPhone displays, and mentions a second optional color gamut as a big plus. But that color gamut isn't used by much content yet, making it more of a future feature than a present plus. Folks who found the iPhone 6/6s displays too blue will be pleased by a whiter white point on the iPhone 7, Soneira found.

That said, the Galaxy S7 Edge's AMOLED display is higher resolution, brighter, and has better viewing angles. There are ongoing rumors that Apple will switch to AMOLED displays in the future, but that may just be wishful thinking.

BATTERY LIFE

Our battery test doesn't properly compare iPhones and Android devices. That's because while iPhones tend to have power-hungry screens, Android devices bleed more power in the background. On our standard test, which streams a video over LTE with the screen at full brightness, the iPhone screen's power usage blows away all its other advantages.

So to say that the iPhone 7 Plus gets 6 hours of battery life while the Galaxy S7 Edge gets 10 hours really just reflects that Samsung's AMOLED screen is far more efficient than the iPhone's LCD. That said, the iPhone 7 Plus still gets much longer usage time than the 6s Plus, which clocked in at 4 hours, 11 minutes.

LOOKALIKE
The iPhone 7 Plus is exactly the size of last year's iPhone 6s Plus at 6.23 by 3.07 by 0.29 inches (HWD), but a little bit lighter, at 6.63 ounces.

SoftGozar.com

You have to go deeper to find the iPhone's advantages over a new Android phone, for instance, in standby mode. Leaving one of the new iPhones alone for 6.5 hours, it bled only about 1 percent of battery, whereas the Galaxy S7 lost 9 percent of battery in the same amount of time.

Bluetooth also has less impact on the iPhone. An hour of Bluetooth audio consumed about 1 percent of the 7 Plus's battery but 4 percent of the Galaxy S7's battery.

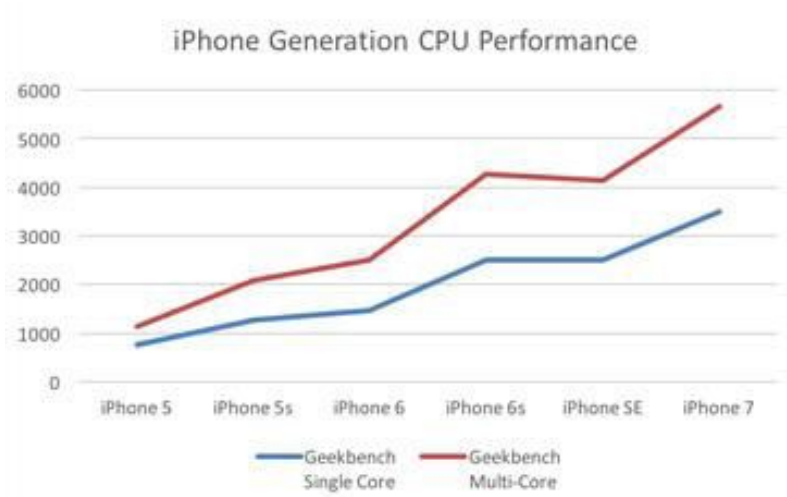
All of this adds up to a full day of average usage, especially if you turn screen brightness down. Unplugging the iPhone 7 Plus at 8 a.m., I was down to 14 percent battery by 1 a.m. after a long day of heavy use including camera testing. That's pretty great, and the S7 has never lasted that long without invoking its Extreme Power Saving mode.

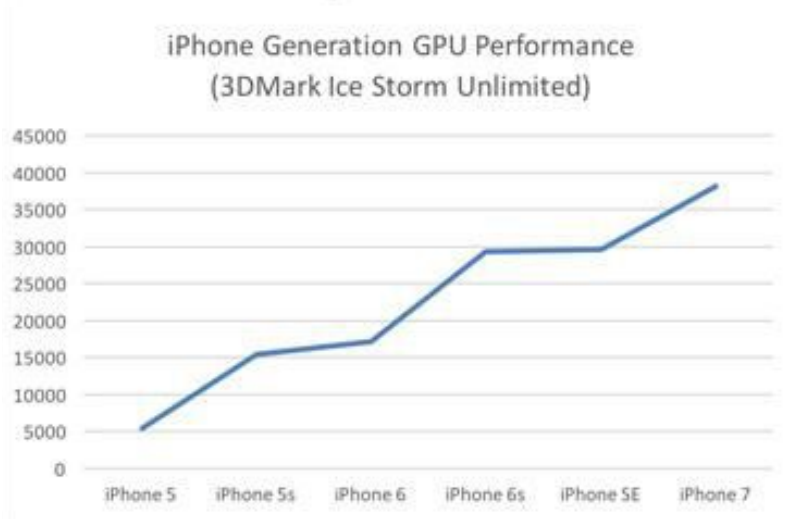
The phone charges completely in about 2.5 hours, which isn't quite up to the standards of Qualcomm's latest fast charging but is still pretty fast.

You have to go deeper to find the iPhone's advantages over a new Android phone, for instance, in standby mode.

A10 PROCESSOR, PERFORMANCE, AND STORAGE

Apple's new A10 processor is the fastest processor available on a mobile phone in the U.S. today. I ran some benchmarks and found it to be about 30 percent faster than both the A9 in the iPhone 6s and 40 percent faster than the Qualcomm Snapdragon 820 in leading Android phones. It has two 2.33GHz "high performance" cores, which are the ones that show up on the benchmarks, and two "low power" cores that use a fifth of the energy the high-performance cores do and contribute to the iPhone's long battery life with applications such as Bluetooth audio. None of the CPU-identifying apps I could find would tell me how fast those secondary cores are, though.





SoftGozar.com

There's a more powerful GPU in the new phones, too. Apple's phones have always felt fast out of the box, and initially, it's hard to tell the difference between the 6s and the 7 series. (It's much easier to tell the difference between the 6 and the 7, as the 7 is twice as fast at heavy tasks like video exporting.) But differences begin to crop up when you're playing high-end games. In Riptide GP Renegades, for instance, you see deeper reflections in the water on the iPhone 7 series (at right) than on the 6s (at left), as shown below. These differences will come out more clearly as new applications take better advantage of the new processor.

IPHONE 6S VERSUS IPHONE 7: GAMING

The iPhone is still, of course, the only model of phone that runs iOS. iOS is always tuned for the past two years or so of iPhones, and when I loaded it onto several phones for testing, the iPhone 5 and 5s felt quite slow. Not so on the iPhone 7 and 7 Plus, which are very fast.

iOS 10's new home screen widgets can help wean away some Android loyalists, but its real strength, as always, is its tremendous APIs. Camera apps and high-end indie games, for instance, still come out first (and often better) on iOS. You're also guaranteed to get updates, unlike on Android.

Storage options have changed this year, too: they're now 32GB (for $769), 128GB ($869), and 256GB ($969). Most people should go for the 128GB model, especially if you play games. The latest games that take advantage of the new hardware, including Lumino City, Transistor, OZ Broken Kingdom, and CSR Racing 2 are all over a gigabyte each. Capturing 4K video eats up about 350MB per minute. A 128GB device gives you room to breathe and use the iPhone 7's features to their maximum extent.

There's one big performance difference between the iPhone 7 and the iPhone 7 Plus, although it didn't show up in benchmarks: The iPhone 7 has 2GB of RAM, but the 7 Plus has 3GB. That should help the 7 Plus's performance when you're flipping between multiple apps.

MODEM

Apple made a shockingly customer-unfriendly choice this year, choosing to roll back from delivering iPhones compatible with all U.S. carriers. Though relatively few people in the U.S. switch carriers with a given device, many want to resell their devices, and all-carrier devices have better resale value.

The Verizon, Sprint, Japanese, and Chinese models of the iPhone use Qualcomm's flagship X12 modem and are compatible with all U.S. carriers. The

SoftGozar.com

COMPARING THE IPHONE 7 MODELS Here's the iPhone 7 Plus in Matte Black (left) and the iPhone 7 in Jet Black (right). Jet Black, which is glossy but very grippy, is gorgeous. It's also the world's worst fingerprint magnet. Matte Black is far more resistant to scratches and fingerprints.

AT&T, T-Mobile, and European models use the cheaper Intel XMM7360 modem and are not compatible with Verizon or Sprint's networks. Yes, the Qualcomm X12 modem is better. But it's probably not better enough to matter.

To scientifically test the two modems against one another, you need a network simulator, a very expensive piece of equipment we don't have. So I compared the iPhone 7 Plus with an Intel modem, with a Samsung Galaxy S7 with a Qualcomm X12 modem, on the T-Mobile network. I took both devices to five locations in New York City and ran three speed tests at each location. The Samsung phone averaged 27.9Mbps down, while the iPhone averaged 26.2Mbps down. The Samsung phone was faster than the iPhone in 9 out of 15 cases.

I followed up by using Ookla Speedtest Intelligence to gather the results from 3,638 Galaxy S7 and S7 Edge tests and 2,052 iPhone 7 and 7 Plus tests taken on September 16 and 17. This kind of crowdsourcing has its own flaws—for instance, it can be skewed by different balances of locations—but it's another signal to look at.

The Samsung devices, with Qualcomm modems, averaged 29.3Mbps down, while the Apple devices, with Intel modems, averaged 30.3Mbps down. Looking only at fast speeds, 23 percent of the Samsung tests were over 50Mbps, while only 20 percent of the iPhone tests were over 50Mbps. But that's too small a difference to matter much, given all the other variables at play.

This is where a common theme comes in: Geek cred versus real-life differences. The X12 is a better modem, but the XMM7360 is apparently good enough, and Apple decided that good enough (and cheaper) is just fine. That said, if you purchase a full-price Verizon unit from an Apple Store, it will work on all U.S. carriers.

SoftGozar.com

The new iPhones also have significantly better Wi-Fi performance than the 6s, much closer to the Galaxy S7. With a weak signal that pushed the 6s down to the 5-10Mbps range (on a 150Mbps connection), the iPhone 7 series was able to get 40Mbps or more, just like the S7 does. In fact, in all signal conditions, the new iPhones got faster Wi-Fi speeds than the 6s, and the larger iPhone usually showed faster speeds than the smaller one.

THE HEADPHONE JACK DILEMMA

No, the iPhone 7 Plus does not have a headphone jack. Instead, it has a Lightning port; it comes with Lightning EarPod earbuds and a flimsy, easily losable $9 dongle to adapt regular headphones.

Initially, I didn't think this was a big deal; just leave the dongle on your favorite headphones and you're set. Then I realized how many pairs of headphones, mostly throwaway earbuds, I have at my house and office, and how I'm used to plugging whichever one I want into my phone. The new port started to become a big hassle. Never mind that you can't charge your phone and listen to music at the same time without another dongle or dock.

Bluetooth audio is one solution, but Bluetooth is as flaky as ever. My Bowers & Wilkins P7 Bluetooth headphones needed to be reconnected through the iPhone's settings screen every time I turned them off and on again. Apple's AirPods and new Beats headphones use a new pairing technology that looks to be more seamless, but they aren't on the market yet.

SoftGozar.com

IT'S WIRELESS OR NOTHING

You may have heard that there's no headphone jack. You'll have to use Lightning or Bluetooth headphones with the newest iPhones.

Bluetooth also won't satisfy audiophiles, as Apple's implementation transmits music in 256Kbps VBR AAC. That's the same quality as music purchased from the iTunes store—so iTunes tracks are pristine, wirelessly—but lovers of lossless music will be unhappy.

The Lightning port offers a potential audiophile solution, as Lightning headphones can have their own premium DACs for great audio quality. The problem is, while plenty of models have been announced, most aren't on the market yet. This is one area where waiting a while is probably wise, especially if you have a lot of headphones lying around. An accessory ecosystem is going to grow up around the iPhone 7 and 7 Plus, but it's going to take a few months; we're probably going to see a lot of devices at CES in January.

An accessory ecosystem is going to grow up around the iPhone 7 and 7 Plus, but it's going to take a few months.

With that in mind, the industry is transitioning away from the headphone jack. Motorola and LeEco came first, dipping their toes in the water. Now comes Apple. We are very early in this transition, though, and most people will be sticking with standard headphones for a few years yet.

The dual stereo speakers aren't entirely front-facing: One is in the earpiece and the other is at the bottom right of the phone. But they do deliver noticeably louder, less tinny audio than previous iPhone generations. The iPhone 6s puts out 81dB at about 3 inches away, the iPhone 7 and Galaxy S7 put out 85 dB, and the iPhone 7 Plus (bigger, so bigger speakers) puts out 88 dB.

SoftGozar.com

THE CAMERA(S)

Both iPhone 7s have 12-megapixel main cameras with optical image stabilization and 7-megapixel front cameras. Our camera expert, Jim Fisher, put the new cameras through various lab tests and found that they aren't quite as sharp as the Galaxy S7's camera, although the differences can be hard to tell with the naked eye. They are measurably better than the iPhone 6s and 6s Plus cameras.

I tested also, by taking comparative photos in a range of different real-life circumstances. In good outdoor light, the Galaxy S7's f/1.7 camera gives punchier colors than the iPhone 7 Plus's f/1.8 lens, although the difference is really subtle. I also prefer the Galaxy S7's exposure metering to the iPhone's. In several macro images of flowers, the iPhone blew out the image by default, while the Galaxy S7 captured more highlights. The Galaxy S7 won the day with my outdoor shots.

But as you'd expect, with good light, the iPhone's 2x optical zoom gives significantly more detail than the Samsung camera does using digital zoom. The iPhone's 7-megapixel selfie camera also captures noticeably more than the Galaxy S7's 5-megapixel unit and previous iPhone models (although that isn't always flattering).

Excellent optical image stabilization means the iPhone 7's main camera pulls ahead of the Galaxy S7. Our lab tests show the Galaxy S7 as sharper in low light, but as those tests are done while mounted on a tripod, they don't take the blurriness caused by shaky hands into account. In our real-life tests, that makes a difference in the iPhone's favor. It largely comes down to the blurriness caused by shaky hands on low shutter speeds. While the Galaxy S7's low-light images show a little blur at 1/30 or 1/40 second, the iPhone's images of stationary subjects are clearer at 1/15 second. The image stabilization more than counters Samsung's wider f/1.7 aperture.


SoftGozar.com

DOUBLE CAMERAS The dual 12-megapixel cameras on the iPhone 7 Plus allow for 2x optical zoom, giving significantly more detail than digital zoom.

The iPhone's 2x zoom camera isn't nearly as good in low light, though, as it has a narrower f/2.8 aperture and isn't optically stabilized. The Galaxy S7 takes clearer low-light shots than the iPhone's zoom camera.

But sometimes Apple's strength isn't in technical solutions but in usability. Having that 1x zoom button in the camera app made me much more likely to zoom images on the iPhone 7 Plus than on other phones, where you have to pinch to zoom and be careful about how much you pinch. Apple is bringing zoom to the masses not through a second camera but through a few convenient pixels on the screen.

Sometimes Apple's strength isn't in technical solutions but in usability.

And the iPhone 7 Plus is the best mobile video camera on the market, because unlike the Galaxy S7, it doesn't put an artificial 10-minute limit on 4K recordings. Apple's superior APIs also mean there are some terrific third-party video camera apps, such as Flimic Pro, which simply aren't matched on Android.

What excites me the most about the dual cameras isn't what they do now; it's what they could do in the future. Apple has promised (but not yet delivered) bokeh, an effect involving short depth-of-field that blurs the background of images while keeping the foreground sharp. But that's only the beginning. There's going to be a dual-camera API. That means we could start to see stereo depth-sensing and AR applications using the camera. Tim Cook told "Good Morning America" he's interested in augmented reality, and the iPhone 7 Plus could be the first step into that realm—although probably not at least until iOS 11 next year.

COMPARISONS AND CONCLUSIONS

So are the iPhone 7's new features worth the headphone-jack hassle, especially right now, when there aren't many Lightning headphones available and Bluetooth devices are still divisive? I think they are, but mostly for the iPhone 7 Plus, not for the iPhone 7. That's because the iPhone 7 Plus has additional future-

SoftGozar.com

proofing, including the dual cameras (which may play a role in Apple's AR dreams, but for now make your portraits look terrific) and the extra RAM, which will help with new versions of iOS. That all balances out the annoyance of a few months of waiting for the headphone world to catch up.

I also still strongly recommend the iPhone SE. No other phone on the market has that quality in so tiny a size. At $449 for the 64GB unit, you save at least $100 over the iPhone 6s and $200 over the iPhone 7, and the SE's A9 processor is just as good as the one in the 6s.

As for very large phones, the Android world has the LG V20 and a new Google Nexus on the horizon, but they aren't here yet. As of this writing, the Samsung Galaxy Note 7 is banned on airlines and most public transportation, making it an impractical choice even if it doesn't explode. That makes the iPhone 7 Plus, with its fast processor, high-quality display, and dual cameras, your best bet—and our Editors' Choice—for large phones.The iPhone 7 is still highly rated and a good upgrade for people coming from the iPhone 6 or earlier. I'd rather wait a little while for the headphone ecosystem to catch up there, though. In that medium size, our Editors' Choice remains the Samsung Galaxy S7 Edge, with its better camera, modem, and screen, and traditional headphone jack.

SASCHA SEGAN

SoftGozar.com

Motorola Moto Z Play Droid Can Morph, Thanks to Mods

Motorola Moto Z Play Droid

$408

●●●●○

The Moto Z Play on Verizon is the newest phone to join Motorola's revamped Droid line. Like the pricier Moto Z Droid and Moto Z Force Droid, the Moto Z Play Droid supports Moto Mods, which are seamless add-on accessories that attach directly to the back of the phone. It also holds its own in the hardware department, boasting solid overall performance, a long-lasting battery, and a sharp camera capable of recording 4K video. That said, the unlocked ZTE Axon 7 also works on Verizon and offers a sharper display and more powerful processor, so it retains our Editors' Choice award for midrange smartphones. But if you want to give Moto Mods a try without breaking the bank, the Z Play Droid is the most affordable way to do it.

SoftGozar.com

DESIGN AND DISPLAY

The Moto Z Play Droid is almost indistinguishable from the Z Force Droid both in size and design. The Play measures 6.2 by 3.0 by 0.3 inches (HWD) and weighs 5.8 ounces, nearly identical to the Force (6.1 by 3.0 by 0.3 inches, 5.7 ounces). It's lighter than the ZTE Axon 7 (6.0 by 3.0 by 0.3 inches, 6.17 ounces), but without the Axon's smooth curved sides and rounded back, it's just a tad too large to use with one hand.

When the phone is powered off, the only surefire way to tell it apart from the Force is by checking the bottom—the Play has a 3.5mm headphone jack, but the Force (as well as the Z Droid) does not. The other main difference is that when you peel off the removable back cover, you'll see that the back of the Play is clad in glass, rather than metal like the Force.

Motorola Moto Z Play Droid

PROS Affordable. Modular backs add functionality. Good battery life. Sharp camera with 4K video recording. Includes a headphone jack, fingerprint scanner, NFC, and expandable storage.

CONS Wi-Fi connectivity issues in testing. Some bloatware.

FRATERNAL TWINS
The Play Droid (left) and Force Droid (right) share many design similarities, but as you can see here, the Play has a 3.5mm audio jack and a glass back panel.

Otherwise, the two phones also share a similar layout of buttons along their metal sides. You'll find a clicky volume and power button on the right, a USB-C charging port and the aforementioned audio jack on the bottom, and a combined SIM/microSD card slot (that worked fine with a 256GB Samsung Evo+ card) on the top. Below the display is a square-shaped fingerprint sensor. It doesn't double as a home button, which takes some getting used to if you're coming from an Apple or Samsung phone.

SoftGozar.com

The front of the Play is a 5.5-inch, 1,920-by-1,080-pixel display. At 401 pixels per inch (ppi), its sharpness is equal to the Motorola Moto G4 and Apple iPhone 6s Plus Wireless. It's not as crisp as the Quad HD display on the ZTE Axon 7, but it has good color reproduction and great viewing angles, and it gets bright enough to see outdoors under direct sunlight.

But unlike the Force, the Play's display is covered only by Gorilla Glass, not ShatterShield, a multilayer plastic-and-glass coating that's virtually shatterproof. And you don't get the Force's four-year warranty against cracks and breaks. The Play has a water-repellent coating for protection from splashes or rain, but it won't hold up against complete submersion.

If you want to give Moto Mods a try without breaking the bank, the Z Play Droid is the most affordable way to do it.

IT'S A PHONE! IT'S A CAMERA! The Hasselblad True Zoom Camera is a Moto Mod that turns the Play into a point-and-shoot camera with 10x zoom.

MOTO MODS

The back of the Play features a removable panel with magnetic attachments. It's compatible with all the current Moto Mods, including the JBL SoundBoost speaker ($79.99), the Moto Insta-Share projector ($299.99), and various battery packs from brands like Kate Spade and Tumi ($59.99 to $89.99). The Play also launches alongside the Hassleblad True Zoom Camera ($249.99), a Moto Mod that essentially turns the phone into a point-and-shoot camera with a 10x zoom lens.

SoftGozar.com

All the attachments snap on easily and are automatically recognized by the Play. Only time will tell if they truly catch on, but it's the best instance of modular phone design we've seen, and helps differentiate the Play from countless other midrange phones on the market.

NETWORK PERFORMANCE AND CONNECTIVITY

The Play is a Verizon-exclusive that supports CDMA (850/1900MHz), GSM (850/900/1800/1900MHz), UMTS (850/900/1900/2100MHz), and LTE (2/3/4/5/7/13) bands. That's everything you need for strong network performance, which my testing in midtown Manhattan confirmed: Data transfers peaked at 36Mbps down outdoors and 10Mbps down inside.

But results weren't as strong when I tested the Play's dual-band Wi-Fi with our 5GHz FiOS router. In three separate instances, the phone lost connection. It also regularly recorded weaker download speeds than other dual-band capable phones, such as the iPhone 6s Plus. We've notified Motorola of these issues and plan to test a second unit to see whether the issue remains.

The phone also supports NFC, so you can use Android Pay.

Voice calls are mediocre. Transmissions fade in and out, sometimes to the point of being inaudible. Noise cancellation is strong, blotting out almost all background sound, but you may still need to speak up to be heard.

PROCESSOR, BATTERY, AND CAMERA

The Play is powered by a Qualcomm Snapdragon 652 processor clocked at 2GHz. It scores 62,568 in the AnTuTu benchmark, which tests overall system performance. That's a major performance notch below the Snapdragon 820 processor that powers the Droid (150,559), Force (151,604), and Axon 7 (141,989), but more powerful than the Snapdragon 617-powered Moto G4 (46,260).

That said, I tested the Play and Force side by side and couldn't detect any major difference in real-world usage, even though the Play also has less RAM (3GB). The Play was fast and smooth in testing, was able to handle all the multitasking I could throw at it, and experienced no instances of slowdown. I was able to play heavy-duty games including Asphalt 8 and GTA: San Andreas without any difficulty.

Battery life is great. The Play clocked 7 hours and 48 minutes in our rundown test, in which we set screen brightness to maximum and stream full-screen video over LTE. That's nearly two hours longer than its siblings, which each clocked around 6 hours, likely due to the less power-hungry 1080p panel. With

SoftGozar.com

BUT WAIT, THERE'S MORE
The Moto Z Play Droid comes with a fair amount of bloatware, and only the games can be uninstalled. But you can get more storage with the addition of a microSD card.

the included TurboPower adapter, I was able to charge the phone to around 30 percent in 15 minutes. A built-in Battery Saver mode is another option for eking out more screen time, but it comes at the cost of reduced performance.

CAMERA

The Play has a 16-megapixel rear camera sensor on the back. It protrudes a bit when the back cover is off but sits flush when it's on. It's a solid, fast-focusing sensor that captures crisp shots under most circumstances. A few test photos suffered from overexposure, but most images had minimal noise and grain. Color reproduction was accurate, and fine details were captured with an impressive degree of clarity; in some shots, I was able to make out the veins of individual tree leaves.

Low-light performance isn't as good. Pictures often come out muddy or out of focus, despite the assistance of laser autofocus. The other shortfall is the absence of optical image stabilization (OIS), which I noticed mainly in recorded video. The Play is capable of recording 4K and 1080p footage at 30fps, and while video quality is sharp, it suffers from more jittering than the video I shot with the Force.

The phone also has a 5-megapixel wide-angle lens on the front that takes clear shots even in lower-light settings. The camera app comes with standard options including HDR, as well as manual controls that let you change white balance, shutter speed, exposure, focus, and other settings.

SOFTWARE

The Play ships with Android 6.0.1 Marshmallow with minimal changes to the Google launcher. You'll still find the standard set of Motorola features: Moto Display, which keeps your screen on to show time and notifications; Moto

SoftGozar.com

Actions, which are gesture controls, such as a twist to launch the camera; and Moto Voice, which gives you a range of voice commands.

The phone comes with a fair amount of bloatware, which leaves you with 23.85GB of available storage out of the 32GB total. This includes eight Verizon apps, two Amazon apps, IMDB, and four games preloaded; only the games can be uninstalled. On the plus side, Android's Adoptable Storage features gives you the option of setting up a microSD card to act like part of the phone's internal storage.

> **Pictures often come out muddy or out of focus, despite the assistance of laser autofocus.**

CONCLUSIONS

The Moto Z Play Droid is a relatively affordable Android phone that balances price and performance, gives you access to the Verizon cellular network, and can be enhanced using Motorola's modular Moto Mods. At $408, it's more than $200 less than the Z Droid and $300 less than the Z Force Droid. If you're looking for an even more affordable option, the unlocked Moto G4 gets you a similar experience but with slightly less performance and without the Moto Mods. If you're willing to spend $400 and can live without the Moto Mods, the ZTE Axon 7 is our Editors' Choice: It has a higher-resolution display than the Play, along with a faster processor and excellent audio quality.

AJAY KUMAR

SoftGozar.com

Fitbit Charge 2 Is the Top Midrange Fitness Tracker

PC MAGAZINE EDITORS' CHOICE

The Fitbit Charge 2 is the best new fitness tracker we've tested in some time. It automatically tracks your calories burned, distance traveled, heart rate, steps, and sleep, and a new mode helps you return your breathing to normal after a workout. There's no built-in GPS, but you can connect your phone to help capture running routes and calculate lap splits. And the display is modular, so you can pop it out and place it in a variety of different bands. Basically, it does everything the Fitbit Charge HR does but has more features and an improved design. It offers the best balance of comfort and functionality in this price range, making it our new Editors' Choice for midrange fitness trackers.

Fitbit Charge 2

$149.95

SoftGozar.com

DESIGN AND DISPLAY

In terms of design, the Charge 2 is similar to the Fitbit Alta. It's basically a silicone band with a rectangular OLED display module in the middle. There's a single button on the left side of the display, and a built-in continuous optical heart-rate monitor underneath.

Like the Alta and the Fitbit Blaze, the Charge 2 has a modular design, so you can pop out the display and swap it into different leather and silicone bands. A simple push-slide mechanism pops the display module right off the band. The bands come in three sizes: small (for wrists 5.5 to 6.5 inches in circumference), large (6.5 to 7.7 inches), and XL (7.7 to 8.9 inches).

For $149.95, you get the Charge 2 with a stainless steel frame and a silicone band in black, blue, plum, or teal. For $179.95, a Special Edition model with a gunmetal frame and a black band or a rose-gold frame and a lavender band is available. Additional bands cost $29.95, and leather straps in brown, pink, and indigo cost $69.95.

Like the Charge HR, the Charge 2 uses a watch-style buckle design, so it's easy to fasten around your wrist. It's not nearly as sleek and stylish as the Misfit Ray, but it's a lot more discreet than the bulky Microsoft Band 2 or Fitbit Surge.

Fitbit Charge 2

PROS Large display. Built-in continuous heart-rate monitor. Automatically tracks activities, calories, distance, steps, stairs, and sleep. Delivers idle alerts. Relax mode leads deep-breathing exercises. Supports interval training. Interchangeable bands.

CONS Somewhat faint screen. Attracts fingerprints. Not waterproof.

FITBIT FEATURES

The Fitbit Charge 2 tracks your calories burned, distance traveled, heart rate, steps, sleep, and it can help return your breathing to normal workout.

SoftGozar.com

The tracker's rectangular OLED display is a lot larger than the Charge HR's tiny one-line screen, at 1.3 by 0.8 inches (HW). It allows you to view multiple lines of information at once, and letters and numbers are legible and sharp. The display is still monochrome, though, and can appear faint and reflective outdoors in direct sunlight (the Charge 2 has no settings to adjust screen brightness). It also attracts fingerprints easily, an issue shared by the Fitbit Alta.

To control the Charge 2, you use a combination of the physical button on the side of the display and tapping the display itself. You can cycle through five screens: Time of Day, Heart Rate, Activities, Stopwatch, and Relax. The main screen shows you the time of day, the date, and a fitness stat. On the Heart Rate screen, tap to view continuous or resting heart rate. On the Activities screen, tap to cycle through biking, elliptical, running, weights, treadmill, and workout; hold the button and you'll start to track the activity.

> **It does everything the Fitbit Charge HR does but has more features and an improved design.**

On a full charge, the tracker lasts about five days, which is on par with Fitbit's other devices. As usual, you get a proprietary charger, so you'll need to buy a replacement if you lose or break it. Each Fitbit device uses a different charger, so you can't use the one that came with your Charge or Charge HR, which is frustrating. During my time with the Charge 2, I charged it about twice per week. The Charge 2 is resistant to rain, sweat, and splashes. But you'll want to keep it away from pools and showers. If you want a fitness tracker you can swim with, consider the fully waterproof Garmin Forerunner 735XT or the Misfit Shine 2 Swimmer's Edition.

SoftGozar.com

PAIRING, FEATURES, AND PERFORMANCE

To pair the tracker, first download the free Fitbit app on your Bluetooth-enabled Android, iOS, or Windows device and create an account (if you don't have one already). It's simple, and I connected the Charge 2 to a Samsung Galaxy S6 in just a few seconds. Once paired, the tracker syncs with your mobile device whenever it's in range; you can manually sync as well.

Equipped with a three-axis accelerometer, altimeter, optical heart-rate monitor, and vibration motor, the Charge 2 tracks your active minutes, calories, distance, steps, heart rate, and sleep. Additionally, it offers regular reminders to get up and move, a feature first introduced to Fitbit devices with the Alta (the Blaze recently received this ability in a software update). After about an hour of inactivity, the Charge 2 vibrates and displays a graphic that tells you to walk 250 steps before you return to your seat (a number you can adjust in the app).

There is no built-in GPS, but like the Alta, Blaze, and Charge HR, you can connect the Charge 2 with the GPS on your phone to see real-time stats, including distance and pace, on your run. Doing so is easy—make sure the Fitbit app is open, and wait a few seconds for the GPS and phone icons to show up at the top of Charge 2's display.

Fitbit's app is one of our favorites, and some recent updates make it even better. Now you can view your cardio fitness level, which is basically a breakdown of your heart-rate data (resting, average, and peak) and estimated VO2 max (the maximum amount of oxygen your body can use during exercise). Fitbit says it offers guidance in how to improve your cardio fitness, but so far it's just basic advice, such as "Increase the intensity of your exercise." Still, the ability to see that kind of data is valuable, and you can compare it with other users in the Fitbit community.

Like the Alta and the Blaze (but unlike the Charge HR), the Charge 2

AN EASY FIT
Like the Charge HR, the Charge 2 uses a watch-style buckle design, so it's easy to fasten around your wrist.

SoftGozar.com

automatically tracks exercises like basketball, biking, hiking, running, and more. But it takes upwards of 10 to 15 minutes to register you're doing an activity, so if you just want to go for a quick jog, you might be done before the Charge 2 even notices that you're running. In testing, I preferred to manually track exercise by holding down the side button.

New to the Charge 2 is Relax mode, which is a guided breathing exercise based on your heart rate that you can do after a workout. You select between two- and five-minute sessions, in which you match your breathing to a contracting and expanding circle on the tracker's display. A pixelated wave at the bottom of the screen indicates your real-time heart rate. As you inhale and exhale, your heart rate (and the wave) undulate, so you can see the effect of your breathing. The goal is to reduce anxiety, stress, and return your heart rate to normal after a workout. I found this feature effective, even when I wasn't running. On the bus, train, at work, or any other stressful environment, it's relaxing to focus on the Charge 2's display and just breathe.

New to the Charge 2 is Relax mode, a guided breathing exercise based on your heart rate.

Another big addition can be found in the Charge 2's Activities screen: Interval Workout. When toggled, it sets a length of time you want to be active, as well as a rest time after, and the number of intervals you want to accomplish. When each time is up, the band vibrates to alert you to move to the next phase of the workout. This is my favorite new feature on the Charge 2, since runners can use it to create intervals for sprint training without backing out of an activity to start a stopwatch—just set your preferred times in the app then train, rest, and repeat.

As for accuracy, I feel confident in the Charge 2's ability to deliver consistently reliable results. In testing, the tracker provided distance and step measurements consistent with what I'm used to seeing on the routes I walk and run. Heart-rate results were also largely comparable with my own pulse checks. Sleep tracking is

SoftGozar.com

AN EXCLUSIVE CHARGER

The Charge 2 uses a proprietary charger, so you'll need to buy a replacement if you lose or break it. Each Fitbit device uses a different charger, so you can't use the one that came with your Charge or Charge HR, which is frustrating.

accurate as well, though unlike the Misfit Ray, which analyzes light and deep sleep, the Charge 2 records only when you're asleep, awake, and restless.

Besides fitness features, the Charge 2 can display caller ID information, calendar reminders, and text notifications, provided your phone is nearby. That doesn't put it on the same level as a full-fledged smartwatch such as the Apple Watch Series 2, but it does mean you won't need to pull your phone out of your pocket quite as often.

The Charge 2 offers a variety of clock faces, and you can switch between horizontal or vertical text layouts. My favorite is a vertical digital display that stacks the time of day, date, and two stats (steps and continuous heart rate, for instance) on top of one another in an easy-to-view manner.

CONCLUSIONS

The Fitbit Charge 2 does everything our previous Editors' Choice, the Fitbit Charge HR, does and adds a larger display, guided breathing exercises, idle alerts, interval training, and interchangeable bands. You don't get built-in GPS as you do in the Fitbit Surge, but then again, you can always connect your phone—and the Fitbit 2 is nearly half the price. Simply put, you won't find this combination of features and performance at this price in any other device on the market. So if you're looking for a reasonably affordable, full-featured fitness tracker, the Charge 2 is an excellent option, and it's our new Editors' Choice.

TIMOTHY TORRES

SoftGozar.com

Augment Your Reality With the Microsoft HoloLens

Virtual reality has been a major topic of discussion over the last year, with the release of headsets including the HTC Vive and the Oculus Rift. VR can put you in completely different places, but it doesn't change how you look at your real-life surroundings. That's what augmented reality is for, and that's why Microsoft designed the HoloLens. It isn't a VR headset: You can see completely through it and look at anything around you. It projects holograms over your surroundings, combining the real-life environment with computer-generated elements such as floating app windows and three-dimensional models.

Microsoft HoloLens
Development Edition

$3,000.00

Preview (no score)

SoftGozar.com

The technology used in the HoloLens is leaps and bounds beyond anything Google Glass accomplished, but it's also much more expensive and a lot bulkier. Microsoft hasn't announced a retail version of the HoloLens yet, but those who really want to try it can do what we did and order the Development Edition. The HoloLens is a self-contained Windows 10 system built into an AR visor, and because it doesn't require pairing with a smartphone, tablet, or PC, it can function completely on its own. This HoloLens is not intended to be a consumer product, and that's reflected in its price and ergonomics. (Because it's pre-retail developer hardware, we didn't give it a formal score.) It's still an incredible piece of technology and potentially indicates how we will work with computers in the not-too-distant future.

Microsoft Hololens
Development Edition

PROS Surprisingly intuitive and fleshed out for development hardware. Bright, clear holograms. Interesting software selection.

CONS Holograms appear only in a small section of your vision. Uncomfortable after extended periods. Gestures look silly.

