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PLUS!
Build your
own **NAS**
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Model B is here **PG. 19**



GET READY FOR NEXT-GEN 5G

Why tomorrow's networks are
for more than your cell **PG. 44**



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Alan
Dexter

SECOND-GENERATION ZEN IS A GAME CHANGER

SUMMER IS OFTEN a quiet time for PC hardware, but this year things are different. We've had a slew of important releases hit our test benches all at once, and it could just be that the PC scene will never be the same again after this summer. Serious words, but reasonable when you're talking about a new PCIe bus that will usher in the promise of incredible storage performance and improved graphics.

In case you've been hiding under a rock, AMD has released a new processor family as well as its much anticipated Navi GPUs this month, and (spoiler alert!) they're both impressive. Admittedly, it's the CPUs that really loosened our collective jaws, but thanks to Nvidia also releasing new GPUs, AMD was forced to drop the prices of its first Navi cards, so they represent much better value than expected.

Of course, Nvidia's new "super" 2060 and 2070 are interesting in their own right, but they highlight once again that competition is good for us, the end user. Manufacturers dropping prices to make their products more tempting always goes down well. The same is true in the CPU space—Intel is guilty of resting on its laurels, but now it genuinely needs to respond, or it'll find itself lagging further and further behind. Price drops from Intel in lieu of new thread-happy chips aren't out of the question.

One area where AMD has come on in leaps and bounds over the original Ryzen is on the memory front. It's no secret that while the original Ryzen was an impressive shift in gear from Team Red, memory support at launch was patchy. It improved over time, to be sure, but that was one area where Intel definitely had a lead in terms of ease

of use. These new Ryzen chips have no such problems; in fact, AMD is pushing memory harder than Intel right now.

Which brings us nicely to the whole subject of RAM, and our main cover feature. What is the optimal amount of memory for any given system? What's more important: capacity, frequency, latency, or price? We show you how to improve this often overlooked subsystem, while ensuring you don't waste money where it isn't needed.

Our other main feature looks at what 5G will mean to you, and where our PCs fit in—it isn't just about cell phones anymore. With promises of connections in the remotest of places, super-low latencies, and the kind of bandwidth that is normally the preserve of fiber, 5G promises a lot. But can it deliver? Turn to page 44 to find out.

Another interesting new release is the Raspberry Pi 4. The tiny computer has seen many improvements over the years, but the most recent iteration really shifts up a gear, with a speedier CPU, improved memory, better buses, and support for dual displays up to 4K. It is genuinely becoming a viable budget desktop machine. We also show you how to build a NAS, get up and running with Docker, protect your network with an SSH honeypot, and much more.

I hope you enjoy the issue!



Alan Dexter is Maximum PC's executive editor and a punisher of hardware. He's been a tech journalist for over 20 years, and has no problem upsetting the PC industry as a whole.

submit your questions to: comments@maximumpc.com

THE NEWS

AMD's Epic EPYC

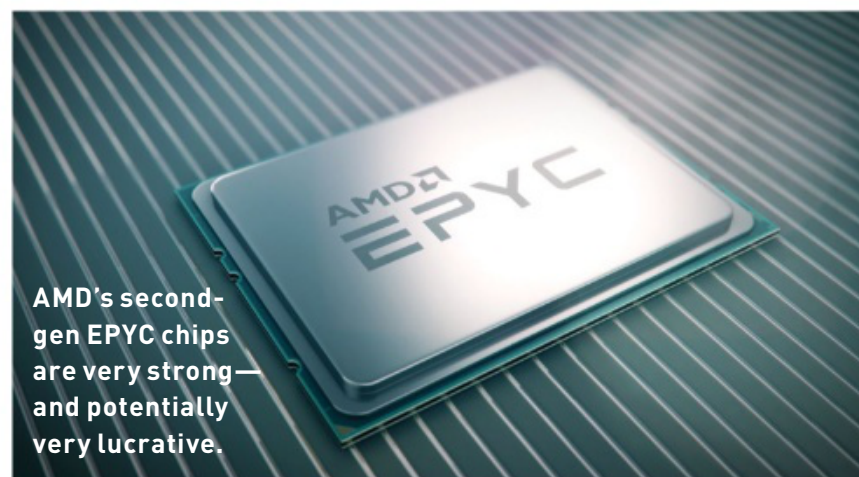
Zen 2 server chips meet every expectation

FOLLOWING the launch of AMD's Zen 2 desktop chips, the next step is Zen 2 server chips, EPYC. Get this right, and there are fortunes to be made, and AMD looks to have got it right. Its new EPYC 7002 series, code name Rome, is due very soon, and numerous details have leaked out. The initial range apparently runs to 19 variants, from eight-core entry chips at under \$500, through to 64-core monsters, which pack eight of AMD's eight-core Zen 2 chiplets into one processor. They all carry a decent amount of L3 cache, from 32GB up to a laudable 256GB. TDPs run from a quite cool 120W to a warm but not overly hot 225W.

We thought it was going to be fast, now we know. An unverified submission to the SiSoft database of an EPYC 7702P, one step down from the halo 7742, put it at the top of the rankings. It looks as if AMD's demonstrations earlier in the year, where a prototype chip humbled a dual-chip Xeon Platinum 8180M system, weren't all spin. Rome will be priced keenly, for server chips: The range tops out at under \$8,000, with the single-socket 64-core chip costing \$4,900. All unconfirmed as yet. Given

that Intel's top Xeon is \$10,000 or so, Rome is competitive as well as fast; we expect nothing less from AMD these days. There's still a fight ahead, though. The Xeon has specific advantages, such as cache and memory latencies, which help some applications that need quick responses, such as databases and analytics. Intel has considerably more resources, too—it actually has more software engineers than AMD has employees in total.

One reason why Rome looks like such a serious contender is that the chip it was designed to go head to head with, Intel's Ice Lake Xeon, isn't ready yet, so it will debut against the established Cascade range, which still uses the Skylake architecture on a 14nm process. So, will AMD sell them by the bucketload, and capture the market? No. It's not that simple. There's more to capturing market share than being competitive. AMD hopes to reach a 10 percent share of the server market by 2020, which looks likely. Dell, for example, plans to triple its AMD offerings. Depending on which figures you use, the company currently has about 5 percent. If things go well,



AMD's second-gen EPYC chips are very strong—and potentially very lucrative.

it could be looking at up to 15 percent within two years. Quite a feat, given AMD started practically from scratch with its first-gen EPYC. AMD has captured some trophies, too, including supplying Rome chips for what will be the world's most powerful supercomputer, Frontier, being built at the Oak Ridge National Laboratory. Rome will be another headache for Intel, one with a financial edge.

Meanwhile, the Zen 2 Ryzen 3000 series has started to reach paying customers—and us, too. See what we make of it on page 72. One unexpected hitch has been with the game *Destiny 2*, which fails completely, hanging on launch. This required the rapid distribution of a BIOS fix to sort out. Those hoping to overclock their 3000s are going to be a little disappointed; there's not much headroom on the first batch. AMD likes to squeeze as much as it can out of any given chip, and sell it running at as close to its maximum potential as possible. Unlike Intel, which

has a habit of moving chips about a bit to fill gaps in its range. Ryzen 3000 sales have been buoyant—Amazon's best sellers list puts the Ryzen 9 3900X at its head, and AMD occupies seven of the top ten slots. It's not exactly a good indicator of actual sales, given how important corporate buyers are, but it shows what people go for when they have a free choice.

Elsewhere, an internal memo at Intel has been leaked online, which makes interesting reading. It gives a potted history of the two companies' rivalry, and what Intel can do to check AMD's resurgence. The author admits that Intel hasn't faced such a challenge since the early 2000s. It's clear the company knows where it has failed, and what to do to recover. Intel is 10 times the size of AMD, and dedicated to staying that way. The good news is that such competitiveness leads to innovation—we haven't seen chip designs forge ahead like this in years. **-CL**



It looks as though AMD's earlier demonstrations of a prototype weren't all spin.

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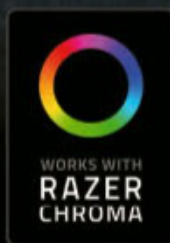
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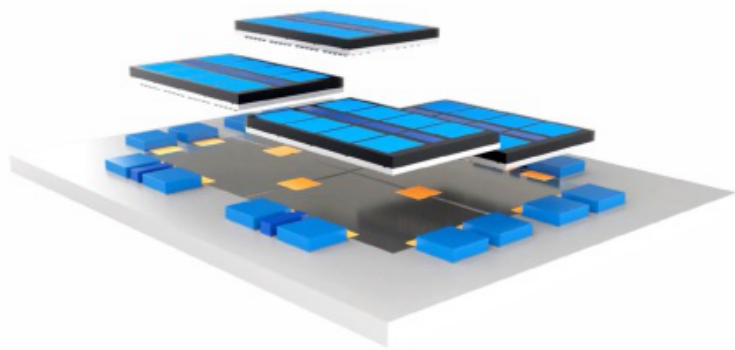


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INTEL'S CHIP SANDWICH

New packaging tech

THE PHYSICAL CONSTRUCTION of chips is becoming increasingly important. You can only shrink a chip so far before the basic laws of physics interfere. AMD's Ryzen 3000 series has introduced the chiplet design to the mainstream. Intel has been working on similar tech for years, has bought companies working in this field, and invested billions. At the SemiCon West trade show, it showed off the results: three new technologies for packaging chips.

Intel already uses EMIB (Embedded Multi-die Interconnect Bridge) and Foveros (chip-stacking technology). EMIB is a way to put a number of chips together on one package, using an interposer layer embedded into the substrate, while Foveros is a method of stacking chips on top of each other. EMIB is used on Kaby Lake G chips, and Foveros is due to appear soon on early mobile Ice Lake chips.

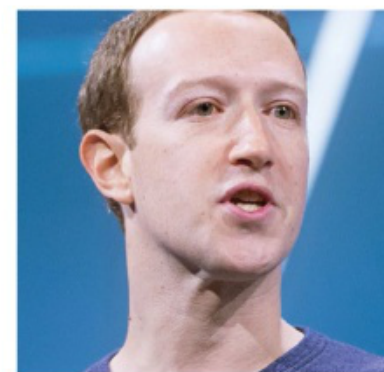
Intel has developed a way of combining these two methods into a new process, putting multiple layers of multiple chips on a substrate, each chip able to connect horizontally and vertically. This is co-EMIB, combined EMIB. It uses two other techniques: MDIO (a physical interface for chip stacking) and ODO (Omni-Directional Interconnect, a new process to build interconnects in any direction). And, yes, this is starting to sound like an electrical engineering class. What's important is that it enables Intel to piece together chips from slices of silicon made using different processes, arranging each element to best advantage, and the entire group can exchange data on-chip at high speed.

You could say that Intel is talking about this now because it has no new processors. However, as traditional design methods reach the buffers, processor packaging is going to be a very big thing, and Intel has made impressive strides. There are problems, specifically the distribution of power, and the heat it generates, which is why the designs are appearing on low-power mobile parts first, but it is the future, and Intel has some class-leading technology in the pipeline. **-CL**

FACEBOOK PAYS \$5 BILLION

FINE DOES LITTLE DAMAGE

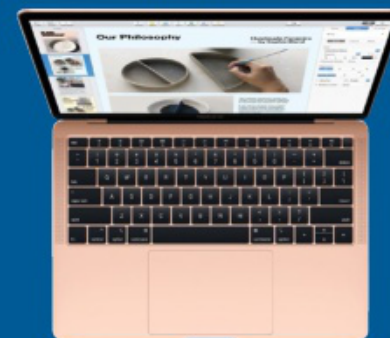
AS IT THREATENED, the Federal Trade Commission has hit Facebook with a \$5 billion fine for its infringements of privacy (handing out the personal data of 50 million people to a third party). As part of the ruling, Facebook has to review and document the way it handles data.



Bad news for Facebook? Not really. It's a large sum, the largest ever imposed by the FTC on a technology company, but Facebook had been expecting it, and budgeted accordingly. The company had set aside over \$3 billion, and has cash reserves of over \$40 billion. Investors weren't worried either; the stock price rose by 1.8 percent immediately after the announcement. If anything, the ruling has shown that Facebook is too powerful to be affected by such actions. However, there are signs that Congress and the Senate are running out of patience. Facebook is being quizzed by the Senate's Banking Committee over its forthcoming digital currency, Libra, and it has not been friendly. Libra is a big deal for Facebook, and legal disruption here could hurt. **-CL**

APPLE TO FINALLY FIX KEYBOARDS?

Butterfly design could go



MACBOOK KEYBOARDS have a tendency to break. The problem first appeared on 2015's MacBook, but it took Apple until June 2018 to admit there was a problem and start paying for repairs. The butterfly switch mechanism used means even a relatively small piece of dirt or debris that works its way under a key can cause it to stop working. It seems Apple is finally going to change the mechanism to the scissor design it used before 2015. Apple hasn't officially announced this yet, but it has applied for patents for a new scissor switched keyboard. Why no official announcement? Because the new design isn't ready yet, and Apple has just refreshed its MacBook Air and MacBook Pro models, which have the butterfly keyboards. Thankfully, they're eligible for free repairs if things go wrong. **-CL**

Tech Triumphs and Tragedies

A monthly snapshot of what's good and bad in tech

TRIUMPHS

AMAZON SPACE PROGRAM

The company plans to launch 3,236 satellites and build a global high-speed Internet network, code-named Kuiper.