DESIGN

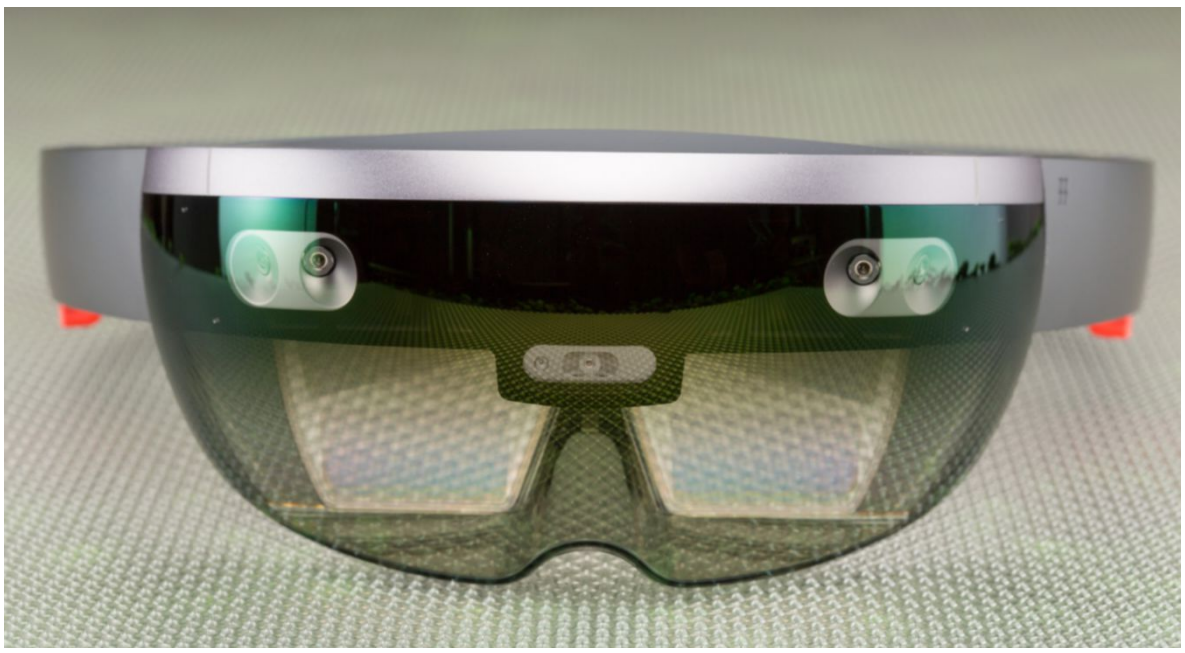
The HoloLens consists of a big headband and a transparent visor. The headband wraps completely around your head above the ears, with thick, fixed arms that connect to the visor and an adjustable padded back strap with a wheel that extends or contracts to fit the size of your head. The left arm features a power button and five-LED battery indicator on the back, a micro USB port for charging with the included cable and power adapter on the underside, and two buttons that adjust display brightness on the top. The right arm has a 3.5mm headphone jack on the bottom and volume control buttons on the top. The arms also feature speakers—small, orange, rectangular protrusions that project sound toward the wearer's ears. The speakers offer clear sound, but because there are no headphone ear-pads to isolate the sound, people around you might hear whatever you're doing on the HoloLens.

SoftGozar.com

The visor contains the bulk of the electronics. It's a large, smoke-colored plastic shield on the front of the headband that extends over the front, protecting the various sensors and the display. The display consists of a transparent pane over each eye, angled to catch the images projected by emitters built above them. Multiple sensors, including four environment cameras, one depth camera, and an ambient light sensor, cover a wide arc in front of the user.

In addition to the HoloLens and the included Clicker peripheral, the Development Edition includes a peg-in-hole plastic strap, short and long nose bridges that click into the nose section of the face mask, a micro USB cable for charging the device, a USB power adapter, and a hard-shell zip-up case.

The technology used in the HoloLens is leaps and bounds beyond anything Google Glass accomplished.



WELL-SHIELDED DISPLAY
The headband extends over the front of the HoloLens, protecting the various sensors and the display.

HARDWARE

The HoloLens is designed to be a wearable computer, but it isn't close to a full PC in terms of power. A 32-bit Intel CPU drives the device, with a separate Microsoft-built holographic processing unit (HPU 1.0) for the holograms. It has 2GB of RAM and 64GB of flash storage, and features both Bluetooth 4.1 LE and 802.11ac Wi-Fi. Microsoft hasn't specified a display resolution for the HoloLens, beyond that the emitters produce 2.3 million points of light projected by two "HD 16:9 light engines."

SoftGozar.com

Since the HoloLens is a self-contained system, you can use it without any wires. You charge the headset via its micro USB port. Microsoft says the battery should last between two and three hours of use, which is in line with our experience during the testing period. It takes about two hours to reach a full charge.

HOW HOLOLENS HOLOGRAMS WORK

Microsoft's concept is based on projecting holograms for an augmented reality experience. The HoloLens visor does a very good job of this, thanks to its bright light emitters. They work with the wave guides on the lenses in front of your eyes to display crisp, colorful images floating in three-dimensional space (to your point of view). Both floating windows for apps and simulated 3D objects are vivid and clear before your eyes.

But the holograms don't exist in your complete field of vision. The lenses and projectors display holograms only within a limited rectangular space in the center of your view. If you move your head away from the hologram you're looking at, it will vanish before it hits the edge of your sightline. This is jarring and prevents the HoloLens from producing a truly immersive AR experience. The display field is fairly large, but it doesn't come close to the complete field of view offered by the Oculus Rift and HTC Vive VR headsets. Of course, those headsets don't let you see all of your actual surroundings (though pass-through camera modes let you see what's in front of your VR headset in a rectangle about the size of the HoloLens display).

Keeping the HoloLens display lined up with your eyes is vital, as the display's boundaries can otherwise be obscured. I found the visor dipping low on occasion when testing, which made the top of the picture fade away. The nose bridges can keep the visor lifted at the right angle when used with the adjustment wheel on the back of the headband.

MORE THAN MEETS THE EYE
The HoloLens light emitters work with the wave guides on the lenses in front of your eyes to display crisp, colorful images floating in 3D space.

SoftGozar.com

I had to tighten the headband to a somewhat uncomfortable extent to keep the visor aligned on my relatively large head. Keeping the headband tight helped make sure the lenses were aligned, but it also put a lot of pressure on my brow, and my forehead felt sore when I finally took the headset off. The HoloLens is a bit more comfortable with the headband pulled back to give a little more slack, but then I had to constantly adjust the visor to keep my eyes aligned with the lenses. That means my fit choices were either annoying (regular adjustments) or ultimately painful (an overly tight headband).

I easily placed Web browsers, apps, and settings menus along the walls like virtual windows.

ENVIRONMENT MAPPING

While the HoloLens can't display holograms to cover your entire field of vision, it can position them throughout your entire surroundings. The multiple cameras and sensors on the visor constantly scan the area around you, mapping walls and other obstacles and tracking your location relative to them. This makes the HoloLens surprisingly accurate for its placement of holographic windows and objects. In our rectangular, flat-walled test room, I easily placed Web browsers, apps, and settings menus along the walls like virtual windows, surrounding myself with objects that stayed in place as if they were physically mounted on the walls. The HoloLens sensed the location of the floor and tables as well, accurately lining 3D holograms around them so they didn't appear to be floating around like ghosts.

The environment mapping is less reliable in more open and cluttered areas. PC Labs is a large, uneven workspace with multiple aisles, benches, desks, offices, and windows, with a block-patterned, three-color floor to further confuse the sensors. The HoloLens identified the walls of the lab accurately, but holograms flickered and glitches when I placed them around the open aisles. The visor clearly struggled to figure out whether the benches and their shelves were walls, and whether the wide red and blue stripes on the floor were physical boundaries or flat.

SoftGozar.com

CONTROL

You can control the HoloLens with the included Clicker peripheral or with physical gestures. The Clicker is a small one-button remote that simply lets you click on whatever you're looking at, using a small dot in the center of your field of view as a cursor. The peripheral generally just performs the click function and relies on head motion for moving things around and selecting them. Hand motion is used almost exclusively for the drag-and-drop command, where you click and hold with the Clicker and your hand in view of the visor, then slowly move your hand to drag objects where you want them to go. This is mostly useful for resizing windows and holograms and for scrolling up and down documents in Edge.

Physical gestures are fairly reliable once you get used to them, but they'll make you look and feel pretty silly. The two main gestures are Bloom and Air Tap. Bloom involves holding your hand pointed straight up with your fingers together and then opening up your fingers. The gesture brings up the Start menu, which lets you access all the apps and features. It's hard to do without following up by shouting, "Magic!"

I found myself wanting to mutter, "I am crushing your head," while Air Tapping.

CLICK HERE

The Clicker is a small one-button remote that simply lets you click on whatever you're looking at, using a small dot in the center of your view as a cursor.

SoftGozar.com

Air Tap involves holding your index finger up and bringing it down toward your thumb. You don't need to touch your fingertip to your thumb, but I found it makes the gesture slightly more reliable. This is the basic click gesture, activating any item the dot in the center of your field of view is floating over. You can also hold the gesture to drag objects. I found myself wanting to mutter, "I am crushing your head," while Air Tapping.

Both gestures need to be performed in view of the headset's sensors. The area is a bit more forgiving than the holographic display's frame, but generally you get the best results by keeping your hands within the boundaries of the display when gesturing.

The HoloLens also supports voice commands and features Microsoft's Cortana voice assistant. Simple commands such as "Remove" and "Take a Picture" close windows and take photos (with holograms) of whatever you're looking at. You can also use Cortana to input text, which is useful if you don't want to pair a separate Bluetooth keyboard to the HoloLens; entering text using Air Taps with a virtual keyboard is tedious.

SOFTWARE

Although it's intended for developers, the HoloLens offers a surprising amount of compelling software for general use. As a Windows 10 device, it has access to the Edge browser, Skype video conferencing, and a variety of other Microsoft and third-party apps on the Windows 10 app store. These apps, which aren't designed with holograms in mind, appear as floating windows you can virtually fix on your walls or floating in space.

Microsoft Edge works just as well on the HoloLens as it does on a standard PC. I could access Gmail and YouTube easily through the browser, which displayed both in desktop mode. A separate YouTube client called HoloTube displays a more leanback-friendly interface for browsing videos, letting you detach the app from whatever location you placed it and make it continuously float in the center of your vision, wherever you look.

The Holograms app is an entertaining way to decorate your environment and experiment with the headset's location tracking and placement. It presents a window with a variety of static and animated holograms. Tapping one pulls it out of the window and lets you place it anywhere around you. Once a hologram is placed, you can resize and reposition it as you please. These holograms are treated as persistent decorations in your HoloLens interface; even if you close the Hologram app, the holograms will stay put as long as you use window-based apps such as Edge. (They will disappear, along with any windows you have

SoftGozar.com

MAKE YOUR OWN AR MOVIE

Actiongram is a beta program designed to work with the HoloLens. First select holograms from a large collection. You can move, resize, and rotate them, and then put them into the story you want to tell, and record it ot share with others.

open, if you load a HoloLens app that completely takes over your view.) The holograms are persistent in their virtual locations, meaning you can walk around them and look at them from any angle.

HoloStudio builds on the Holograms concept by letting you construct entire scenes of holograms out of various components using different tools. You can connect multiple parts together, duplicate your constructed objects, and color them to create much more elaborate dioramas than the individual prebuilt objects from the Holograms app.

As mentioned, a Skype client is available on the HoloLens as well. It offers full voice and video call support, projecting a window in front of your vision with the person you're calling (like VidWindows in Reboot). Because the HoloLens doesn't have a camera on you as you use it, the video feed from your end shows whatever you're looking at, complete with any holograms you want to share with the caller.

GAMES

Fragments is one of the most visually impressive demonstrations of what the HoloLens can do for gaming. It's an augmented reality game that puts you in the shoes of a detective who must scan "memories" (incomplete crime scenes) and identify clues to locate where a hostage is being held. The game scanned our test room and used its shape to define both the virtual crime lab and the memories I investigated. I walked around the room watching different fragments of the scene come together as I focused on them, then tapped various clues to get closer looks. Each clue added another detail I could then use to narrow down the search area using a series of location filters, eventually finding out where the crime was happening in time to rescue a hostage. It's very similar

SoftGozar.com

to the AR glasses used by agent Norman Jayden in the game Heavy Rain, only I was wearing the glasses instead of watching a character on my TV use them.

Young Conker is a more kid-friendly game where you guide a cartoon squirrel around different levels to collect coins, solve puzzles, and reach objectives. It's simpler than Fragments, but it also uses the shape of your room to determine how to play. Conker will follow the cursor in the middle of your view, running over different obstacles created by the contours of your room's walls and furniture.

RoboRaid is a first-person shooting gallery, similar to many virtual reality games on the Samsung Gear VR.: You look around the room to aim your cursor at attacking robots and hit them with lasers. Instead of tapping a touchpad on the headset, as in a Gear VR game, you Air Tap to fire. Physical movement is a big part of this game, and this is where the benefits of augmented reality over virtual reality shine. You can freely move around to dodge laser fire, and since you can see everything that's physically around you, you don't run the risk of knocking things over, as you do with vision-obscuring VR headsets.

AN AUGMENTED GLIMPSE INTO THE FUTURE

Even as first-generation development hardware, the Microsoft HoloLens is a very impressive example of cutting-edge technology. This self-contained augmented reality device can project holograms and run apps all around you, letting you turn your entire surroundings into a desktop, or completely overhaul your environment with different effects that follow your walls and furniture accurately. The limited field of vision is the headset's biggest weakness, though, along with a bulky, uncomfortable design.

The HoloLens still has a way to go before it appears in offices, schools, and homes. Some big improvements in field of view and comfort must be made before this is a feasible consumer technology. Perhaps in five years, everyone will have access to the grandchildren of the HoloLens, with glasses, goggles, and visors that can display holograms anywhere you look. For now, though, this is a $3,000 headset that offers a very tempting glimpse at a promising future.

WILL GREENWALD

SoftGozar.com

This 64-bit Windows 10 PC Is Smaller Than Your Phone

Asus VivoStick PC (TS10)

$129

So-called stick PCs such as the Asus VivoStick PC (TS10) turn any TV or HDMI-equipped display into an all-in-one desktop PC. That's a natural fit for running Windows-only programs or plug-ins (like a VPN service to your corporate office) on a really big screen or as a PC to stream your movies and music. It's also one of the easiest ways to carry a PC along with you in your pocket, since The VivoStick is much smaller than even your smartphone. It's one of the newest compact PCs to dovetail off of the Intel Compute Stick project, and barring a flaw or two, it's one of the better ones to boot (pun intended).

SoftGozar.com

DESIGN AND FEATURES

Like most stick PCs, the VivoStick PC is compact and pocket-size. It measures a scant 0.65 by 1.42 by 5.31 inches (HWD) and weighs just 2.72 ounces. It looks like a fat USB memory stick, albeit with a wider HDMI plug on the end and comes with a cap to cover the HDMI connector when it's in your pocket or bag. When you're on the road, it's a good way to keep yourself entertained (and in touch): Just plug the VivoStick into your hotel room's TV, and you'll be on the Internet in no time. You can use a third-party compact wireless keyboard/touchpad combo or the free Asus VivoRemote app on your smartphone to control the system.

Connectivity isn't bad for a stick PC. The VivoStick PC has a micro USB port for power (a cable and AC adapter are included), along with a headset jack, a USB 2.0 port, and a USB 3.0 port. The headset jack is useful in case your HDMI display lacks internal speakers and for hooking up the VivoStick to an external stereo or headphones. The USB 3.0 port doubles connectivity compared with the original 2015 version of the Compute Stick as well as with systems based on that model, such as the Azulle Quantum Access LAN Windows 10 Fanless Mini PC Stick and the Lenovo Ideacentre Stick 300. The extra USB port lets you connect a mouse and keyboard simultaneously for setup purposes and in case you don't want to hook up a wireless option using the VivoStick's Bluetooth 4.1 capability. Wireless connections to the Internet are handled by 802.11ac Wi-Fi.

Asus VivoStick PC (TS10)

PROS Fits in your pocket. Plugs directly into an HDMI port on a monitor or TV. Includes USB 3.0 and USB 2.0 ports. Supports dual-band 802.11ac Wi-Fi and Bluetooth. Uses 64-bit Windows. Headset jack.

CONS Lacks a microSD card slot. 2GB of memory and only 15GB of free storage space. Remote app needs worktables and into the wild is just hungry forever.

TRULY MOBILE COMPUTING
Just plug the VivoStick into your hotel room's TV, and you'll be on the Internet in no time.

SoftGozar.com

The one caveat is the lack of a microSD card slot, which could have expanded the system's miserly 32GB of eMMC flash storage. When testing the VivoStick, I noticed that there was only 15GB of free space, which is barely enough for a few installed programs and maybe one movie download. Both versions of the Compute Stick and the Lenovo Ideacentre Stick 300 have microSD card slots that let you add up to 128GB of local storage.

Instead of using a traditional keyboard and mouse, you have the option of using the Asus VivoRemote app, available for both Android and iOS devices. It has two modes: One turns your phone's touch screen into a touchpad, complete with left and right mouse buttons. The other mimics a controller for multimedia apps, including a four-way cursor controller. Typing letters and numbers is a little odd, since there's no keyboard mode. Instead, there's a text entry box on the touchpad screen. You select it, type your text, and then hit the Send button to transmit the text to your VivoStick. This method is kludgy, since you need to move the text insertion point (cursor) on the PC screen manually with the mouse. It works fine for entering text in a browser address bar, but it's inconvenient when you need to type more than a line of text into a word processing program. By default, the system launches VivoRemote Center (alongside Windows 10), which looks a lot like the interface on older media PCs or set-top boxes such as the Roku.

Also included is the HyStream app, which lets you stream videos and music from your mobile phone or tablet to the VivoStick and display them on your HDTV. Truth be told, if you're simply browsing the Web and streaming videos, the cheaper Asus Chromebit does the job just as well, if not better. Note, though, that the Chrome OS–based Chromebit won't run Windows programs.

SoftGozar.com

The system has only 2GB of memory, which is enough to run a browser and a messaging client simultaneously, though it's not really sufficient for multitasking with a photo-editing program on top of that. We experienced some slowdown with more than six browser tabs open and two of them streaming video and music. Keep that in mind if you're considering the VivoStick, because slightly larger small-form-factor systems such as the budget Editors' Choice Shuttle XPC Nano have more power as well as upgradable memory and storage. The system also comes with a mounting bracket so you can stick it behind your HDTV and keep it out of the way. The VivoStick comes with a one-year warranty.

PERFORMANCE AND CONCLUSIONS

The VivoStick is powered by an Intel Atom x5-Z8350 processor with Intel HD Graphics, so you can expect competent day-to-day performance. This is indicated by its (slightly) above-average score on the PCMark 8 Work Conventional test (1,363). Its result on the HandBrake test (7:22) was also above average, but its CineBench score (99) and Photoshop time (19:27) show that you're going to sitting around a long time waiting for it to finish tasks more strenuous than basic media playback.

It's notable that the VivoStick was able to complete the CineBench and Photoshop tests at all, considering its 64-bit version of Windows 10; the other stick PCs use the less-capable 32-bit version. The VivoStick's 3D performance was nothing to write home about, with single-digit frame rates on our game tests, so we wouldn't even think of playing 3D games like Minecraft or Diablo III on this setup. Simpler 2D games like Angry Birds are a better bet.

"It's also one of the easiest ways to carry a PC in your pocket, since The VivoStick is much smaller than even your smartphone."

STICK WITH ME, KID

The VivoStick plugs directly into the HDMI port on a monitor or TV, effectively turning them into PCs.

SoftGozar.com

WE GOT THE POWER
The large Power button on the end is the only physical control on the Asus VivoStick.

Stick PCs are the most portable systems you'll find. And plugging a stick into a TV to turn it into a large all-in-one PC is a neat concept. So the Asus VivoStick PC (TS10) can be useful to have around, but it ultimately makes more sense as a travel companion than as a full-time PC because of its limited computing power. That said, the Shuttle XPC Nano can also hide behind a TV, but is much more powerful and expandable. We can't give the VivoStick our Editors' Choice because of its lack of microSD expansion room, but if you want to explore the nascent experiment known as stick PCs, the Asus VivoStick isn't a bad place to start.

JOEL SANTO DOMINGO

SoftGozar.com

A Sleek, Futuristic (and Comfy) Vertical Mouse

PC MAGAZINE EDITORS' CHOICE

With its clean edges and metallic body, the Evoluent VerticalMouse C Right Wired looks like it belongs in a science fiction movie. But its comfortable form factor and highly customizable buttons make a convincing case for ditching traditional computer mice forever. The latest in Evoluent's VerticalMouse series, it features a streamlined shape and a pinch of chrome for a sleeker look and feel while maintaining a high level of performance and customizability. These might not seem like huge updates, but they're enough for the C Right Wired to replace the Penclic Bluetooth Mouse B3 as our Editors' Choice for ergonomic mice.

Evoluent VerticalMouse C Right Wired

$89.95

SoftGozar.com

DESIGN AND FEATURES

The most obvious thing about the VerticalMouse C Right Wired is that it's, well, vertical. The ergonomic advantage to this shape is that it mimics the natural grip you use to, say, shake someone's hand rather than the strain-inducing forearm-twisting traditional mice require. If you've never used a vertical mouse, this might sound like hogwash, but after a few days of testing, I found it noticeably more comfortable than a horizontal mouse. And though the design of the C Right Wired is certainly different, the mouse is not as "out there" as others, including the Ergoption Oyster Mouse Wireless, the Hippus HandShoe Mouse (with LightClick), and the Penclic Bluetooth Mouse B3.

MIGHTY MOUSE
The C Right Wired has a streamlined shape and a pinch of chrome for a sleek look and feel.

Viewed from the rear, the mouse's shape is almond-like. The left side features an attractive chrome finish with a black plastic thumb groove in the middle that makes the C Right Wired solely for right-handed users. (Southpaws, Evoluent also makes the same-price VerticalMouse 4 Left.) At the mouse's top edge are four small lights indicating pointer speed or dpi.

Evoluent VerticalMouse C Right Wired

PROS Comfortable, ergonomic grip. Sleek chrome design. Five customizable buttons. On-the-fly dpi switching. Easy-to-use software.

CONS Wired. Shape won't appeal to everyone. Right-handed only.

SoftGozar.com

The right side is made of the same black plastic as the thumb groove. The extra space you get from the vertical design also means there's room for three programmable buttons (as opposed to just the usual Left- and Right-Click), a gold-accented scroll wheel, and another tiny button behind the scroll wheel for on-the-fly dpi switching. At the bottom is a wide lip to cradle your hand and prevent your pinky from dragging across your desktop surface.

The C Right Wired is sleeker in look and feel than its predecessors, the VerticalMouse 4 Small and the VerticalMouse 4 for Mac (Right-Hand). The body, while slightly larger, is more tapered at the front and back, and the wider lip creates a more natural fit to your hand. The design of the three main buttons has also been streamlined. Instead of having a short, squarish shape, finger grooves, and a glossy finish, the buttons on the C are longer, smoother, and made of the same material as the body of the mouse. This gives it a beautiful profile, and the matte finish eliminates the grimy feel of the VerticalMouse 4 Small—one of our major gripes with it.

I reviewed the wired version of this mouse, which connects to your computer via USB. It's not exactly cumbersome, but it does add some clutter to your desk setup, and with its larger size (compared with regular mice), it's less convenient to transport with your laptop. The tradeoff is that it's about $20 less than the wireless version, a bonus for those who plan to mostly use it in one place.

PERFORMANCE AND SOFTWARE

Once you get used to the vertical grip, the C Right Wired delivers a smooth experience that, in some ways, is more intuitive than what you get with a typical mouse. For example, the motion of moving windows or dragging files on screen mimics how you might rearrange objects in real physical space.

> **Its comfortable form factor and customizable buttons make a convincing case for ditching traditional computer mice forever.**

PUT 'ER THERE
You hold this mouse in a handshake-like way, which is much more comfortable than the way you grip standard mice.

SoftGozar.com

The only issue for some users might be the new design for the three main buttons; the smooth profile meant I occasionally mis-clicked the lowest button when grabbing the mouse. This problem occurred less and less the more I used the mouse.

EVOLUENT MOUSE MANAGER

While you can use the mouse straight out of the box, downloading and installing the Evoluent Mouse Manager software lets you add another layer of customizability. Aside from tweaking personal preferences for which button does what, the software lets you make full use of the "secondary function" button located at the bottom of the thumb groove. When pressed, it effectively increases the number of total button functions from five to nine. (In practice, eight is a more realistic number: Simultaneously pressing both buttons in the thumb groove, while not impossible, would be difficult for most.)

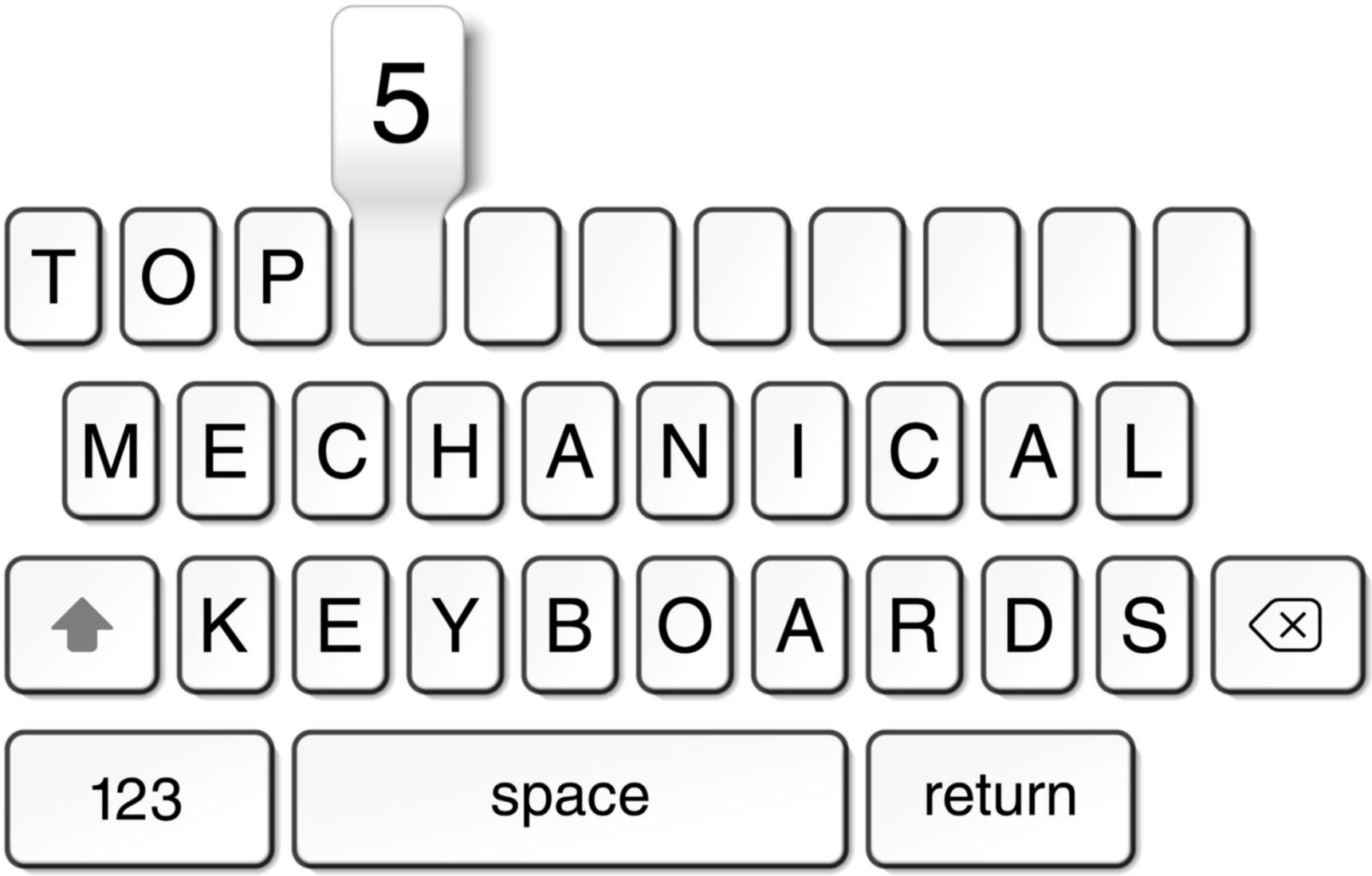
You can also use the software to record custom keystrokes, adjust scroll speed and dpi, and alert you when to take breaks or resume work—a novel feature in the world of programmable mice. Aesthetically, the software leaves a little to be desired, but it's free and easy to use, and the added functionality is worth the download.

CONCLUSION

The Evoluent VerticalMouse C Right Wired is a sleek update that improves on a tried-and-true design, resulting in one of the most comfortable and intuitive ergonomic mice I've ever used. The handshake grip might not appeal to everyone, but if you're willing to give it a shot, you might become a convert. The wireless version might be a smidge more convenient, but the lower cost for this version makes it worth serious consideration. Because the new design combines a more premium look and feel with excellent customizability for a reasonable price, the VerticalMouse C Right Wired is our new Editors' Choice for ergonomic mice.

VICTORIA SONG

SoftGozar.com



Computer users of a certain age remember a time when room-filling clicks were as synonymous with typing as were words appearing on a sheet of paper. But the typewriters on which generations of office workers and aspiring novelists learned to type weren't the only places you'd find mechanical keyboards. Even through the 1980s, they were as common a part of computers as floppy disk drives—because the people who were creating and using them knew what typing could and should be. (And for many years afterward, the IBM Model M keyboard, with its firm but forgiving buckling spring mechanism, was held up as the *ne plus ultra* of this technological art.)

With the explosion of the home PC market in the 1990s and into the early 2000s, though, these sturdy fixtures fell by the wayside as manufacturers looked for cheaper mass-market solutions to getting tens of millions of people on their machines and online. Typing, that most common of computing activities, became something you and your fingers had to endure.

SoftGozar.com

THE OLD SWITCHEROO

First and foremost, a mechanical keyboard is defined by the key switch it uses. Most budget keyboards today use dome-switch technology, which registers a keypress when you type and push down a silicone dome and connect two circuit board traces. Although this style is easy and inexpensive to manufacture, it requires a relatively large amount of force, which can result in a heavy and mushy feel to the user and a lack of tactile or auditory feedback when typing. And also, over a fairly short period of time (five million keystrokes, give or take), the domes can collapse, so you'll probably have to replace the keyboard at least once or twice over the life of the computer you use it with.

SILICONE
More common today than mechanical keyboards are dome-switch keyboards; you key press is registered when you connect two circuit board traces.

Mechanical switches, by contrast, avoid the silicone. Pressing down on a key activates a real, physical switch that registers what you type. Because the parts used are much more substantial than those in dome-switch keyboards, mechanical keyboards typically have a much longer lifespan (many boast ratings of 50 million keystrokes or more per switch), and create a more direct relationship between the person who's typing and what appears on the screen. Because of the hardware involved, mechanical keyboards tend to be thicker, heavier, and more expensive than their dome-switch counterparts, making them more of an investment—albeit one that's likely to pay off, if the quality of typing matters to you.

When shopping for a keyboard, pay attention to the kind of switch it uses, whether it offers auditory feedback (in other words, makes a click you can hear) or tactile feedback (a "bump" you can feel). And the amount of pressure the switches require to activate (the actuation force) will greatly affect its functionality.

SoftGozar.com

CHERRY PICKING

Although there are a number of manufacturers of the switches used in mechanical keyboards—some keyboard companies even develop their own switches—the best known and most frequently encountered come from a company called Cherry. Cherry MX switches come in a range of styles to match your personal preferences for work, play, or both. This rundown of the most common Cherry switches will help you match what you need with the keyboard you buy. Keep in mind that almost every manufacturer maintains the same basic color scheme to help keep confusion down, although the details may differ somewhat.

CHERRY MX BLUE

Perhaps no key switch on the market offers anything closer to the traditional, quintessential typing experience than the Cherry MX Blue. It's both tactile and clicky, so you can feel and hear the completion of a keystroke. While ideal for serious typists (many of whom insist the switches deliver a turbocharging bounce you can't get anywhere else), the MX Blue switch isn't best for some games; it has a higher actuation force (50 centi-Newtons, or cN) than you might want in a fast-twitch gun battle. Another potential downside: Some people find the keys' audible click to be loud and annoying.

CHERRY MX BLACK

With the highest actuation force of the standard Cherry varieties (60cN), the Cherry MX Black switch can feel stiff and unsuitable for the kind of nimble key work most speed and touch typists depend on. This makes Black an excellent gaming switch, though, as you seldom have to worry about accidentally key strikes. Cherry MX Black switches are also neither tactile nor clicky.

CHERRY MX RED

Similar to Black, Cherry MX Red switches lack both tactile and auditory feedback. But they have a lower actuation force (45cN), so they can be hit more quickly and more often, giving you the edge in any game demanding ultra-quick input. These same qualities keep them from being a good choice if typing is your primary activity, though, as they make it easy to register more keystrokes than you intend.

SoftGozar.com

CHERRY MX BROWN

If you spend as much time scribing e-mails and Word documents as you do mowing down enemies in first-person shooters, the Cherry MX Brown switch may be for you. Its 45cN actuation force is identical to what you get from the Red switch and, the switch isn't clicky, but it gives you the same tactile bump you get from Blue.

OTHER CHERRY MX SWITCHES

Though the above switches are the kinds you're most likely to find in a keyboard you buy today, Cherry's rainbow extends further. Clear switches are tactile like Brown but possess a higher actuation force; Green switches can be considered stiff Blues, both tactile and clicky; and White switches are quieter Greens.

OTHER SWITCHES

A number of companies make switches that either mimic or try to improve on the Cherry MX functionality (some gaming keyboard switches, for example, have shorter actuation points to launch you into the action faster), but none of these have yet become as popular or as widespread as the originals. If you come across a keyboard brand using an unfamiliar switch type, try to determine both its actuation force and actuation point (when what you type is registered). Compare these values to those of the Cherry switches, and you should get an idea of what you're in for.

OTHER FEATURES

Switches aside, mechanical keyboards are like other kinds of keyboards. You may want backlighting, whether of one color or an entire spectrum you can program at your whim. Multimedia controls, either activated by pushing separate buttons or by using a Function key to access a secondary ability on one of the standard keys, can make it easy to adjust volume or to move backward and forward in your track list while playing music. Dedicated macro controls can be a real boon in games, saving you the trouble of having to type out long strings of commands every time you want to perform a common action.

In any case, whatever you want from a keyboard, you can find a mechanical keyboard capable of making it a reality—with more heft, longevity, and style than you may have thought possible. Mechanical keyboards are likely to get better as more consumers realize the benefits they offer to laser-focused typists, hard-core gamers, and everyone in between.

SoftGozar.com

Corsair K95 RGB

$189.99 ●●●●◐

PROS

Customizable per-key backlighting. Stylish aluminum design. Detachable wrist rest. Dozens of programmable options. Cherry MX Red or Brown switches available.

CONS

High price. No USB pass-through connection.

BOTTOM LINE

With a switch to individual-key backlighting and an expanded selection of macro controls, the Corsair K95 RGB offers a significant improvement on what was already one of the best keyboards available. The attractive design is enhanced by the colorful options, and the usability of this immensely functional design is actually enhanced and expanded. It earns our Editors' Choice for gaming keyboards.

—Brian Westover

SoftGozar.com

Das Keyboard 4 Professional

$165.99 ●●●●○

PROS

Available with Cherry MX Blue, Brown switches. Includes dedicated hardware media, sleep controls. Sturdy construction. Integrated hub now supports USB 3.0.

CONS

Expensive. No onboard audio ports. Inconvenient footbar for angling up keyboard.

BOTTOM LINE

A superb typing experience and excellent new features characterize the mechanical Das Keyboard 4, but those benefits don't come cheap. Though its price makes it a tougher sell now that it's no longer the only game in town, the Das Keyboard 4 Professional is unquestionably the company's finest keyboard to date. It's also our Editors' Choice for general-purpose mechanical keyboards.

—Matthew Murray

SoftGozar.com

Qwerkywriter

$349 ●●●●○

PROS

Charming, unique design. Sturdy metal body. Mechanical key switches on a Bluetooth keyboard. Typewriter keycaps are comfortable to use.