TAKE ON DEEPMIND

The AI machine's AlphaStar will star as an opponent on some *StarCraft II* servers.

NEW APOLLO MISSION

A computer restorer has managed to get an Apollo Guidance computer to mine bitcoin—very, very slowly.

TRAGEDIES

UNPACK AT YOUR PERIL

A researcher has built a new zip bomb that doesn't use recursive data, and packs 4.5PB in a 46MB file.

6,000 EXABYTES LOST

A power failure at five of Toshiba's memory foundries cost six weeks' production; prices are expect to rise.

COMPULSORY MALWARE

In parts of China, border guards install malware on visitors' phones to extract personal data.

Switch Lite This Fall

NINTENDO HAS A NEW VERSION OF ITS SWITCH CONSOLE, and it's not what pundits were expecting. The Switch Lite is a smaller, all-in-one handheld version, with built-in controllers. Gone is the Switch's innovative two-in-one design, and it's back to basics. Nintendo's two biggest-selling consoles ever, the DS and Game Boy, were handheld, and only the PS2 has sold more than the DS. The Switch Lite is pitched as an upgrade for the 150 million people who want their Nintendo gaming handheld.

The Lite is, of course, lighter and smaller: The 720p screen drops from 6.2-inch to 5.5-inch. It'll play any Switch game that supports handheld mode. However, you won't be able to play games that require motion detectors, although it will sync to Joy-Con controllers. There's no TV output, HD rumble, or kickstand. The innards are as its big brother, though, with 32GB of expandable storage, and custom Nvidia Tegra silicon. The battery is a bit smaller, and said to be good for three to six hours.

The integrated controller has raised worries about reliability. The Switch's Joy-Con controllers had a nasty habit of developing "Joy-Con drift," where it continuously registers a movement. Infuriating, but at least you could replace the controller. Let's hope the new version has seen a spot of re-engineering, or is at least easy to fix.

Nintendo's Switch has been a huge hit, selling over 34 million units since its launch in March 2017. A technically improved Switch 2 has been rumored for some time, but not this year, it seems. The Switch Lite can be yours for \$200 this September. **-CL**

Nintendo's Switch Lite will cost \$100 less than the original, and come in yellow, gray, or turquoise.



Raspberry Pi 4 Practically a PC

The Raspberry Pi has reached its fourth major incarnation, and has received a bump in power with the quad-core Cortex processor now running at 1.5GHz. There's dual-HDMI with support for 4K at 60Hz. It also gets a pair of USB 3.0 ports, so you can easily attach some speedy peripherals. The Pi has now reached the point where it can be used to build a workable, if basic, desktop machine for under \$100. Twenty-five million Pi boards have been sold so far. Quite a feat for something designed as a teaching aid for computer science students. You'll want the 4GB model if you plan to use it for streaming video or browsing the net. Read our review, page 79. **-CL**

DisplayPort Hits 16K

The Video Standards Authority has made the biggest update to the DisplayPort standard since it was defined in 2007, with version 2.0. Max resolutions have been pushed to 16K, and bandwidth has tripled to 80Gb/s. This equates to running two 8K 120Hz HDR screens at once. We have higher refresh rates, and expanded HDR support across the board, as well as data mapping. Everything is backward compatible. This is just in time: Monitors are starting to go beyond 4K; Apple has 6K screens, and others have gone beyond that. TVs have reached 8K. We can expect compliant monitors in the next round of model refreshes, starting early next year. **-CL**



AMAZON PLANNING A HOME ROBOT

The sci-fi trope could be coming to live with you

HOME AUTOMATION is rapidly becoming a battleground between the tech giants, notably Google and Amazon. Smart speakers are now firmly established as part of the digital furniture, but Amazon has plans to go further—its Lab126 is said to be working on a home robot, code name Vesta. Prototypes have been described as waist height, wheeled, and navigating using an array of cameras. It has been demonstrated responding to voice control by being summoned.

What you do with it is another question. A mobile smart speaker is moderately useful, but it has to be easier to just buy a couple more Echo Dots. And if you've ever wondered why the Echo Dot is so cheap, it's because people with smart speakers spend more on Amazon. Researchers have estimated that regular Amazon Prime users spend \$1,300 a year on Amazon goods and services, while those with a smart speaker spend \$1,700.

Currently, the best home robots are either toys or dedicated to a single task, such as being a vacuum cleaner. Something that is truly multi-purpose, and genuinely useful, has evaded us as yet. The Asus Zenbo is one such attempt—it isn't cheap, costing \$600-\$900, and it doesn't do much more than be a smart speaker and digital camera that can follow you around (although you'll have to open doors for it unless they are "smart," too). The Zenbo is licensed for US sale, but hasn't made it beyond Taiwan as yet. Despite early design awards, and the first batch selling out quickly, interest and backing has waned. Amazon has made no public announcements on its robot project, although something is brewing at Lab126, because engineers have been pulled from other projects to work on it. This could be fun. **-CL**

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Jarred Walton

TECH TALK

Chip Yields, Binning, and the Silicon Lottery

THE PRIMARY BUILDING BLOCK of modern computers is the silicon microchip, made from 300mm silicon wafers, cut from a large silicon crystal cylinder. The monolithic crystals are grown from a seed crystal dipped into a molten vat of nearly pure silicon.

That “nearly” is important. Small impurities in the wafers can lead to errors or non-functional parts. It’s not just impurities, though; the crystalline structure of the wafer also varies slightly. Chips from the center of a wafer tend to be “better” than those near the edge, so they may require less voltage to hit the same clock speed, or may run at higher clock speeds at the same voltage.

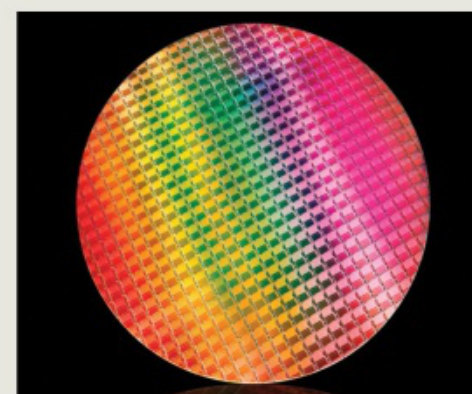
Because of the complexity of modern CPUs and GPUs, rather than having one failed circuit ruin the whole chip, redundancies are built into the design, and it’s possible to disable portions of a chip. Take AMD’s new Ryzen CPUs, where everything from the Ryzen 5 3600 up through the Ryzen 9 3950X is built using the same eight-core CCD (core chipset die) that measures 74mm². The 3600/3600X and 3900X all use CCDs with only six cores enabled, while the 3700X/3800X and upcoming 3950X use CCDs with all eight cores enabled. Why would AMD disable two CPU cores in each CCD on some parts? To improve chip yields and overall profitability.

Each silicon wafer contains potentially hundreds of chips, but not every chip from a wafer behaves the same. After the initial manufacturing process, each wafer gets cut into chips. These are tested to determine how good each is in a process called binning. Some may work perfectly, others may be effectively useless, while many fall somewhere in between. The percentage of functioning chips is the

yield. Most companies don’t report their yield, though rumors and estimates suggest that Intel’s first-gen 10nm process had yields in single digits: Less than 10 percent of the potential 10nm processors were viable—and that’s after Intel disabled the Gen10 graphics, and with a small dual-core die. In contrast, it’s estimated that by harvesting partially functioning dies, yields for AMD’s new Zen 2 parts may be 85 percent or higher.

This is important as each wafer has a relatively fixed cost—perhaps \$7,000–\$10,000. This is also why smaller chips are preferable to larger ones, as more can fit within the space of a wafer. A small 74mm² chip like Zen 2 has a potential of nearly 800 chips per wafer, while Intel’s 10-core Skylake-X chips are around 322mm² and only fit about 170 per wafer. With a defect density of 0.1 per cm², the 10-core Skylake-X might lose up to a third of the potential chips (without harvesting), while the Zen 2 CCD would only have about 8 percent defective chips.

Binning addresses multiple aspects. Firstly, there’s the harvesting of partially functioning dies—so your RTX 2060 that uses the same TU106 GPU as the 2070 only has 30 out of a potential 36 SMs enabled, as well as two memory



Intel’s 10nm process has changed significantly to improve yields for the upcoming Ice Lake CPUs.

controllers disabled. Binning also determines the ideal voltage and frequency, and sometimes a chip that is otherwise fully functional might get downgraded because it can’t run at the desired speed. AMD’s RX 5700 and RX 5700 XT use the same Navi 10 GPU, but besides having 256 fewer cores, the 5700 is clocked about 150–200MHz lower.

The best chips are sold as the fastest, most expensive parts, while the functional but not quite as good chips are sold as lower tier parts. However, the gap between the “best” and “worst” functional chips from a wafer may be quite small. But for newer manufacturing nodes like TSMC’s 7nm or Intel’s upcoming 10nm, the gap is more likely to be larger. So, you won’t hit the same clock speeds on second or third tier products, no matter how hard you try to overclock. Unless you’re lucky, and win the silicon lottery with a great chip sold as a second-tier part.

Jarred Walton has been a PC and gaming enthusiast for over 30 years.



Some chips may work perfectly, others may be useless, many fall somewhere in between.

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Alex Campbell

OPEN SOURCE

Much Ado About 32

CANONICAL RECENTLY MADE WAVES in the Linux gaming community by announcing that it would be dropping 32-bit support from Ubuntu 19.10, to which Valve announced that it would cease supporting Ubuntu. What's the big deal?

If you're under a certain age, you might not remember purchasing a 32-bit system or CPU for a build. The last 32-bit system I bought was my Asus EeePC—which has an Intel Atom N270—back in 2009. For most PCs still running today, there's a darn good chance that it's a 64-bit system. Hell, even a Raspberry Pi or your smartphone is 64-bit.

That's a good thing: Most desktop systems today come with at least 8GB of RAM. Most laptops you can buy rarely have less than 8GB as well. Because of the limited address range available to 32-bit CPUs, most OSes don't have more than 4GB of addressable memory on a 32-bit system. The advance of 64-bit systems has been partly responsible for systems with large filesystems, large amounts of memory, and larger file sizes.

If you're not up on your computer science, here's a quick refresher: A 64-bit system is said to have 2^{64} bits for its largest integer value, equivalent to about 8 bytes per integer. In comparison, a 32-bit integer is 2^{32} bits, or about 4 bytes. A 16-bit integer has 2^{16} bits, or two bytes.

So the question comes up: If the world of consumer electronics is effectively 64-bit, why on earth does 32-bit support matter?

The simple answer is that some programs or libraries are still distributed as 32-bit. While 64-bit systems can run 32-bit programs, it requires some translation, because of the differences in memory addresses and other programming nuances. This is why a 64-bit Linux system

requires a slew of 32-bit libraries to run a 32-bit program. The collection of libraries needed for 32-bit compatibility is essentially a copy of 64-bit versions that may already be on the system. This means that you could potentially double the storage requirements for the system's libraries at worst, and increase the complexity of the installed system at best.

What started the hullabaloo in the Ubuntu sphere was the notion that 32-bit packages and libraries are rarely used, and by extension, rarely patched or updated. (Again, few people actually run native 32-bit systems.) Because there aren't that many eyes looking at the 32-

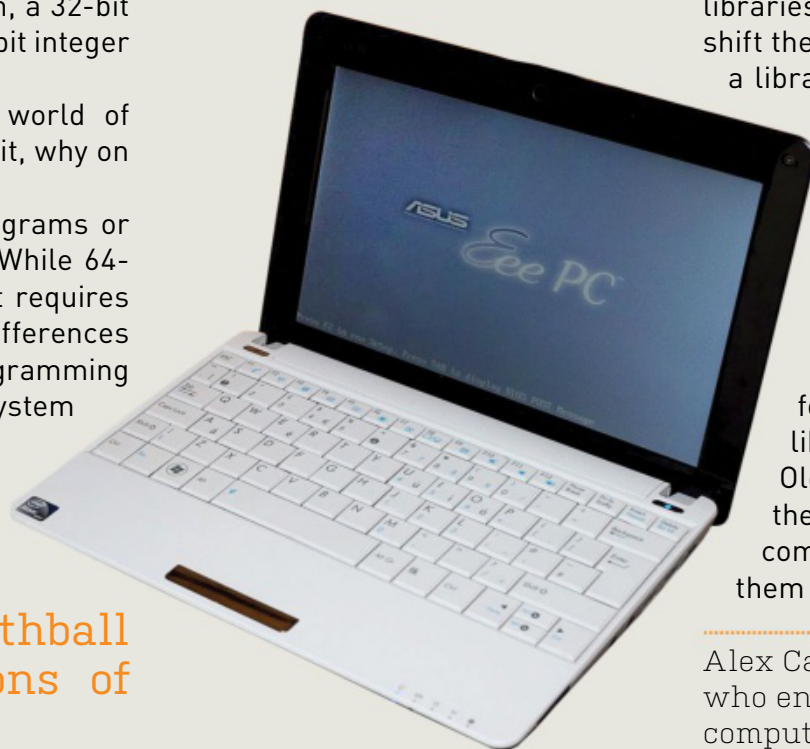
bit packages or code, Canonical planned to mothball 32-bit support for reasons of security and stability. In a blog post, Canonical specifically cited Spectre and Meltdown as vulnerabilities that have no mitigation in 32-bit.

The original announcement drew concern from gamers and creatives (using Ubuntu Studio) who rely on 32-bit compatibility to run key pieces of software. Valve noted in a post that Steam and many of the Steam games available for Linux are 32-bit. WINE, the Windows compatibility layer for Linux, also makes heavy use of 32-bit libraries.

Canonical's response was to continue providing access to 32-bit libraries, but with a warning that it could not guarantee the security of a system when running them. Canonical said that Ubuntu will work with app developers to deploy 32-bit programs in containers, with all the required libraries bundled with them. That way, a user doesn't have to maintain and update 32-bit libraries from a repo. This will shift the responsibility for keeping a library updated from the user to the app developer.

While 32-bit systems are a thing of the past for most of us, there's still a large number of 32-bit applications. Until every legacy program is rewritten or compiled for 64-bit, we need extra libraries to run them. Old programs never die, they just require additional compatibility layers to keep them running.

Alex Campbell is a Linux geek who enjoys learning about computer security.



Canonical planned to mothball 32-bit support for reasons of security and stability.

**“ A creative man
is motivated by
the desire to achieve,
not by the desire to
beat others.**

—
AYN RAND

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THE LIST

8 MOST EXCITING FEATURES OF THE RASPBERRY PI 4

8 NATIVE GIGABIT ETHERNET

Previous Raspberry Pi models were capped at 300Mb/s, but the Pi 4 can now supply the full bandwidth.

USB 3.0

The number of USB ports hasn't changed, but they've been upgraded: Two of the four ports now support USB 3.0.

7

UPDATED VIDEO DECODE

Resolution isn't the only thing that's improved; the new hardware decode of HEVC video supports up to 60fps, double the Raspberry Pi 3.

3

UP TO 4GB OF DDR4

The Raspberry Pi 3 had 1GB of RAM at LPDDR2, while this model comes in three flavors: 1GB, 2GB, or 4GB, all at crisp LPDDR4 speeds.

6

1.5GHZ QUAD-CORE CPU

A new 64-bit ARM Cortex-A72 processor from Broadcom promises maximum performance figures up to three times as fast as the previous Cortex-A53 CPU.

2

MICRO HDMI PORTS

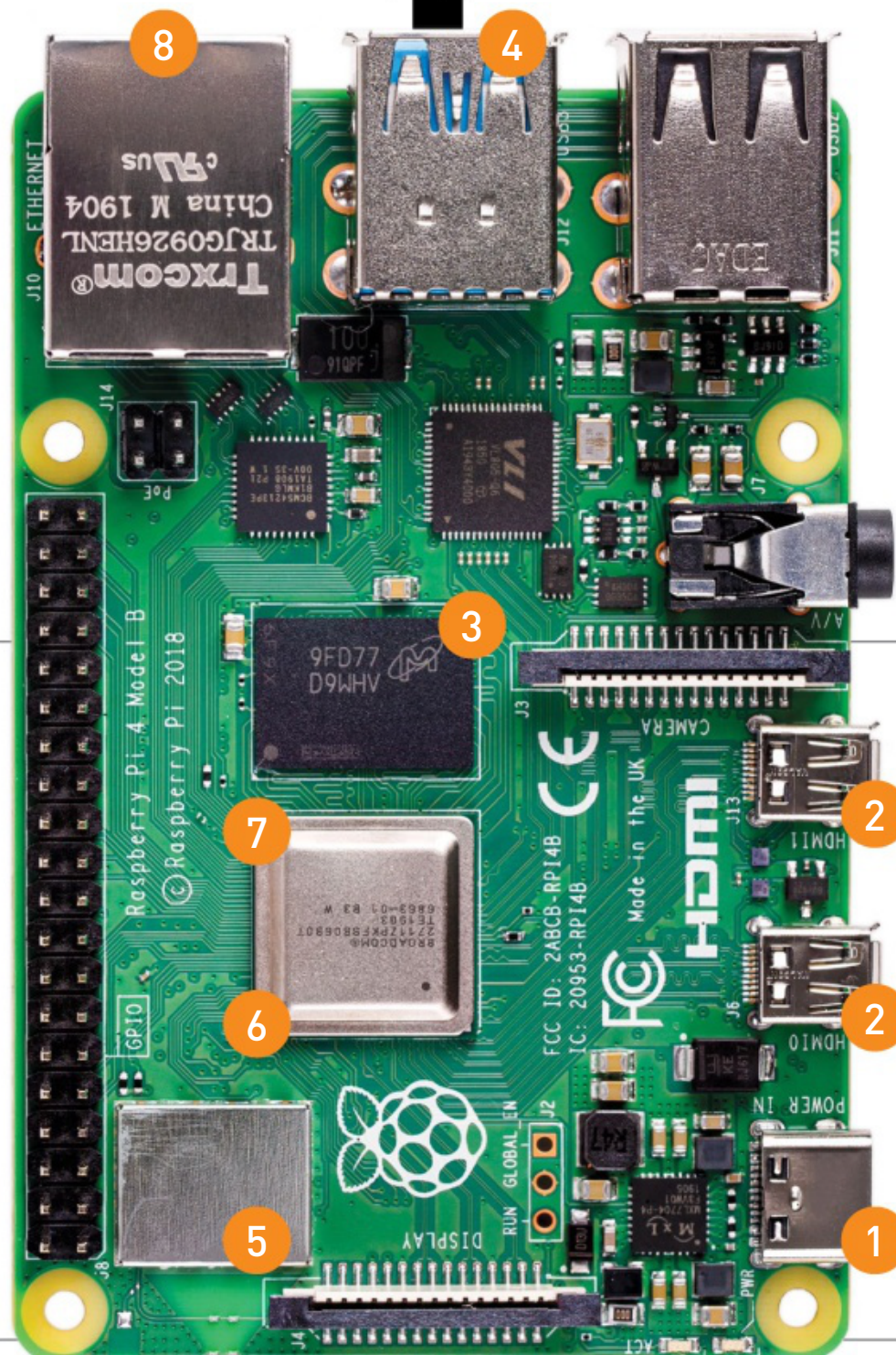
With two Micro HDMI ports, the Raspberry Pi 4 can support two monitors in 1440p, or one monitor in 4K.

5 BLUETOOTH 5.0

Not much to talk about here. Bluetooth 5.0 goes faster, further, and draws less power than its predecessor, Bluetooth 4.2.

USB-C POWER

While the voltage might still be capped at 5V, the Raspberry Pi 4 swaps from Micro-USB to a USB-C power connector.



DOCTOR

THIS MONTH THE DOCTOR TACKLES...

- > Linux on the Go
- > AMD Upgrades
- > Cryptic BSODs

Mobile Linux

Dear Doctor, I am trying to install Ubuntu on my HP Stream Notebook. The problem I'm having is that I can't get the notebook to boot from my USB drive. Please help! **-Matthew Parr**

THE DOCTOR RESPONDS: It sounds like you've already downloaded Ubuntu and created a bootable thumb drive. But the notebook's eMMC storage device is the first device it looks to at startup, so Windows loads before the UEFI even sees your USB key. The fix should be as simple as rearranging the firmware's boot order.

With the USB drive plugged in, repeatedly tap F10 as the Stream powers on. If you're successful, the HP Setup Utility should appear. If not, it'll continue loading Windows and you'll have to try again. Once the UEFI opens, go to the "Storage" tab and scroll down to "Boot Order." Under "Legacy Boot Sources," find the USB key and make sure it appears before "Hard Drive" in the list. Press F10 to accept the selection. Now tab over to the "File" menu and choose "Save Changes and Exit."

The next time you boot up, your notebook should start



HP's low-cost Stream notebooks include Windows 10, but make excellent candidates for a lightweight OS, such as Ubuntu, too.

with the thumb drive you prepared. Just remember to switch your hard drive back to the first position once Ubuntu's installer finishes.

Next-Gen AMD

Hi Doc, I am finally upgrading to Windows 10, but I want to mirror my current setup, and have some concerns. I use the C: drive as system storage, while the D: drive is a data disk. I remember having to manipulate the registry to stop software automatically installing to C:, so the drive could be smaller. Is this the case with Win 10?

I'm also considering building a new system and

have a question about AMD's Ryzen processors. Is it worth waiting for the company's next generation of chips and X570 chipset, or should I move forward with its X470-based platform and a Ryzen 7 2700X that I upgrade later? This machine will be tasked with moderate gaming, moderate photo editing, and all my other everyday tasks.

Also, what components would be potentially affected by the AMD X570 chipset?

-Thom Mason

THE DOCTOR RESPONDS: Be careful with registry-based modifications that change the location of your Program

Files folder. Although there are numerous tutorials online explaining how to alter Windows 10's default installation directory, most of them are also loaded with comments complaining about unanticipated side effects. Microsoft even has a Windows support page stating it doesn't support changing the location of the Program Files folder by modifying the ProgramFilesDir registry value.

If you want to free up space on your C: drive, try less invasive relocations. The Doc moved his Documents folder to a networked storage appliance by right-clicking it, selecting "Properties," tabbing over to "Location," and redirecting the contents to his E: drive. That saved almost 250GB on his priciest SSD. You can also change the default install directory of applications downloaded from the Microsoft Store by clicking "Start → Settings," then "System." Select "Storage" from the left-hand pane, then scroll down to "Change where new content is saved." In that submenu, you have the option to redirect new apps, documents, music, and so on. This works best if you configure it on a fresh copy of

submit your questions to: doctor@maximumpc.com

Windows, because it doesn't apply retroactively.

Talking of new installations, AMD's third-gen Ryzen CPUs will be available by the time you read this, and they're definitely worth the step up from prior models. Not only do you get more cores for your money, but 7nm manufacturing means the latest processors still fit into friendly power envelopes. Improved instruction-per-cycle throughput, larger caches, and lower memory latencies are all reasons to consider an upgrade.

The X570 chipset is the first with PCI Express 4.0 support. AMD's Radeon RX 5700 and 5700 XT graphics cards are already compatible with its higher transfer rates, as are several just-released SSDs. As new graphics, storage, and networking processors are released, many will exploit the increased throughput PCIe 4.0 offers to squash bottlenecks that PCIe 3.0 imposed. Beyond a faster bus, X570 offers up to eight USB 3.1 Gen 2 ports, and there's no such thing as too much USB connectivity.

Fix or Upgrade?

Doc, I built my PC in 2014, using an Asus Z97-PRO, an Intel Core i7-4790K, 16GB of memory, a recycled Radeon HD 5570, and a PC Power & Cooling Silencer 750W PSU. I run six hard drives, two of which are set up as RAID 1. My boot drive is a 1TB Samsung 850 EVO.

I'm having some issues with the system. When it reboots, the PC hangs on Asus Q-Code 64. Per the manual, that corresponds to "CPU DXE initialization is started," which isn't particularly descriptive. If everything locks up for two or three minutes, I hit the reset button and start again. Sometimes I have to repeat this process a couple of times before I get to the boot screen. Unfortunately, I think this machine is on its way out to pasture. Do you have any ideas about what could be

wrong, or would I be better off starting a new build?

If I go with something new, I'd like a modern machine built on an Intel processor. What would you recommend in the 4790K's original price range from the current Core i7 or Core i9 family? I'll also need a motherboard able to support the new chip—something comparable to my Asus Z97-PRO.

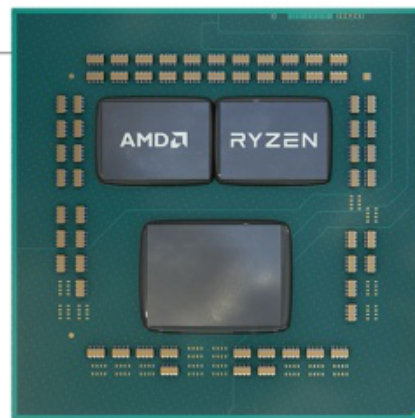
I'm not into gaming, so I think that any modern CPU's integrated graphics will be way ahead of my Radeon HD 5570, and the only overclocking I'm interested in is what the motherboard can do automatically. I run nanoCAD and Office 2019, plus Plex for TV viewing over Wi-Fi. The most important software I run is Virtual Weather Station for reporting readings to the National Weather Service private weather station program, so uptime is of the utmost importance (I can go 41 hours before I start losing weather station data).

At the very least, I'm looking for a new ATX motherboard, a processor, and at least 16 to 32GB of memory. I wanted to wait another year for Intel to get its act together on 10nm manufacturing, but I might not have a choice if my system can't be fixed. Any recommendations you can make would be appreciated.

—Edward Carl Knack

THE DOCTOR RESPONDS: Your system is locking up during its Driver Execution Environment phase, which consists of several steps, and is thus difficult to troubleshoot. There are, however, several options you can try.

Are you running the motherboard's latest BIOS? The first version dropped in May 2014, while the newest build was published in 2018. Asus's release notes for almost every update state "Improve system stability." There's a fair chance that whatever is causing your



The latest Ryzen CPUs provide a big performance boost in single-threaded tasks, making them a worthwhile upgrade.

system to hang was addressed along the way.

If that doesn't help, test your memory modules by removing one, then, if necessary, swapping them. Check if the DIMMs are configured to operate at a more aggressive data rate than they officially support. Even if not, try dialing them down to a more conservative setting and see if stability improves. Continue by disconnecting USB-attached devices, one by one, to see if they're interfering with your system's initialization process.

Hopefully, one of those tips helps breathe enough life into your system that you can wait the year you planned. But if you decide to pursue a new build anyway, it sounds like you could get by with relatively mainstream components and save significant money. Intel's Core i5-9600K does a great job balancing reasonable pricing with screaming performance from six execution cores and a boost frequency of up to 4.6GHz. Its UHD Graphics 630 engine is nothing to write home about, but if you have no real need for 3D graphics, it should suffice.