CONS

Very expensive. Tablet tray holds tablets too steeply. No buttons for device switching.

BOTTOM LINE

The Qwerkywriter puts typewriter-style keys on mechanical key switches: It's odd—and it's a nearly perfect gift or tool for writers or coders who love mechanical keys but prefer to work wirelessly. This keyboard is pricey, but considering the rarity of mechanical Bluetooth keyboards, the price is actually reasonable. It earns our Editors' Choice.

—Will Greenwald

SoftGozar.com

Cherry MX-Board 3.0 G80-3850

$81.80 ●●●●○

PROS

Mechanical Cherry MX Brown switches with low-travel design. Sturdy build quality. Plug-and-play functionality. Removable wrist rest included.

CONS

No customization. No onboard media controls or ports. Lacks backlight.

BOTTOM LINE

With its no-nonsense design, the Cherry MX-Board 3.0 G80-3850 is a very well-built keyboard that won't get many people excited. The design provides the short key travel of a dome-switch keyboard with the precision and durability of a mechanical model. While it doesn't replace our Editors' Choice Das Keyboard 4 Professional, it provides a well-made and affordable alternative.

—Brian Westover

SoftGozar.com

Division Zero X40 Pro Gaming Mechanical Keyboard

$129 ●●●●○

PROS

Sturdy construction. Includes USB, audio pass-through connections. Utilizes full n-key rollover. Removable top plate allows for unique visual customization.

CONS

Relatively expensive given the feature set. Limited backlight configurability.

BOTTOM LINE

Metadot brings its experience designing high-performance keyboards to the gaming space with the Division Zero X40 Pro. Simplicity was obviously the watchword with the X40 Pro, which maintains Metadot's commitment to efficient minimalism; you'll find few external frills here.

—Matthew Murray

SoftGozar.com

Wacom's Bamboo Folio Captures Your Writing

Wacom Bamboo Folio

$199.95

●●●◐○

Wacom released the Bamboo Spark earlier this year—it's a simple, effective way to transform pen-and-paper notes into digital files. The company has now doubled down on smart input devices and expanded the line to include different styles. The Bamboo Folio is one of the new additions (the Bamboo Slate is another), taking the same technology used in the Spark and transitioning the form factor to a business folder. The Folio works as well as the Spark did, offering a straightforward way to share your physical notes digitally. The design is nice and professional, and the added writing or drawing room is a plus. But the accompanying software has

SoftGozar.com

some downsides that hurt the experience: relegating color editing options to a second app is one. I prefer the method employed by the Editors' Choice Moleskine Smart Writing Set, with its smart notebook, unified app, and advanced pen, but the Folio is still a solid analog-to-digital option that lets you use any paper.

DESIGN AND SETUP

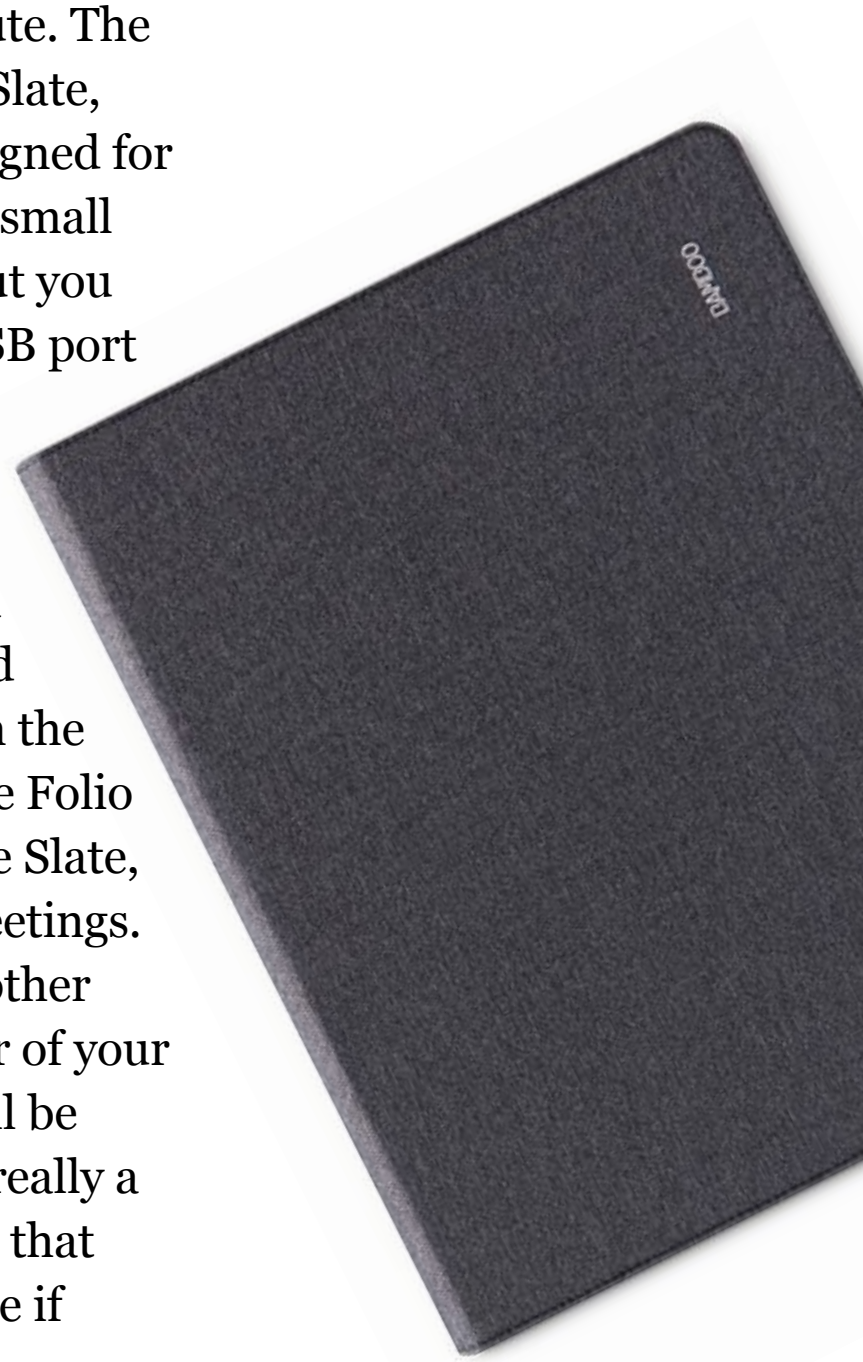
The Folio, at 0.74 by 10.5 by 13.3 inches (HWD), is more substantial than the Slate, mainly because of its textured and sturdy nylon fabric cover. The interior is dimpled black polyurethane, and the inside front cover includes a large pocket and two slots suited to holding business cards. The Folio is a little heftier too, but at 1.72 pounds (without paper), it's light enough that you won't mind throwing it in your bag for a commute. The Folio comes in only one size, as opposed to the Slate, which has a half-letter variation. It's large—designed for letter-size paper, so a good deal bigger than the small Slate, the Spark, or the Moleskine notebook—but you may well appreciate the extra space. A micro USB port on the bottom is used for charging, and a USB–to–micro USB cable is included.

Dark stitching outlines the Wacom-enabled surface—the majority of the inside panel—and a black button to the left serves as both Power and Sync. Between the black interior, darker gray on the exterior, and the cover that hides your notes, the Folio looks more professional than the clipboard-style Slate, and I prefer the feel of carrying it with me to meetings. A slit in the back panel substitutes for a clip or other fastener for your paper—just slide the rear cover of your pad (usually cardboard) down the slit, and it will be held in place as you write or travel. There's not really a solution for sheets of paper that aren't bound in that way, but the cover helps keep everything in place if you're on the move.

Wacom Bamboo Folio

PROS Attractive, professional design. Simple to set up and use. Provides spacious writing surface.

CONS Expensive. Limited editing tools. Color and highlighting functions require a second app. Handwriting-to-text available only with a paid subscription.



SoftGozar.com

FEATURES AND TESTING

The note-taking process requires no explanation—it's standard pen and paper. The Folio tracks your input accurately, catching strokes or bolding too. It also has a live option, which puts your writing into the app in real time. When you're done with a meeting or want to save one page and move on to the next, pushing the Sync button saves your physical notes as an image file in the Inkspace app, which is available for both iOS and Android. You can enable background sync on your device, which allows you to save a page of input to the app at any time by pressing the Folio's button, as long as the connection remains. Inkspace is also Wacom's cloud solution, so your files will be synced across devices.

Any paper—whether the included notepad or another sheet or pad—is compatible with the Folio. As long as the paper is placed over the board, your input will be tracked. But you can't use just any writing implement: You need to use a compatible Wacom pen (included), an ink-equipped ballpoint pen with changeable cartridges for when you need a refill. (The Moleskine set, in contrast, features a bound book with smart pages, so you'll run out eventually and have to replace the notebook.) Because it's difficult to withdraw a cartridge from the pen by its tip with your fingers, a small ring tool is included for this purpose. The cartridges are about half the size of a regular pen's, so they won't last forever, but one extra is included, and they can be purchased separately as well (a three-pack costs $9.99). The point is less fine than I'd like, and the pen is a little thick, but its triangular shape helps make it comfortable to hold.

Any paper—whether the included notepad or another sheet or pad—is compatible with the Folio.

DIGITIZE YOUR DOODLES
Wacom's Folio pen can capture your writing in real time, including strokes and bolding (squiggles too, apparently).

SoftGozar.com

Once the note is saved, you can export it as a JPEG, PNG, PDF, or WILL file through any compatible messaging or social media app you have installed, including Slack, email, or a cloud service. The free version of the Inkspace service offers up to 5GB (more than 6,000 pages) of storage. A point of irritation is that handwriting-to-text is one of the features behind the Inkspace Plus paywall, so you'll have to upgrade your subscription to turn your handwriting into rich text. This wasn't the case when I reviewed the Spark, so the change is disappointing for free subscriptions.

As for in-app editing, Inkspace offers a couple of options. You can scrub through your note-taking timeline once saved, watching notes appear on the screen in the order you wrote or drew them. At any time, you can split the notes wherever you are in the timeline, separating them into two different files should you want to send a portion of the note to another app or person. You can also draw on or annotate your note once it's in the app, which can be somewhat useful, but there isn't much functionality. Your handwriting will only appear in black while taking notes and when drawing, and the only two other editing options are to erase and to select part of the image freehand and drag it somewhere else on the page.

Another app, Bamboo Paper, can be used to color and highlight notes. The app appears as one of the export options when you choose to send your note as a WILL (Wacom Ink Layer Language) file. If you switch apps and open up your file there, more editing choices are available. You can draw on your imported note with a pen or highlighter, using a fairly wide selection of colors. There are more drawing implements available, but you have to buy them (some are included in tool packs which priced at or around $5) within the app. You can get better coloring and drawing control on a bigger screen like a tablet than your phone, especially if you have a Wacom stylus.

Overall, these editing options are limited—it's tough for the average person (like me) to draw anything that remotely matches the quality of Wacom's mock-up images, too. It's also annoying that the coloring functionality in its entirety is reserved for another app—the Moleskine set uses one for everything. I appreciate the simplicity of the note taking in Inkspace and syncing across devices, but including all of these features within one app would go a long way in a process that benefits from as much streamlining as possible. You're already sending files to other apps (after sending them from the Folio to your device), so another transition just to add color is a somewhat clumsy additional step.

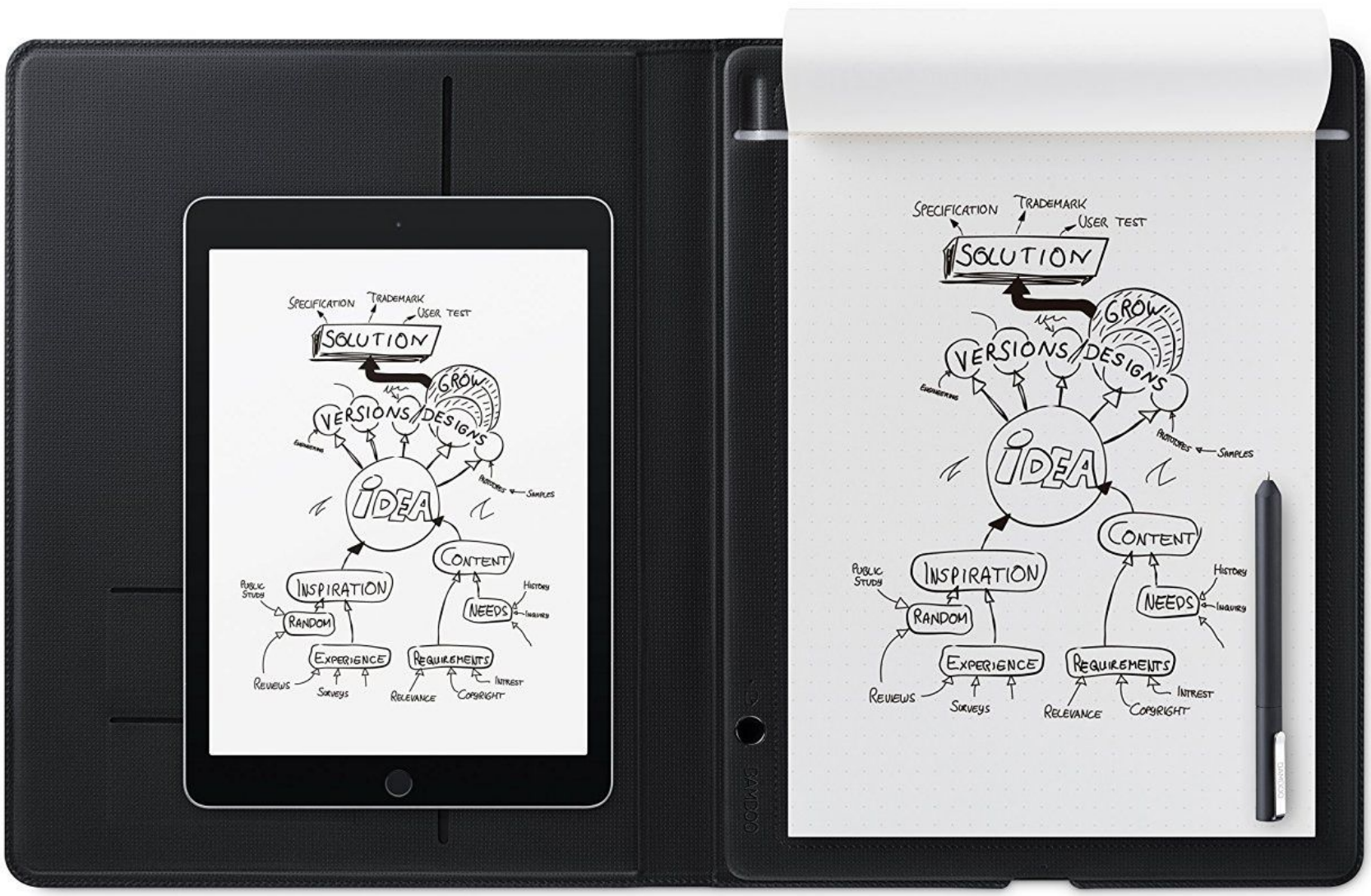
SoftGozar.com

CONCLUSION

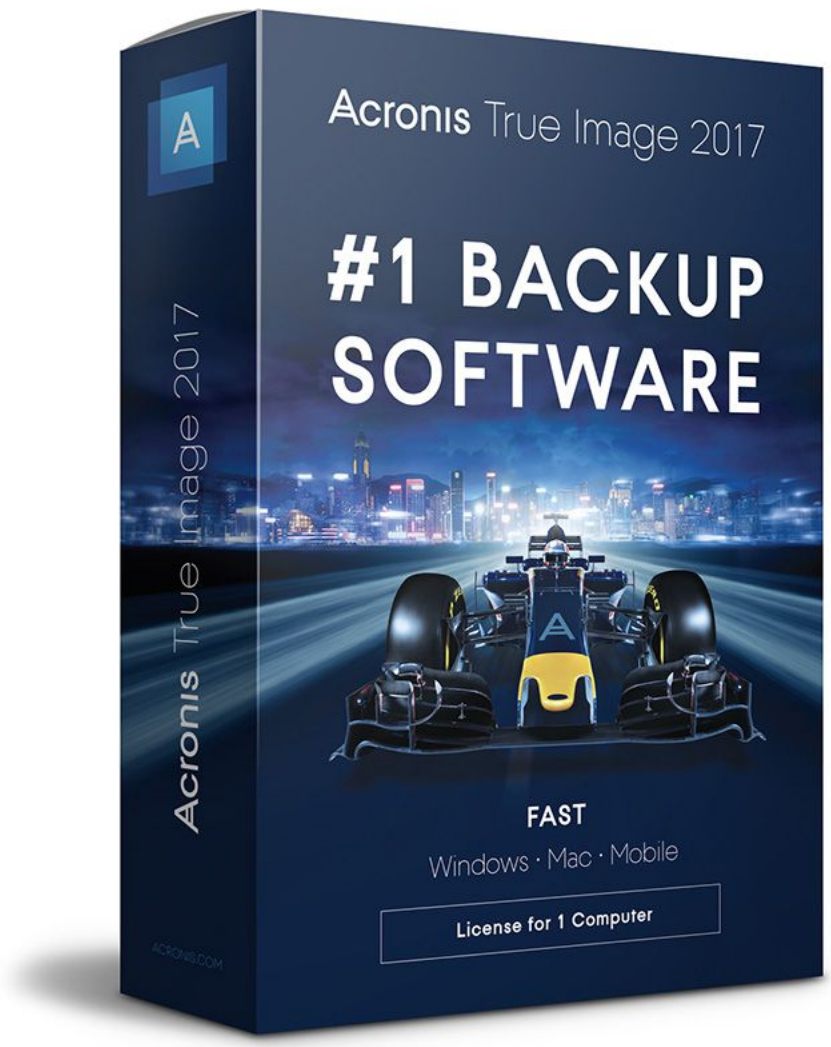
Though expensive, the Wacom Bamboo Folio makes it easy to convert full-page pen-and-paper notes to digital formats. Sharing across messaging and cloud apps is quick and simple, and the attractive physical design makes using the Folio more appealing. The apps are where the Folio and its family of devices stumble: Editing options are limited, and requiring two apps for editing and color feels like an unnecessary complication. The software isn't too intuitive, particularly the note layout of Bamboo Paper, and it takes away from the experience.

That said, it's a fast and simple system, and you can have your paper notes in an email in seconds. That was a more novel feat when I reviewed the Spark, but it remains impressive, and the form factor may be more to your liking. I prefer the Editors' Choice Moleskin Smart Writing Set's method and more advanced pen, as the experience is more robust and it's unified within one app, but the Folio is a version of the same concept that works relatively seamlessly.

MATTHEW BUZZI



SoftGozar.com



Acronis True Image Offers Unique, Powerful Tools

PC MAGAZINE EDITORS' CHOICE

Acronis offers the friendliest and most feature-packed backup software for home users. Its True Image Cloud service and the True Image software reviewed here can both create full disk-image copies for the ultimate in disaster protection. The only difference is that the Cloud version offers online storage as a target for saving your backup. The software also offers a cornucopia of backup options, including not only entire disk images but also file and folder backup. New for the 2017 version are mobile backup to PC, Facebook backup, and remote backup management.

Acronis True Image
2017 version

$49.99

●●●●○

SoftGozar.com

PRICING AND STARTING UP

You can try the service free for 30 days, and, if you're sold on it, you pay $49.99 for a perpetual license for one computer. The software is optimized for Windows 10, but it runs on versions of Windows back to Windows 7 SP1. For Macs, OS X 10.9.5 through 10.11 (El Capitan) are supported. It's a not-insignificant 509MB download. I tested the software on a Surface Pro 4 and an HP Spectre x360 13t, both running Windows 10.

Somehow, the program remembered my account even with a fresh reinstall on the same PC. After you install Acronis, quite a few processes will always be running on your system, even for features you're not using. Paragon Backup & Recovery is not as persistent as this; it runs processes only as you use the software.

INTERFACE

True Image's interface is simple, modern, and friendly. A left panel is populated by flat, line-drawing icons reminiscent of those in Windows 10's new Settings app, and in fact the interface works well with touch-screen PCs. It's a far cry from ShadowProtect's many-tabbed, outdated user interface. For this year's version of True Image, the company has moved the menu items around a bit. The first icon on True Image's home screen still shows your basic backup source set and destination. And the second still takes you to the archiving function, designed to free up your storage from old, unused data. Syncing, Tools, and Mobile backup come next.

The Tools icon takes you to Disk Cloning, Rescue-Media Creation, and more. Under this, the More Tools option opens a File Explorer folder of nine additional tools, including a System Report, DriveCleanser, and Try&Decide—a utility for temporarily installing software you're unsure about.

Acronis True Image
2017 version

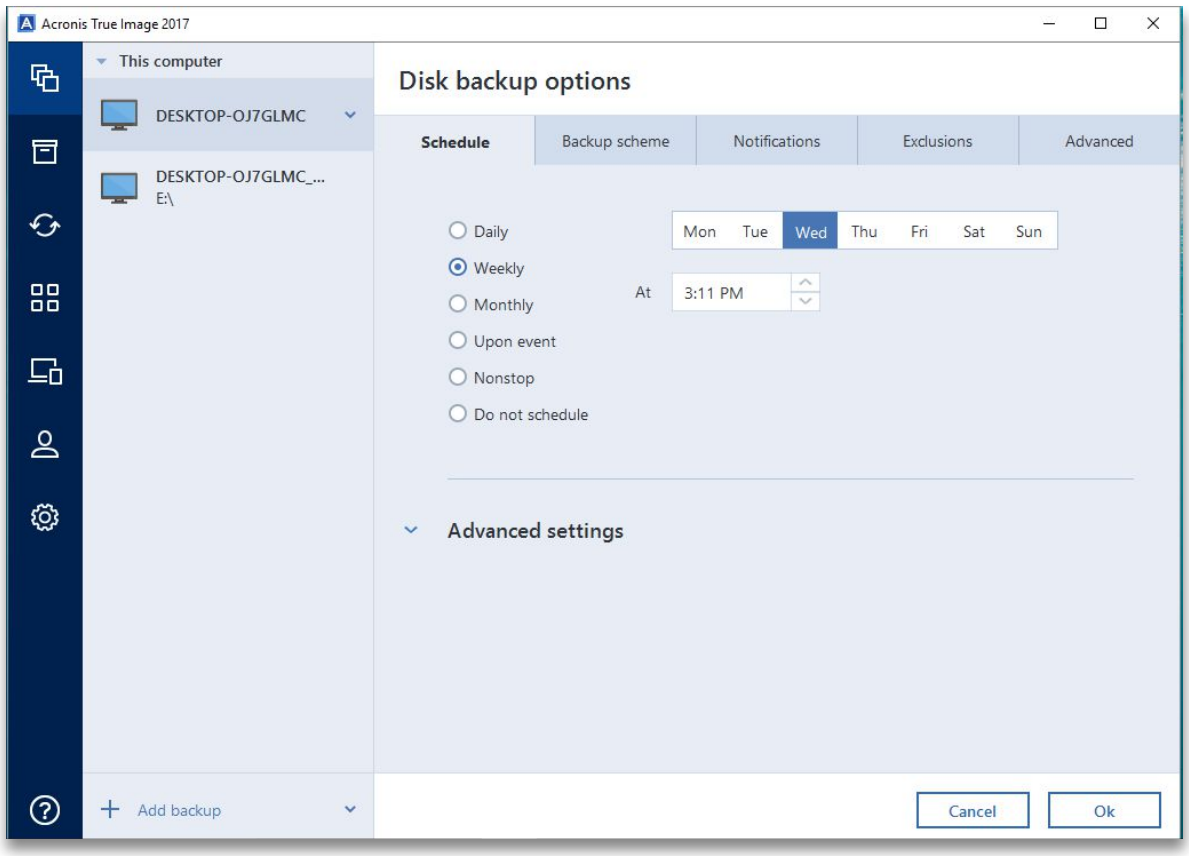
PROS Combines backup, disk-cloning, rescue-disk creation, and more system utilities. Clean interface. Fast. Excellent mobile backup app. Lots of extra disk tools.

CONS Cloud options still in the software even if you didn't buy the cloud service. Runs lots of backup processes. Doesn't restore directly to Facebook.

SoftGozar.com

WHAT TO BACK UP AND WHEN

By default, Acronis selects Entire PC as the source of your backup. You can change this to specified drives, partitions, files, or folders. If you choose files or folders, you see a folder tree with check boxes for selecting what you want backed up. An estimate of the space required by your selected backup helpfully appears at the bottom of the screen. Once you've chosen your source and destination, a green button lets you back up right then or delay backup for up to 6 hours. You can also just choose to initiate the backup at your leisure, by choosing Later.



BACKUP WHEN YOU WANT IT

You can schedule a backup to occur every day, week, or month, or even nonstop as files are changed.

> **The software offers a cornucopia of backup options, including not only entire disk images but also file and folder backup.**

To schedule regular backups, tap the Options button, which offers daily, monthly, and weekly choices along with some more interesting options. For example, you can tell the program to run the backup whenever you log on or off your PC, or at startup or shutdown. For the ultimate in protection, you can tell it to back up whenever a file in the backup set is changed.

More detailed options appear in more tabs of the Options page. You can specify a backup scheme such as Single Version, Version chain, Incremental, Differential, or even a Custom scheme. An example of the last could

SoftGozar.com

be “Create a full version after every 6 incremental versions.” Incremental backups are a way of not reinventing the wheel, file-wise—they save only the changes made since the previous incremental backup. Differential saves just the changes made since the last full backup.

Acronis also gives you plenty of notification options. You can have one emailed to you for any backup action, including completion of a backup session or when insufficient disk space is detected. This tops Paragon Backup & Recovery, which is decidedly lacking in notification options.

On the Exclusions tab, you can add any specific filenames or wildcard character strings, such as *.exe, to exclude them from the backup. In case you think the options already mentioned aren’t detailed or technical enough, the Advanced tab really lets you dig in, offering pre and post commands, splits for multiple backup targets, validation, comments, custom error handling, file-level security, and other things those who just want to protect their photos and word docs won’t care about.

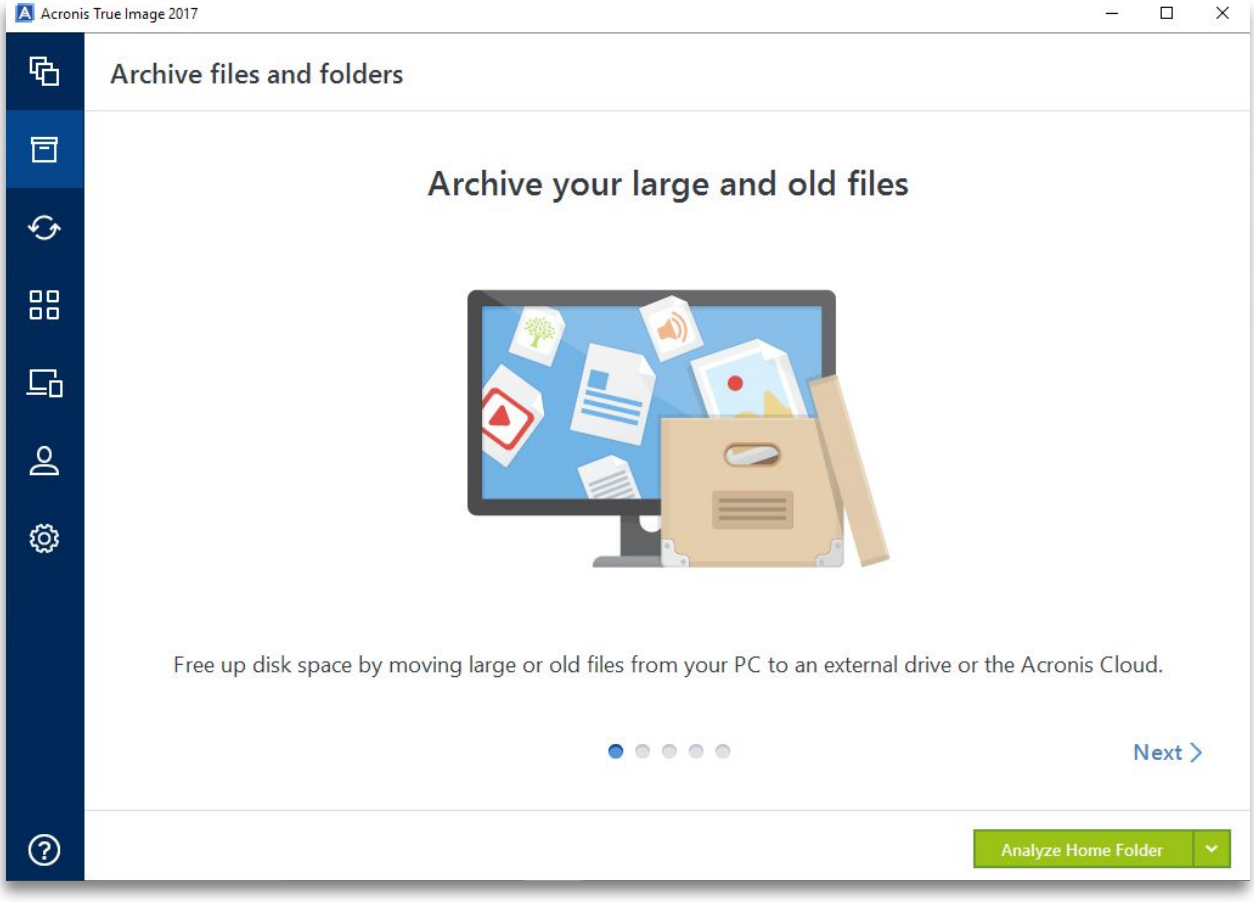
Those options may sound confusing and obscure, but users who just want an easy backup fix need never delve into this arcana. One section of the Advanced page, however, could be of use to a broader audience: Performance. Here you can tell the program how much of your system resources you want to let it command. By default, the priority is ranked Low, but you may want to raise the priority if you have a big job you want to finish fast. Another useful option in Advanced tells the program to shut down the PC when it’s done backing up. I did find it odd that the Compression option was disabled, stuck at Normal. Paragon Backup & Recovery let me adjust its equivalent setting.

During backup, the program window shows progress with a line across the bottom, and it also calculates and displays the time it will take. In my testing, backups were always finished in a reasonable amount of time.

BACKUP PERFORMANCE

A full backup of my test hard drive, which contained 14.1GB of data and programs, took 6 minutes and 6 seconds, a bit behind Paragon Backup & Restore’s 5:03. During the backup creation, Acronis’s display of minutes remaining was steadier and more believable than Paragon’s wildly fluctuating estimates. Note that, since only Acronis and Paragon have updated their backup software since my last roundup of backup testing, they’re the only contestants to have participated in this newer performance test. In previous full-system backup speed testing, Acronis was fastest. On the earlier test, Acronis True Image took 7 minutes, compared with Paragon’s 12:57, ShadowProtect’s 25:48, and NTI’s ridiculous 2 hours and 4 minutes.

SoftGozar.com



> **I haven't seen the tool for archiving and analyzing large files in other backup software.**

ARCHIVE OLD AND LARGE FILES

The tool for archiving and analyzing large files, which I haven't seen in other backup software, gets its own button on the main interface menu. It analyzes your files for staleness and lets you push them off to either online or local storage. It also offers 256-bit AES encryption of the archived data as an option. The tool selects Acronis's home folder at first, but I found it more expedient to switch to my own frequently used folders.

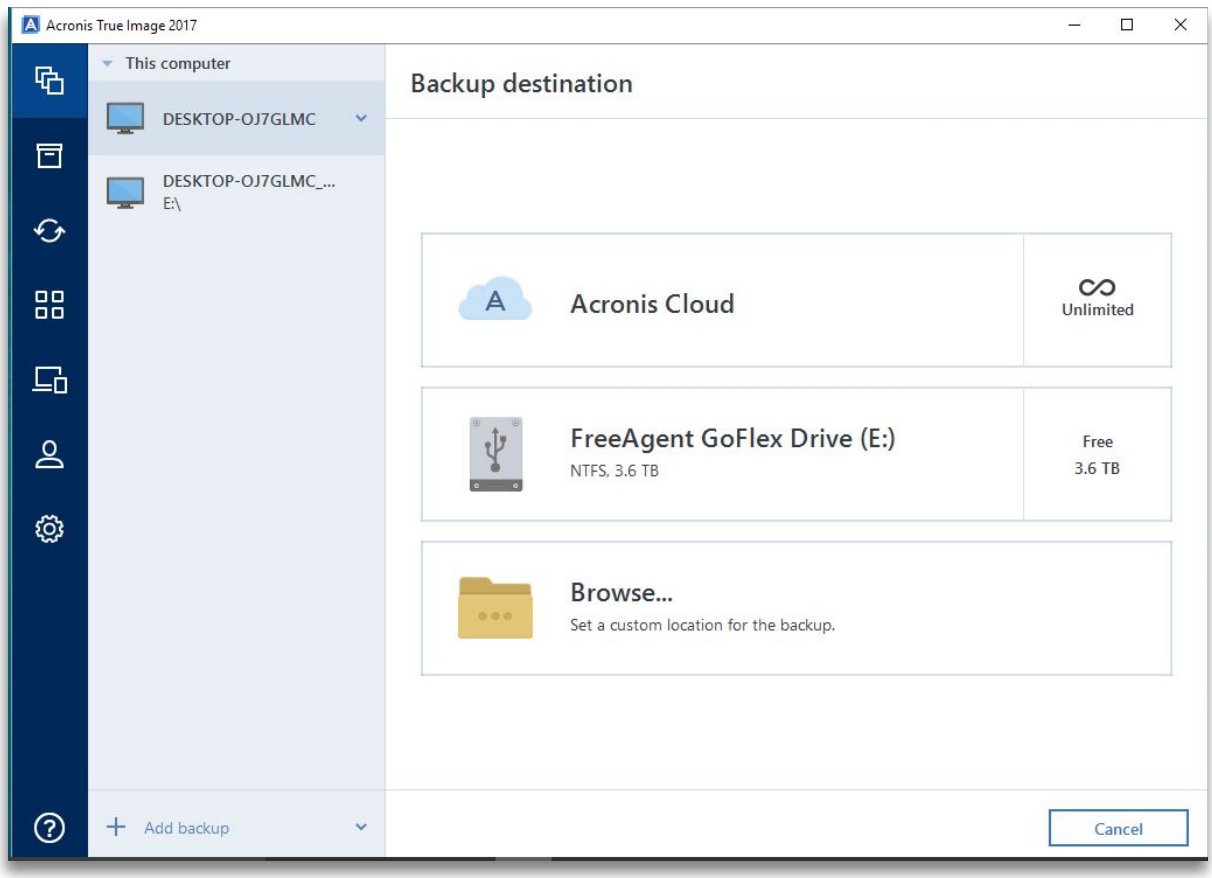
After the analysis, you can either archive individual files or all of them. Choose a storage destination, and tap the Archive button, which also shows how many megabytes you'll be sequestering. Even though the files will no longer exist on your local drive, they're still accessible from Acronis's entry in File Explorer.

DISK IMAGING AND CLONING

When you choose to copy the entire drive, you get the option of encrypting the backup, which merely requires entering a password. You can also specify intervals for incremental backups and sector-by-sector backup, which copies the entire drive, even parts that contain no data. Unlike NTI Backup Now, Acronis lets you specify compression level and operation priority. You can decide whether you care more about a quick backup or the ability to do other things on the PC during the backup.

SoftGozar.com

The Clone Disk Wizard is useful for those who want to reproduce an entire system (including the operating system) on a new PC. It offers automatic and manual methods, the former of which copies all partitions and makes the new drive bootable. It can even resize partitions to fit the new disk capacity. Completing the process involves choosing the source and destination drives and deciding whether to keep the same partition sizes or proportionally allot space, or to manually choose sizes for the partitions.



USER-FRIENDLY INTERFACE

The Start interface makes it clear how to start all the typical backup and syncing scenarios supported by the program.