Decoding BSODs

Hello Doctor, I am a long-time subscriber and owe much of my building skills to *Maximum PC*. One of my newer systems is running Win 10 Pro, a Core i7-7820X CPU, 64GB (four 16GB sticks) of Corsair Vengeance DDR4 memory in an SO-DIMM form factor, an ASRock X299E-ITX/ac mobo, a GeForce GTX 1060 6GB, and a 1TB Samsung SSD 960 Pro. All that hardware is

stuffed into a Lian Li PC-Q37 mini-ITX case.

Everything was good until a few weeks ago. I ran a search using Chrome and was hit by a BSOD. As Windows 10 typically bounces right back after a restart, I figured it was a fluke. I haven't figured out what happened, though. I use the rig for video rendering, and I don't game. I've had no other issues. I simply cannot use Chrome without crashing.

I've tried deleting and reinstalling Chrome via safe mode. I ran virus scans. I wiped the drive, reformatted, and reinstalled Windows. I even stripped the system down and reseated all the hardware. The problem persists. Sometimes the PC freezes right away when I try to open Chrome and I get a blue screen that says "WHEA_UNCORRECTABLE_ERROR." My research suggests this is a hardware error. I updated Windows, all of my drivers, I checked for BIOS updates, and have not overclocked the CPU or GPU. The only workaround I've found is to install Chrome Portable in a thumb drive and execute the browser that way. Consider me stumped!

—Stacey Bisceglia

THE DOCTOR RESPONDS: It's unfortunate that Microsoft's "WHEA_UNCORRECTABLE_ERROR" message isn't more descriptive. However, the fact that Chrome Portable works when the installed version doesn't suggests that there's a setting difference. Open both versions and type "chrome://settings," scroll down and expand the "Advanced" link, then check to see if "Use hardware acceleration when available" is selected. If it is on one and not the other, match them up to the build that doesn't crash. The Doc wonders if a recent graphics driver update is causing problems that manifest when Chrome tries to leverage your GPU. Rolling back to an older driver might help, if so. 🔄

LONG-TERM

Desktop memory is becoming more affordable; *Christian Guyton* examines what that could mean for you



MEMORY

RAM IS A CORE COMPONENT of any computer. With DDR4 now well and truly entrenched in the memory market and DDR5 on the horizon, manufacturers are looking out in different directions: massive 64GB and 128GB sets running across eight channels, and faster speeds than ever seen before. Frequencies only continue to rise, with companies such as HyperX and Corsair pushing commercially available sticks at well over 4,000MHz.

But it ain't cheap. RAM price-per-GB skyrocketed between 2016 and 2018, although recent trends have shown that DDR4 kits have slowly lowered in price from the latter half of 2018. RAM offering 3,000MHz and above remains expensive, with a seemingly endless list of brands and product lines

to choose from. It's daunting. The vast majority of modern memory comes packaged with integrated heatsinks, with many sporting multicolored LEDs to boot. Some beefier packs even come with their own coolers, mounting awkwardly above the DIMM sockets. With an open mind and an even more open wallet, it's easy to spend a silly amount of money.

Choosing RAM in this day and age can be a laborious process, but fear not—as always, *Maximum PC* has got your back. Over the next few pages, we're going to break down the technology and nuances behind random-access memory, and discuss which kits are best for which builds. A discerning eye is important when buying RAM; what you pay for is not always what you get.



Size Does Matter

WHEN LOOKING AT MEMORY KITS, there are three key elements to consider: capacity, speed, and latency. We're going to take a look at capacity first, as it tends to be the biggest deciding factor when choosing your RAM. Industry regulation from standardization body JEDEC (more on that later) means that memory only comes in certain multiples: 2GB, 4GB, 8GB, and so on, doubling each time.

For consumer use, the standard maximum capacity of DDR4 chips is 16GB, due to limitations in transistor size, although a theoretical 32GB per chip is possible, so the largest commonly

available capacity per DIMM slot is 32GB. 64GB sticks are available, but not for general consumer use; they're more likely to be found in server farms. With a mobo supporting full memory capacity, the current maximum available for desktop systems is 128GB.

Of course, 128GB is far more than the average PC will ever need. RAM should be chosen based on the requirements of the system; it can be one of the more expensive components of a fresh build, and it's easy to overspend on capacity that isn't required. With that in mind, here's our guide to how much RAM your system should need.



4GB

■ Consider this a bare minimum. If you're building on a seriously tight budget, or just looking for a basic PC for office work (think word processing, not giant spreadsheets), 4GB of basic DDR4 will do. As memory frequency has less of an impact on Intel processors than AMD ones, we recommend opting for slower RAM, such as DDR4-2133, paired with a cheap Intel Core CPU. This memory won't cost much—a stick of 4GB RAM shouldn't run you much more than \$20 right now. Dual-module kits are also an option, using two 2GB sticks to improve performance, but these can cost more, and the difference is likely to be minimal. Rigs such as this also make for affordable home theater PCs or cryptocurrency mining units, although some cryptos can be CPU-intensive, so a slightly better processor is a good idea.

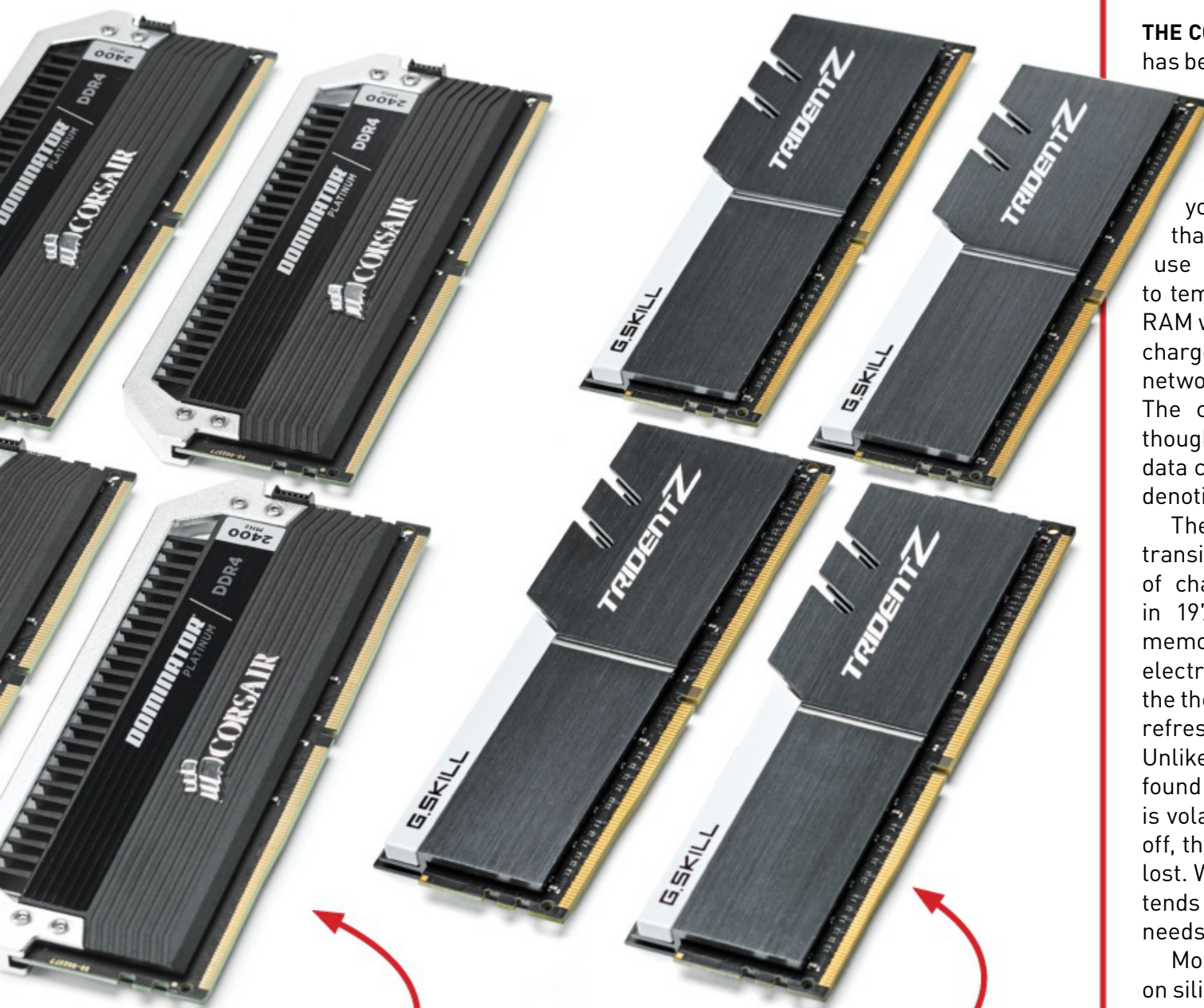
8GB

■ If you're looking for a standard PC, 8GB of RAM is the way to go. Capable of handling any office work and low-end gaming, 8GB of dual-channel memory will serve any basic build well. It's worth bearing in mind that if your GPU doesn't have much VRAM, some games attempt to cache large texture files to the system's DRAM. If you're running an older graphics card with less than 4GB of video memory, 16GB of memory could be a better call. This only applies for more graphically demanding games, though; if your poison is lightweight indie gaming, 8GB is plenty. Older triple-A titles ought to be fine, too, if you've got an appropriate GPU to back you up. Make sure you go for dual-channel; a single stick of 8GB DDR4 will work, but the performance difference will be more noticeable in games.

16GB

■ For mid-range gaming supported by a decent GPU, 16GB of DDR4 is a necessity. Games are becoming increasingly demanding when it comes to RAM; if you're looking to play in anything higher than 1080p, 16GB may not always be enough. The uptick in multiplatform games being ported to PC has resulted in a lot of poorly optimized triple-A titles hitting our screens, too, which have a tendency to gobble up RAM. 16GB should be able to cope with other tasks, though; image manipulation and intermediate video-editing work shouldn't be an issue. You'll likely have two options: 4x 4GB or 2x 8GB. Doing your research is worthwhile; one kit might appear better value for its performance, but if your CPU and mobo are only going to support dual-channel memory, you won't be able to reap the benefits of a quad-channel kit.

Stepping Back Through Time



32GB

■ Some RAM kits have got significantly cheaper over the past year. In early 2018, 32GB of DDR4 could set you back \$400 or more, but prices have dropped by around half since then. At the moment, a kit of four 8GB sticks should only set you back \$100-\$200, even at higher speeds, such as 3,600MT/s. With this new affordability in mind, 32GB (or more) becomes a more distinct option. If you're looking to edit 4K video, use 3D rendering programs, or play high-end games at maximum graphical settings, you'll want at least this much memory to play with. For gaming purposes, 32GB will be overkill for most modern games, but also serves to future-proof your system. Again, if you're rocking four 8GB modules, as opposed to two 16GB ones, make sure that you've got support for quad-channel memory.

64GB+

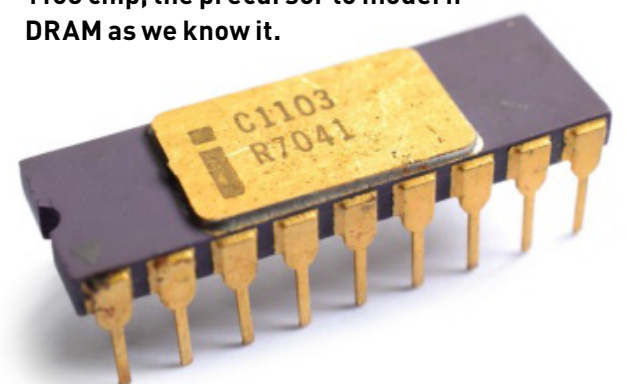
■ It wasn't that long ago that the notion of putting 64GB in a desktop PC was faintly ridiculous, in terms of both cost and necessity. Today, though, 64GB of high-speed RAM (over 3,000MT/s) can cost as little as \$250, making it feasible in a high-end system for gaming or editing tasks. While 32GB modules are available, we recommend a quad-channel kit of four 16GB sticks; dual-channel runs the risk of RAM bottlenecks. 64GB will give any system serious oomph, but if you have money to burn, 128GB is an option too. It's hard to see where this would be required—advanced high-res videography, perhaps—but the option exists. DDR5 promises to up that maximum to 256GB, which will likely only serve a niche role for heavy data analysis tasks and video processing in 8K and beyond.

THE CONCEPT of random-access memory has been around since the 1940s, although it didn't exist in its current form until 1968. When we talk about RAM here, we mean DRAM—dynamic RAM—the kind of memory you're probably familiar with: Sticks that plug into your motherboard and use binary capacitors and transistors to temporarily store readable data. Early RAM worked differently, using electrically charged spots on cathode ray tubes or networks of magnetized metal rings. The core principles remain the same, though—the points of positive or negative data could be read in any order, therefore denoting them as “random access.”

The current model of RAM, using transistors to store data as combinations of charges, came into commercial use in 1970 with the Intel 1103 chip. This memory requires a constant supply of electricity, with the minuscule charges on the thousands of transistors needing to be refreshed hundreds of times per second. Unlike storage memory (such as that found on traditional SSDs and HDDs), RAM is volatile; once the computer is powered off, the charges dissipate, and any data is lost. While non-volatile RAM does exist, it tends to be too slow for normal memory needs, and can suffer from other issues.

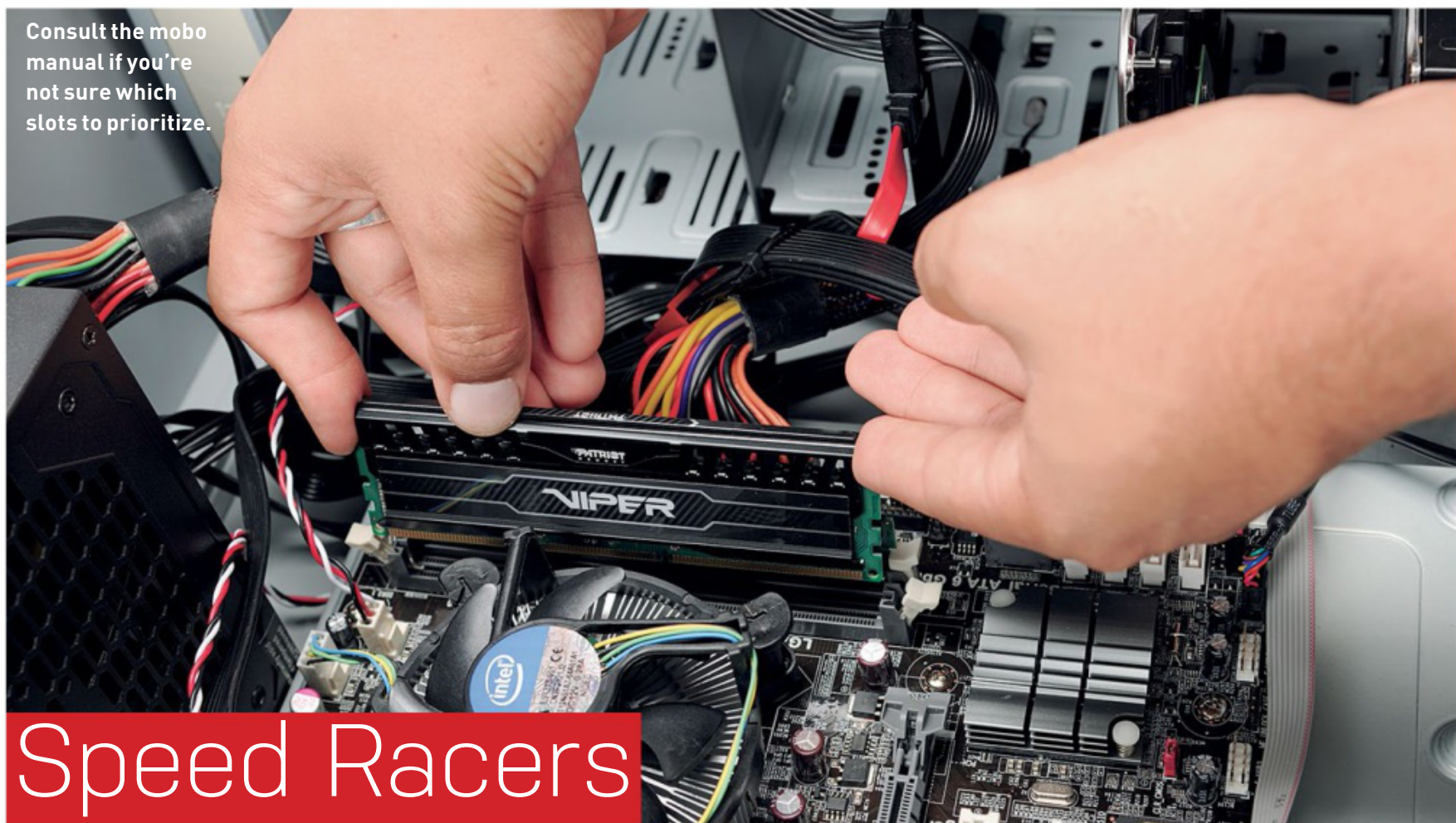
Modern DRAM uses solid-state memory on silicon circuitry, unlike the ceramic and magnetic components of the Intel 1103. It functions in much the same way, though, losing data once the power is turned off. Nowadays, RAM is used for a wide variety of computing functions, most commonly for graphical tasks, be that rendering 3D objects in real time in a game, or editing video footage. DRAM is found in more than just the heatsink-equipped silicon sticks you can buy in varying sizes and kits; it operates inside modern graphics cards, games consoles, even calculators.

Say hello, Grandpa... This is the Intel 1103 chip, the precursor to modern DRAM as we know it.



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Consult the mobo manual if you're not sure which slots to prioritize.



Speed Racers

WE KNOW, MEMORY SPEED can be complicated. Speed and frequency are often treated as interchangeable statistics, because they are directly tied to each other; RAM, like many other components, operates at a specific frequency. This frequency represents the number of times per second an individual transistor gate can open and close. With memory operating at, say, 1,000MHz, these transistors can cycle at a fairly nippy 1,000 million times per second.

If you're the memory-savvy type, though, you might be more familiar with the MT/s figure than MHz. Shorthand for megatransfers per second, MT/s was introduced as a metric for memory speed when DDR (double data rate) was first produced, because the newer format of memory was able to process data at twice the speed by registering an additional data transfer on the rise and fall of the clock. Frustratingly, many manufacturers chose to ignore this standard, meaning that current-generation memory quotes frequency figures that are double their true operating frequency. If you examine memory speed using system status analysis software, such as CPU-Z, you'll find that your 3,000MHz memory is actually running at around 1,500MHz. MT/s is technically the more accurate figure, but MHz is more widely used.

Obviously, more speed is better. Commercially available memory speeds have been rising steadily over the last few years, with the current DDR4 standard reaching as high as 4,800MHz (or MT/s, to be more precise). Higher speeds reduce your real-world memory latency, and enable the transferral of more data within a set period of time. This enables superior performance in rendering functions and other tasks, although not all processors are affected equally; if you're rocking an Intel CPU, you'll find that increasing your memory speed will have a far smaller impact than on an AMD processor. For now, then, capacity remains more important than frequency.

Memory speed does impact another important feature of your RAM, however. The channel bandwidth of any memory kit is determined by memory speed; for those not in the know, the

bandwidth is the maximum amount of data that can be transferred between the memory and CPU within a set period of time. This is calculated by multiplying the transfer speed (in T/s), the system memory bus (in bits), and the number of channels the memory is capable of accessing simultaneously. So, for a set of dual-channel DDR4-3000 memory running with a CPU using a 64-bit bus, the channel bandwidth would be $3,000,000,000 \times 64 \times 2$, which is 384,000,000,000 bits per second. A gigabyte per second equals to 8 billion bits per second, so we end up with the far more palatable figure of 48GB/s. This is the absolute maximum data rate that this system could achieve; attempts to do anything demanding faster transfers than this would result in memory bottlenecking.

Assuming that you're not going to meddle too much with your CPU, that means that data transfer is determined by more than just memory speed. When choosing what RAM to put in your system, consider the advantages of a quad-channel kit over dual-channel (provided your CPU supports it of course—most mainstream CPUs are resolutely dual-channel). To be fair, dual-channel memory support represents a good standard for the average system, but quad-channel support effectively double your channel bandwidth, so if you're using your system for tasks that demand massive data transfers (such as 4K+ video editing, or large-scale texture production), four can be the golden number.

Channel support is tied to your motherboard, too. Many high-end boards support quad-channel memory, but if you're considering a memory upgrade for a slightly older system, do bear in mind that your motherboard might only support dual-channel. Four DIMM slots is no guarantee of quad-channel support; many four-slot boards have two primary slots (which logically should be A1 and B1, but are sometimes A1 and A2 or A2 and B2, depending on the manufacturer), which provide full dual-channel speeds. This works both ways: Plug in only one stick of dual-channel memory and you'll get half the channel bandwidth. Smaller motherboards, such as the ITX format, have only two slots with dual-channel support, due to their layout specifications, even on X299.

Quality Control

THE JOINT ELECTRON DEVICE ENGINEERING COUNCIL (JEDEC) is the body responsible for maintaining industry standards when it comes to numerous solid-state components, including RAM. With over 300 members, including Microsoft, Intel, and Apple, JEDEC pools resources to push hardware development forward.

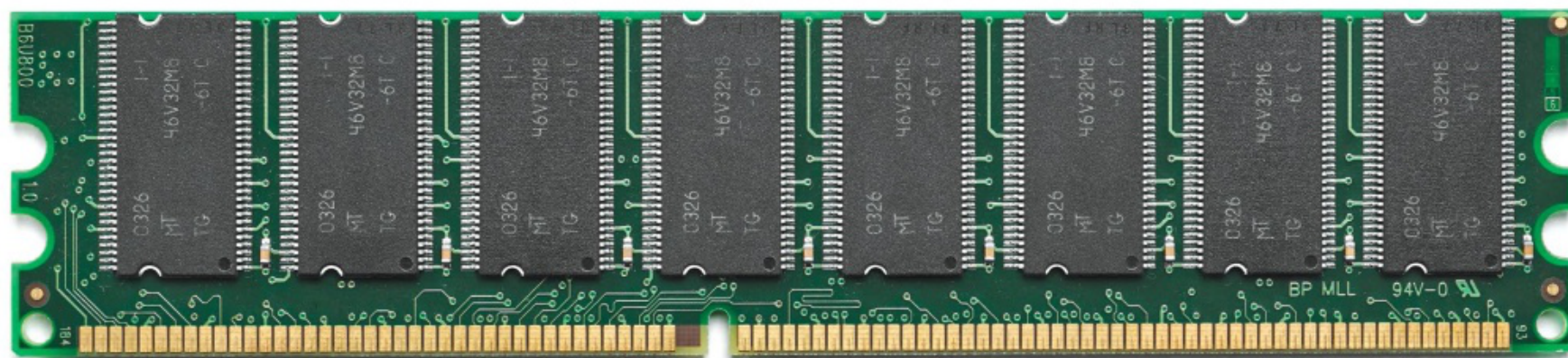
Its most important contribution to RAM standards is the adoption of a unified connection format for motherboards (the DIMM slot) to ensure compatibility, but that's not all. Standards for data transfer rates and latencies are determined by JEDEC, so consumers choose between speeds such as DDR4-3000 and DDR4-3200, instead of 3060, 3111, 3187, and so on. It's simple enough in principle, but these constraints ensure memory is easily put into straightforward brackets for our convenience.

JEDEC's members are also responsible for producing new hardware within the RAM universe. The up and coming memory standard is DDR5, which was ratified in March 2017 (not to be confused with GDDR5, a memory standard for GPUs). Some

manufacturers (such as SK Hynix) have confirmed that their DDR5 memory is complete, and desktop DRAM modules should be available later this year. This next-gen memory will be able to reach higher speeds than any units from DDR4, and draw less power per module, thanks to integrated voltage regulators.

While it might sound like a minor improvement, this shift in standards has implications beyond RAM design. With voltage controlled on the memory sticks, motherboards will no longer require voltage regulators for RAM, which will enable manufacturers to focus on other features, but could cause compatibility issues in the not-too-distant future. DDR5 will double the bandwidth available, so 128GB may become more mainstream, and 256GB builds will become a possibility for high-end tweekers. Memory speeds will hit a staggering new maximum at 6,400MT/s, the fastest available within DDR5.

JEDEC doesn't actually require heatsinks to be integrated on RAM.



Latency & Timings



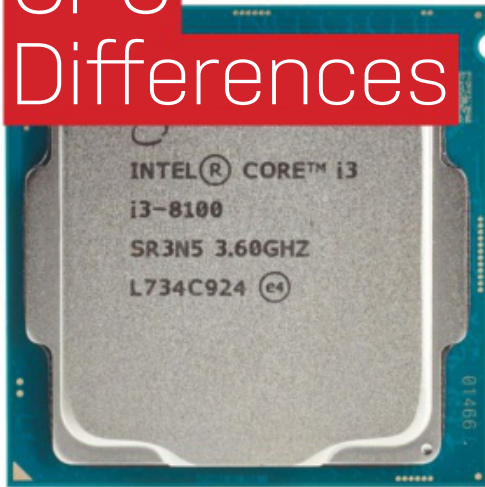
■ **Memory speed isn't the only thing that affects your RAM. Latency and memory timings encompass a huge variety of key statistics that affect memory performance, and many of those numbers will be meaningless unless you're a die-hard hardware-head. The one to look out for is CAS (column address strobe) latency, which is an indicator of how quickly the RAM stick responds to a memory call.**

Bear with us, because it's going to get mathematical. CAS latency by itself isn't necessarily a helpful figure—in order to get a genuinely useful number, there's a formula you need to use. Real-world latency = (2,000/RAM speed) x CAS latency, with speed measured in MT/s and latency measured in nanoseconds. So, if you've got a memory kit that runs at 3,000MT/s and has a CAS

latency of 16ns, the kit's real latency is 10.6ns.

However, faster memory tends to come with greater CAS latencies, so the actual performance gains can be minimal, even when you seek out higher frequencies. The ideal memory kit has a high frequency and a low CAS latency, and overclocking is an option, but there's a lot of potential messiness there. If you're running an Intel system, variation in speed isn't going to make much difference; real-world latency in DDR4 and beyond is starting to become increasingly homogenized, regardless of frequency, so buying high-speed RAM can become a waste of money. The impact on some tasks is more notable; gaming and 3D rendering is less affected by memory speed than large-scale data analysis.

CPU Differences



■ We've mentioned that memory specs have different impacts on Intel and AMD processors. In broad terms, memory speed hasn't historically made much difference to processor performance, but with AMD's Ryzen series of CPUs, that norm changed in a big way. Due to conventional processor architecture, Intel CPUs (currently the Core series) only see minimal gains from

memory speed; a couple of percent at best in the vast majority of benchmark functions.