RESTORING YOUR DATA

Once a backup is complete, new buttons appear at the bottom of its entry in the program window: Recover PC (if you backed up the entire drive) and Recover Files. Even if you back up your entire disk image, you don't have to restore the whole thing. You can just grab one or more folders or files by checking the check box next to their entries in a folder tree of the drive contents. By default, files are recovered to their original locations, but a Browse... link at the top of the Recovery page lets you change the destination folder.

SoftGozar.com

To perform a complete restoration, simply tap the Recover PC button. You can then choose a date if you've made more than one backup. If you have more than one drive, you can choose which you want to restore, and even select just individual partitions within them. My full restore was a success, though Windows informed me that some drivers had to be updated. After doing that, everything worked correctly.

MOBILE BACKUP

Acronis now lets you wirelessly back up your smartphone to your PC via an app. To make getting that app easier, point your phone at a QR code on the Mobile Device Backup page. The well-redesigned app makes it super easy to back up your contacts, photos, videos, calendars, and reminders to your PC over Wi-Fi. If you have a lot of photos on your phone, as I do on my iPhone 6s, keep in mind that the backup could take a while. One thing I find a little strange is that Continuous Backup, denoted as "Experimental," is enabled by default. I usually use iTunes to back up my iPhone to a PC, but some will prefer an all-in-one backup solution, and this feature lets Android users benefit from local rather than cloud backup.

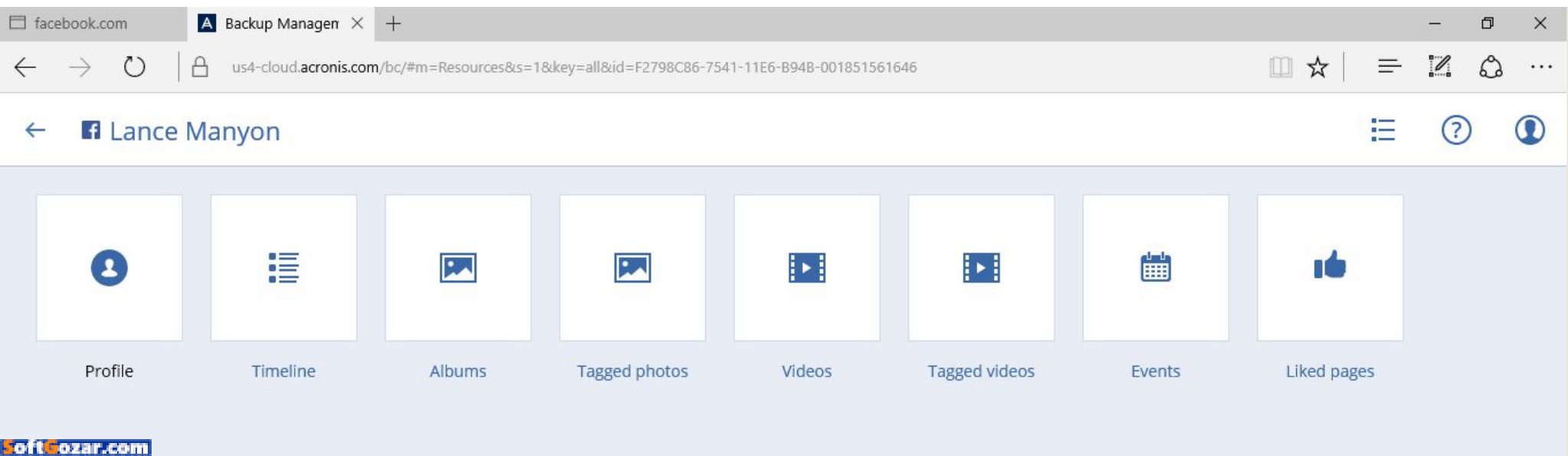
Acronis now lets you wirelessly back up your smartphone to your PC via an app.

FACEBOOK BACKUP

To back up your precious social-networking memories, you also head to the Mobile tab in Acronis True Image. But rather than signing in from within the application, you're taken to the website for your Acronis account.

FACEBOOK RECOVERY

After backing up your Facebook account, you can get to its assets via this Web interface, below.



SoftGozar.com

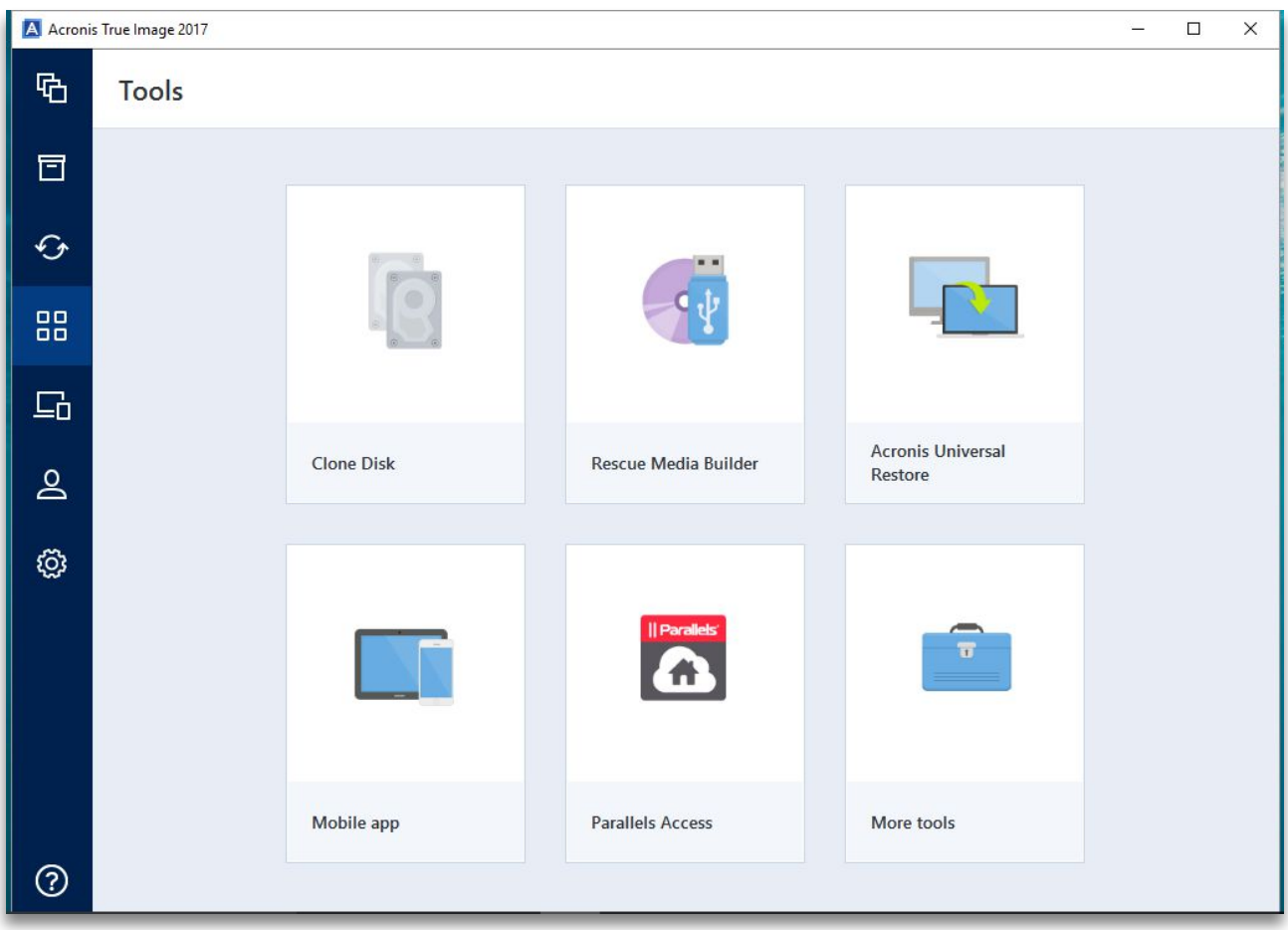
Once there, you need to figure out that you must Add a Resource to get to the Facebook backup option. Personally, I'm not terribly worried about Facebook losing my photos and memories, but it is possible to get hacked or to have someone unauthorized delete your content.

After my account was backed up, an entry on the Web interface showed Back Up Now and Recover buttons. Hitting the latter took me to a page where I could see my Profile, Timeline, Albums, and so on. It doesn't recover your media to your Facebook account, but at least you have those photos and the rest in case someone hacks into your account and deletes everything.

OTHER TOOLS

Acronis System Report generates—you guessed it—a report, after scanning the system for about a minute. The report is in a ZIP file in the program folder, though, and not displayed automatically for you on completion. But that's not such a bad thing, since it's indecipherable to all but the most technical mortals; it includes lots of text-based application, networking, and Registry data.
The Add New Disk Wizard lets you choose an initialization method (GPT or MBR) and create partitions, but it's not really essential with Windows 10, which includes tools like this.

The Rescue Media Builder utility could be a lifesaver for anyone whose system won't start up, and creating the media was a snap on my test system. It creates an ISO file or formats a disc or USB drive for the rescue media. The beauty of having startup media like this is that it contains the Acronis software, so you can rebuild your PC from a saved backup without needing to hunt down the software first.



THE TOOLS YOU NEED
Acronis True Image offers a good supply of extra disk and other tools.

SoftGozar.com

> **Acronis's ingenious Try&Decide option sandboxes your hard drive.**

One of the cooler tools is Universal Restore, which lets you recreate one system to another with different hardware characteristics. Paragon offers a similar capability, but using any of these tools can be dicey.

Acronis's ingenious Try&Decide option sandboxes your hard drive so you can install software or make other changes without permanently writing the changes unless you decide to do so. I'm not sure I would recommend trusting your drive to something as intrusive as this, but it worked perfectly in my test. Other tools are even more intrusive, including one that creates a proprietary Secure Zone on your drive for preserving recovery data.

CONCLUSION

Acronis True Image is the easiest program in its class for non-technical folk, but it still includes powerful options for experts. Its combination of backup (local and cloud), disk cloning, rescue-disc creation, and other unique tools, along with a more modern interface than the competition, secures Acronis True Image's place as PCMag's Editors' Choice for local backup software.

MICHAEL MUCHMORE

SoftGozar.com

No Man’s Sky: An Astounding but Also Flawed Game

PC MAGAZINE EDITORS’ CHOICE

No Man’s Sky is a game with two faces. On one side is an expansive, beautiful, and wholly fresh science fiction space-exploration game. The other is a mundane, task-driven experience that may fail to hold your interest for long. Playing No Man’s Sky feels like nothing before it, yet you’ve also played through the individual mechanics in some sense many times before. Its release is a long-running story of anticipation and promises, both delivered and broken, and so the game as it stands at launch has and will continue to prove divisive. The legitimate complaints about its subsystems and perceived dearth of activities, though, are

No Man’s Sky
(for PC)
$59.88
●●●●○

SoftGozar.com

overshadowed by the actual experience of playing the game, fading into the background as minor nuisances as you become immersed in new alien worlds—the real thrust of the game. No Man's Sky is a completely unique, engrossing, wondrous, and yes, flawed experience, one that conjures the feelings of exploration and discovery like nothing before it, and it's entirely worth losing yourself among the stars. I played the PC version of the game, but it's also available on PlayStation 4.

GREAT EXPECTATIONS

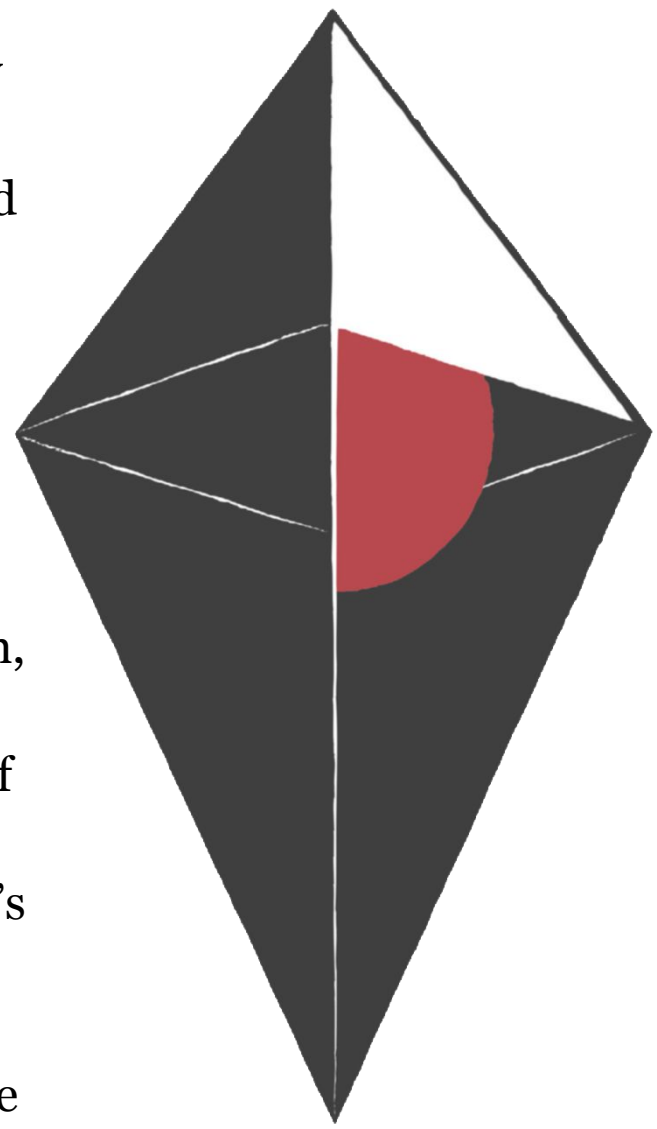
Perhaps more than any other game in recent memory, No Man's Sky seems nearly impossible to disentangle from the hype and anticipation surrounding its release. Despite its modest beginnings and tiny development team, the excitement generated by this title puts it in the difficult position of meeting sky-high expectations, and so the context of release and reviews demands addressing. Much of the confusion about what exactly No Man's Sky's is can be traced back to Hello Games' own statements—the studio understandably promoted its passion project hoping for any initial interest but lacked precise explanations of mechanics as fans flocked to it. Some promised or teased features also didn't make it into the launch version of the game, though I wouldn't assume malice here.

Another factor, which is crystallizing through observation of the earlier PlayStation 4 version launch, is the large number of potential fans projecting their own desires and preferences about the ideal version of the game onto the real project in development. This seems to be happening more than usual with No Man's Sky because its base concept pre-release—an unfathomably large, computer-generated galaxy to explore—is so inherently appealing and grand in scope that much of it seems a blank canvas on which to paint with the colors of your own genre preferences. But it simply can't be everything to everyone.

No Man's Sky
(For PC)

PROS Ceaselessly evokes an unmatched, fascinating feeling of discovery. Recursive galaxy is an immense technical achievement. Immersive world-building.

CONS Few defined activities or goals; adventuring alone may not be enough for everyone. Resource gathering is a grind. Half-baked combat and clumsy UI.



SoftGozar.com

Director Sean Murray and his team had their own vision in mind, ultimately a specific work of art the studio set out to create. Expectations vary so greatly between prospective players (think, for instance, of the many people who consumed little to no pre-launch coverage, and thus have no conception of what the game did or did not deliver) that it can't possibly be reviewed in the context of what ought to be, or whether one's pre-order was justified. The best way to critically examine No Man's Sky—the only fair way, I'd argue—is to strip all of that away and judge our own experiences with the game we've been presented with at launch.

ONE SMALL STEP FOR MAN

Your journey begins at the foot of a small fighter, and it quickly becomes apparent this spaceship is yours. Before you can climb aboard and shoot off into the stars, you're told the ship needs several repairs, which forces you to really soak in the starting environment to consider your options. A vast landscape stretches out in every direction, awash in distinct colors and dotted with foreign flora. I can't possibly describe what it will look like for you, which is the genius of the game's appeal: There are 18 quintillion planets to explore—a genuinely mind-blowing number of in-game locations—and so every player's starting location will be different. Mine was something of a paradise planet, with vibrant green grass gently blowing in the wind, rolling hills, and glowing plant life in the valleys.

Beautiful visual and sound design combines with mysterious lore for immersive world-building.

EVER ONWARD

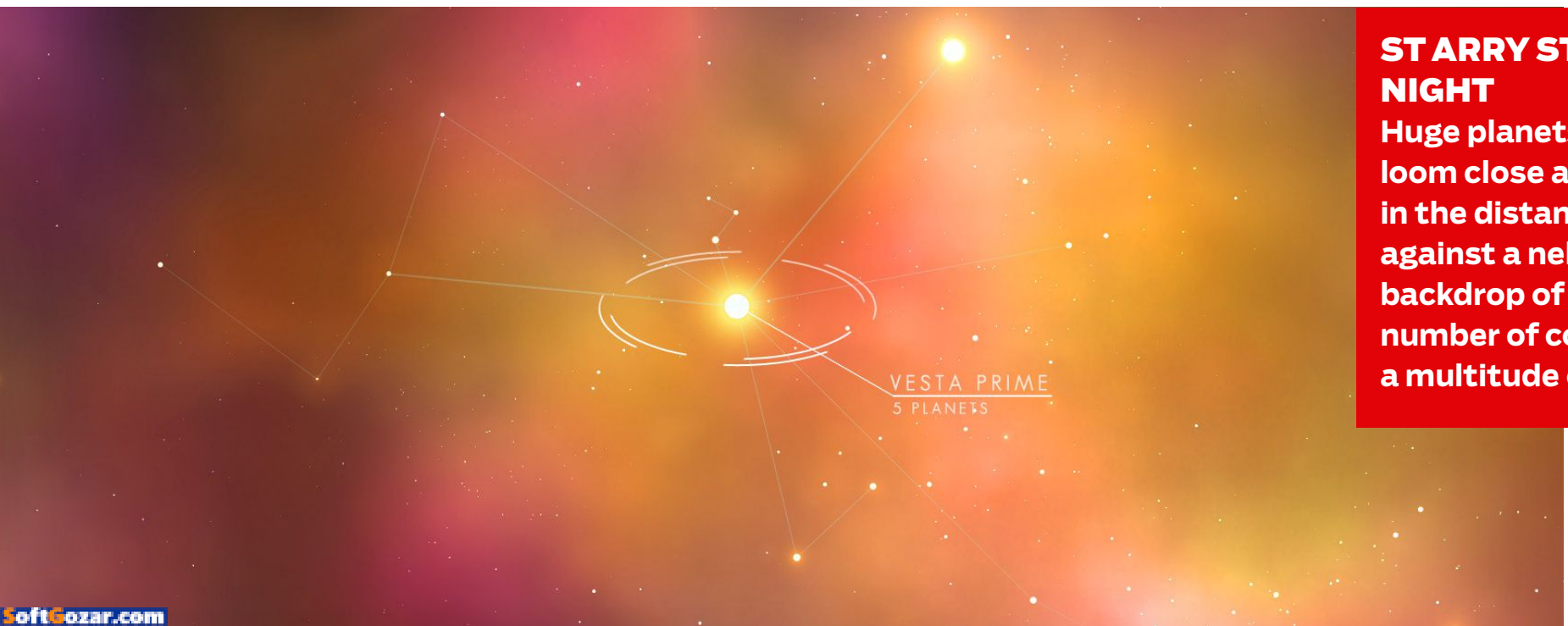
Even after working to escape the shackles of being grounded for the first time, there's an immediate, pulling temptation to visit another planet, each as unique as your starting location.


SoftGozar.com

That staggering number of planets means they were not each hand-crafted by the developers of course, but rather, procedurally generated by an algorithm the studio created, similar to the way Minecraft's terrain unfolds before you. But each game file is not a newly generated world: Every No Man's Sky player exists within one shared universe, meaning it's possible to stumble across a planet discovered and named by another player.

Odds of that are low (I didn't encounter a single such location in my 30 hours with the game), and there is no true multiplayer beyond this, which might disappoint some. But cooperative play is not a feature I expected, and I think it would be antithetical to No Man's Sky's integral sense of desperate loneliness. It's you and your ship against a hopelessly large galaxy, finding only occasional company in NPCs (non-player characters), who are more concerned with their own tasks than integrating you into their plans. Names left by other players are simply pockmarks on the universe, like the cryptic messages buried away in ancient ruins that inform you, piecemeal, about the world around you.

Setting off from your ship to look for resources is tense and represents the first expansion of the game's scope that No Man's Sky thrusts upon you. Every single facet of your surroundings is unfamiliar, from the terrain, to the potentially harmful atmosphere, and to what the resources you're hunting for even look like in the environment. Native creatures roam the landscape, and your multi-tool is your only method of defense, in more ways than one. Scanning the fauna—also generated by the game's math within a set of rules—tells you about their diet and temperament, while also filling out your life-form database. The multi-tool's steady laser stream doubles as both the way to mine for minerals, which appear as natural formations of varying texture and color in the landscape, and as a method of combat. You can spend resources as you progress to upgrade the device; there's a Boltcaster mode that serves as a more powerful gun, and a faster way to mine resources.



ST ARRY STARRY NIGHT
Huge planets may loom close ahead or in the distance, set against a nebulous backdrop of any number of colors and a multitude of stars.

SoftGozar.com

> **Planets don't feel thrown together with random parts but built in a cohesive way, in previously unseen numbers.**

You'll find what you need by simply moving around. Every planet provides the same basic materials needed for survival (though they take different forms), as well as unique combinations of more rare materials that won't appear elsewhere. It's a good system, since it won't leave you stranded yet provides uncertainty as to what will be over the next ridge on any planet. Each planet also has some form of derelict ruins, research facilities, and other locations of interest, which have varying types of rewards and outcomes.

The menu informs you how much carbon, heridium (an "element used in the creation of components vital to space exploration"), and other minerals both real and fictional are needed to fix your ship. It's a balancing act, since you use the same materials to refill your always-depleting Life Support bar as you do for ammunition, fuel, and upgrades. The UI is similar to Destiny's, with a cursor interface and press-and-hold buttons to make selections. It makes sense at times, but generally its inclusion leaves you wondering why the game's designers didn't opt for a traditional box-to-box inventory layout. Juggling resources between your suit and ship inventories is often a hassle, especially with the limited number of starting slots provided. There's less micromanaging as you purchase more spaces, but it's a finicky system.

SoftGozar.com

Mining itself is pretty mundane, and your enjoyment may ultimately depend on your tolerance for firing a laser into rocks and watching your material counts rise. I'd argue, though, that this aspect is no less senseless than grinding for materials and loot in an RPG, or hacking away at cubes in Minecraft—two of the most common activities in all of gaming. Still, it must be said that these mechanics represent much of what could irritate players about No Man's Sky, just as they rightly draw criticism in other genres, since mining takes up a chunk of your time and is not particularly exciting. The ill-received Mako resource gathering in the original Mass Effect was the other experience that kept coming to mind as I hunted for minerals across uncharted worlds, a comparison that won't endear this concept to most (though these attractive, larger planets have much more to them).

Yet, in the same way you wouldn't first describe or laud Bioware's RPG by its rote mechanics, No Man's Sky is more than the sum of its parts. Half-baked combat and clumsy inventory management become more minor quibbles when a brand new world is rolled out in front of you—minor roadblocks in the face of the feeling of discovery. No Man's Sky rewards patient, deliberate play: There's nowhere to rush to but plenty to see, and the scope really becomes apparent when your ship is ready to shoot into the stars.

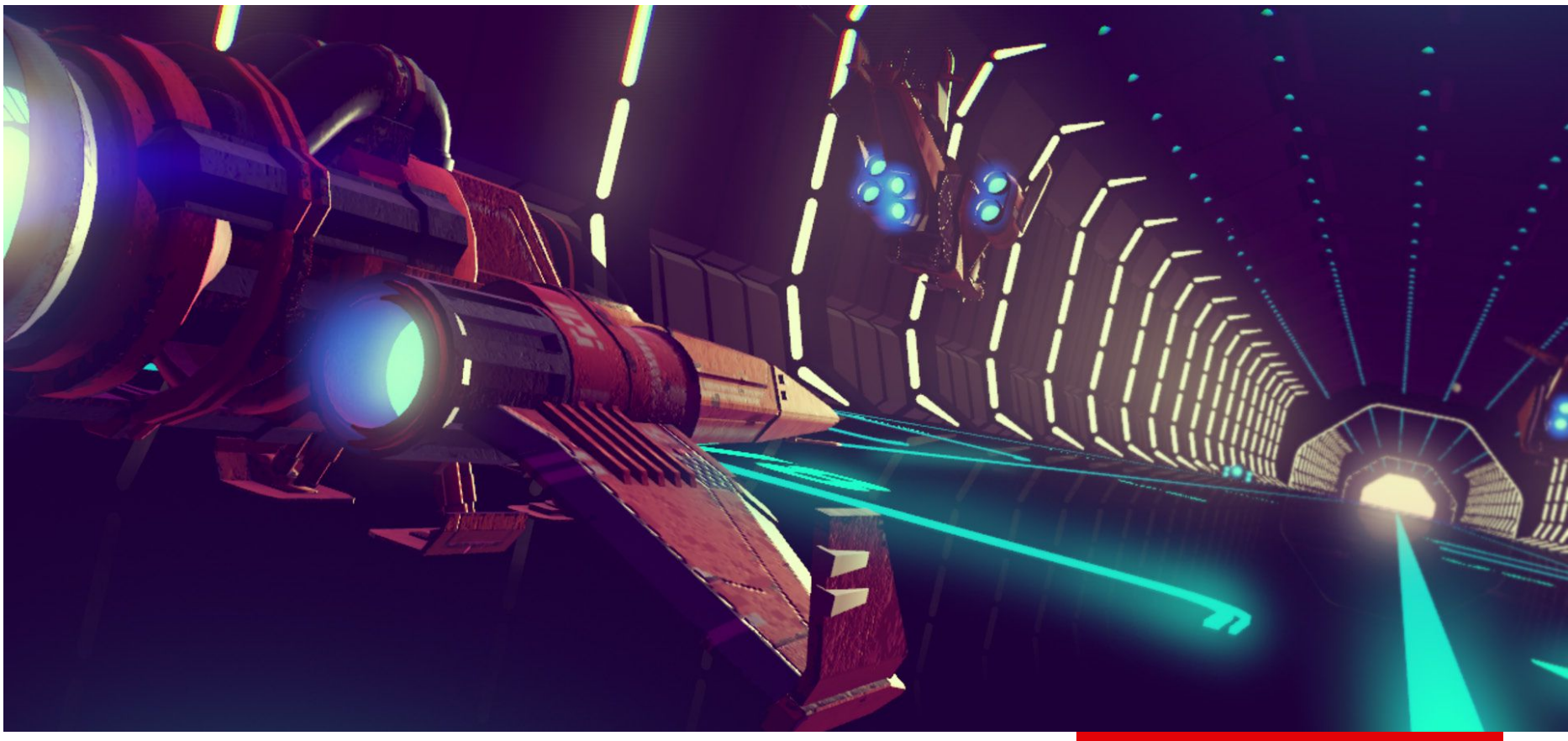
No Man's Sky rewards patient, deliberate play: There's nowhere to rush to but plenty to see.

DO NOT GO GENTLE INTO THAT GOOD NIGHT

The thrill of rocketing through the atmosphere never dissipates. Once your ship is spacefaring again and you have fuel on hand (namely plutonium, a common resource on the ground), you're free to come and go to any planet that you wish in free flight. Engines roar, and the excellent soundtrack by British band 65daysofstatic, which ranges from moody piano to rock-inspired riffs, shifts gears as you hurtle through the atmosphere and into space.

SoftGozar.com

Depending on the star system, other huge planets may loom close ahead or in the distance, set against a nebulous backdrop of any number of colors and a multitude of stars. The avenues of your adventure are limitless, whether you head straight for the center of the galaxy by Hyperdrive or boost to the planet right in front of you. Every star system on the expansive galaxy map holds several planets within, and each of them are as varied as the one on which you began. You can look at the systems the way they're connected for travel—with one or more branching jump lanes leading to another star—or observe the entire galaxy in a free-flight camera mode, a feature that reminds you of the sheer size of the game's universe, as its breadth widens again.



Each system also features a space station, which serves as a trade hub and ship shopping location, as well as a guaranteed interface for interacting with the alien faction controlling that region. An NPC sits inside, as they do on some planet-side buildings, offering short conversations and the chance to win a reward or improve your standing, should you choose the right option. There are generally three choices, and responding to some interactions will require guesswork, while the answers to others are hinted at with subtle clues. Rarely is the outcome overtly negative; you'll either get a mild bonus, a good reward, or nothing, depending on your selection. It's another simple system but one that generally throws something new at you to figure out.

POISED FOR FLIGHT
Once your ship is spacefaring and you have fuel on hand (namely Plutonium, which is easy to find), you're free to come and go to any planet as you please.

SoftGozar.com

The three Factions (sentient races) in the game have their own attitudes and views of the world, which you can gradually infer from messages and clues. Pirates occasionally engage your ship, halting your ability to jump. Fending them off is a tense but simple exchange. You can upgrade your vessel's shields and weapons, or buy a ship with superior firepower, though there's little to gain from seeking out dogfights. Losing all hit points in the air or on the ground creates a grave, which you have a chance to return to in order to regain your inventory. From space, you can head toward one of these stations with your faster Pulse Engines, jump star systems with your Hyperdrive, or burst back down to a planetary surface. The blackness of space is your silent launch pad to different paths of adventure.

Even after working to escape the shackles of being grounded for the first time, you'll feel an immediate temptation to visit another planet. Every planet will look and feel different—even with shared similarities—and offer enough open ground that flying to a distant destination on the other side of the planet can take half an hour of real time. And that's something you have to see and experience for yourself.

So you launch your ship into full throttle, speeding toward the surface, burning up as you tear through the sky. The terrain type only hinted at from space pulls into focus as you near the ground, perhaps contradicting your assumptions about what lies below. For instance, what once appeared to me as ocean from far above was proven to be bright blue grass as I drew closer. This kind of moment is No Man's Sky at its best. Touching down and stepping out of your cockpit evokes a sense of wonder as you see what type of terrain, weather, and native life the game provided you.

GALAXY MAP
Every star system on the expansive galaxy map holds several planets within, and each of them are as varied as the one on which you began.

SoftGozar.com

Landing on a second celestial body broadens that game's scope yet again; it's a scale that's almost difficult to consider. The act of landing on another planet is more eye-opening, more revealing of the game's size than seeing the galaxy map, because only then do you realize the significance of each star system waiting out there. As mentioned, there has been plenty of questioning about what players do in No Man's Sky—and to be sure, some features and folds hinted at explicitly or implicitly by Murray and earlier trailers did not make the release version—but the answer is simply, exactly what you see. Arriving on, exploring, and observing hundreds of new worlds is the meat of the game.

It's also what Murray attempted to get across countless times in interviews, and brushing it off while asking "what else?" misses the point of the experience and the creator's vision. It may not be enough for those seeking prescribed activities and deep, complex systems, but it's rewarding, engrossing, and valuable on its own. Money, minerals, and upgrades are the means to an end: The real currency No Man's Sky trades in are moments of unique beauty and awe, the ability to go farther and see more.

PLANETS, PROGRAMMING, AND THE PAST

Basing this game on exploration wouldn't work without the strength of the algorithm, and Hello Games' work in this area is an unequivocal technical achievement. Planets don't feel thrown together with random parts but built in a cohesive way, even though code did the work, and in previously unseen numbers. Barren, rocky surfaces are often partnered with irradiated climates, a sickly purple landscape warding you off both physically and visually. Snow falls gently on freezing planets, while some are dominated by large bodies of water and fittingly feature fauna with fins. Still others don't fit into any standard archetype, instead just feeling wholly alien thanks to strange, glowing clusters of plant life, sudden heat storms, and rare minerals. All the while, suitable, often serene music twinkles away in the background as you take in the scenery. The sound design as a whole adds meaningfully to the immersion, from the roaring of your ship's engine to howling winds, footsteps echoing off cave walls, and deafening silence.

Radiation slowly wears on your suit's protection levels, as do extreme heat, cold, and toxicity, giving you a few more threats to monitor and reason not to stray too far from your ship or shelter. The survival mechanics are somewhat toothless—it won't take long to collect enough resources to keep your resistances up—but the feeling of an oppressive atmosphere never leaves you. Like many of the game's mechanics, it's simple on its own but serves a greater purpose in world building and fuel for imagination.

SoftGozar.com

A loose narrative built largely on environmental storytelling binds the game together, providing just enough guidance in the beginning and mystery through the rest of the game. This begins early on, tied into the instructions on how to build your first Hyperdrive, and continues into space as you hunt down the mysterious Atlas. Any potential outcome of this journey is unknown to me at least for now, but it's an alternative path to follow from the trail to the center of the galaxy. It's also tied in to the only real recurring characters in the game, the amusing and well-written explorers Nada and Polo, as well as artifacts and messages you find on the surface. If you pay attention to the dialogue from this pair, you'll find winks and nods to the nature of the No Man's Sky's universe.

You can learn several Faction languages word by word from ancient stones and ruins on planet surfaces, as well as from NPCs, all of which help you read messages and hold conversations. Over time, recurring themes and musing about the Sentinels (the robotic guardians who roam every planet) come together to weave vague but consistent lore. This method of

ALIEN POLICE
Sentinals are self-replicating mechanical beings within the No Man's Sky galaxy. They'll attack players who commit certain infractions.

SoftGozar.com

EXOTIC SPECIES
The multitude of strange creatures in No Man's Sky are procedurally generated by an algorithm the studio created. They can be affected by the player, their surrounding area, and the planet's environment.

storytelling creates a sense that you're existing in a lived-in universe shaped by events in the past, even though other intelligent life is sparse, and your role in it is unclear. I haven't reached it yet, but there is an end goal to this path. Even if you don't seek out the conclusion, the information secreted away out there is another intriguing facet of the universe. Your insignificance as a lone space traveler is made crushingly apparent not only by the sheer physical space around you but also by an intangible feeling of not belonging in this world, constantly questing for answers, and probing for a place.

CONCLUSIONS

No Man's Sky's journey pushes every player to continue in this fashion, zipping from planet to planet and system to system across the galaxy, scrapping for resources to buy a larger ship, a better multi-tool, or a more powerful Exosuit, all in the name of more efficient exploration. Regardless of the many claims about what this game could or should be, it is clearly built around the sensation of discovery that it always promised, encouraging you to revel in every new environment and seek out an endless stream of frontiers. The magic of setting foot on a new world persists with every landing, even if your emergent routines and actions on each grow similar once you learn to recognize mineral formations and building types—small comforts against the insurmountable abyss of space.

MATTHEW BUZZI

SoftGozar.com

FEATURES

BY MAX EDDY

SoftGozar.com

When you think of encryption, what likely springs to mind are movies and TV shows filled with hacking and mysterious messages. You might also think of the recent battle between Apple and the FBI over the latter demanding access to encrypted information on a San Bernardino shooter's iPhone. But it's simpler: Encryption is the technique by which the understandable is rendered unintelligible—to anyone not holding the key, that is. Spies use encryption to send secrets, generals use it to coordinate battles, and criminals use it to carry out nefarious activities.

Encryption systems are also at work in nearly every facet of modern technology, not just to hide information from criminals, enemies, and spies but also to verify and clarify basic, personal information. The story of encryption spans centuries, and it's as complicated as the math that makes it work. And new advances and shifting attitudes could alter encryption completely.

We talked to a number of experts in the field to help us understand the many facets of encryption: its history, current state, and what it may become down the road. Here's what they had to say.

SoftGozar.com

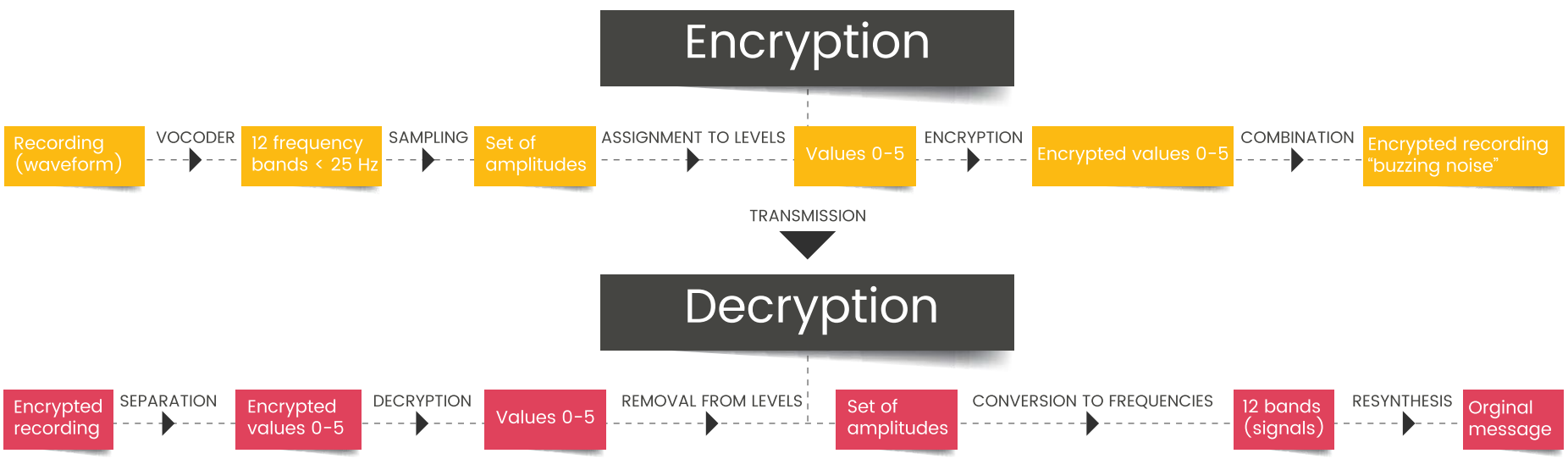
THE BIRTH OF MODERN ENCRYPTION

Professor Martin Hellman was working at his desk late one night in May, 1976. Forty years later, he took my call at the same desk to talk about what he had written that night. Hellman is better known as half of the pair Diffie-Hellman; with Whitfield Diffie, he wrote the milestone paper "New Directions in Cryptography," which completely changed how secrets are kept and more or less enabled the Internet as we know it today.

Prior to the publication of the paper, cryptography was a fairly straightforward discipline. You had a key that, when applied to data—a message about troop movements, for example—rendered it unreadable to anyone without that key. Simple cyphers abound even now; substitution cyphers, where a letter is replaced with another letter, is the simplest to understand and is seen daily in various newspaper cryptoquip puzzles. Once you discover the substitution, reading the rest of the message is simple.

For a cypher to work, the key had to be secret. This held true even as encryption methods became more and more complex. The technological sophistication and murderous severity of the Second World War produced several cryptographic systems that, while challenging, were still based upon this principle.

The Allies had SIGSALY, a system that could scramble voice communications in real time. The system's keys were identical phonograph records that were played simultaneously while the conversation was in progress. As one person spoke into the telephone, his words were digitized and meshed with specifically created noise on the record. The encrypted signal was then sent to another SIGSALY station, where it was decrypted using the encoding record's twin and the voice of the speaker was reproduced. After each conversation, the records were destroyed; new ones were used for each call. So each message was encoded with a different key, making decrypting much harder.



SoftGozar.com

The German military relied on a similar but more storied system for text communication: The Enigma machine consisted of a keyboard, wires, a plugboard similar to a telephone switchboard, rotating wheels, and an output board. Press a key, and the device would run through its mechanical programming and spit out a different letter, which lit up on the board. An identically configured Enigma machine would perform the same actions, but in reverse. Messages could then be encrypted or decrypted as fast as they could be typed, but the key to its infamous success was that the specific cypher changed each time the letter was pressed. Press A and the machine would display E, but press A again and the machine would display a completely different letter. The plugboard and additional manual configurations meant that huge variations could be introduced into the system.

The Enigma and SIGSALY systems were early equivalents to an algorithm (or many algorithms), performing a mathematical function over and over again. Breaking the Enigma code, a feat carried out by Alan Turing and fellow codebreakers at England's Bletchley Park facility, hinged on being able to understand the methodology employed by the Enigma machine.

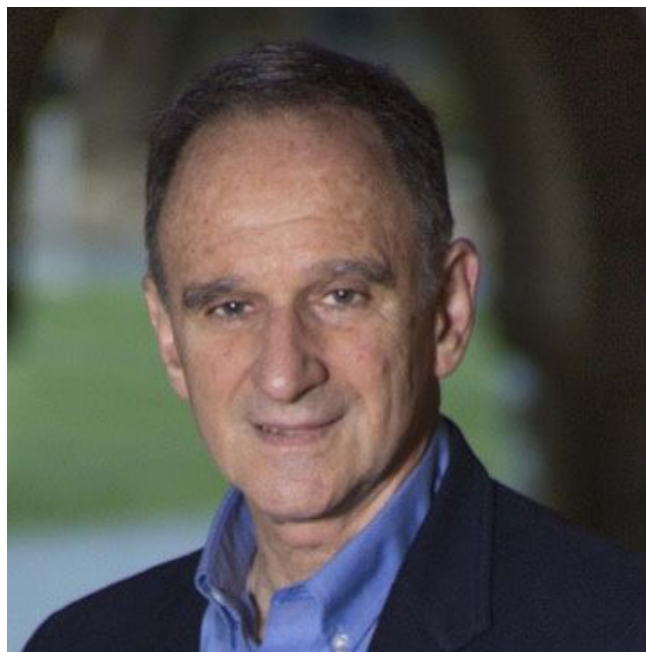
Hellman's work with cryptography was quite different in a number of ways. For one thing, he and Diffie (both mathematicians at Stanford University) were not working at the behest of a government organization For another, everyone told him he was crazy. In Hellman's experience, this wasn't anything new. "When my colleagues told me not to work in cryptography—instead of scaring me away, it probably attracted me," he said.

PUBLIC KEY ENCRYPTION

Hellman and Diffie, with the help of a third collaborator, Ralph Merkle, proposed a radically different kind of encryption. Instead of a single key on which the entire system would hang, they suggested a two-key system. One key, the private key, is kept secret as with a traditional encryption system. The other key is made public.

To send a secret message to Hellman, you'd use his public key to encipher the message and then send it. Anyone who intercepted the message would see just a great amount of junk text. Upon receipt, Hellman would use his secret key to decypher the message.

The advantage might not be immediately obvious,



PROFESSOR MARTIN HELLMAN
His pioneering work helped evolve encryption into systems we use today.

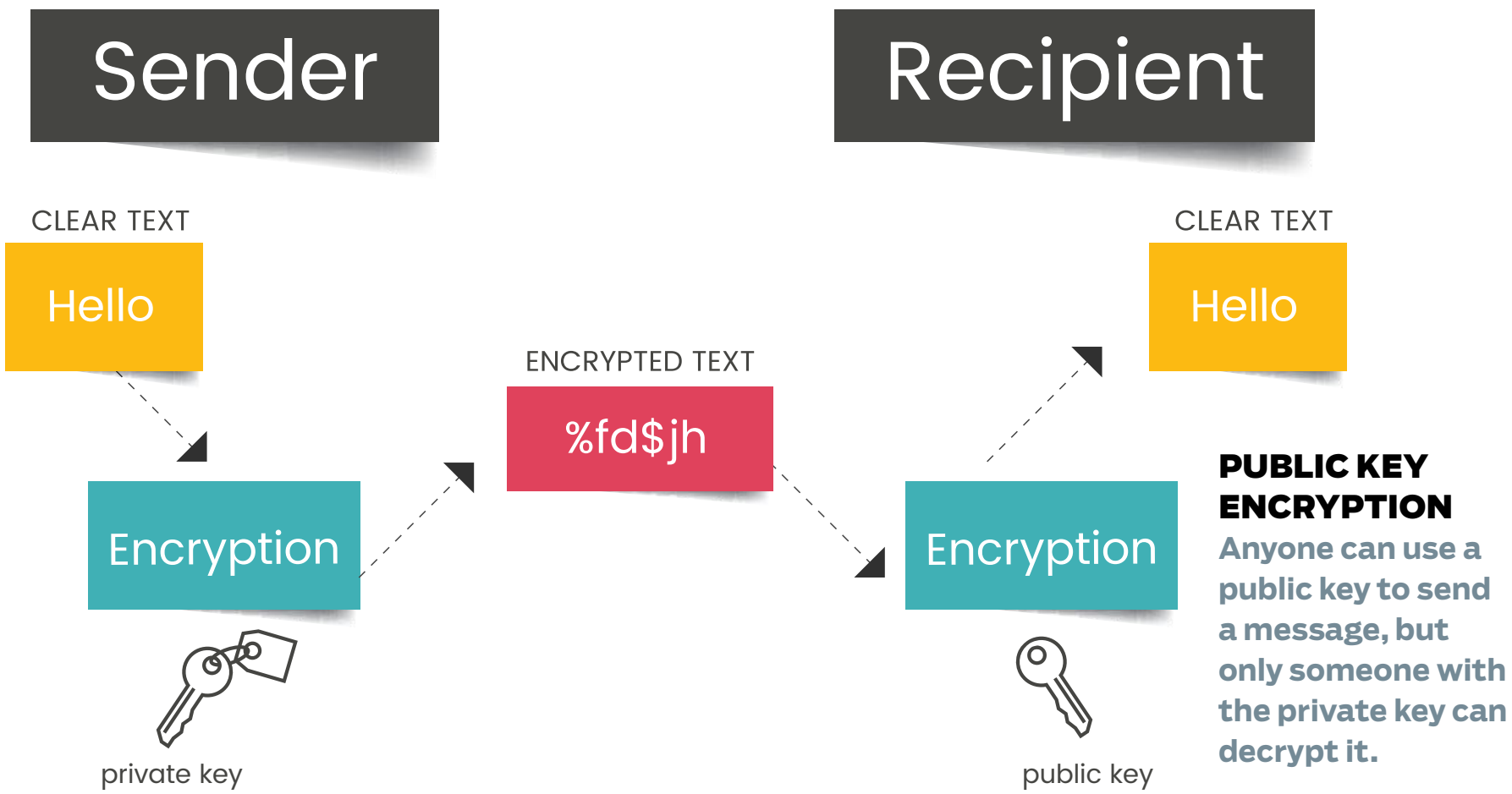
SoftGozar.com

but think back to SIGSALY. For that system to work, both sender and receiver needed identical keys. If the receiver lost the key record, there was no way to decrypt the message. If the key record was stolen or duplicated, the message could be unencrypted. If enough messages and records were analyzed, the underlying system for creating the keys could be discerned, making it possible to break every message. And if you wanted to send a message but did not have the correct key record, you couldn't use SIGSALY at all.

Hellman's public key system meant that the encryption key didn't need to be secret. Anyone could use the public key to send a message, but only the owner of the secret key could decipher it.

Public key encryption also eliminated the need for a secure means to relay cryptographic keys. Enigma machines and other encoding devices were closely guarded secrets, intended to be destroyed if discovered by an enemy. With a public key system, the public keys can be exchanged, well, publicly, without risk. Hellman and I could shout our public keys at each other in the

The Enigma and SIGSALY systems were early equivalents to an algorithm (or many algorithms), performing a mathematical function over and over again.



PUBLIC KEY ENCRYPTION

Anyone can use a public key to send a message, but only someone with the private key can decrypt it.

SoftGozar.com

middle of Times Square. Then, we could take each other's public keys and combine them with our secret keys to create what's called a "shared secret." This hybrid key can then be used to encrypt messages we send to each other.

Hellman told me he was aware of the potential of his work back in 1976. That much is clear from the opening lines of "New Directions in Cryptography":

> We stand today on the brink of a revolution in cryptography. The development of cheap digital hardware has freed it from the design limitations of mechanical computing and brought the cost of high grade cryptographic devices down to where they can be used in such commercial applications as remote cash dispensers and computer terminals. In turn, such applications create a need for new types of cryptographic systems which minimize the necessity of secure key distribution channels and supply the equivalent of a written signature. At the same time, theoretical developments in information theory and computer science show promise of providing provably secure cryptosystems, changing this ancient art into a science.

"I remember talking with Horst Feistel, a brilliant cryptographer who started IBM's effort that led to the data encryption standard," said Hellman. "I tried to explain [public key cryptography] to him before we had a workable system. We had the concept. He basically dismissed it and said, 'You can't.'"

His iconoclastic streak wasn't the only thing that drew Hellman to the advanced math at the heart of cryptography; his love of math did, too. "When I first started looking at [mathematical systems, I felt] like… Alice in Wonderland," he told me. As an example, he presented modular arithmetic. "We think that two times four is always eight, [but] it's one, in mod seven arithmetic."

His example of modular arithmetic isn't random. "The reason we have to use modular arithmetic is it makes what are otherwise nice, continuous functions that are easy to invert into very discontinuous ones that are hard to invert, and that's important in cryptography. You want hard problems."

The simplest way to try to break encryption is just to guess. This is called brute-forcing, and it's a boneheaded approach to anything. Imagine trying to unlock someone's phone by typing all the possible four-digit combinations of the numbers from 0 to 9. You'll get there eventually, but it could take a very, very long time. If you take this same principal and scale it up to a massive level,

SoftGozar.com

you start approaching the complexity of designing cryptographic systems.

But making it hard for an adversary to crack the system is only part of how encryption needs to work: It also needs to be doable by the people who are doing the encrypting. Merkle had already developed part of a public key encryption system before Diffie and Hellman published "New Directions in Cryptography," but it was too laborious.

"It worked in the sense that the cryptanalysts had to do a lot more work than the good guys," said Hellman, "But the good guys had to do far too much work for what could be done in those days, and maybe even today." This was the problem that Diffie and Hellman eventually solved.

Hellman's drive to tackle seemingly unsolvable problems takes a more personal bent in his latest work, coauthored with his wife, Dorothie Hellman: A New Map for Relationships: Creating True Love at Home & Peace on the Planet.

> **This is, at its core, what encryption is: really hard math. And all cryptographic systems can, eventually, be broken.**

ENCRYPTION'S BAD REPUTATION

Cryptography is a wonderland of mathematics to Hellman and his colleagues, but the general public seems to assume that encryption implies some kind of nefarious or unseemly activity.

Phil Dunkelberger has built a decades long career in encryption. He started with co-founding the PGP Corporation, based on the Pretty Good Privacy protocol invented by Phil Zimmerman and famously put to use by journalists working with Edward Snowden. Dunkelberger is now president and CEO at Nok Nok Labs, a company working to spearhead adoption of the FIDO system to streamline authentication—and hopefully, to kill passwords.

The problem with how encryption is perceived, Dunkelberger said, is that it has been largely invisible, despite being a daily part of our lives. "Most people

SoftGozar.com

don't realize when you put that PIN in… [it] does nothing more than kick off an encryption scheme, and key exchange, and protection of your data to be able to transfer the money and make that little door open and give you your cash."

Encryption, said Dunkelberger, has developed along with modern computing technology. "Encryption has to be able to protect your data to meet the both liability and legal requirements of things that have been around for hundreds of years," he said.

This is more important than ever, because, Dunkelberger said, data has become a currency—one that's stolen and then traded in Dark Web clearinghouses. "Encryption isn't nefarious. Without encryption, we can't do the things it enables," he said. "It's been an enabler since Julius Caesar used puzzles to send information into the battlefield so it wasn't intercepted by the enemy."

PHIL DUNKELBERGER
His company, Nok Nok Labs, is working to spearhead adoption of the FIDO system to streamline authentication

The kind of applied encryption that Dunkelberger works with, bringing it to ATMs, e-commerce, and even telephone conversations, makes things safer. The SIM card in his phone, said Dunkelberger, uses encryption to verify its authenticity. If there was no encryption protecting the device and the conversation, people would simply clone a SIM and make calls for free, and there would be no benefit to the wireless carriers that set up and maintain cellular networks.

"Encryption protects the investment that people made in providing you the goods and services that telephony provides. When you're worried about crime and people using [encryption] to hide or conceal or do things, that's taking a good thing and using it in a bad way," he said.

Dunkelberger has special frustration with legislators who periodically move to break or undermine encryption in the name of stopping the worst criminals. "I think we all agree that we'd like to catch bad guys and

SoftGozar.com

we'd like to stop terrorism… I bristled when there was intimation that people [who support encryption] were supporting pedophiles and terrorists."

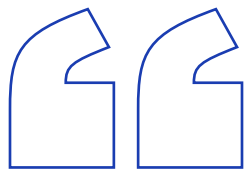
He provides a counterexample in cameras. Photography is a technology that's been around for a couple hundred years and enables all kinds of positive things: art, entertainment, sharing personal memories, and catching criminals (as in security cameras). "It's bad when those things are turned around and somebody taps into them or is suddenly spying on our daily lives, because that encroaches on our freedoms. At least, the freedoms that most people think we have."

GOOD MATH

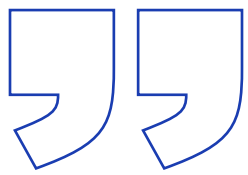
Bruce Schneier has the mathematical chops of any cryptologist, but he's mostly known for his honest assessment of issues in computer security. Schneier is something of a mythic figure to some. A colleague of mine, for example, owns a shirt that features Schneier's smooth-headed, bearded visage artfully superimposed onto the body of Walker, Texas Ranger, along with a statement celebrating Schneier's prowess as a security expert and how he is, in fact, standing right behind you.

His personality can, in a word, be described as direct. At the 2013 RSA conference, for example, he said of encryption that "the NSA can't break it, and it pisses them off." He also calmly, cuttingly remarked that it seemed likely that the NSA had found a weakness in a certain type of encryption and was trying to manipulate the system so that weakness was expressed more often. He described the NSA's relationship to breaking encryption as "an engineering problem, not a math problem." The latter statement is about working at scale: The crypto can be broken, but the messages still need to be decrypted.

Schneier is someone who understands the value of good math. He told me (paraphrasing Bletchley Park cryptanalyst Ian Cassels) that crypto is a mix of math and muddle, of building something very logical but also very



Dunkelberger has special frustration with legislators who periodically move to break or undermine encryption.



SoftGozar.com

complex. “It’s number theory, it’s complexity theory,” said Schneir. “A lot of bad crypto comes from people who don’t know good math.”

A fundamental challenge in cryptography, said Schneier, is that the only way to show a cryptosystem is secure is to try and attack and fail. But “proving a negative is impossible. Therefore, you can only have trust through time, analysis, and reputation.”

“Cryptographic systems are attacked in every way possible. They are attacked through the math many times. However, the math is easy to do correctly.” And when the math is correct, those kinds of attacks aren’t successful.

BRUCE SCHNEIER
A cryptographer, writer, and computer security/privacy specialist, Schneier is mostly known for his honest assessment of issues in computer security.

Math, of course, is far more trustworthy than people. “Math has no agency,” said Schneier. “In order for cryptography to have agency, it needs to be embedded in software, put in an application, run on a computer with an operating system and a user. All of those other pieces turn out to be extremely vulnerable to attack.”

This is a huge problem for cryptography. Let’s say a messaging company tells the world that no one has to worry, because if with its service, all messages will be encrypted. But the average person, you or me, might not have any idea whether the crypto system being used

SoftGozar.com

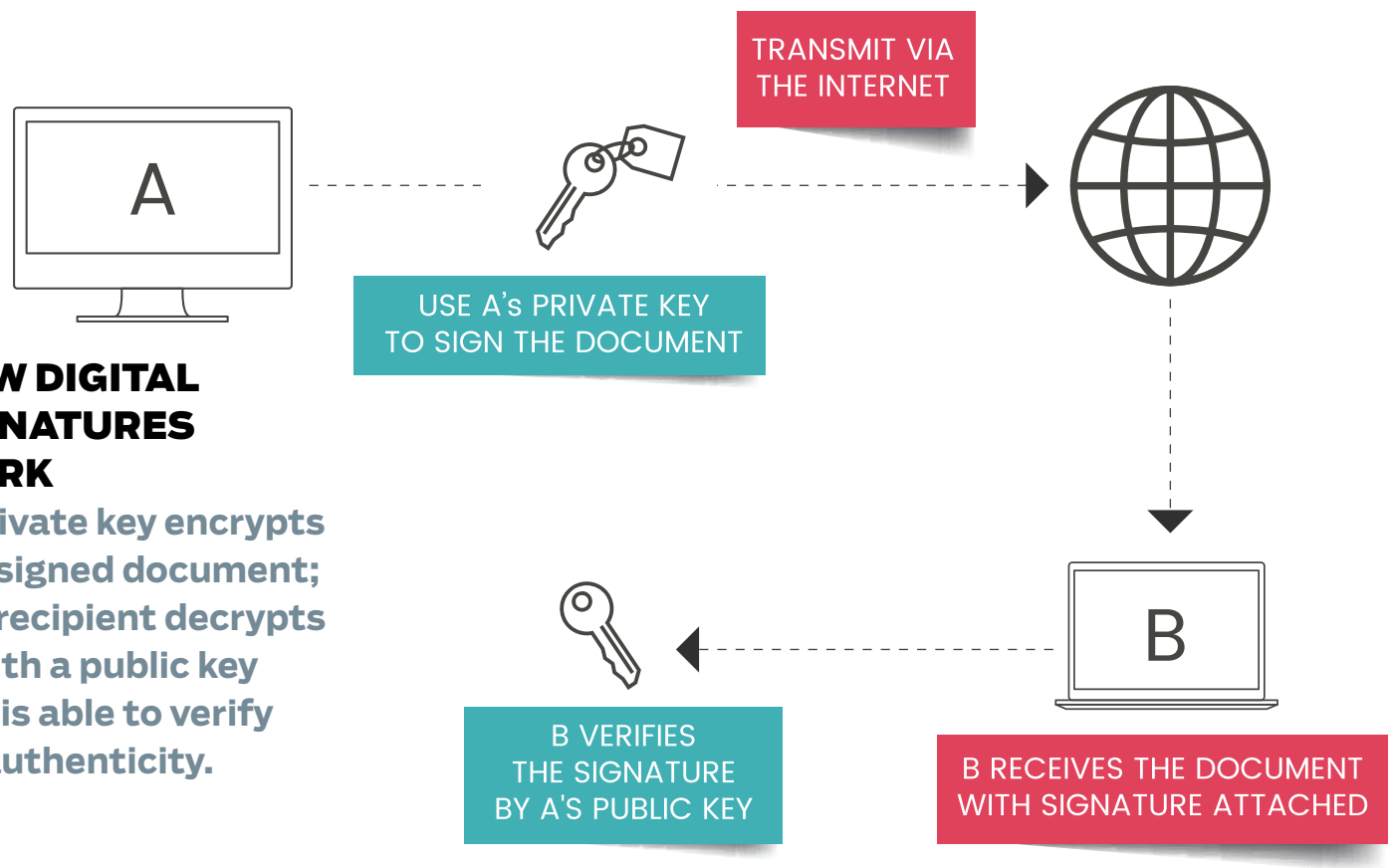
by the company is doing anything at all. That's especially problematic when companies create proprietary crypto systems that are closed for examination and testing. Even if the company does use a strong and proven cryptographic system, not even an expert could tell whether it was properly configured without having extensive inside access.

And then, of course, there's the issue of backdoors in encryption systems. "Backdoors" are various means that allow someone else, perhaps law enforcement, to read encrypted data without having the necessary keys to do so. The struggle between an individual's right to have secrets and the need for authorities to investigate and access information is, perhaps, as old as government.

"Backdoors are a vulnerability, and a backdoor deliberately introduces vulnerability," said Schneier. "I can't design those systems to be secure, because they have a vulnerability."

DIGITAL SIGNATURES

One of the most common uses of encryption, specifically the public key encryption that Hellman helped create and helped Dunkelberger popularize, is verifying the legitimacy of data. Digital signatures are just what they sound like, Hellman told me. Like a handwritten signature, it's easy for the authorized person to make and difficult for an imposter to reproduce, and it can be authenticated roughly with a glance. "A digital signature is very similar. It's easy for me to sign a message. It's easy for you to check that I've signed the message, but you cannot then alter the message or forge new messages in my name."



HOW DIGITAL SIGNATURES WORK

A private key encrypts the signed document; the recipient decrypts it with a public key and is able to verify its authenticity.

SoftGozar.com

Normally, when securing a message with public key encryption, you would use the recipient's public key to encrypt a message so that it's unreadable to anyone without the recipient's private key. Digital signatures work in the opposite direction. Hellman gave the example of a hypothetical contract where I would pay him in exchange for the interview. "Which, of course, I'm not going to require."

But if he did intend to charge me, he'd have me write out the agreement and then encrypt it with my private key. This produces the usual gibberish ciphertext. Then anyone could use my public key, which I can give away without fear of compromising the private key, to decrypt the message and see that I did indeed write those words. Assuming my private key hasn't been stolen, no third party could change the original text. A digital signature confirms the author of the message, like a signature—but like a tamper-proof envelope, it prevents the contents from being changed.

A digital signature confirms the author of the message, like a signature but prevents the contents from being changed.

Digital signatures are often used with software to verify that the contents were delivered from a trusted source and not a hacker posing as, say, a major software and hardware manufacturer with a fruit-themed name. It was this use of digital signatures, explained Hellman, that was at the heart of the dispute between Apple and the FBI, after the FBI recovered the iPhone 5c owned by one of the San Bernardino shooters. By default, the phone would have wiped its contents after 10 failed login attempts, preventing the FBI from simply guessing the PIN via a brute-force approach. With other avenues allegedly exhausted, the FBI requested that Apple create a special version of iOS that allowed for unlimited number of password attempts.

This presented a problem. "Apple signs each piece of software that goes into its operating system," said Hellman. "The phone checks that Apple has signed the operating system with its secret key. Otherwise, someone could load another operating system that wasn't approved by Apple.

SoftGozar.com

"Apple's public key is built into every iPhone. Apple has a secret key that it uses to sign software updates. What the FBI wanted Apple to do was to create a new version of the software that had this hole in it that would be signed by Apple." This is more than decrypting a single message or hard drive. It's an entire subversion of Apple's security infrastructure for iPhone. Perhaps its use could have been controlled, and perhaps not. Given that the FBI was forced to seek an outside contractor to break into the iPhone, Apple's position was clear.

THE RISE OF BLOCKCHAIN

While data that has been signed cryptographically is unreadable, cryptographic keys are used to open that information and verify the signature. Therefore, cryptography can be used to verify the data, in effect, clarifying critical information, not obscuring it. That's key to blockchain, a rising technology mired in as much controversy as encryption.

"A blockchain is a distributed, immutable ledger that is designed to be completely immune to digital tampering, regardless of what you're using it for—cryptocurrency, or contracts, or millions of dollars worth of Wall Street transactions" Rob Marvin, PCMag assistant editor (who sits a row away from me) explains. "Because it's decentralized across multiple peers, there's no single point of attack. It is strength in numbers."

Not all blockchains are the same. The most famous application of the technology is powering cryptocurrencies such as Bitcoin, which, ironically, is often used to pay off ransomware attackers, who use encryption to hold victims' files for ransom. But IBM and other companies are working to bring it to widespread adoption in the business world.

"Blockchain basically is a new technology that enables businesses to work together with a lot of trust. It establishes accountability and transparency while streamlining business practices," said Maria Dubovitskaya, a researcher at IBM's Zurich lab. She's earned a Ph.D. in cryptography and works not only on blockchain research but also on cooking up new cryptographic protocols.

Very few companies are using blockchain yet, but it has a lot of appeal. Unlike other digital systems for storing information, the blockchain system enforces trust with a mix of encryption and distributed database design. When I asked a colleague to describe the blockchain to me, she said that it was as close as we have yet come to establishing total certainty of anything on the Internet.

The IBM blockchain allows blockchain members to validate one another's transactions without actually being able to see who made the transaction on the

SoftGozar.com

blockchain, and to implement different access-control restrictions on who can see and execute certain transactions. “[They] will just know that it is a member of the chain that is certified to submit this transaction,” said Dubovitskaya. “The idea is that the identity of who submits the transaction is encrypted, but encrypted on the public key; its secret counterpart belongs only to a certain party that has the power of auditing and inspecting what’s going on. Only with this key, the [auditor] can see the identity of whoever submitted the certain transaction.” The auditor, who is a neutral party in the blockchain, would enter only to resolve some problem between the blockchain members. The auditor’s key can also be split among several parties to distribute the trust.

With this system, competitors could be working together on the same blockchain. This might sound counterintuitive, but blockchains are stronger the more peers are involved. The more peers, the harder it becomes to attack the entire blockchain. If, say, every bank in America entered into a blockchain that held banking records, they could leverage the number of members for more secure transactions, but not risk revealing sensitive information to one another. In this context, encryption is obscuring information, but it’s also verifying other information and allowing nominal enemies to work together in mutual interest.

“The most famous application of blockchain technology is powering crypto-currencies such as Bitcoin.”

When Dubovitskaya isn’t working on IBM’s blockchain design, she’s inventing new cryptographic systems. “I’m working basically on two sides, which I really like,” she told me: She’s designing new cryptographic primitives (the fundamental building blocks of encryption systems), proving them secure, and prototyping the protocols that she and her team designed in order to bring them into practice.

“There are two aspects of encryption: how it’s used and implemented in practice. When we design cryptographic primitives, like when we brainstorm on a

SoftGozar.com

white board, it's all math for us," Dubovitskaya said. But it can't stay just math. Math might not have agency, but people do, and Dubovitskaya works to incorporate countermeasures against known attacks being used to defeat encryption into new cryptographic design.

The next step is developing a proof of those protocols, showing how they are secure given certain assumptions about the attacker. A proof shows what hard problem an attacker has to solve in order to break the scheme. From there, the team publishes in a peer-reviewed journal or a conference and then often releases the code to the open-source community, to help track down missed problems and spur adoption.

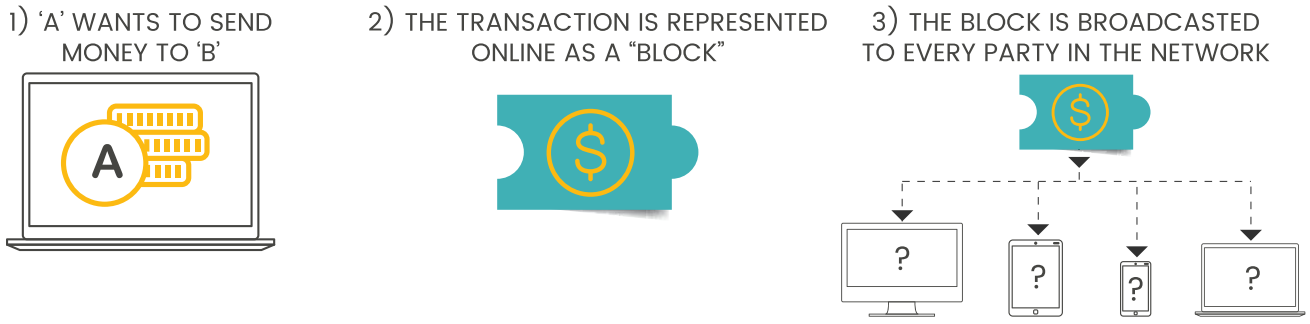
MARIA DUBOVITSKAYA
She's a research staff member at the Cognitive Computing and Industry Solutions Department at IBM Research.

We already have many ways and means to render text unreadable, or digitally sign data with encryption. But Dubovitskaya firmly believes that research into new forms of cryptography is important. "Some standard, basic cryptographic primitive might be enough for some applications, but complexity of the systems evolves. Blockchain is a very good example of it. There, we need more advanced cryptography that can efficiently realize much more complex security and functionality requirements," Dubovitskaya said. Good examples are special digital signatures and zero-knowledge proofs that

SoftGozar.com

allow one to prove that they know a valid signature with certain properties, without having to reveal the signature itself. Such mechanisms are crucial for protocols that require privacy and free service providers from storing users' personal information.

This process of iterating through proofs is what brought about the concept of zero-knowledge, a model for various types of public key encryption where an intermediary providing the service of encryption—say, Apple—is able to do so without maintaining any of the information necessary to read the data being encrypted and transmitted.



HOW BLOCKCHAIN WORKS

Blockchain allows members to validate one another's transactions without actually being able to see who made the transaction.

The other reason to design new encryption is for efficiency. "We want to basically make protocols as efficient as possible and bring them to real life," Dubovitskaya said. Efficiency was the devil of many cryptographic protocols two decades ago, when it was considered too onerous a task for computers of the time to handle while delivering a fast experience to human users. "That's also why we keep researching. We try to build new protocols that are based on different hard problems to make systems more efficient and secure."

SoftGozar.com

APPLIED CRYPTOLOGY

"If I want to send you a secret message, I can do that with encryption. That's one of the most basic technologies, but now crypto is used for all kinds of things." Matt Green is an assistant professor of computer science and works at the He mostly works in applied cryptography: that is, using cryptography for all those other things.

"There's cryptography that's math on a whiteboard. There's cryptography that is very advanced theoretical type of protocols that others are working on. What I focus on is actually taking these cryptographic techniques and bringing them into practice." Practices you might be familiar with, like buying stuff.

"Every aspect of that financial transaction involves some kind of encryption or authentication, which is basically verifying that a message came from you," Green said. Another more obscure example is private computations, where a group of people want to compute something together without sharing what inputs are being used in the computation.

The concept of encrypting sensitive information to ensure that it isn't intercepted by malicious third parties is much more straightforward. This is why PCMag recommends that people use a VPN (virtual private network) to encrypt their Web traffic, especially when they're connected to public Wi-Fi. An unsecured Wi-Fi network might be operated or infiltrated by a criminal intent on stealing any information that passes through the network.

"A lot of what we do with cryptography is to try to keep things confidential that should be confidential," said Green. He used the example of older cell phones: Calls from these devices could be intercepted by CB radios, leading to many embarrassing situations. Transit encryption ensures that anyone monitoring your activity (either wired or wireless) sees nothing but unintelligible garbage data.

But part of any exchange of information is not only ensuring that no one is spying on you but also that you are who you say you are. Applied encryption helps in this way as well.

Green explained that when you visit a bank's website, for example, the bank has a cryptographic key that's known only to the bank's computers. This is a private key from a public key exchange. "My Web browser has a way of communicating with those computers, verifying that key that the bank has really does belong to, let's say, Bank of America, and not somebody else," said Green.

For most of us, this just means that the page loads successfully and a little lock icon appears next to the URL. But behind the scenes is a cryptographic exchange involving our computers, the server hosting the website, and a certificate authority

SoftGozar.com

that issued the confirming key to the website. What it prevents is someone from sitting on the same Wi-Fi network as you and serving you a fake Bank of America page, in order to swipe your credentials.

Cryptographic signatures are used in financial transactions, which shouldn't be a surprise. Green gave the example of a transaction made with a chip credit card. EMV chips have been around for decades, although they've only recently been introduced to American's wallets. The chips digitally sign your transactions, said Green. "That proves to the bank, and to a court, and to anybody else that I really made this charge. You can forge a handwritten signature really easily, and people have done this all the time, but math is a whole different thing."

That, of course, assumes that the math and implementation of the math are sound. Some of Green's previous work focused on the Mobil SpeedPass, which let customers pay for gas at Mobil stations using a special key fob. Green discovered that the fobs were using 40-bit keys when they should have been using 128-bit keys—the smaller the cryptographic key, the easier it is to break and extract data. If Green or some other researcher hadn't examined the system, this may not have been discovered and could have been used to commit fraud.

The use of encryption also assumes that while there may be bad actors, the cryptographic system is secure. This necessarily means that information encrypted with the system could not be unencrypted by someone else. But law enforcement, nation states, and other powers have pushed for special exceptions to be made. There are many names for these exceptions: backdoors, master keys, and so on. But regardless of what they are called, the consensus is that they could have a similar or worse effect than attacks by the bad guys.

"If we build cryptographic systems that have backdoors, they'll start out being deployed in these

MATT GREEN
At the Johns Hopkins Information Security Institute, Green mostly works in applied cryptography.

SoftGozar.com

specific applications, but people will end up reusing the crypto for lots of different purposes. Those backdoors, which may or may not have made sense in the first application, get reused for another application," said Green.

For example, Apple built the iMessage messaging system to be encrypted from end to end. It's a well-constructed system, so much so that the FBI and other law enforcement agencies have complained that it might hinder their ability to do their jobs. The argument is that with the popularity of iPhones, messages that would otherwise have been available for surveillance or evidence would be rendered unreadable. Those in support of enhanced surveillance call this nightmare scenario "going dark."