With Ryzen, though, AMD did something different: The interface that connects the processor cores together—called the Infinity Fabric, if you subscribe to funky hardware marketing jargon—is controlled from the integrated memory controller on the chip. What this means is that

when supported by faster RAM, the memory controller can run faster, and transfer data between the cores at higher speeds, improving overall processor performance.

This was a stumbling block for Ryzen in the early days, because when the processor line first became available in 2017, memory was significantly more expensive. The effects of memory speed on Ryzen chips works both ways: Slower

RAM can result in poor performance compared to similar Intel Core CPUs. As memory has become cheaper, though, Team Red looks more and more attractive. A few hundred additional MT/s can make a difference in processor performance of 10 percent or more, which can be pumped up even higher when combined with CPU overclocking to produce some very impressive numbers.

The Bottleneck

IN THE EARLY YEARS of commercial RAM, before the turn of the century, there was a serious disparity between CPUs and memory. Referred to as the "memory wall," a problem arose where CPUs were developing faster than RAM technology, with RAM speed only increasing by 10 percent in the 14 years leading up to 2000, while CPU speeds increased by approximately 55 percent. For a long time, it looked like memory speed limitations might cause a significant bottleneck in the improvement of computer performance.

Since then, CPU speed increases have slowed, due in part to physical design barriers around heat dissipation and die size in new chip designs. With the improvement of caching tech to speed up key processes and bridge the gap between CPU and RAM speed, it looks like the "memory wall" might be a fallacy.



What Else Can My RAM Do?

RAM DOES MORE than simply boost your PC's processing power. If you're particularly software-savvy, you may be familiar with the concept of a RAM disk: a block of RAM that is used by your system as a temporary secondary storage drive. Using specific software (such as DataRAM RAMDisk), it's possible to partition a segment of memory to be used as a drive. These virtual drives can be incredibly fast—far faster than conventional SSDs or HDDs—and theoretically have no limits on read/write times.

The main drawback of virtual RAM disks is that they lose all stored data when powered down, making them particularly vulnerable in the event of system crashes or power failure. They're also an expensive way of producing storage space to work on files—RAM is simply more costly than physical drives. However, there are other advantages. RAM disks can be ideal for working with decrypted versions of encrypted files, and you can set up regular backups of your data to a physical drive to get around the risk of data loss on crashes. It's possible to keep data stored on a persistent storage drive, set to recreate it on

the RAM disk when the system boots. Most interestingly, RAM drives can be used to access compressed files without having to decompress them first, using systems such as cRAMfs on Linux. With memory capacity ever increasing, RAM disks may become more relevant in the not-too-distant future.

Other mechanics of RAM have been slowly integrated into modern operating systems for ease of use. Virtual memory, for example, involves the partitioning of hard drive space as a "paging file," which is then used for storing excess data when the physical RAM is operating at capacity. Windows does this automatically, using the paging file as additional memory space to prevent program crashes. This function can be disabled in Windows 10 to free up disk space, although it's not recommended if you're running anything less than 32GB, and does put you at greater risk of system instability. Modern BIOSes also incorporate "shadow RAM," where ROM functions instead use DRAM locations to speed up access times. The benefits of doing this manually are minimal, though, particularly with modern ROM chips.



Best RAM Choices For Your System

WHATEVER PLATFORM you're looking to build, memory is going to be an integral part of it. We're going to break down the different potential purposes of new system builds, and assign the best RAM for the job in each scenario. RAM might have become cheaper over the last year, but it's still all too easy to splurge when you don't really need to.

Bear in mind that these are only loose recommendations; follow the specs as a guideline, rather than the manufacturer. As always, though, we advise you to stick with recognized brands, such as Corsair, Crucial, G.Skill, and HyperX. If you can't find the manufacturer's name listed anywhere in this magazine, tread lightly.



HIGH-END WORKSTATION

HyperX Predator 64GB (4x 16GB) @ 3,000MT/s **\$395**

■ To be honest, there are no wrong answers here. If you're hankering after a PC for seriously demanding digital creative work—whether that's large-scale 3D modeling or 4K video editing—the sky's the limit when it comes to memory capacity. We've gone for a mid-range 64GB kit here, with a real-world latency

of just 10ns, but if you've got the cash to splash, consider faster or even larger modules. Corsair's Dominator Platinum series provides some excellent 64GB and 128GB kits, for example. Make sure your CPU and motherboard support quad-channel memory bandwidth, as is the case with any four-module RAM kit.



OFFICE WORK

Corsair Vengeance LPX 8GB (2x 4GB) @ 2,400MT/s **\$44**

■ If you're just keeping it simple, this is all you need—8GB of RAM will comfortably handle light office work, be it spreadsheets or slideshows, and is more than capable of supporting your usual array of web-browsing activities. We would be a little wary of loading up on Chrome tabs, however, with only eight

gigs behind you, but this should be able to carry you through everyday tasks. We contemplated going for Team's slightly faster 2,666MT/s model in the T-Force Vulcan line instead, but the price difference was minimal, and for baseline performance, 2,400MT/s is more than enough.



BASIC WORKSTATION

Team T-Force Vulcan 32GB (2x 16GB) @ 3,000MT/s **\$130**

■ Even with low to mid-level photo and video-editing work, 32GB of memory is the way to go right now. It won't necessarily be cheap, but the affordability of higher-capacity DDR4 kits has improved no end over the past year, perhaps due to the looming release of DDR5. This much memory

will run rendering tasks well, and equip your system for high-definition videography. If you're looking for a fast system to run tools such as Photoshop or After Effects, look no further. 2,400MT/s will be plenty for Intel systems; if you're on an AMD machine, it may be worth splashing out for a little more.



BASIC AMD GAMING

Ballistix Tactical 16GB
(4x 4GB) @ 3,000MT/s **\$85**

■ The Ballistix Tactical memory isn't particularly exciting to look at (perhaps check out Corsair's Dominator line if you're looking for some more eye-candy-worthy modules), but it provides excellent performance for a sensible price. With a high frequency and a CAS latency of 16, this kit will pair nicely with a mid-range GPU for

some straightforward 1080p or even 1440p gaming. It won't necessarily be able to hit maximum settings in every game you play, but well-optimized titles will give you no problems. Should you decide to upgrade your GPU, a memory upgrade is worthwhile, too, and the Tactical or Elite series are good ones to stick with.



HIGH-END AMD GAMING

Corsair Dominator Platinum
RGB 32GB (4x 8GB)
@ 3,600MT/s **\$330**

■ This is where it starts to get expensive. We're cranking up the speed to make sure your AMD system's latency stays low, and paying the extra price for 32GB ensures your build is future-proofed. Most games don't use 32GB—16GB is usually recommended—but with GPU improvements, that

could change. With this much capacity, there won't be any danger of running low on available memory, even when you're bashing your system with ultra 4K graphics. The Dominator Platinum RGB is a lovely looking kit, too, with fully addressable LEDs on every module.



BASIC INTEL GAMING

Ballistix Sport LT 16GB
(2x 8GB) @ 2,400MT/s **\$70**

■ There's nothing much to write home about here, but this Ballistix kit will do the job and do it well. Memory speed is less of a factor when you're looking at RAM for Intel systems, so you can save yourself a few dollars by opting for a slightly more conservative frequency. The Ballistix Sport series is

Crucial's more affordable memory, but that doesn't make it any less effective. It also runs at just 1.2 volts, meaning it has some of the lowest power draws found within the DDR4 standard. It also has a CAS latency of 16, which means it keeps your real memory latency at 13.3ns.



HIGH-END INTEL GAMING

G.Skill Trident Z RGB 32GB
(2x 16GB) @ 3,000MT/s **\$165**

■ Once again, we don't need to push to boat out too much when it comes to memory speed in an Intel machine. Unlike the Dominator Platinum RGB kit, this set comes with two 16GB modules instead of 4x 8GB ones, so if you're running a system with more than two DIMM slots, make sure you're using

the prioritized connectors for maximum speed. This is G.Skill's own RGB offering, and they're pretty sweet to look at. A CAS latency of 16 means this might not be the fastest RAM around, but it's an extremely good price for 32GB. The extra capacity can come in handy for streaming memory-intensive games. ⏻

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WAYS TO

CUSTOMIZE WINDOWS

Nick Peers reveals quick tips and tricks to give Windows a fresh look

OFF-THE-SHELF is good as far as it goes, but there comes a time when you want to put your personal stamp on something, and with Windows, you'll be surprised by just how much control you can wield over its look and feel. We've dug out no fewer than 60 tips to help you customize it to your personal satisfaction.

There's a reminder of some familiar tips, but we've dug deeper to reveal buried settings and little-known techniques that can do more than simply change the background picture or apply a color scheme. Indeed, we open this feature by introducing two free tools that, between them, open up a wide array of customizable

options that normally require you to be a maestro at Registry editing. You'll tackle the desktop and its constituent parts: Start menu, Taskbar, and File Explorer. You'll also discover how to replace parts of the desktop with more visually appealing (but no less practical) alternatives, transform the way you navigate your filesystem with a handy File Explorer add-on, and even make fundamental changes to the desktop itself, replacing the Windows 'skin' with an alternative, offering not just a new coat of paint, but a fresh approach to how you interact with Windows. Come on, let's get those brushes out....





Desktop, Taskbar, & Start Menu

01 Tools of the Trade

Many of the tips in this feature can be applied with the help of two powerful tweaking tools, so start by downloading both Ultimate Windows Tweaker (<https://bit.ly/uwt-10>—you'll find links to Windows 7 and 8.1 versions here, too) and Winaero Tweaker (<https://winaero.com/download.php?view.1796>). Once downloaded, extract the contents of the ZIP files—Ultimate Windows Tweaker runs as a portable app, and Winaero Tweaker gives you the option of installing it in portable form, too.

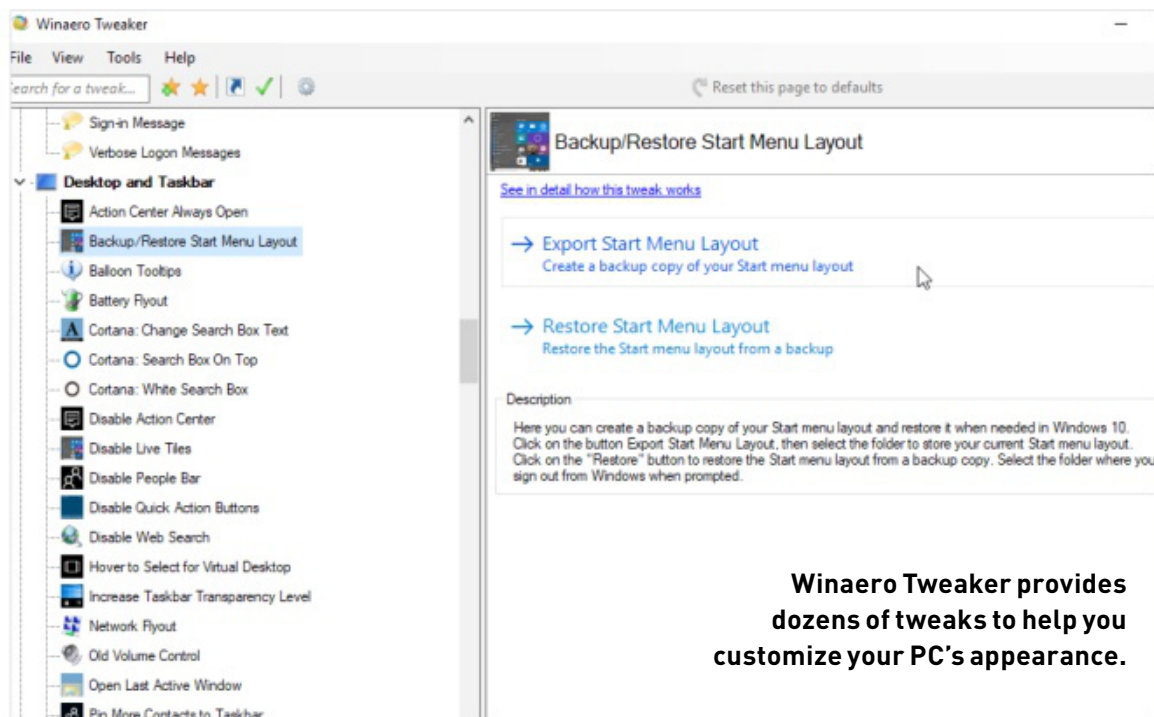
02 Quickly Access Windows' Personalization Settings

To start customizing, right-click the desktop and choose "Personalize" to jump straight to "Settings → Personalization → Background." From here, you can change your background to a picture, a solid color, or a slideshow of photos within a single folder on your PC.

03 Customize Your Desktop Background

If you're dissatisfied with Windows' rather meager desktop background offerings, download and install John's Background Switcher from <https://bit.ly/johnbckswtch> for more choice—after installation, you're directed to the "Add" button, where you define sources for your photos. These can include specific folders on your PC as well as various online sources (including Dropbox and OneDrive folders, plus RSS feeds, Instagram, Google, and Flickr).

You'll see several switching options at the bottom of the main window—pay



Winaero Tweaker provides dozens of tweaks to help you customize your PC's appearance.

attention to the "Picture Mode" dropdown, where you can display multiple photos at once in various ways. There's also a "More" button for fine-tuning all aspects of this clever background tool.