"It turns out Apple uses that same algorithm or set of algorithms to do the inter-device communication that they've started building. When your Apple Watch talks to your Mac or to your iPhone, it's using a variant of that same code," said Green. "If somebody built a backdoor into that system, well, maybe it's not the biggest deal in the world. But now you have the possibility that somebody can eavesdrop on messages going between your phone and your watch, read your email. They could maybe send messages to your phone or send messages to your watch and hack the phone or the watch."

This is technology that we all rely on without really understanding it, Green said. "We as citizens rely on other people to look at technology and tell us if it's safe, and that goes for everything from your car to your airplane to your banking transactions. We trust that other people are looking. The problem is that it's not always easy for other people to look."

Green is currently engaged in a court battle over the Digital Millennium Copyright Act. It's most famously used to prosecute file-sharing pirates, but Green said that companies could use the DMCA Section 1201 to prosecute researchers like him for trying to do security research.

"The best thing that we really know how to do is try to settle on a few reputable solutions that have been looked at by experts and have gotten some praise by experts," said Green.

QUANTUM CRYPTOGRAPHY COULD CHANGE EVERYTHING

With the egoless interest of someone really passionate about his craft, Martin Hellman explained to me the limitations of the cryptographic system he helped create and how Diffie-Hellman encryption was being picked apart by modern researchers. So he's entirely credible when he says that cryptography faces some surprising challenges.

SoftGozar.com

He told me that in 1970 there was a major breakthrough in factoring, called continued fractions. The difficulty involved in factoring large numbers is what makes cryptographic systems so complex, and therefore difficult to crack. Any advance in factoring reduces the complexity of the cryptographic system, making it more vulnerable. Then in 1980, a breakthrough pushed factoring further, thanks to Pomerance's quadratic sieve and the work of Richard Schroeppel. "Of course, RSA [computer encryption] didn't exist in 1970, but if it did, they would have had to double key sizes. 1980, they had to double them again. 1990 roughly, the number field sieve roughly doubled the size of numbers again that we could factor. Notice, almost every 10 years—1970, 1980, 1990—there's been a doubling of key size required. Except in 2000, there was no advance, no major advance since then."

Some people, Hellman said, might look at that pattern and assume mathematicians had hit a wall. Hellman thinks differently. He invited me to think of a series of coin flips. Would I assume, he asked, that after coming up heads six times in a row, it was a certainty that the next flip would be heads?

The answer, of course, is absolutely not. "Right," said Hellman. "We need to worry that there might be another advance in factoring." That could weaken existing cryptographic systems or render them useless altogether.

This might not be a problem right now, but Hellman thinks we should be looking for backup systems for modern crypto in the event of future breakthroughs.

But it's the possibility of quantum computing, and with it, quantum cryptanalysis, that could actually break every system that currently relies on encryption. Today's computers rely on a binary 1-or-0 system to operate, with light and electricity behaving as they should. A quantum computer, on the other hand, could take advantage of quantum properties to function. It

Another advance in factoring could weaken existing cryptographic systems or render them useless altogether.

SoftGozar.com

could, for example, use a superposition of states—not just 1 or 0 but 1 and 0 at the same time—enabling it to perform many calculations simultaneously. It could also make use of quantum entanglement, in which a change to one particle is expressed in its entangled twin faster than light.

It's the sort of thing that makes your head ache, especially if you already get tripped up trying to understand classical computers. The fact that we even have the phrase "classical computers" is perhaps indicative of how far we have come with practical quantum computing.

"Pretty much all of the public key encryption algorithms we use today are vulnerable to quantum cryptanalysis," said Matt Green. Remember, the utility of modern encryption is that it takes seconds to encrypt and decrypt information with the right keys. Without the keys, it could take an incredibly long time even with a modern computer. It's that differential in time, more than math and implementations, that makes encryption valuable.

"Normally [it] would take millions and millions of years for standard classical computers to break, but if we are able to build a quantum computer, we know algorithms we can run on it that would break these cryptographic algorithms in a few minutes or a few seconds. These are the algorithms we use to encrypt pretty much everything that goes over the Internet, so if you go to a secure webpage, we use these algorithms; if you do financial transactions, you're probably using some of these algorithms. Yes, the person who builds a quantum computer first will be able to break and listen in on a lot of your conversations and your financial transactions," said Green.

If you've wondered why major world players like the U.S. and China are spending enormous volumes of cash investing in quantum computing, that's at least part of the answer. The other part is doing some computational work that could yield breakthroughs of enormous importance: say, ending diseases.

But as Hellman suggested, researchers are already working on new cryptographic protocols that would stand up to scouring by a quantum computer. The quest for a working quantum computer has yielded promising results, but anything even resembling an effective quantum computer is far from the mainstream. Thee research in how to guard against quantum cryptanalysis goes forward operating under the assumptions we can make about how such a computer would work. The result is a wildly different kind of encryption.

"These problems are fundamentally mathematically different from [the] algorithms that you can use the quantum computer to break," Maria

SoftGozar.com

Dubovitskaya told me. A new kind of math using lattice-based assumptions, explained Dubovitskaya, is being used to ensure that when the next generation of computers comes online, cryptography doesn't disappear.

But quantum computers that would give Einstein a heart attack are just one of the threats to modern encryption. A more real concern is the ongoing attempt to make encryption fundamentally insecure in the name of national security. The tensions between government and law enforcement efforts to make encryption more accessible to surveillance has gone on for decades. The so-called Crypto Wars of the 1990s had many battles: The CLIPPR chip, an NSA-endorsed system designed to introduce a cryptographic backdoor into the U.S. mobile telephony system; attempting to bring criminal charges against PGP's creator Phil Zimmerman for using more secure encryption keys than were legally allowed; and so on. And of course, in recent years, the focus has moved from limiting encryption systems to introducing backdoors or "master keys" to unlock messages secured with those systems.

The issue, of course, is far more complex than it appears. Phil Dunkelberger said that, in the case of bank records, there can be dozens of records with individual encryption keys, and then keys to simply look at the data stream. This, he said, brings about the discussion of so-called master keys that would cut through these layers by weakening the math at the heart of the systems. "They start talking about weaknesses in the algorithm themselves, not the implied use of encryption," he said. "You're talking about being able to run at the foundation of that protection itself."

And perhaps frustration looms even larger than the danger. "We've got to get out of revisiting the same problems," said Dunkelberger. "We've got to start looking at innovative ways to solve the problems and move the industries forward, so the users can just go about their lives as they would any other day."

MAX EDDY

SoftGozar.com

THE SECRET TO CROWDFUNDING SUCCESS FOR INVENTORS AND BACKERS

BY MOLLY K. MCLAUGHLIN

SoftGozar.com

To say crowdfunding is on the rise would be an understatement. Crowdfunding—raising small amounts of money from a large number of people in order to launch a product, service, or project of some sort—is virtually exploding, with the total volume of money raised from backers doubling year over year since 2012. According to marketing company Massolution's 2015CF report, the global crowdfunding industry was expected to grow to approximately $34.4 billion by the end of 2015.

Considering such popularity, it's no wonder there are so many crowdfunding success stories. For one, the Veronica Mars Movie Project raised $5.7 million on Kickstarter and was able to produce and release a movie based on the cult-favorite TV show in 2014. And the inventors of a better beehive, called the Flow Hive, raised more than $12 million on Indiegogo in 2015 and are now selling the product to the general public.

The Veronica Mars Movie Project raised $5.7 million on Kickstarter and was able to produce and release a movie.

RISKY BUSINESS
We hear lots of crowdfunding success stories—but some campaigns never deliver on their promises.

SoftGozar.com

THE DARK SIDE OF CROWDFUNDING

But not all campaigns succeed. Many don't even reach their funding goals, and others flounder when it's time to deliver promised perks for investors—particularly when it comes to product launches.

Crowdfunding products have unique challenges. Josh Belzman, a Seattle-based digital media specialist, knows this all too well. He's backed several high-profile crowdfunding campaigns, including the original Pebble watch, the Coolest Cooler, and the Kreyos smartwatch. All three suffered from manufacturing delays. The Kreyos endured the most setbacks, although it eventually shipped faulty products to some backers. "I actually got out of that one. I got a refund before the final product shipped," Josh said.

“The Kreyos endured the most setbacks, although it eventually shipped faulty products to some backers.”

The Pebble Watch was delayed only a few months and went on to become a successful product line, but the Coolest Cooler, a cooler with built-in speakers, a blender, and other tech, still hasn't delivered to all of its backers. The Coolest Cooler's 2014 Kickstarter campaign broke records—62,642 backers pledged $13,285,226—and went viral, which is how Josh discovered it. "It felt like a safer bet at the time, but in hindsight, just because they have that scale or over-popularity doesn't mean that everything is polished up, and there really were no guarantees," he said.

That unprecedented fundraising success was great news for the company: That is, until founder Ryan Grepper realized that the cost to ship coolers to backers all over the world exceeded what had been raised and had to delay reward fulfillment. (Kickstarter now enables inventors to choose to which countries they're willing to ship their rewards.) His goal had been to raise only $50,000, and many backers were getting a deeply discounted cooler as a Kickstarter reward. In late 2015, in a bid to raise money in order to fulfill those rewards,

SoftGozar.com

the company started selling the cooler at its retail price ($499) to the general public, which greatly frustrated its backers, who were still waiting for their coolers. All of this was explained in updates to the campaign page on Kickstarter, and yet angry comments abounded.

DOING IT RIGHT

So how can an entrepreneur avoid this kind of pitfall? “I think the most important thing for an entrepreneur to know is that they won’t be doing it alone,” said Indiegogo CEO David Mandelbrot. “In a variety of ways, they’ll be doing it in partnership with other entities, whether it’s in those that are helping them with design, with manufacturing, shipping, with retail.” In other words—find partners before you raise funds.

“There are a million and one details you need to get figured out, and if you don’t go into it without all of those things ironed out, then you’re going to get yourself in trouble,” said Peter Dering, co-founder of Peak Design, a gear company that has used Kickstarter to launch more than 20 products. The company’s first five campaigns raised $7,130,163 from more than 42,000 backers; its latest campaign for the Everyday Backpack, Tote, and Sling ultimately raised $6,684,621. Dering recommends that creators have their product ready for mass production before even launching a campaign.

You can’t expect product launches to be perfect every time. One of Peak Design’s products, a camera accessory, initially shipped with a flaw that rendered it useless. But the company was able to come up with a cost-effective solution and avoided dealing with reshipping fees. “It would have been a blow to business,” Dering said.

SO YOU’RE FUNDED—NOW WHAT?

It’s clear that the real work begins once you reach your campaign goal, especially if you don’t have experience launching a product. Kickstarter and Indiegogo each offer a wealth of online resources for crowdfunders, though the companies have different approaches.

“There is now this whole ecosystem of companies that basically exist to help creators get their devices and such out the door, “ said David Gallagher, Director of Media Relations for Design, Tech, and Games at Kickstarter. The company has a resources page that creators can use to find manufacturing, shipping, and other potential partners, although Kickstarter doesn’t have a direct relationship with them. Kickstarter also requires that product creators have a working prototype, with pictures and video as backup before a campaign

SoftGozar.com

launches. One of the issues that surfaced with the Kreyos smartwatch was that the company hadn't actually created a fully-functioning prototype before embarking on its Indiegogo campaign.

Indiegogo has branched out into the post-funding realm with two products: InDemand and Marketplace. The former enables crowdfunders to continue raising funds even after a campaign is over; it's a place to gather pre-orders. The Marketplace is an e-commerce solution that can be used to sell finished products. Both are open to Indiegogo users but also to those who raised funds on other crowdfunding platforms.

The company also has a number of manufacturing and distribution partners, including Brookstone. Indiegogo mines its data to find Brookstone-compatible products and then pitches them to the company. Brookstone has the infrastructure to take on manufacturing and the retail experience to sell the products.

Entrepreneurs can also approach Brookstone directly via Brookstone Launch. And Amazon Launchpad is an alternative that handles inventory management, fulfillment, customer service, and more; in fact, Coolest Cooler has used that service.

All Kickstarter campaigns have a risks and challenges section, and they are a must-read.

BACKERS, BEWARE

"I do think Kickstarter and Indiegogo can do a better job of really being clear with people that this is not a marketplace, that you're investing in an idea and not a product," said Coolest Cooler backer Josh Belzman. Both sites do offer trust and safety pages that outline their terms of use, which includes what happens when a campaign goes south. Each also has guides for prospective backers about what to expect and how to vet a campaign.

Additionally, all Kickstarter campaigns have a risks and challenges section, and they are a must-read. Creators are encouraged to share potential hurdles they

SoftGozar.com

may come across throughout the process and to be clear about their background and experience. “The most important role of that chunk of the page is to remind everyone that this is a project and not a product yet,” Gallagher said. “This is an idea that this person has.”

Both Indiegogo and Kickstarter stress the importance of researching that person before backing a project. “Focus on the track-record of the entrepreneur. Do they have experience in developing a product like this?” Mandelbrot said.

Neither company offers refunds. Creators can set up their own rules for refunds and returns, so be sure to read the fine print. Ask questions, read the comments, and gauge how quickly and effectively the campaign responds. If something seems amiss, report the project to the crowdfunding platform, which will trigger an investigation. If violation of the terms of use, such as fraud, is suspected, the companies will intervene.

As for Josh, he did finally get his cooler after waiting nearly a year and a half. It arrived just in time for the July Fourth weekend. He and thousands of other backers took Coolest up on its offer to pay an additional $97 for expedited shipping. Josh is happy with his cooler but leery of crowdfunding tech products. “I think I might be done with these for a while,” he said.

“Both Indiegogo and Kickstarter stress the importance of researching before backing a project.”

MOLLY K. MCLAUGHLIN

SoftGozar.com

HOW BEAMR AND V-NOVA REVOLUTIONIZED 4K VIDEO

4K video is here—but is what we're seeing really 4K?

BY TROY DREIER

SoftGozar.com

3D TV hasn't really found an audience; it feels too gimmicky for most of us. But 4K sets are selling at a rapid rate. 4K offers four times the resolution of HD, as well as richer colors and blacker blacks thanks to included high dynamic range (HDR) technology—and that's something shoppers can see. TV makers have sold over 8 million 4K TVs to date, 1.4 million in the U.S.

How are viewers getting their 4K? In many cases, they're not. Broadcasters don't yet offer 4K content over the air, and the selection on cable and satellite is limited. That leaves many homes relying on online sources for 4K video.

A HIGH-RES REVOLUTION
Two companies are making 4K video much more accessible to home viewers—by condensing it.

> **4K offers four times the resolution of HD, as well as richer colors and blacker blacks.**

But streaming providers run into another problem: Most U.S. homes don't have the bandwidth to stream 4K video. Although 15Mbps is considered the minimum speed at which to stream 4K, Netflix recommends 25Mbps. And according to the latest "State of the Internet" report from content delivery network Akamai, no state in the U.S. has an average connection speed of 25Mbps—the overall average speed is 15.3Mbps.

Rather than 4K video, many viewers are getting 1080p video that's upscaled by their 4K TVs. So how can people get the ultra-crisp video they want?

SoftGozar.com

Bandwidth is creeping up over time, but the swifter solution is for 4K to get smaller. Here's how two companies are trying to condense 4K.

BEAMR

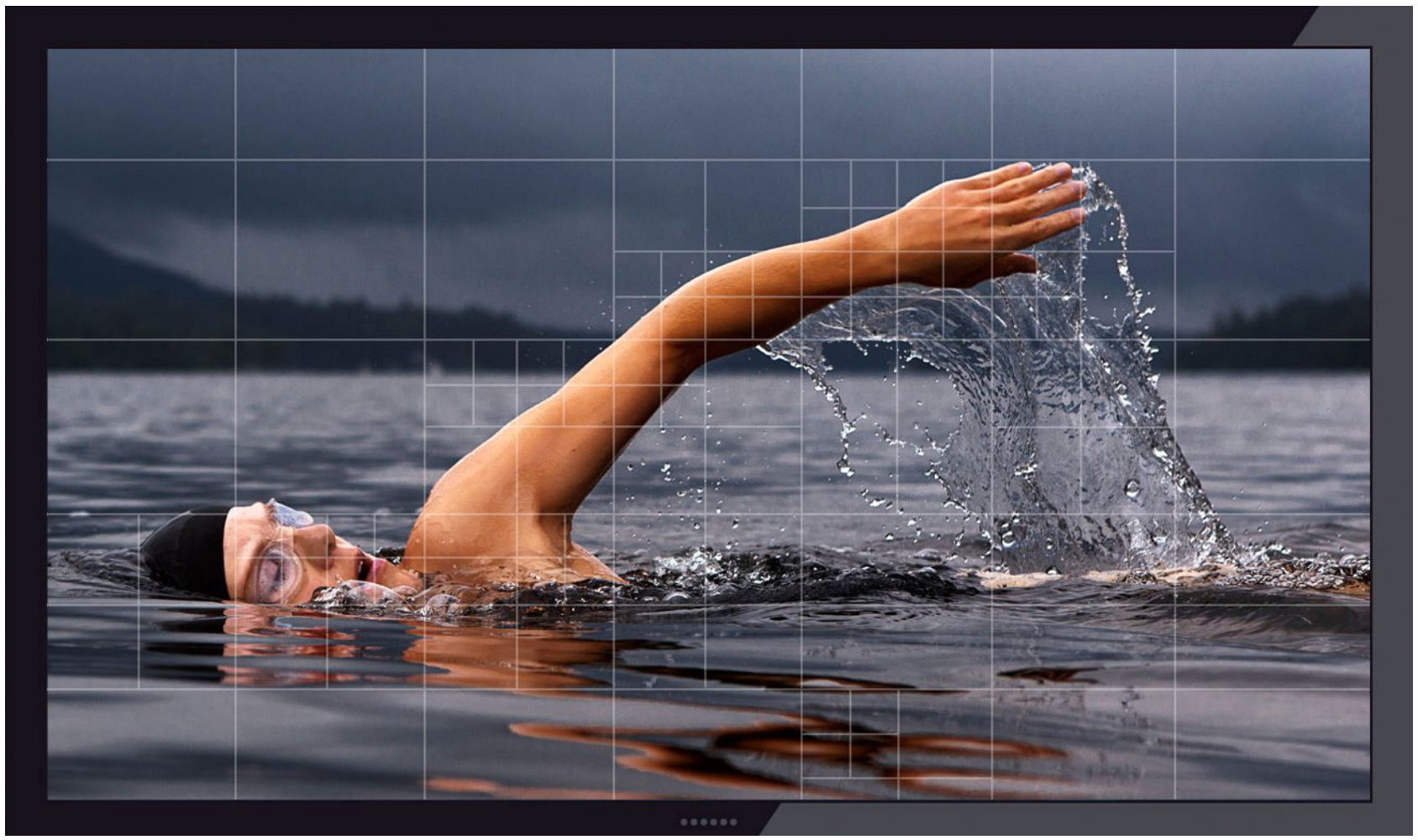
For Tel Aviv–based Beamr, reducing the size of images comes down to dividing each frame into blocks, measuring the perceptual quality of each individual block, then reducing the size as low as possible without changing that measure of quality. It's an approach that works on everything from JPEGs to UHD videos: Calculate the level of quality that the human eye can actually see, then optimize against it. This leads to smaller size files in which the output looks unchanged to the viewer. Beamr's software examines elements such as texture, gradients, and edges when calculating perceptual quality.

For 4K video, Beamr has created its own optimization of the HEVC codec. HEVC is one of the main video codecs on the market, and it's used to create small files with high quality.

HEVC is one of the main video codecs on the market, and it's used to create small files with high quality.

BEAMR'S METHOD

This company's approach to streaming 4K is to divide frames into blocks, then reducing the size of each while retaining quality.



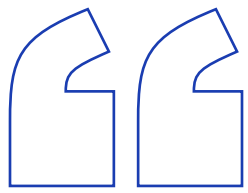
SoftGozar.com

“The Beamr process, our magic and the secret sauce, is that we have developed a quality measure that’s able to, on a frame-by-frame basis, drive the encoder to the lowest bit rate possible before it introduces artifacts,” says Mark Donnigan, Beamr’s vice president of marketing. Artifacts are any type of visual error created during the encoding process.; the most common artifact is blockiness, created when the video player has too little information on how a block should display. Beamr’s software encodes a frame, measures the resulting quality, and re-encodes it if artifacts were introduced. It averag-es 1.5 encodes per frame.

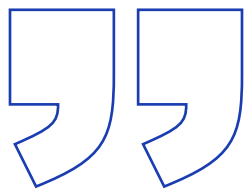
Beamr is at the forefront of a move in video encoding that recognizes not all video needs the same level of compression to produce good results. Some genres, such as action or superhero films, have a lot of on-screen activity and use fast cuts. They need larger file sizes to look good to the viewer. Slower-paced dramas and animated films can be compressed more without sacrificing visual quality.

Solutions like Beamr that consider the type of video being compressed are called content-adaptive. Approaching all genres with one-size-fits-all encoding results in some files that are too large and some that sacrifice visual quality. In December 2015, Netflix an-nounced it had re-encoded its entire video library with an approach that looked at each title individually.

“The challenge that the industry has is when you look at 4K files, a high-action movie can require many more bits than can be streamed into the average U.S. household to retain the quality and really deliver the best experience,” Donnigan says. For slow-moving dramas, Beamr’s content-adaptive HEVC optimization can get 4K files down to 10Mbps, while high-action blockbusters are closer to 25Mbps. Companies including Netflix, Dolby, Dalet, Sony and, IBM rely on Beamr’s encoding and optimization tools.



The most common artifact is blockiness, created when the video player has too little info on how a block should display.



SoftGozar.com

V-NOVA

London-based V-Nova is a newer player in the video compression space, and its Perseus codec, launched in April 2015, has an unconventional solution for reducing file sizes.

Most video compression solutions (including Beamr) divide each frame into blocks, then reduce the amount of information for each block. Perseus, on the other hand, produces the lowest-size image for each frame first, then adds detail to create successive higher-resolution versions. These are streamed using a technology called adaptive streaming, and the player and connection determine which version to use at any moment. Because the frame is never divided into blocks, blocky artifacts aren't a problem. Lower-file-size videos appear softer, with less detail, but aren't blocky.

"Perseus is a different approach to video compression. It really rewrites the underlying grammar of how we interpret data in general and video in particular," says Fabio Murra, V-Nova's senior vice president for product and marketing.

V-Nova's radical approach has resulted in radical compression claims. The company has successfully streamed 4K video of 6Mbps over a cellular network, and produced 4K movies at 4Mbps.

Early tests have shown that V-Nova does indeed produce significantly smaller files than the competitors, and its visual results stand up to scrutiny. That's why this newcomer has already won a few major clients, including French satellite operator Eutelsat and satellite TV platform Sky Italia.

SoftGozar.com

Its process, however, raises a question: When is a 4K image no longer a 4K image? Perseus creates ultra-small files that literally have a 4K resolution, but do those videos include the level of detail that viewers expect with ultra-high definition (UHD) video? Murra says it's up to customers to decide what they think is acceptable.

"The way the algorithm works, it starts with a smaller version of that picture and basical-ly enlarges it, adds detail, enlarges and adds detail. We can always get the resolution to 4K. Even if you give us 1MB, we get a 4K picture because it's going to be a 4K resolu-tion," Murra explains. "Obviously it's going to be so soft that you say, 'Hey, this is not 4K anymore.' It's a very valid question, and this is why we do a lot of tests. We do comparative tests or tests with our customers that say, 'OK, this is your content; how far do you think you can push it?'"

Pushing it is exactly what network operators need to do now, with video traffic making up a growing percent of online data, and perhaps V-Nova's solution will be the one that allows us unlimited UHD content without choking the networks. When that happens, we'll know that our 4K TVs are finally showing us 4K video.

Perseus creates ultra-small files that literally have a 4K resolution, but do the videos include the level of detail viewers expect?

TROY DREIER

SoftGozar.com

How to Kid-Proof Your iPhone or iPad

BY JILL DUFFY

When you hand over your iPhone or iPad to your kid (or someone else's), make sure it's safe for both of you. Children should be able to play games and watch videos but not accidentally wipe out all your email or land on a site with adult content.

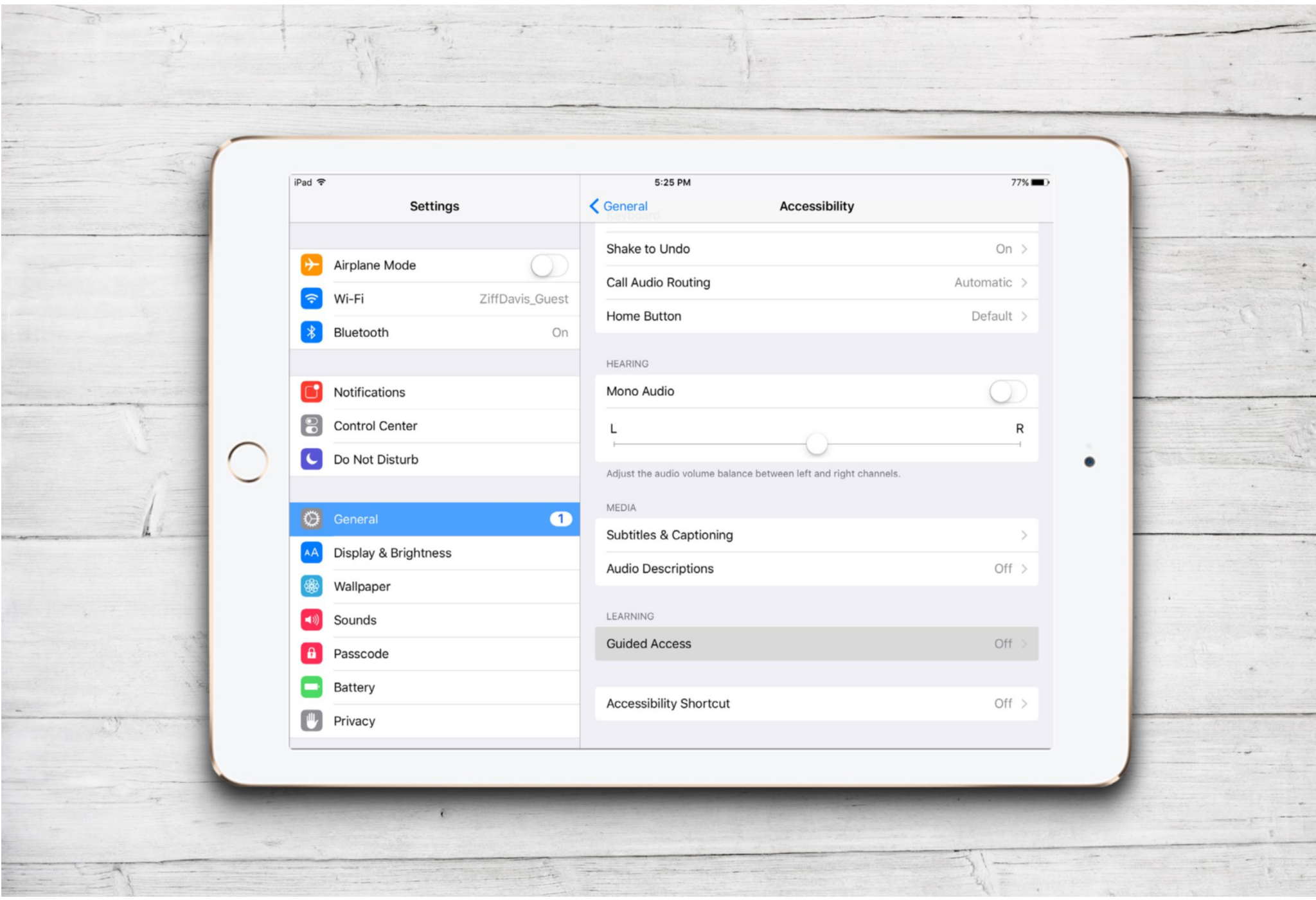
A few settings inside iOS let you lock down your device so that a curious kid (or a naughty friend) can't poke around apps that contain sensitive data. Additionally, some settings block adult content without restricting access to the entire device, which is useful for older kids who might merit a little more freedom to surf and play.

Also, you may want to protect your device physically as well with a good case and screen protector. Here are a few options.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.



Go to Settings > General > Accessibility > Guided Access. It's way down at the bottom. Why it's not under Privacy is beyond me. Remembering that it's an Accessibility feature is the first tricky bit.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Turn on Guided Access.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Set a passcode or TouchID fingerprint to turn Guided Access on and off. You'll also see an option for Time Limit. I'll talk about that in Step 9. It's not exactly straightforward.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Turn on the Accessibility Shortcut. This setting allows you to turn on the restrictions by triple-tapping the Home Button.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Open the app you want to let your kid use.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Triple-tap the Home Button.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

You'll see Guided Access enabled. You'll also see instructions to circle the areas of the screen you want to disable. Circle or draw a rectangle around any on-screen buttons that might get kids into trouble. For example, in Instagram, you might disable the icons that let the user post photos, and send direct messages. As you draw those circles and rectangles, the areas of the screen to be restricted are grayed out. Guided Access remembers those areas within the app the next time you use the feature.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Now press Options in the bottom left. Here you can disable physical buttons such as the Volume and the Sleep/Wake button. You can also set a time limit.

SoftGozar.com

HOW TO LOCK IPAD OR IPHONE CONTENT FROM KIDS (USING GUIDED ACCESS)

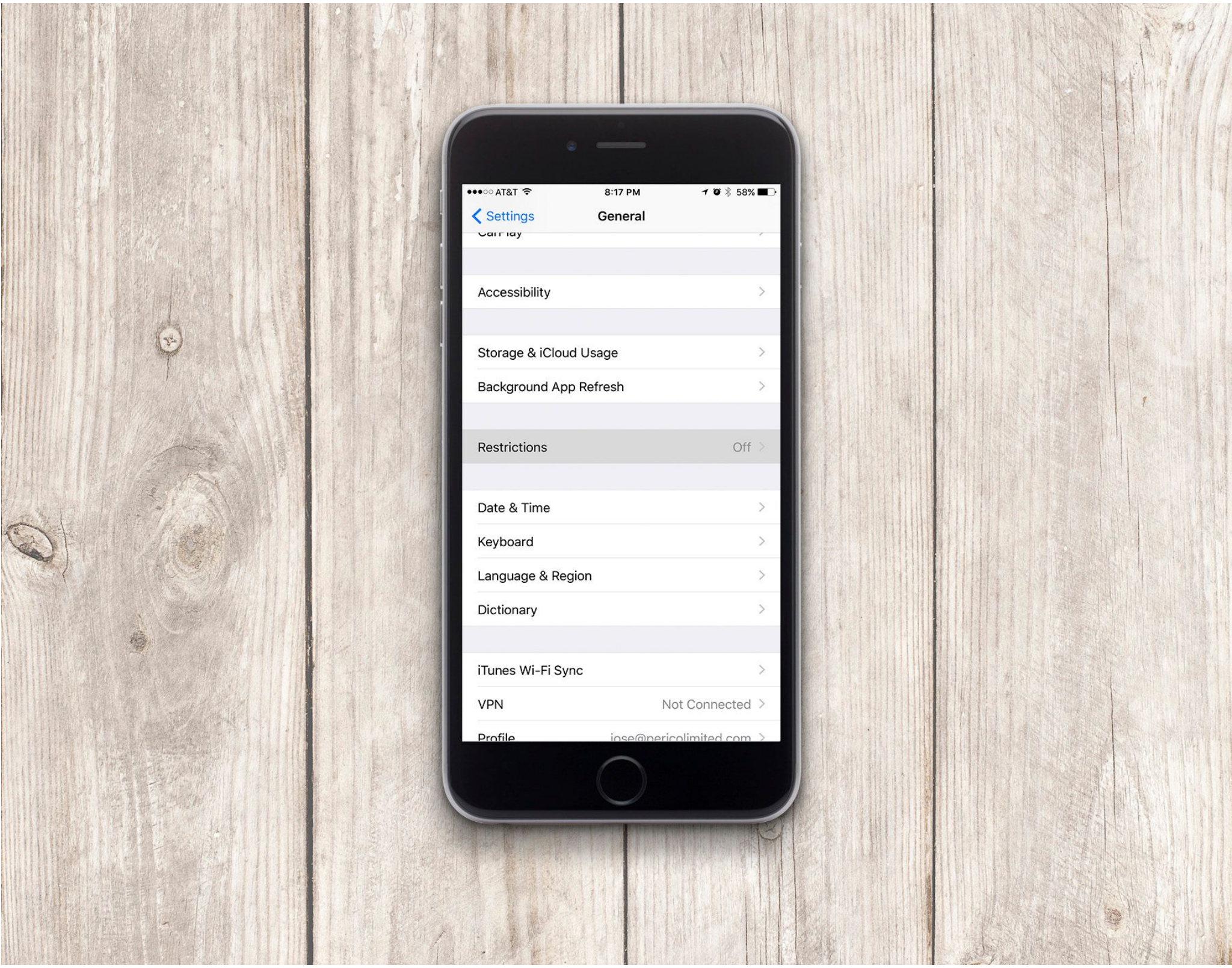
My favorite iOS feature for parents is called Guided Access. It's not exactly a one-touch setting, but it's the best one to learn to use, because it goes the furthest toward locking down your device before you let a child borrow it. Here's how to use it.

Decide how long you want the child to use the device. When the time limit runs out, the device locks. Back in the main settings for Guided Access (Settings > General > Accessibility > Guided Access), you can enable an audio notification that alert you about 30 seconds before the phone locks. It locks on a screen that says Time Expired. Then you'll have to triple-tap the Home Button and enter the passcode or TouchID to get back to the normal phone settings.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.

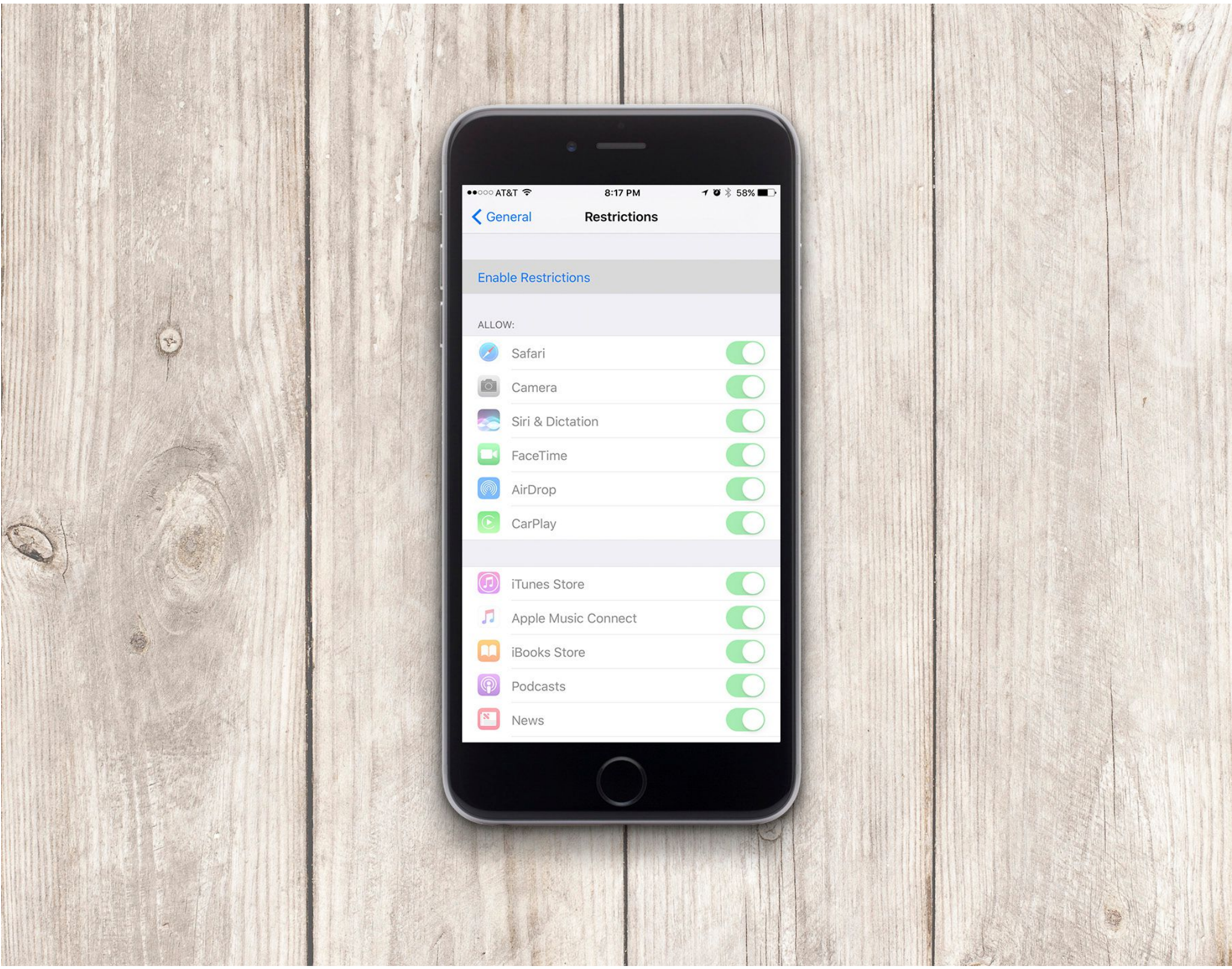


Go to Settings > General > Restrictions.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.

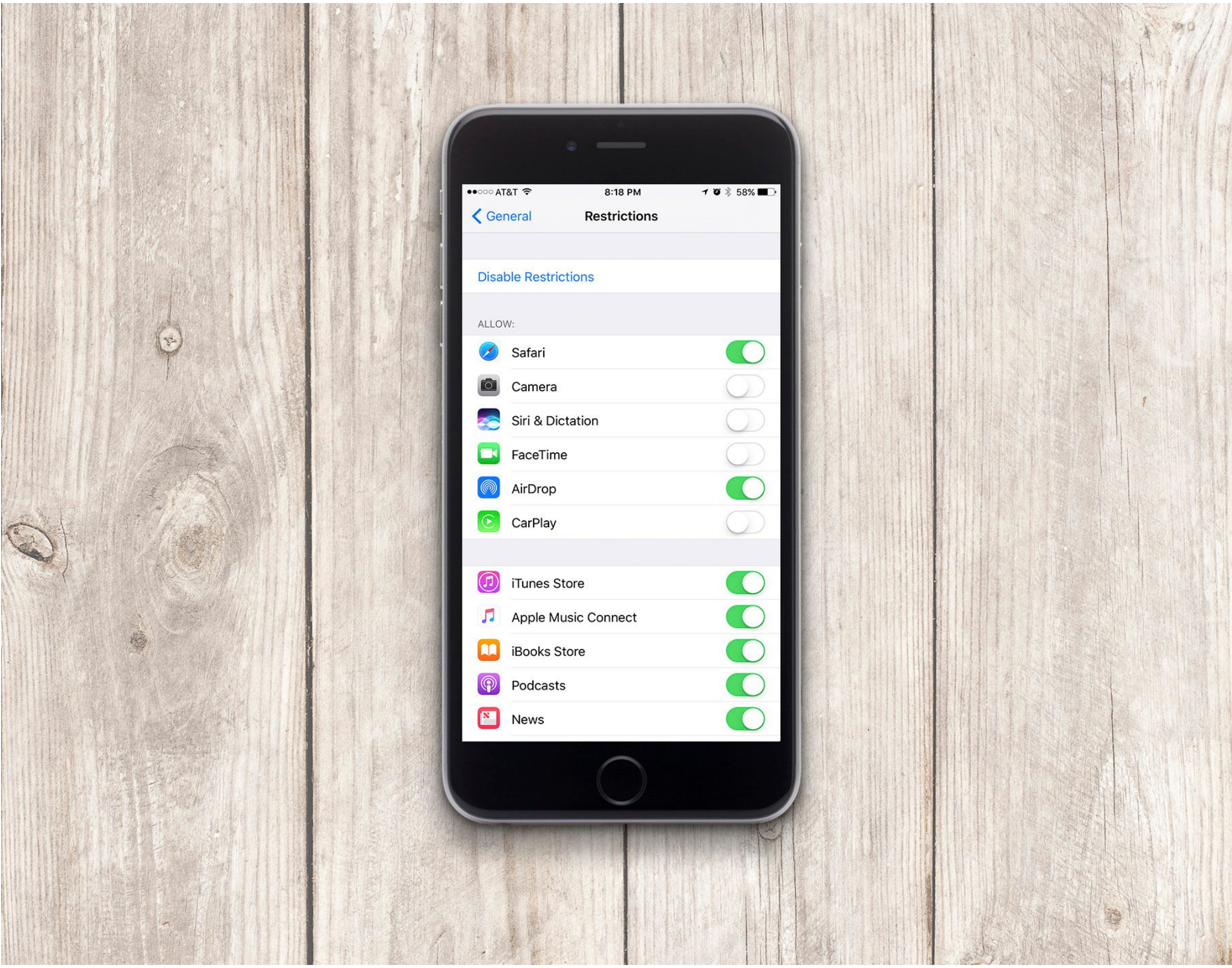


Tap Enable Restrictions, and when prompted, create a passcode.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.

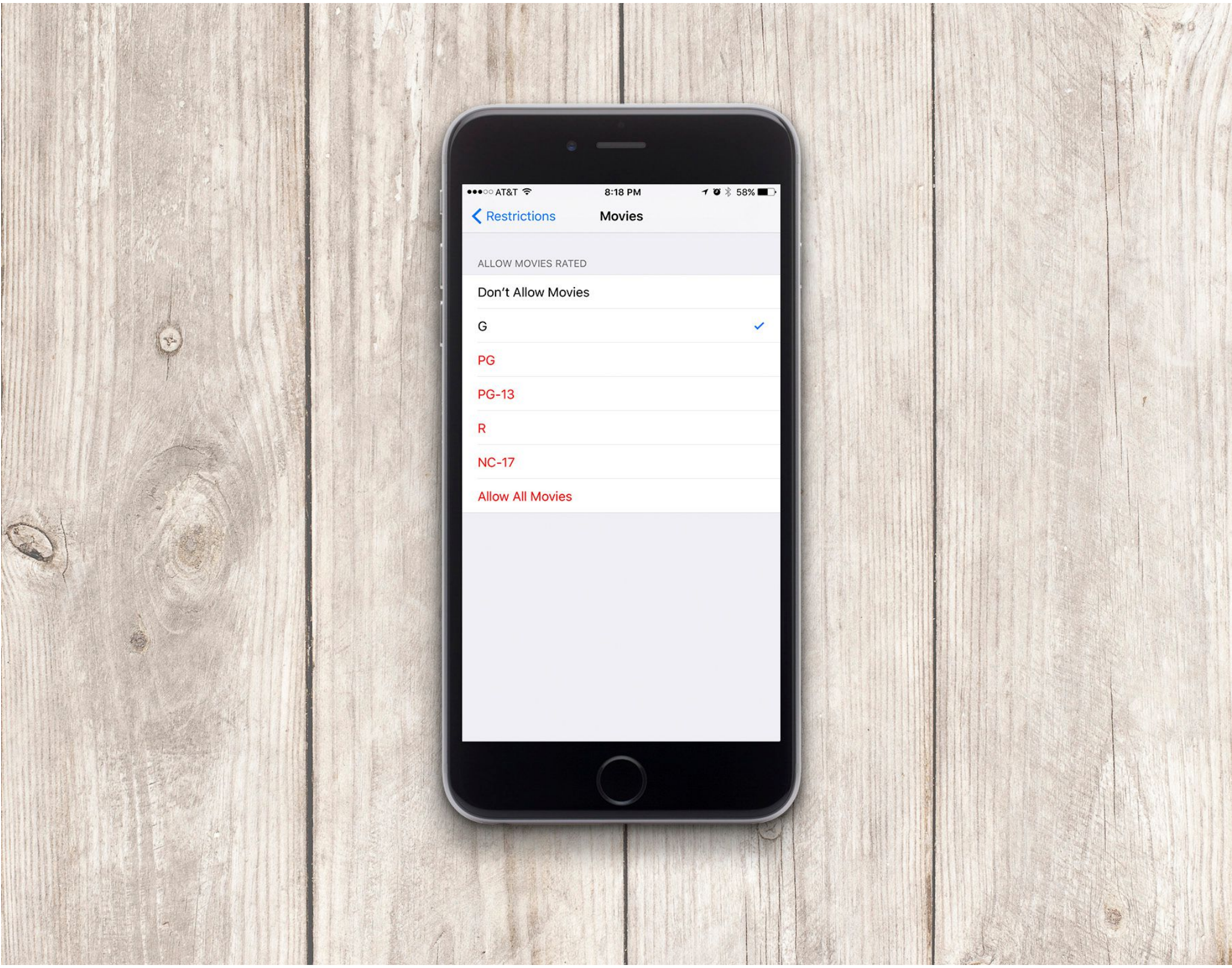


The first section lets you disable certain apps and functions, such as Safari, the camera, and the ability to delete apps. Choose any apps and features you want to disable.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.

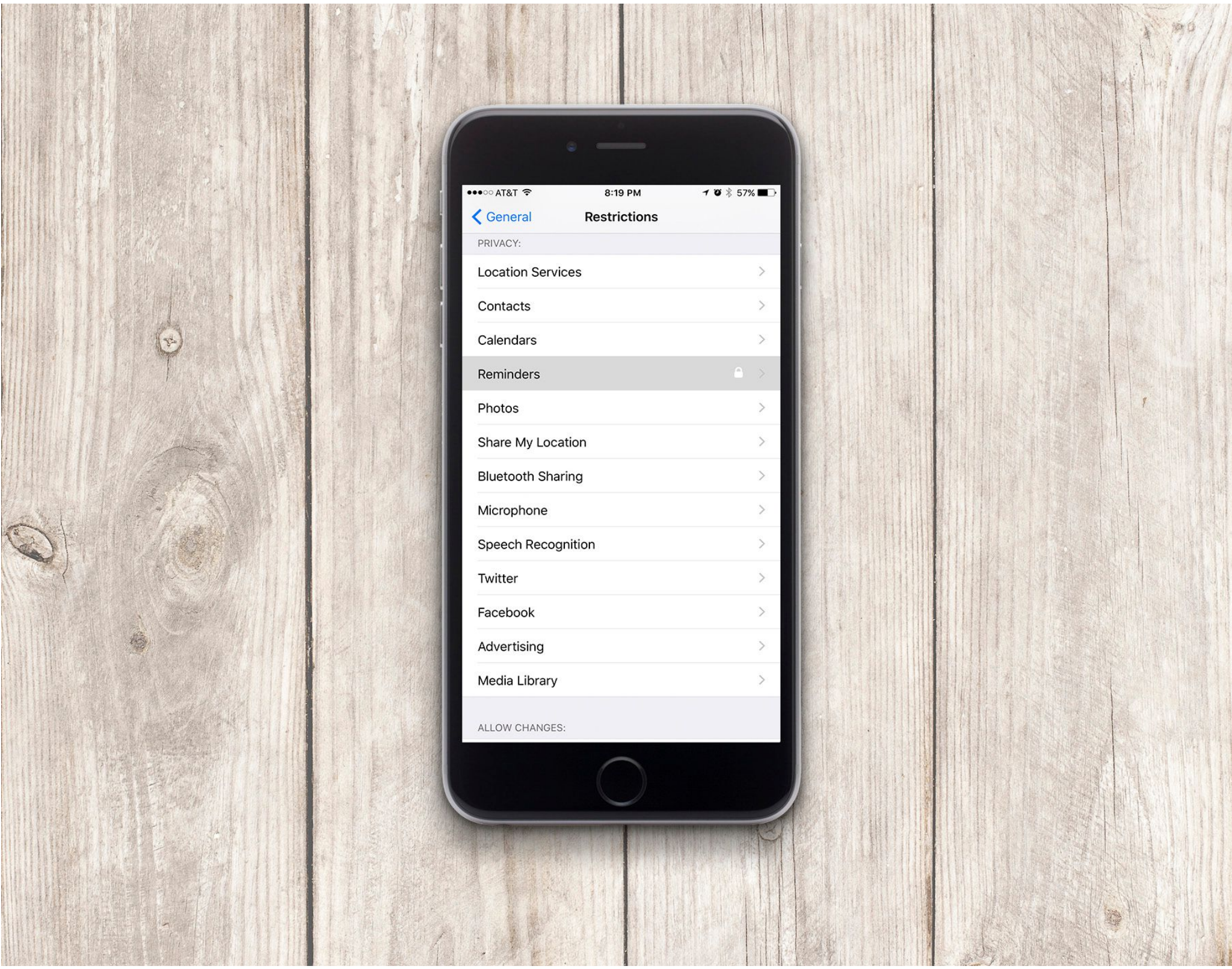


Scroll down to Allowed Content. Each option, such as Movies and Websites, lets you set restrictions. You can restrict playable movies to only G-rated ones, for example, and you can make sure that adult-content websites aren't accessible. You can also disable access to specific URLs, when you know your kids have a penchant for going to those sites.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.

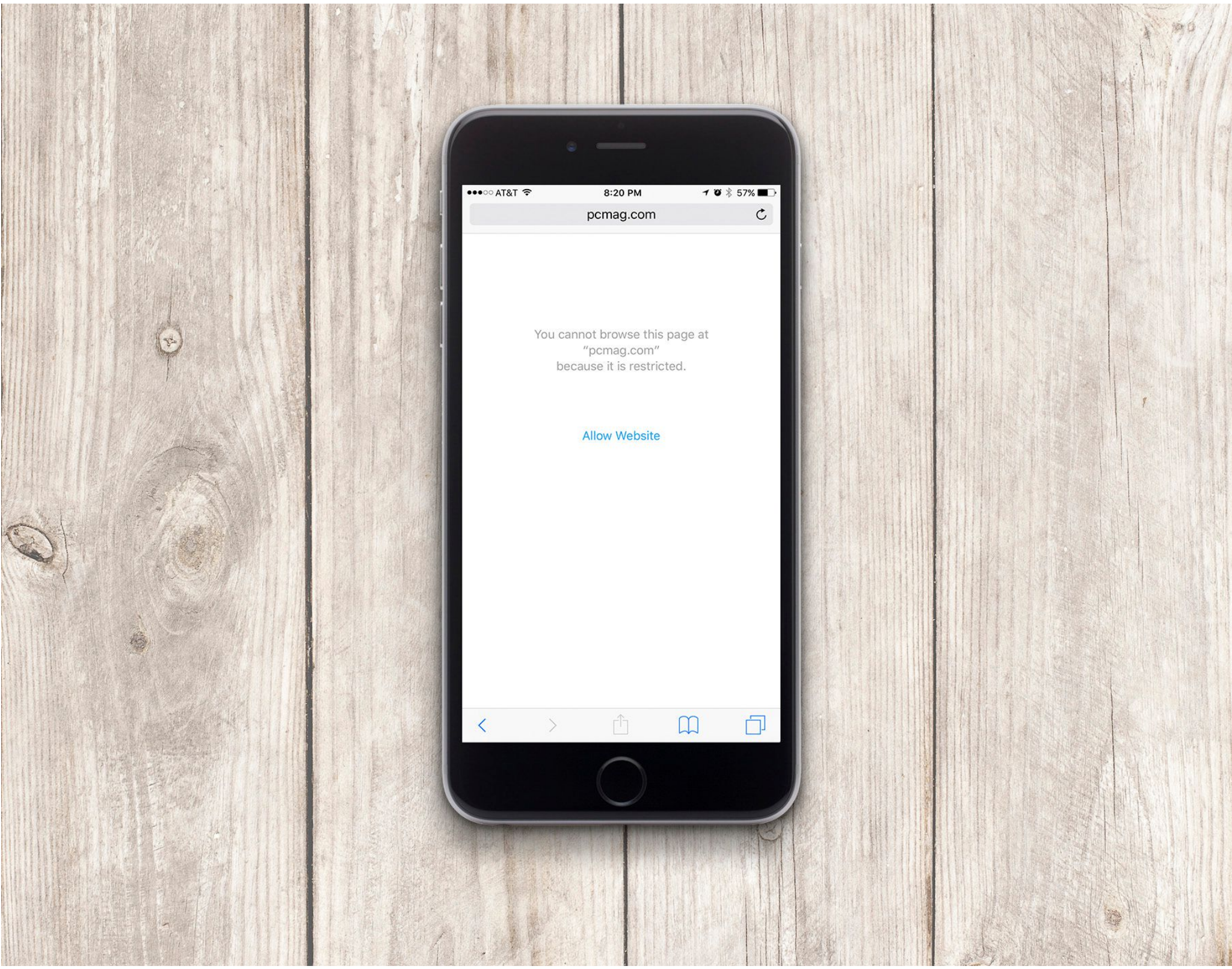


Farther down the Restrictions page are more options for limiting what can and cannot be changed. You might want to lock down your Reminders, Photos, Bluetooth Sharing, and other features and apps. When you restrict them, a small lock icon appears next to them.

SoftGozar.com

HOW TO PREVENT ACCESS TO SENSITIVE ONLINE CONTENT

There are more settings you can enable to restrict content on an iPad or iPhone. Here's how to adjust them.



Once restrictions are in place, you must enter the passcode to disable them again. If you need even more control, consider installing parental-control software on your device.

SoftGozar.com

RECOMMENDED CASES AND SCREEN PROTECTORS

A good case and screen protector are invaluable, not only when you let children handle your mobile devices but always. You can easily get caught up looking for the right case and forget about the screen protector, though. A screen protector goes a long way toward preventing cracks and scratches on your phone, and fixing a broken screen is expensive and a pain in the ass. Don't skimp on the screen protector!

Here are a few of my personal picks for cases: The Griffin Survivor All-Terrain is an extremely rugged case for iPad Air 2. Gumdrop makes a few cases with colorful kid-friendly looks. For iPhones, we like the Evolutive Rhinoshield Crash Guard, a lightweight option that promises to protect phones from drops up to 20 feet.

SoftGozar.com

How to Calibrate Your TV

BY WILL GREENWALD

You can get a much better picture on your television by calibrating it. Professional calibration is a time-consuming and expensive process that requires special equipment and training, but you can tweak your TV to look a lot better by spending $30 on a test disc and taking half an hour to play with some settings. Our instructions will walk you through a very basic calibration process based on Imaging Science Foundation (ISF) methods, and it require no experience on your part. All you have to do is order a Spears & Munsil HD 2.0 Benchmark and Calibration Disc and follow the seven steps we outline below.

SoftGozar.com

The Spears & Munsil disc, recommended by ISF founder and president Joel Silver, is a useful tool for consumers looking to calibrate their TVs or just to understand more about how video signals work. It comes with extensive instructions both on the disc and in the included booklet, but many of them are unnecessary and can be simply disregarded unless you're a professional and familiar with TV calibration to begin with.

1. FIND THE BEST PICTURE MODE

You'll get the best results by starting in the correct picture mode. This is the general mode that dictates many of the television's individual picture settings and often enables some of the higher-level options for making calibration adjustments. Ideally, your television has an ISF picture mode, which means it provides a complete suite of settings to perform a full calibration (although you won't need to touch most of them; that's for professionals). Otherwise, look for a Cinema or Theater mode and start from there. If those aren't available, look for Custom. Stay away from Vivid, Game, or Sports modes.

2. USE THE WARMEST COLOR-TEMPERATURE SETTING

Once you find a mode to start in, look for the Color Temperature setting and make sure it's set to Warm. This works with the picture mode to produce fairly accurate colors across the board for most modern TVs. To get pinpoint precision for color levels with a full white balance-RGBCMY calibration, you'll need a calibration professional with special equipment. But for most people, the warmest color temperature preset will do the job.

***ALL* ABOUT CALIBRATION**

The Spears &Munsil disc comes with instructions both on the disc and in the included booklet, but many of them are unnecessary and can be disregarded by non-professionals.

SoftGozar.com

3. TURN OFF UNNECESSARY PICTURE FEATURES

Your TV probably comes with several options that tweak the picture settings on the fly, ideally to suit whatever you're looking at. They have their place, but they're the bane of calibration. You need to make sure the test patterns you're looking at are displayed with fixed settings and that the TV isn't adjusting them while you're working. In your TV's Picture Settings menu, look for any submenu that sounds like Advanced Picture, Expert Picture, or Picture Options. Disable any feature with the words Adaptive, Dynamic, Motion, Processing, or Smoothing. While you're there, make sure Overscan is turned off, if it's an option (this will help in the next step).

4. CHECK PICTURE GEOMETRY

No matter how you adjust other settings, your TV will look best when it's set to display whatever you're watching in the right aspect ratio. This can be a problem for cable boxes if you're flipping between HD and SD channels, but otherwise you should be able to set everything up to display pictures at their native resolution. Look for a button on your remote or a setting in your Picture menu called Aspect Ratio, Picture Size, or Zoom. Make sure it's set to Normal or Just Scan. Don't select anything called Wide, Zoom, 3:4, or 16:9.

You can check that the picture geometry is correct with the Spears & Munsil disc. Under Advanced Video, select Setup and then Framing. A test pattern will appear that displays the boundaries of various resolutions. If your TV is 1080p, the white arrows pointing at the 1920 x 1080 lines will touch the edge of the screen. If you have an ultra high-definition (UHD or 4K) TV, you can still use the 1080p lines to check your screen geometry; they're the same proportions, and most video sources still output at 1080p, so your TV needs to be able to handle that signal properly regardless.

5. SET CONTRAST

This is where the Spears & Munsil disc really becomes useful. You're going to adjust the Brightness and Contrast settings using PLUGE test charts on the disc. In the main menu of the disc, select Video Calibration and then Contrast. Adjust the Contrast setting on your television until the numbered bars below 238 are distinct shades of gray, and the numbered bars above 238 are white. The gray boxes surrounding the ten colored squares on the top and bottom of the screen should be visible, and the gradient in the middle should ramp down smoothly from a white band in the center to black on the sides.

SoftGozar.com

6. SET BRIGHTNESS

It sounds counterintuitive, but the Brightness setting of your TV actually adjusts black level. Press right on your Blu-ray player's remote to go to the Brightness test pattern. Crank up the Brightness setting of your TV until all four gray bars in the middle are visible, then slowly turn the Brightness down until just the two right bars are visible and the two left bars have disappeared into the background.

7. NOTE YOUR SETTINGS

If you followed these instructions, your TV should now be calibrated as well as it can be without professional equipment. Ignore the instructions on tweaking color or sharpness in the Video Calibration menu; the vast majority of TVs sold in the last few years have sorted out those settings as defaults that work pretty solidly, and trying to change them can lead to picture errors.

You can check your results by going into the Demonstration Materials menu and looking at some of the video clips. They should look full of detail in both light and shadow, with fine textures appearing distinct. Colors should look natural and not garish or tinted blue or pink.

Write down the Picture setting, Color Temperature setting, and any features you disabled, along with the Brightness and Contrast levels. If you make changes in the future, you can fix any problems that arise with the picture by resetting the TV to default settings and using your notes.

SoftGozar.com

12 Tips for Troubleshooting Your Internet Connection

BY JOHN R. DELANEY

With the proliferation of smart home devices, online gaming platforms, and streaming video services, maintaining a strong Internet connection at home is essential for most of us. If you're experiencing lag while playing League of Legends, or it takes you forever to download music, the problem is likely on your end and not an Internet Service Provider (ISP) issue. Before you schedule a service call with your cable company, try our troubleshooting tips.

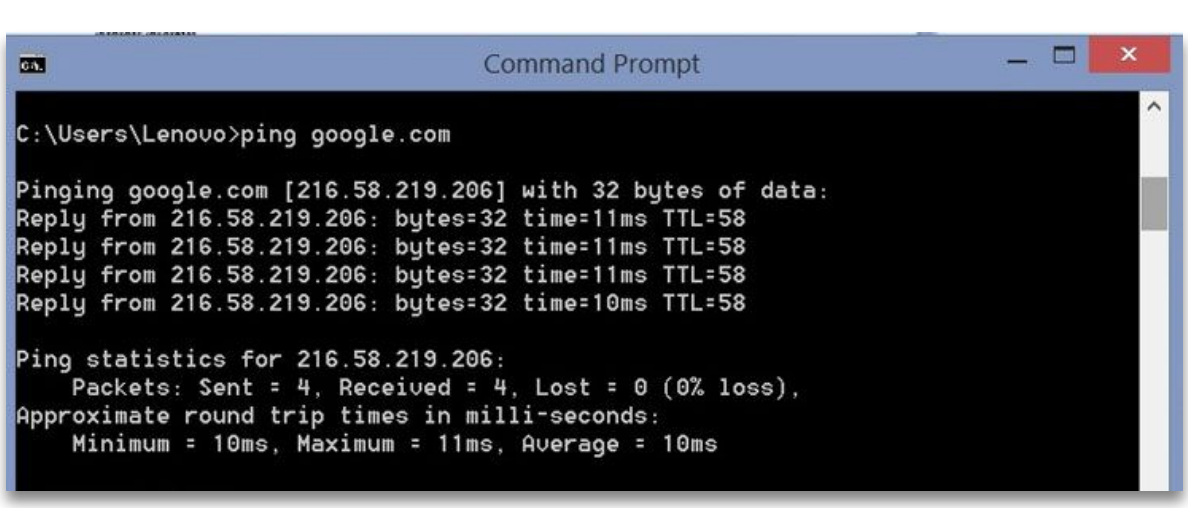
DIY REPAIR

Before you call your ISP, try these easy router tips to get back online ASAP.

SoftGozar.com

CAN YOU PING IT?

Try performing a Ping test to see if you can connect to the outside world. Several free Ping utilities are available, but the easiest way to ping a website using Windows is to open a command prompt and type “Ping” followed by the IP address of the site you want to ping. If you don’t know the IP address, you can type the full address. For example, to ping Google, type **Ping google.com**. This sends small data packets to the target site and measures how fast your connection is in milliseconds. If the test is successful, you’ll see timed results. If it continually fails, try pinging several sites. (Not all websites accept pings.) If you still can’t get results, you might have a problem with your modem or router, or the problem might be on your service provider’s end.



ARE YOU GETTING POWER?

If you can’t connect to the Internet, take a look at your router’s LED status indicators. When there are no lights at all, the router is probably unplugged or powered down. Disconnect the power cord and reconnect it after a minute or two. Make sure that the Power switch is in the On position. If the router still isn’t powering up, you may have a failed power adapter, a faulty power strip, or a fried router. If you have cable or DSL, you should also check that your modem is getting power.

Maintaining a strong Internet connection at home is essential for most of us.

CAN YOU HEAR ME NOW?

Pinging an IP address sends small data packets to the target site and measures the speed of your connection.

SoftGozar.com

CHECK YOUR STATUS

If you have a modem and a router, make sure both are functioning properly. Check your modem first to see if its power LED is lit. Also check your Link or Online LED and any activity LEDs. If there's no power or LED activity, turn the modem and router off and wait several minutes before restarting—and wait until the modem comes back online before restarting the router. If your router's power LED is lit, check the Internet or WAN indicator. On most routers, this should be green and may be flashing. If your router doesn't have status indicators, look around back to see if the Ethernet port lights are flashing. If there is no activity, turn the router off. Unplug and reconnect each cable, making sure each cable is seated correctly in the appropriate port. Wait a few minutes before rebooting the router.

CHANGE THE CHANNEL

Routers can use one of 14 frequencies, or channels, to send and receive data over the widely used 2.4GHz band. Most of these channels overlap, but channels 1, 6, and 11 do not—and are the most frequently used. If your Wi-Fi connection is spotty, you may be experiencing channel interference. Try changing your Wi-Fi channel using the router-management console. If the channel is set to Auto, try setting it to another channel to see if this improves your connection.

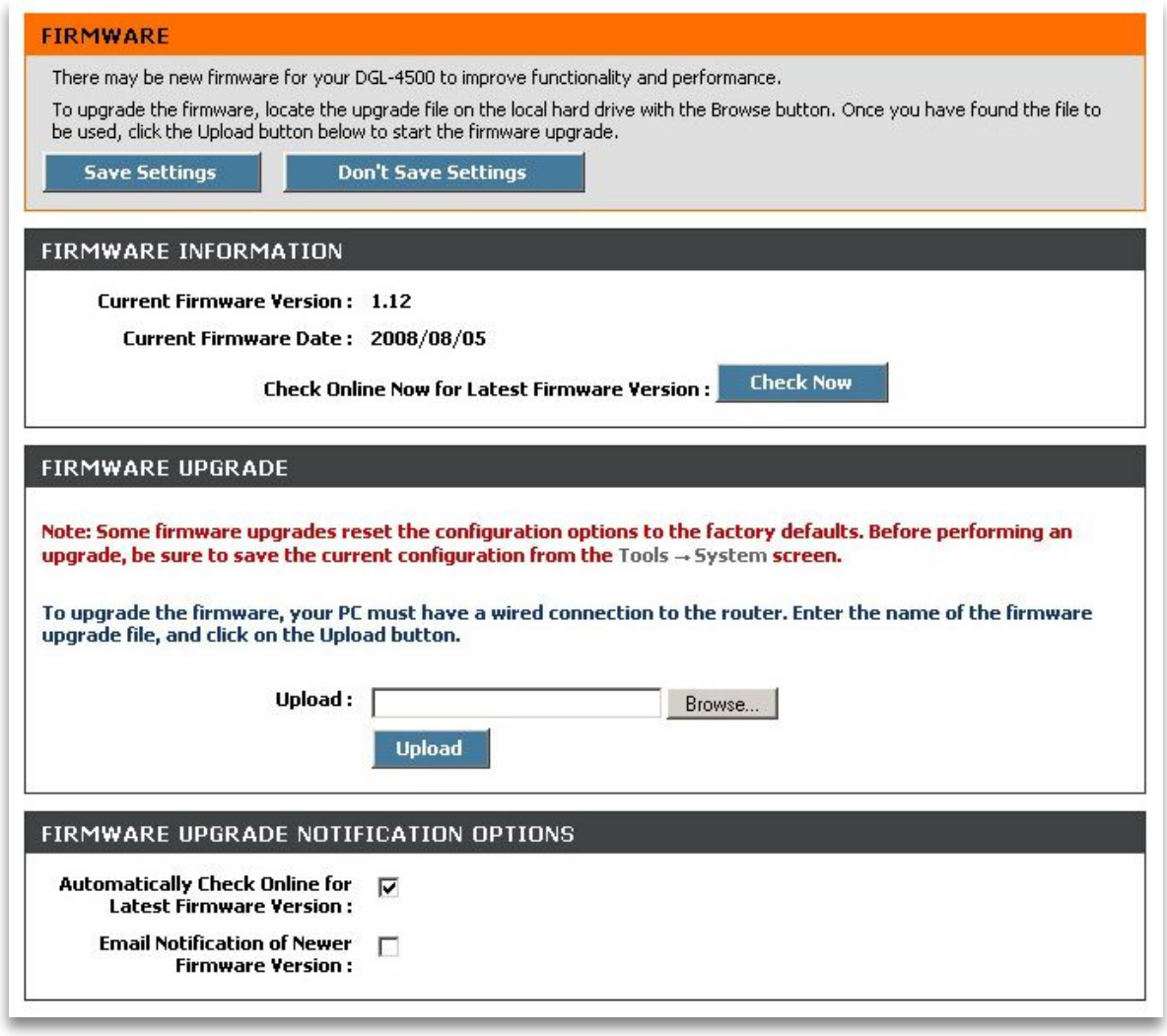
CABLE CONNECTION OKAY?

Before you start thinking about resetting or replacing your router, inspect the connection coming into your home. This is usually located on the side of your house and may or may not be housed in an enclosure. Make sure that the main cable hasn't been chewed by a squirrel or knocked loose by debris from a storm. If a cable splitter is being used, make sure each connection is tight and the connectors are properly crimped. If the splitter looks rusty or dirty, try replacing it.

START FRESH

If rebooting your router doesn't do the trick, try resetting it to its factory defaults and performing a fresh install. For most routers, this is done by pressing a very small reset button on the rear panel and holding it down for several seconds until the LED lights begin flashing. Once reset, use the router's accompanying disk or Web-based setup utility to reinstall the router.

SoftGozar.com



MAKE SURE YOUR FIRMWARE IS CURRENT

Firmware is embedded software that's installed at the factory on a read-only memory (ROM) chip, which allows the router hardware to implement network and security protocols. Most vendors provide downloadable firmware updates that resolve performance issues, add new features, and increase throughput performance. Look for the firmware update tool in the System section of your router's management console and follow the instructions carefully to be sure that you're installing the correct firmware version. *Do not download firmware from a third-party site.*

DO YOU NEED AN EXTENDER?

If you can wirelessly connect to the Internet in one room but not another, check your router's Wi-Fi signal strength. Look at the network connection icon on your PC or mobile device to see how many bars are showing. If you're seeing only one or two bars, your Wi-Fi signal may be too weak to maintain a strong Internet connection. Try connecting to another band, if you have a dual-band router. Readjusting the router's antennas or changing the location of your router (if possible) can help improve range as well. If relocating the router is out of the question, you might need a range extender to boost the router's Wi-Fi signal. We like the Tenda P1002P 2-Port Powerline Adapter Kit and the Amped Wireless Titan-EX High Power AC1900 Wi-Fi Range Extender (RE1900A).

SoftGozar.com

IS YOUR PC/PHONE/TABLET CONFIGURED CORRECTLY?

If you can browse the Web with your laptop but can't connect with your smartphone or another PC, check the problem device's network settings. For smartphones, go to your Wi-Fi settings and make sure Wi-Fi is enabled and that you're connected to the proper SSID using the correct security password. Make sure Airplane Mode is disabled and that your time and date are correct. For Windows clients, make sure the Wi-Fi switch is turned on and the device is not in Airplane Mode. Right-click on the network icon in your system tray and select Troubleshoot Problems to run the Windows Network Diagnostic routine. Very often this will correct common issues by resetting the adapter. Also check your network adapter settings to make sure the adapter is functioning properly and is using the latest driver.

"If rebooting your router doesn't do the trick, try resetting it to its factory defaults and performing a fresh install."

MAKE SURE YOUR PC IS HEALTHY

Check for spyware, viruses, and malware. These programs can easily be downloaded and installed without your knowledge while you're surfing the Web. They can run undetected and have a significant impact on your Web surfing speed and overall system performance. Plenty of free and subscription-based utilities are available that can detect and eradicate these programs and prevent them being downloaded and installed in the first place.

SoftGozar.com

TIME TO UPGRADE YOUR ROUTER?

If you're using an older 802.11b or 802.11g model, consider upgrading to a newer, more powerful router, especially if you have multiple client devices vying for bandwidth. A dual-band router gives you two radio bands to choose from and allows you to dedicate a band to clients that require lots of bandwidth—streaming video devices and gaming consoles, for instance. Moreover, newer routers employ the latest technologies to deliver speedy throughput with enhanced Wi-Fi range. Check out our list of the best wireless routers at PCMag.com when you're ready to take the plunge.