04 Override Color Scheme

Windows automatically changes the color scheme of desktop items to match the background, but you can also force your own choice of color via "Settings → Personalization → Colors." You can switch between light and dark modes here, too.

05 Create Custom Color Palette

Fed up with having to click "Custom Color" to choose a different one to Windows' own

offerings? Fire up Winaero Tweaker and go to "Appearance → Custom Accents," where you can define up to eight custom colors of your own. These appear under "Recent Colors" in the "Personalization" dialog box for easy access.

06 Pick a Theme

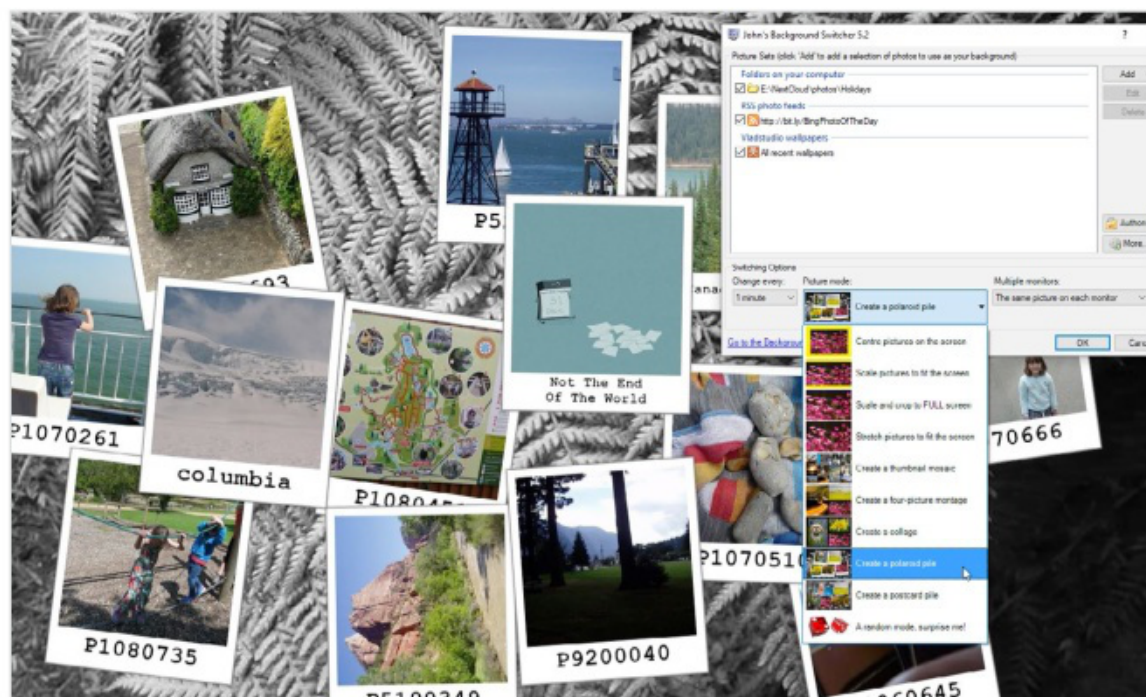
The quickest way to change your desktop appearance is through the "Themes" section under "Settings → Personalization." Several are provided, or click "Get More Themes in Microsoft Store" to browse hundreds more—click "Get" followed by "Install" to add one to your collection. Some themes change the mouse pointer and desktop icons—you can prevent them from doing so in Winaero Tweaker under "Appearance → Theme Behavior."

07 Change Your Account Picture

Open a photo of yourself in an image editor like Paint.NET (www.getpaint.net), then crop in to a headshot (make the selection tool 1:1 for a perfectly square crop), and save the image. Now navigate to "Start → Settings → Accounts," and click your current photo under "Your Info" to select the new one. Previous shots are kept, enabling you to switch between them.

08 Set Up a Screensaver

Energy-saving LCD monitors have largely rendered screensavers redundant, but if you're still hankering after one, head to "Personalization → Lock Screen," then scroll down and click "Screensaver Settings" to set one



John's Background Switcher is perfect for adding more pizzazz to your desktop backdrop.

up. Download more screensavers from www.screensaversplanet.com (many of which are free)—save the EXE file to your computer, then double-click it to add the screensaver to the available list.

09 Start Menu Precautions

Before making major changes to your Start menu, navigate to “Desktop and Taskbar → Backup/Restore Start Menu Layout” in Winaero Tweaker to export the current layout—just in case.

10 Customize the Start Menu

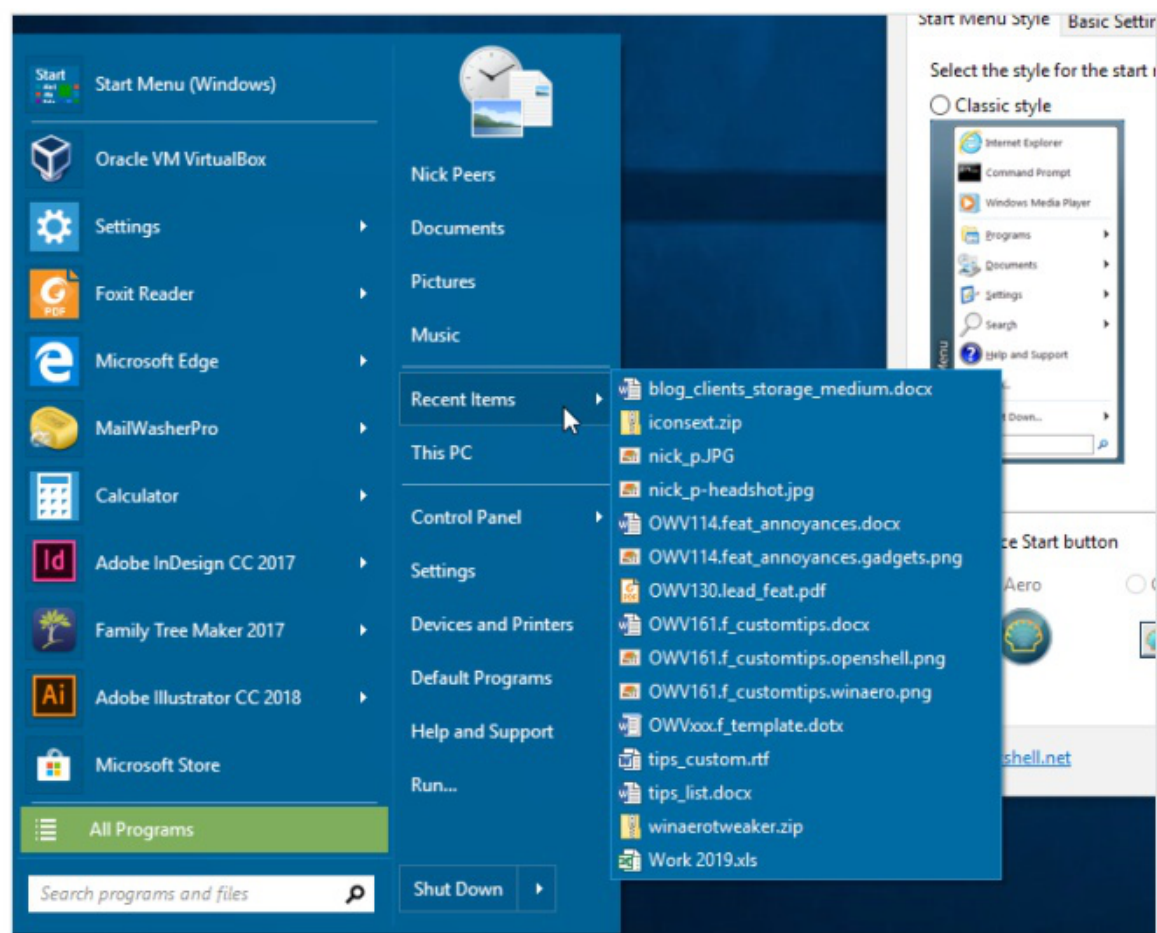
Use the “Personalization → Start” section of “Settings” to configure certain aspects of the Start menu. Tiles can be added by right-clicking items and choosing “Pin to Start Menu.” You can then click and drag items around to rearrange them, or click and drag items on top of each other to group them in a folder.

11 Lock the Start Menu

After you’ve set up the tiles to your satisfaction, open Ultimate Windows Tweaker and navigate to “Customization → Universal UI,” then check “Lock Start Tiles” to prevent accidentally rearranging them in future.

12 Ditch the Start Menu

Still hankering after the Windows 7 Start menu? Our old favorite alternative Start menu—Classic Start—has been resurrected under a new name, and updated to work with the latest version of Windows 10. Download and install Open-



Still hankering after the old Start menu? Open-Shell is the new name for Classic Start.

Shell from <https://open-shell.github.io/Open-Shell-Menu>—during installation, click “Classic Explorer” and “Classic IE,” and choose “Entire feature will be unavailable” to avoid installing them.

13 Customize the Quick Access Menu

Press Win-X to access the alternative Start menu. You can choose which options appear on it by downloading and running

the portable Win + X Menu Editor (<https://winaero.com/download.php?view.21>).

14 Restore Desktop Gadgets

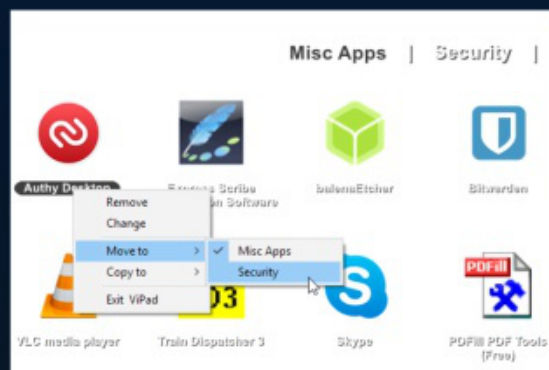
Do you miss the old Windows 7 gadgets that provide extra functionality on the desktop? Visit <http://win10widgets.com> to download Win10 Widgets, a customized version of Rainmeter (www.rainmeter.net), with the gadgets pre-installed and running.

15 Organize Your Desktop Icons



A INSTALL ICONS

Download and install Vi-Pad (<http://lee-soft.com/vipad>)—if the SmartScreen filter appears, click “More” and unblock the program. During installation, click “Yes” when prompted to copy all existing desktop icons to the Vi-Pad window, which will happen in real time as you watch.



B ORGANIZE ICONS

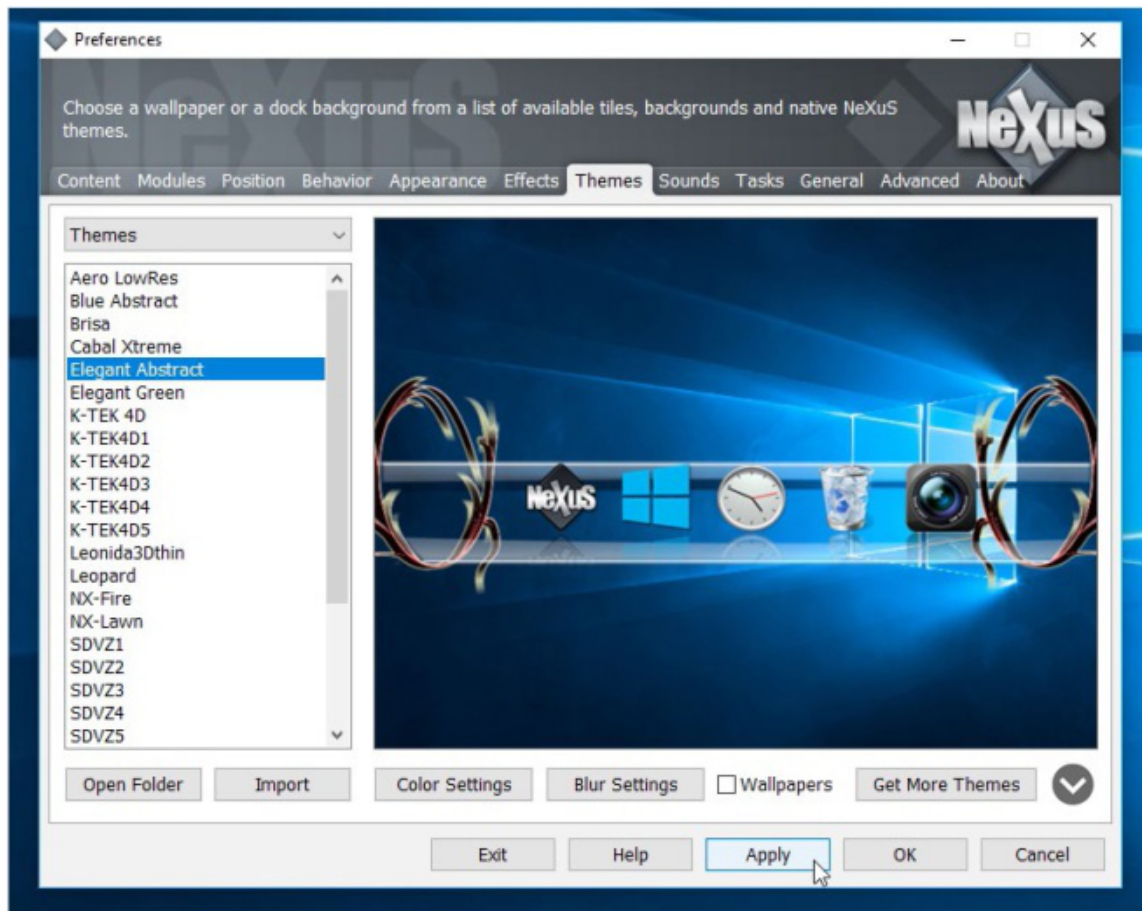
All shortcut apps appear in a single tab—“New Tab”—spread over multiple pages. Right-click “New Tab” to rename it, or use the “+” button to create additional tabs, so that you can organize your apps into more categories. Once that’s done, right-click an app icon to move it to that tab.