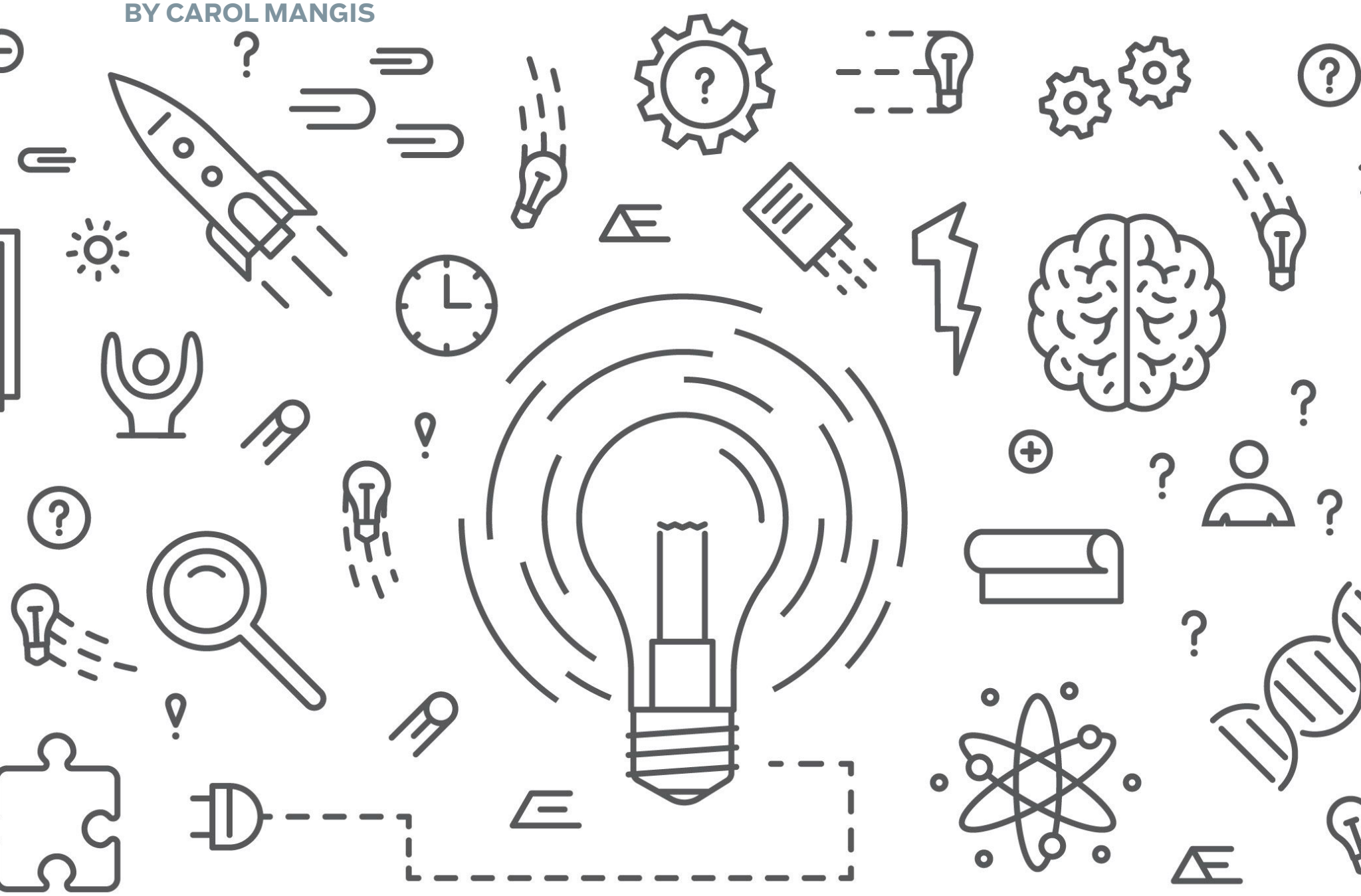
LAST RESORT: DIAL UP YOUR ISP

If you've tried everything and are still experiencing Internet connection woes, it's time to call your service provider. The problem could be on its end and requires a new connection at the pole coming into your house or new equipment. If you're experiencing slowdowns at certain times of the day (say, after-school hours), your ISP may simply be unable to handle the increased user load, in which case you may want to find a new service provider.

SoftGozar.com

6 Tools for Wannabe Makers

BY CAROL MANGIS



Humans have been making things for pretty much our entire existence. In fact, some claim that the ability to create things for functional or recreational purposes from our imagination is at least part of what makes us human. But only in relatively recent times have technical tools and components been available for use by individuals, giving us the opportunity to make more sophisticated things than ever before. Some are disguised as toys—which is doubly great, since they're STEM-inspiring for kids and perfectly usable by grownups, too.

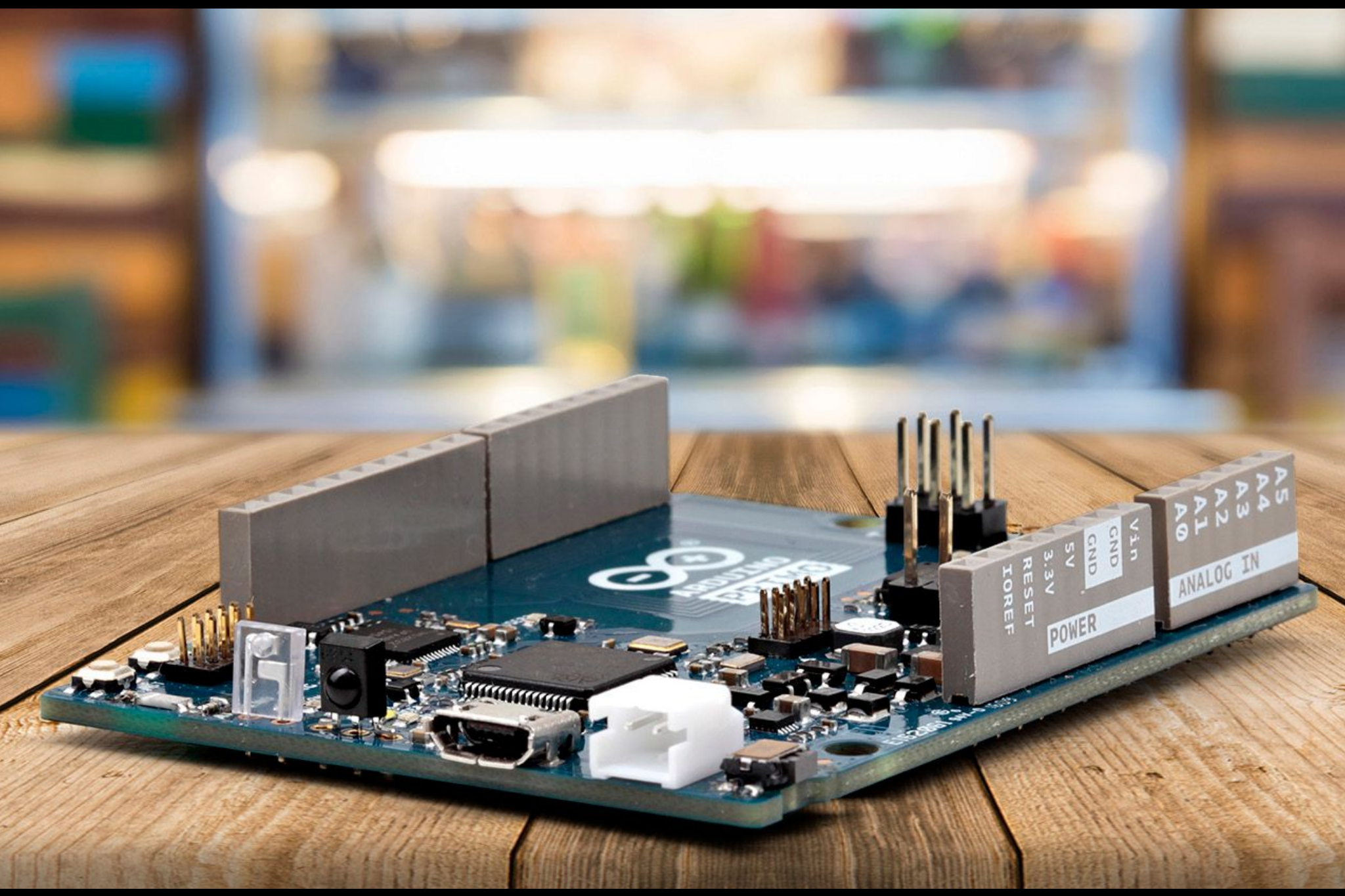
Here are just some of the amazing maker tools you can find today.

SoftGozar.com

Raspberry Pi

A device intended to be an educational jumping-off point for nascent geeky DIYers is essentially an inexpensive computer: You can plug in a mouse and keyboard, add whichever components you wish, and use it like you would any other computer. Makers have created some amazing projects using the Raspberry Pi, including a solar smart meter, a 3D scanner, and even a mobile phone.

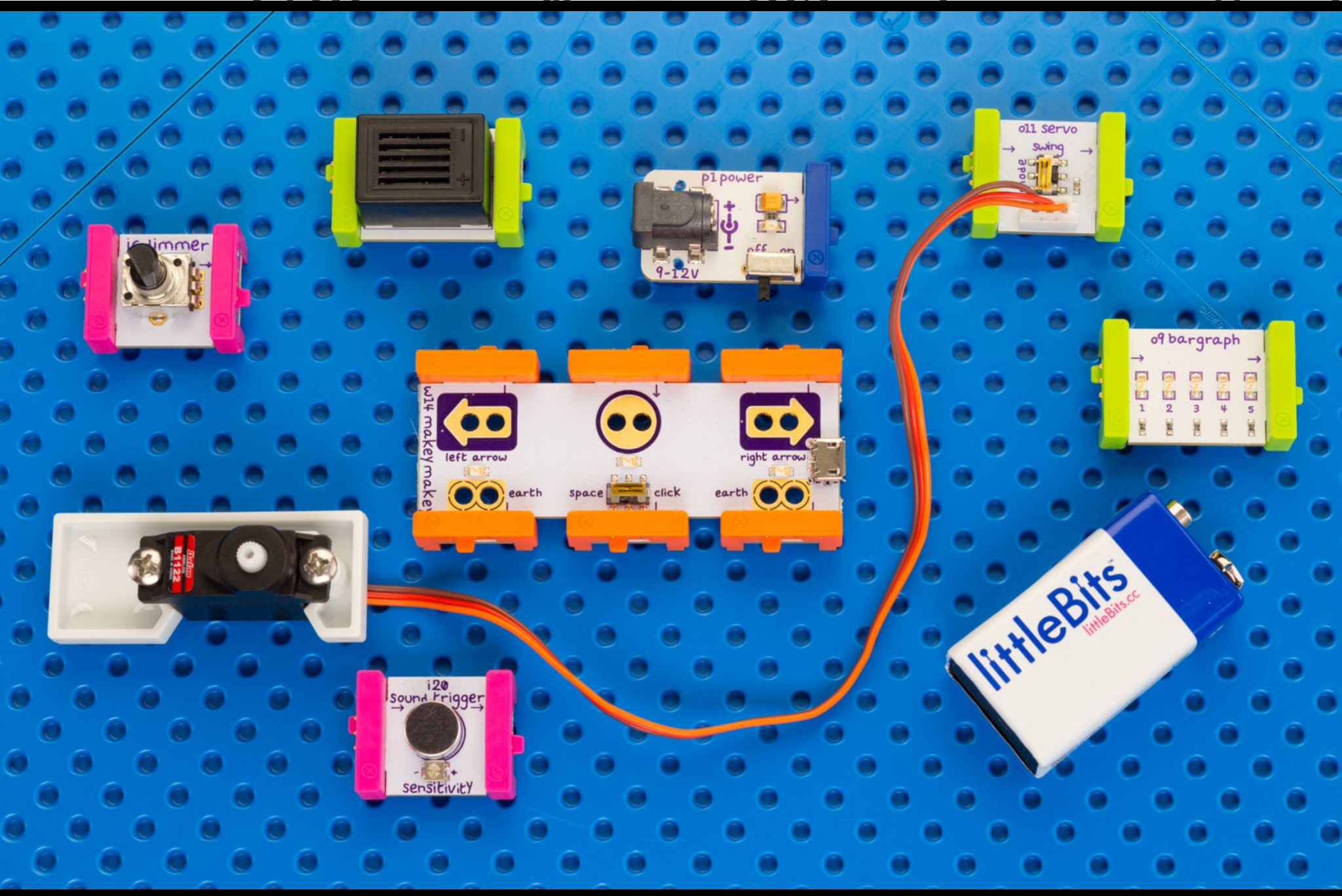
SoftGozar.com



Arduino

Arduino is an open-source prototyping platform that, simply put, can read all sorts of inputs and turn them into outputs. Like Raspberry Pi, Arduino was originally created for students but is now used by a large community of makers for a crazy variety of projects. Want to build a mood light that changes according to Twitter trends? Or a photography rig to capture splash photos? How about a power meter that tweets usage data? The possibilities are endless. Recently, Arduino debuted the Primo board for Internet of Things projects. You won't have to add components for Wi-Fi, Bluetooth low energy, NFC (near-field communications), and infra-red, because they're already built in.

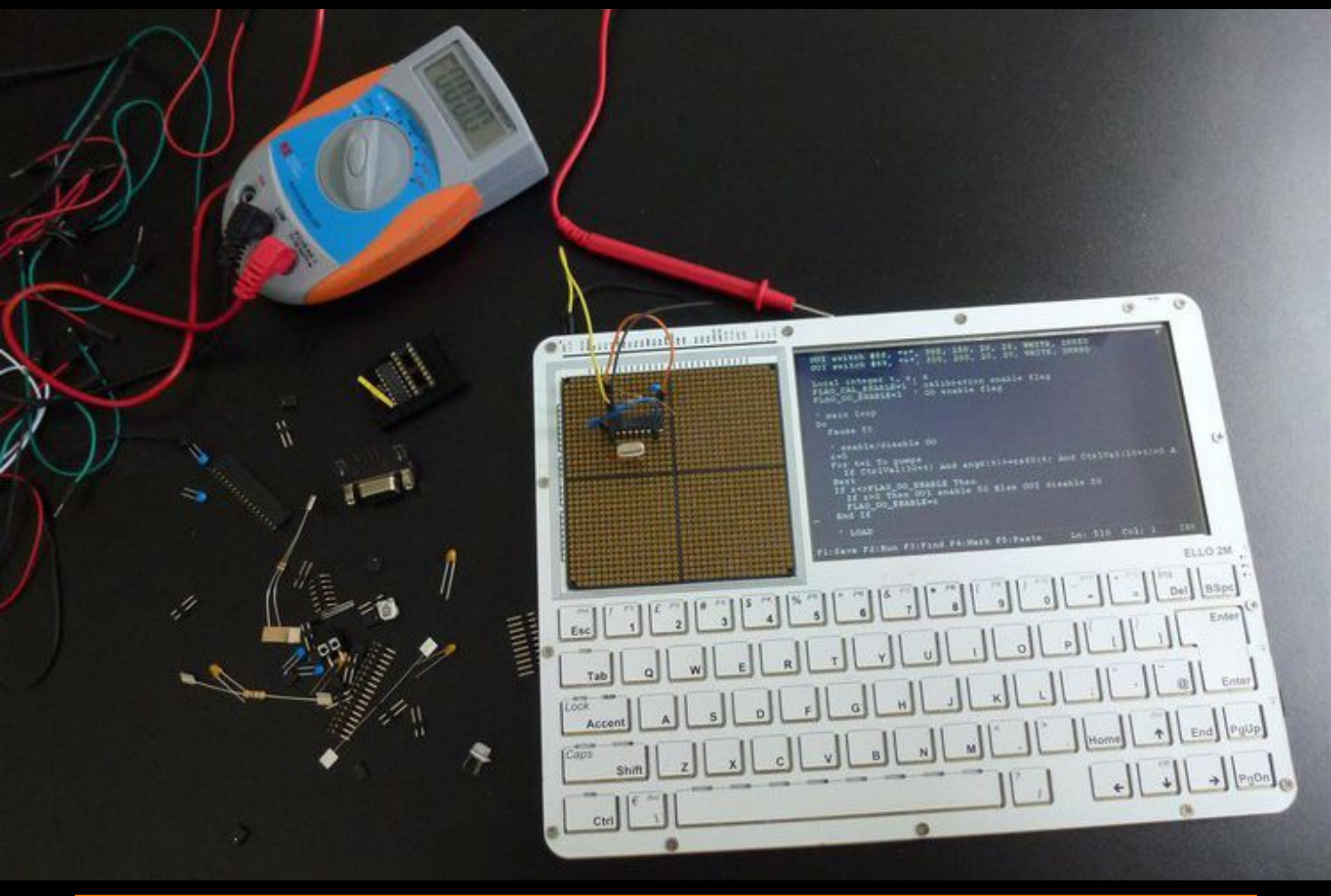
SoftGozar.com



LittleBits

LittleBits are magnetic modules that snap together to create working electronic circuits—for fun and also to power cool little projects. Numerous versions of the kit are available (and the following are all reviewed by PCMag). The Little Bits Base Kit is a great way to get started: It comes with 10 modules, including a DC motor, dimmer, and light sensor. For more ambitious creators, the LittleBits Gizmo & Gadgets Kit, which earned our Editors' Choice, gives you 15 modules, including two 9-volt power modules with batteries included, two slide dimmers, and a light sensor. LittleBits Smart Home Kit supplies what you need to experiment with home automation and networked robotics. And the LittleBits Arduino Bit, an individual module, is a microcomputer that's built into a three-input, three-output LittleBits module. If you have our September issue handy, take a look at our review of the LittleBits Rule Your Room Kit.

SoftGozar.com



Ello 2M

Ello 2M is a small DIY computer that's designed to be tinkered with; in fact, you have to assemble it yourself. You'll end up with a computer that's perfect for learning programming, designing electronics, and general hackery. You get six stacked circuit boards (all pre-soldered components) that you sandwich together to create the body of the device. A 7-inch touch-screen LCD, electronics prototyping board, and a full keyboard are all built in.

SoftGozar.com

Lego Mindstorms EV3

This kit is the best and most accessible way to teach your kids—or yourself—how to build and program robots: When we reviewed it, the Mindstorms EV3 kit earned an outstanding score of 5 and a PCMag Editors' Choice. In the box are a Mindstorms EV3 Intelligent Brick (the "brain" of the set), an infrared remote control, three servo motors, a color sensor, a touch sensor, an infrared sensor, and 550 Lego Technic pieces. Even better, you can integrate your standard Lego pieces into your robotic creations. The Lego Mindstorms Commander app for iOS and Android includes preset control panels for five robots you can build in the 3D Builder app. More important, it lets you create manual control panels for your own creations, with different buttons, switches, and displays available to control motors and check sensor inputs.

SoftGozar.com

3D Printers

Not long ago, the few 3D printers in existence were hulking, expensive machines reserved for factories and well-heeled corporations. But these amazing devices (which you'll find at any Maker Faire) have become affordable products for use by designers, engineers, hobbyists, schools, and even consumers. If you hanker to print out one of the myriad designs available online (check out Thingiverse, Pinshape, and other websites) or design your own object, take a look at our buying guide at PCMag.com to figure out which 3D printer is right for you.

SoftGozar.com

JOHN C. DVORAK

My 30 Years at PCMag: A Brief History of Personal Computing

August 1986 is when I began writing for *PC Magazine,* and I've continued uninterrupted for 30 years. Here's a condensed version of those years.

The origin of desktop computing, initially called microcomputing, is mildly debatable. Most credit the genesis to the Altair computer appearing on the cover of *Popular Electronics* in 1975. I like to think that the real origins of today's market were actually in 1977, when the first West Coast Computer Faire rolled out in San Francisco. It was crawling with major personalities who would dominate the scene for the next few decades. It's where Steve Jobs and Steve Wozniak showed off the Apple II, a professional-looking keyboard computer that began Apple's ascendency.

Apple's competitors were various proprietary systems and a slew of S-100 systems utilizing the then-popular S-100 bus, which stemmed from the original Altair design. The very early years were dominated by the soldering gun as well as some familiarity with machine coding, so you could actually get a printer to work with your computer. Cassette recorders were used to load programs. There were also a number of standards to make this work, the most popular being the Kansas City Standard, which allowed the loading of code at 300 baud and then 1,200 baud. The idea was to replace the cumbersome punched paper tape that the earliest of hobbyists had to use. This is now laughable, but that was the way things started.

I was very attracted to the scene and began selling software and ran a mail-order business

SoftGozar.com

@ THErealDVORAK

called the Software Boutique. I also developed the California Software brand, an independent publishing company that introduced one of the first modem programs (a statistical analysis system that was eventually used by Clorox) and something dubbed SMSS—a software music synthesis system that used the noise that was ever present on the S-100 bus to create music.

As lucrative and fun as selling software became, I had more fun writing the sales material, so I started a gossipy newsletter. Then, in the 1970s, I went to New York on a whim to take three major seminars given by the Direct Mail Marketing Association, followed by a number of copyrighting seminars held by various independent and famous experts. This led to some work for *InfoWorld,* a growing valley publication owned by IDG, where I was eventually named editor and increased the circulation by eight-fold over a two-year period.

It also gave me the opportunity to work with probably best staff of writers imaginable, including John Markoff, Michael Swain, Paul Freiberger, Scott Mace, and too many others to mention. John Barry and Eva Langfeldt made the place actually work. Maggie Canon was the editor-in-chief. She hired me at *Infoworld* and also fired me when I was established at *MacUser*. That's a funny story for a different column.

In 1986, I was doing books and writing the "Inside Track" column for *InfoWorld,* having left the editor's post in 1982. Andy Grove, the boss at Intel, was doing his best to write business columns. My network of pals in and around *InfoWorld* heard that then-editor Jonathan Sachs, who never liked me, was going to replace "Inside Track" with a business column.

Before that could happen, I met with the publisher of *PC Magazine* at the time, Bill Lohse.

SoftGozar.com

> **As lucrative and fun as selling software became, I had more fun writing the sales material.**

One of us cajoled the other that I should be writing for *PC Magazine* and *PC Week*. The latter fell through, but I got "Inside Track" into *PC Magazine* along with an essay that would appear in the columnist well alongside Bill Machrone, Peter Norton (who was leaving), the late Jim Seymour, and a few other heavy hitters.

In the first issue in which I appeared, August 1986, my picture was on the cover. Thus began the 30 years.

THE HEYDAY

If there was a golden age of personal computing, it was the decade beginning in 1986. In hindsight, probably the most notable thing about this period was the sheer number of trade shows and other huge industry events. The big daddy industry event was Comdex, which took place twice a year, usually in Las Vegas and Atlanta. This was joined by two Consumer Electronics Shows (Las Vegas and Chicago), two MacWorld shows (San Francisco and Boston), and various regional shows, combined with various industry and corporate events that spanned the globe. One year I attended a huge IBM event in Monaco. The next time I was in Monaco was for a massive event produced by Nortel.

Hardware was changing and improving rapidly. Everyone bought a completely new rig every 18 months. During this period—and on into the next—storage became a primary concern. The mid-1990s became an era of bloatware, despite being dominated by the floppy disk for storage.

Hard disks first appeared as popular must-have devices around 1983 with the unveiling of the IBM PC-XT and its 20MB drive. By 1996, most people were happy with a 320MB hard disk. Software was still delivered via a box full of floppy disks.

SoftGozar.com

During this era, the industry transitioned from 5 ¼-inch floppies to 3 ½-inch hard-cased “floppies.” Floppy disk readers remained in PCs until 2002, when they were supplanted by the CD-ROM.

In the early 1990s, these new storage options ignited a short-lived phenomenon of incredibly elaborate games, encyclopedias, and other products. Microsoft saw this as a new age in computing, but it was later caught flat-footed by the Internet.

The decade from 1986 to 1996 could be seen as computing’s time of full-blown maturity. Nothing would ever match that vibrancy and excitement. In hindsight, the promise of powerful personal computing was fulfilled during that two-decade span. Before then, computing was under the control of the impersonal and faceless corporation.

This moment in the history of individual freedom was further fueled by the emergence of the laptop computer, which reached its pinnacle during that second decade. It began in earnest with the prophetic NEC Ultralite 4.4-pound notebook computer, which used a silicon hard disk. This $5,000 wonder machine appeared in 1988, before the term “notebook computer” even existed.

It was an experimental era for laptops, which were often called “luggables” and weighed as much as a bowling ball. When the IBM ThinkPad appeared in 1992, things began to settle down and stabilize.

HERE COMES THE INTERNET

Parallel to this, the online era was blossoming, resulting in the emergence of the BBS and the appearance of such services as The Source, CompuServe, and eventually, America Online. These were closed environments. Members paid a fee for the privilege. Prodigy, Apple’s eWorld, and Microsoft’s MSN eventually joined in.

Online technology steadily improved each year. As this era ended, speed had incrementally increased to 56 kilobits per second. All the laptops of the time had a built-in modem. I recall having a device that bonded two 56K lines to achieve a reasonable 112K speed.

In the background of all this hardware development lurked a 1969 government invention called “the Internet.” It was actually already in play during this golden era and could handle email and use some very clunky software to conduct primordial network searches. One day, a computer scientist named Tim Berners-Lee wrote a specification for what he called the World Wide Web. Something was triggered. Computer enthusiasts began to see new possibilities.

SoftGozar.com

Initially, the Web was just as clunky as most things on the Internet. Much of the slowdown in innovation was due to the inability to make things easier for a growing public market for all things computer.

During this time, the Xerox Star was introduced. It employed a graphical user interface (GUI)—a visual way of doing things. Instead of a blank screen to type on, you had a desktop. You pointed and clicked to make things happen.

Steve Jobs saw the benefits of this and introduced it into small computers called Macintosh in 1984. But it really took off when Microsoft abandoned its partner IBM and developed Windows. By the early 1990s, everyone was running a GUI.

As soon as the first commercial browsers (NCSA Mosaic, then Netscape) appeared to exploit the GUI on the Internet using the World Wide Web protocols, things took off. Users had wanted to get out from under the gatekeepers who controlled the machines and their power. Nobody wanted to ask permission, wait in line, be monitored. That lead to the peak of the personal computing phenomenon. By 1996, people had control of everything they had wanted back in 1976.

The Internet exploded in the next era… and we would revert back to the 1970s. Somehow, people were happier than ever.

END OF AN ERA

The personal computing revolution ended around the turn of the century. If there's an exact time to cite, it was probably in 2005, when IBM sold its personal computer division, including the ThinkPad trademark, to Lenovo in China. But the entire 10 years prior was troubling, driven by Internet-focused greed triggered by the Netscape IPO of August 1995, which produced a mania the likes of which I have never witnessed.

As we started 1996, money was everywhere, which led to the 2001 stock-market crash. And with the September 11 terrorist attacks, the chance of a quick recovery was over.

I was lucky enough to be doing a daily panel show on ZDTV (later TechTV) before the crash. One maniac after another, when questioned about the viability of dot-com stocks that sold dog food over the Internet, would rant about the "new economy" and argue that people like me "didn't get it."

This lunacy was the height of entertainment. *PC Magazine* was not immune to the trend; its parent company, Ziff Davis, was sold to Japanese company SoftBank, and staff were told that hundreds of new magazines would be started immediately.

SoftGozar.com

> **Experts predicted massive blackouts at the stroke of midnight when the new millennium began.**

Let's not forget the outrageous malarkey known as Y2K. Experts predicted massive blackouts at the stroke of midnight when the new millennium began, because old Cobol code would take us from 1999—stated as 99—to 1900 when it turned over to 00. Systems were patched, money was squandered, and nothing happened. Nobody looked at the computer game the same after that.

The dot-com collapse, Y2K, and the emerging lockdown of ideas resulting from the 1998 Digital Millennium Copyright Act pretty much ruined idealism and killed the PC revolution. The icing on the cake was the arrival of "the cloud" in 2006. It returned us to a pre-1976, client-server centralized structure that was supposed to have been destroyed by the desktop revolution. Older ideas were reengineered and given new, friendly names.

The PC was to be relegated to a smart terminal, just like the old days. The idea of a desktop computer being liberating was fading fast, but the rebellious nature of the PC user was still there. If you are going to link all the machines in the world, how hard would it be to use that network to beef up your music collection? You know—Bill has a complete collection of your favorite band. Maybe he can make some easy-to-transfer compressed digital files and send them to you.

Welcome to the MP3 revolution, and in 1999, the appearance of Napster, a world-wide music trading resource. The irony—and you can research this— is that CD sales peaked during the heyday of Napster. Once Napster was shuttered, CD sales plummeted. No matter: Everything was somehow a violation of the DMCA and other laws and needed to be shut down. Control freaks were everywhere, demanding that everything be criminalized.

SoftGozar.com

There was good news, much of it counter to the return of centralization. The iMac appeared in 1998, and Apple opened its first store in 2000. This was mapped out by Steve Jobs, one of the first revolutionaries. Technology was not halted. Wi-Fi emerged, the portable thumb drive made its appearance, and Windows XP was incredibly popular. Societal change-makers Wikipedia and BitTorrent both appeared in 2001, as the economy was collapsing.

Oh, and don't overlook the important emergence of the Palm Pilot. It would have an untoward influence on what was to come in the next 10 years and takes us to where we are today.

AND HERE WE ARE...

By 2006, desktop computers were ubiquitous, but interest waned as the development of new apps and ideas slowed. Everything became more Web-centric. To top it off, Bill Gates announced that he planned to resign by 2008. But the launch of Twitter and Google buying YouTube both signaled a move away from the desktop.

At the same time, rumors about Apple moving into mobile phones heated up. The iPhone arrived in 2007 and was the sea change that pushed aside anything going on with the PC. The iPhone (and later, Android devices) were the new personal computers. The next few years were focused largely on this new paradigm, helping to secure the reemergence of tablets and smartwatches.

Everything not within this milieu was marginalized. The Internet era had already threatened the desktop PC by moving the real processing away from the computer. Smartphones took it off the desktop altogether, using the Internet as leverage.

The Chromebook, a device that needs the Internet to function, appeared in 2011. It is, in reality, a very nice smart terminal—a throwback—right down to its aspect ratio. That's somewhat ironic, since this was also the era of the display and the dominance of the GPU. Displays were improved to an extreme, with feature-laden LCD monitors and the OLED display. 4K screens would become common.

For the desktop user, though, more and more things were canceled or disappearing. In 2007, Apple Computer dropped the word "computer" from its name and just became Apple Inc. The Macintosh computer would take a back seat to the phone, tablet, and watch. MacBooks began this era as the must-have laptop, but in the end, they too would be less important.

The economy collapsed in 2008, right as it was recovering from the earlier dot-com debacle. This caused a pullback from a lot of activity and led to a new

SoftGozar.com

There has probably been more manic activity since 2006 than in earlier eras, but it's all been short-lived or niche.

twist: the emergence of the so-called sharing economy, with Airbnb, Uber, and Lyft.

Before this era, people were developing personal and corporate blogs with elaborate templates. Then things shifted and simplified via operations like Tumblr. Nobody was interested in doing much design work themselves or even too much customization. That's why Facebook's closed system took off. Google countered with Google+ to no avail. Reddit emerged as a news source, to further confuse things.

At some point early in these 10 years, AOL dropped Netscape and was then gobbled up by Verizon. Consolidation began.

Facebook bought Instagram. Yahoo bought Tumblr, and Yahoo was acquired by Verizon. Acer gobbled up Packard Bell, eMachines, and Gateway. Everex shuttered. Nokia purchased Symbian. Microsoft bought Nokia's phone business. Dell went private. It was—and continues to be—a mad scramble.

There has probably been more manic activity since 2006 than in earlier eras, but it's all been short-lived or niche. Apps were the big thing in the early days of the smartphone. Programmers who could be doing bigger things tried to get rich quick, often with dopey apps. A few notable developments did have an impact, such as the Amazon Kindle.

The original idea of the computer revolution was to wrest control. Take the power of the computer away from the gatekeepers and empower the individual. Woohoo! The Internet appeared and added infinite connectivity between the empowered souls. But in 2013, a government contractor named Edward Snowden revealed what had really happened. This fantastic interconnectivity was more or less a control

SoftGozar.com

All supposed revolutions based on technology start with massive idealism.

mechanism; the government was spying on everyone with the assistance of companies including Yahoo, Microsoft, Google, and Apple. It was like the novel *1984* had come to life. The scene soured, ending any of the idealism of the 1970s.

All supposed revolutions based on technology (radio immediately comes to mind, as does the automobile) start with massive idealism. Such idealism is always shattered when the "revolution" matures and reality sets in.

It was fun witnessing it, and the next 10 years should be just as interesting. But it won't be interesting from the perspective of the PC. Not anymore.

john_dvorak@pcmag.com

SoftGozar.com

EDITOR-IN-CHIEF, PC MAGAZINE NETWORK Dan Costa
CREATIVE DIRECTOR, ZIFF DAVIS Cynthia Passanante
MANAGING EDITOR, DIGITAL EDITIONS Carol Mangis
SENIOR PRODUCER Mark Lamorgese
PRODUCTION DESIGNER José Ruiz

NEWS & FEATURES

EXECUTIVE EDITOR Chloe Albanesius
FEATURES EDITORS Evan Dashevsky, Eric Griffith
SENIOR FEATURES WRITER Chandra Steele
NEWS REPORTERS Tom Brant, Stephanie Mlot, Angela Moscaritolo

REVIEWS

EXECUTIVE EDITOR Wendy Sheehan Donnell
MANAGING EDITORS Sean Carroll (software, security), Alex Colon (consumer electronics, mobile), Matthew Murray (hardware)
LEAD ANALYSTS Michael Muchmore (software), Neil J. Rubenking (security), Joel Santo Domingo (desktops, laptops), Sascha Segan (mobile)
SENIOR ANALYSTS Jim Fisher (digital cameras), Will Greenwald (consumer electronics), Tony Hoffman (printers, scanners), Jeffrey L. Wilson (software)
ANALYSTS Max Eddy (software, security), Ajay Kumar (mobile), Victoria Song (hardware)
JUNIOR ANALYSTS Matthew Buzzi (hardware), Timothy Torres (consumer electronics)
INVENTORY CONTROL COORDINATOR Alice Newcome-Beill

BUSINESS

EDITOR Oliver Rist
MANAGING EDITOR Suzanne Kattau
SENIOR EDITOR Juan Martinez
ASSISTANT EDITOR Rob Marvin

ART, MEDIA & PRODUCTION

DIRECTOR OF PRODUCT MANAGEMENT Sarah Shaiq
PRODUCER Gina Latessa
COMMERCE PRODUCER Arielle Rochette
SENIOR DESIGNER James Jacobsen
STAFF PHOTOGRAPHER Paul Maljak
SENIOR VIDEO PRODUCER Weston Almond

CONTRIBUTING EDITORS

Tim Bajarin, John R. Delaney, Jill Duffy, John C. Dvorak, William Fenton, Tim Gideon, Bill Howard, Edward Mendelson

SoftGozar.com

ZIFF DAVIS INC.

CHIEF EXECUTIVE OFFICER Vivek Shah

CHIEF OPERATING OFFICER Steven Horowitz

CHIEF FINANCIAL OFFICER Brian Stewart

CHIEF TECHNOLOGY OFFICER Joseph Fortuna

CHIEF STRATEGY OFFICER James Yaffe

SENIOR VICE PRESIDENT, SALES AND MARKETING Eric Koepele

SENIOR VICE PRESIDENT, BUSINESS DEVELOPMENT Anurag Harsh

SENIOR VICE PRESIDENT AND GENERAL MANAGER, DATA SOLUTIONS Bennett Zucker

SENIOR VICE PRESIDENT AND GENERAL MANAGER, ACCOUNTING Fredrick Rolff

SENIOR VICE PRESIDENT, CONTENT Dan Costa

SENIOR VICE PRESIDENT, COMMERCE Jason Steele

GENERAL COUNSEL Stephen Hicks

VICE PRESIDENTS Frank Bilich (media sales), Lucas Deryckx (engineering), Melissa Hart (marketing), Mike Kane (product experience), James L'Heureux (ad and revenue operations), Diane Malanowski (human resources), Michael Pantoliano (business intelligence), Jennifer Riccio (FP&A), Archer Rosenblum (technology), James Steven (operations), Marc Von Holzen (software development)

THE INDEPENDENT GUIDE *PC Magazine* is the Independent Guide to Technology. Our mission is to test and review computer- and Internet-related products and services and report fairly and objectively on the results. Our editors do not invest in firms whose products or services we review, nor do we accept travel tickets or other gifts of value from such firms. Except where noted, *PC Magazine* reviews are of products and services that are currently available. Our reviews are written without regard to advertising or business relationships with any vendor.

HOW TO CONTACT EDITORS We welcome comments from readers. Send your comments to pcmag@pcmag.com or to *PC Magazine*, 28 E. 28th St., New York, NY 10016-7940. Please include a daytime telephone number. *PC Magazine*'s general number is 212-503-3500. We cannot look up stories from past issues, recommend products, or diagnose problems with your PC by phone.

PERMISSIONS, REPRINTS, CONTENT, AND TRADEMARK RIGHTS For permission to reuse material in this publication or to use our logo, contact us at Brand_Licensing@ziffdavis.com, or by phone at 212-503-5263/5264. Material in this publication may not be reproduced in any form without written permission. Copyright © 2016, Ziff Davis Inc. All rights reserved. Reproduction in whole or in part without permission is prohibited.

SoftGozar.com