C ADD NEW ICONS

You can drag new shortcuts into any tab from the desktop or from File Explorer. Right-click the program’s Taskbar notification area, and choose “Settings.” Uncheck “Use Windows DWM” to make it translucent. You can also make the icons larger or smaller, using the slider at the top of the menu.

Taskbar and Notifications



WinStep Nexus is a visually slick—and practical—alternative to the Taskbar.

16 Make Use of the Taskbar

The Taskbar is the best location for any, and all, shortcuts that you need. Right-click your existing desktop or Start menu shortcuts, and choose “Pin to Taskbar” to add them. You can then drag and drop icons within the bar to order them logically.

17 Minimize the Search Box

Does the new search bar take up too much room on your Taskbar? Right-click an empty part of the Taskbar, and choose “Cortana → Show Cortana Icon” to replace it with a clickable icon; or choose “Cortana → Hidden” if you never use it.

18 Resize the Taskbar

Running out of space for shortcut icons? Make them smaller by right-clicking the Taskbar, choosing “Taskbar Settings,” and flicking the “Use Small Taskbar Buttons” switch to “On.” Or right-click the Taskbar and uncheck “Lock the Taskbar.” Click the top edge of the Taskbar and drag up to add space for an extra row.

19 Move the Taskbar

While it’s unlocked, you can also click and drag the Taskbar to a different edge of the screen—pin it left or right for a vertical list, or at the top if it suits your way of working better.

20 Show Labels

If you only have a handful of icons on the Taskbar, open Taskbar settings, scroll down, and change “Combine Taskbar Buttons” to “When the Taskbar is Full” or “Never” to view a label, which helps you to easily view—and switch between—open documents within the same application.

21 Add Toolbars

Right-click the Taskbar and you’ll

see a Toolbars menu, enabling you to add extra features to it—you can select “Address” to add a URL bar for opening websites in your default web browser, for example. To add easy access to your entire PC, choose “Toolbars → New Toolbar.” Select “This PC” and click “Select Folder.” From here, click “>>” next to “This PC” to access any folder or drive with just a few clicks.

22 Increase the Size of Taskbar Peek Thumbnails

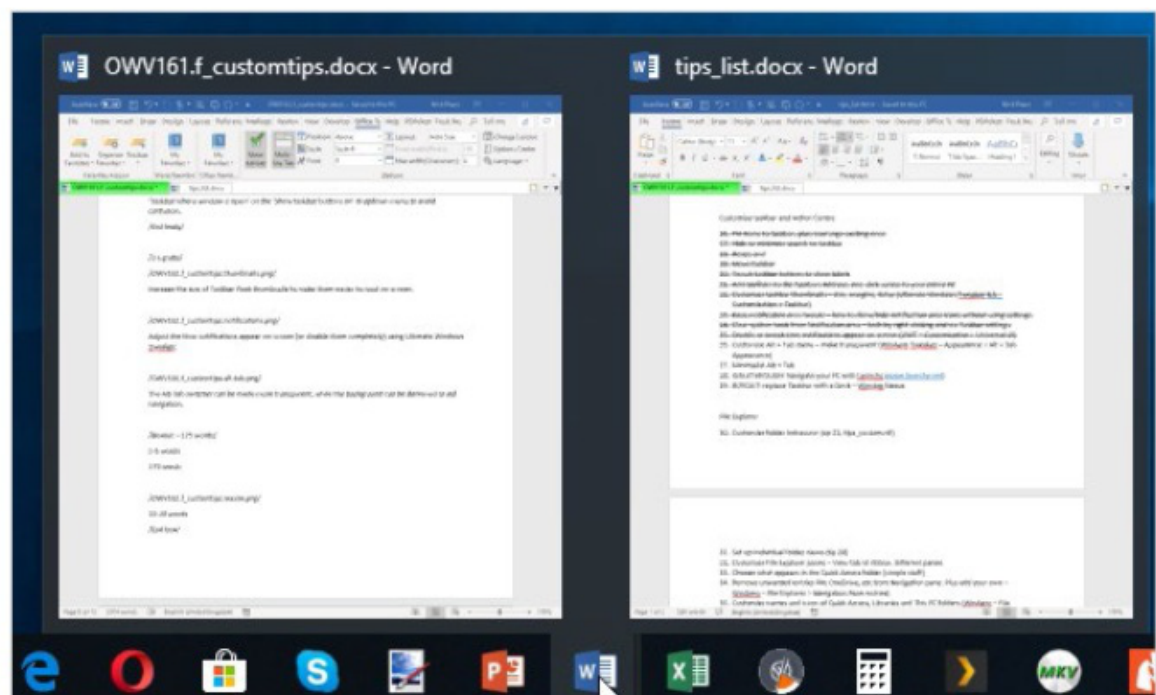
When you roll your mouse over an open program’s Taskbar icon, you get a pop-up thumbnail of open document(s)—it’s a bit small, so open Ultimate Windows Tweaker, navigate to “Customization → Taskbar,” and try setting the minimum and maximum thumbnail size sliders to 400. Click “Apply Tweaks,” and after File Explorer restarts, you should instantly see an improvement.

23 Tweak the Notification Area

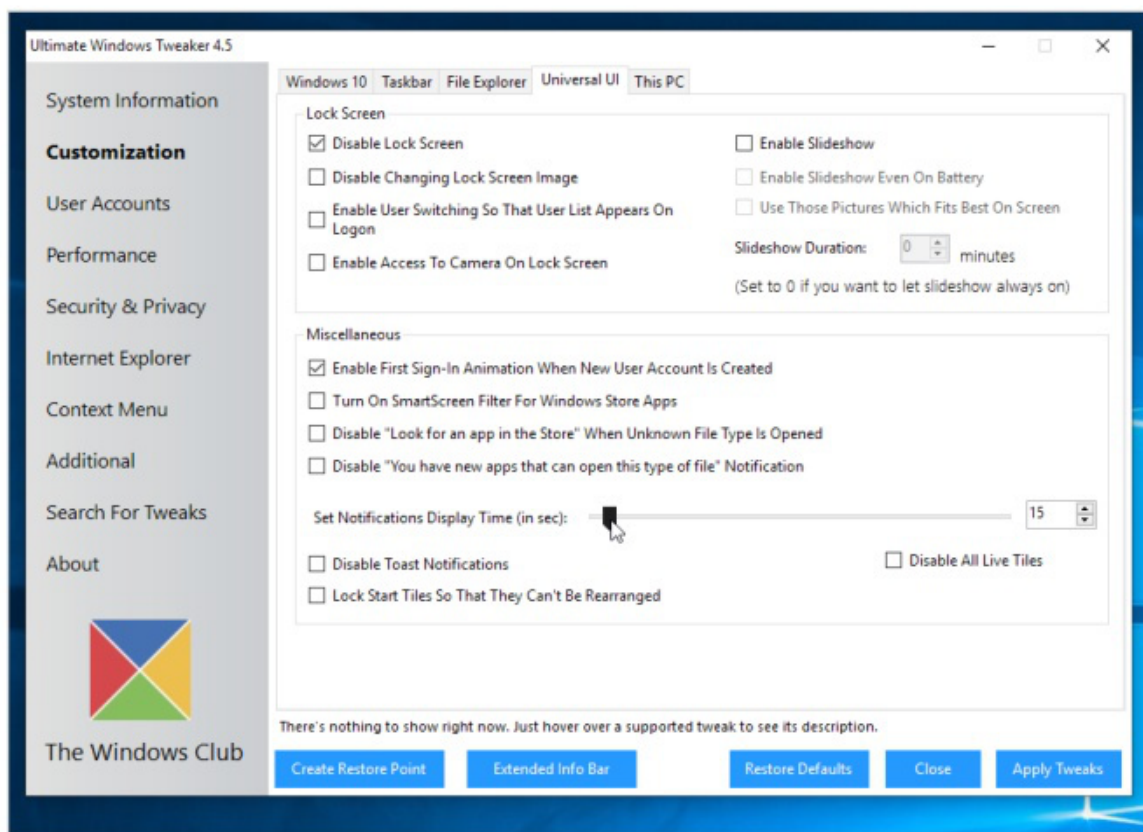
You don’t need to delve deep into Taskbar settings to change the behavior of the Taskbar’s notification icons. Simply drag icons between the notification area and its “holding area” (click “^” to reveal it). To remove icons permanently without closing the parent application, check out the program’s own settings.

24 Clear System Icons

Windows places several icons of its own in the Taskbar notification area—some elements, such as the touchpad or



Increase the size of Taskbar Peek thumbnails to make them easier to read on screen.



Adjust the time notifications appear (or disable them) using Ultimate Windows Tweaker.

touch keyboard, can be shown or hidden via the Taskbar's right-click menu; others, including the clock and the Action Center button, can be removed under Taskbar settings (click "Turn System Icons On or Off" under "Notification Area").

25 Adjust Notification Pop-Ups

While you can tweak many aspects of the Action Center on your PC via "Settings → System → Notifications & Actions," one thing you can't do from here is adjust how long—five seconds—

individual notifications appear on screen. To change this setting, open Universal Windows Tweaker to the "Customization → Universal UI" tab. The slider enables you to increase the time from five seconds right up to 300 seconds. Alternatively, you can disable them completely (check "Disable Toast Notifications").

26 Replace Your Taskbar

The Windows Taskbar is efficient, but not exactly visually pleasing. Fans of the macOS dock should examine the free version of WinStep Nexus (www.winstep.net),

which combines a more eye-catching aesthetic with functionality that renders the Taskbar redundant. Not only does it include all the expected features—drag and drop shortcuts from your Start menu or desktop to add them to the dock—but you can also add modules such as email checker and weather forecast gadgets.

27 Tweak the Alt-Tab Menu

It may not be as glamorous as the new Timeline, but the Alt-Tab feature is still the quickest way to switch between open apps and windows on your PC. Tweak its looks courtesy of Winaero Tweaker: Navigate to "Appearance → Alt + Tab Appearance," where you'll find sliders to adjust its transparency, plus make the desktop darker when it's invoked.

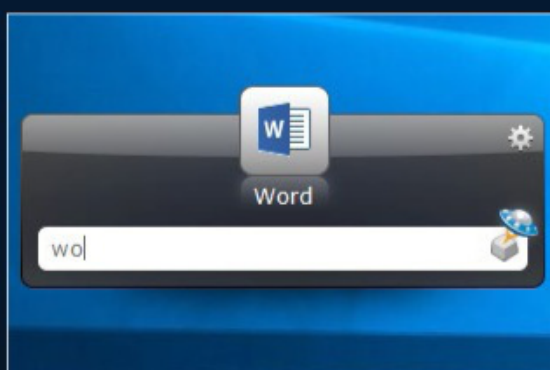
28 Minimalist Alt-Tab

You'll also see an option to "Enable Classic Alt + Tab Dialog"—check this, then click "Restart Explorer" to replace the thumbnails with a minimalist icon-based task switcher, with the currently selected icon's window title displayed beneath it to help you navigate.

29 Multi-Display Settings

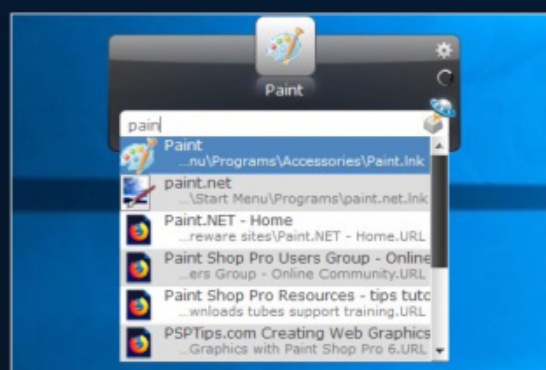
If you have two monitors connected to your PC, head over to the Taskbar settings, where you'll see options for configuring the Taskbar independently on each display—we recommend selecting "Taskbar Where Window is Open" on the "Show Taskbar Buttons On" drop-down menu, to avoid confusion.

30 Launch Programs Quickly



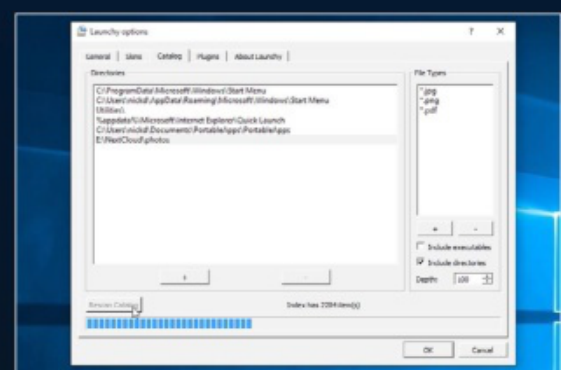
A GETTING STARTED

Download Launchy from www.launchy.net—you can either install it or run it on demand as a portable app. Once Launchy has, er, launched, it sits unobtrusively in the Taskbar notification area. To bring it into focus, press Alt-Spacebar, then start typing the name of what you're looking for.



B SEARCH AND SELECT

An icon representing a program pops up—if it's the correct one, press Enter. Wait a few seconds, and more matching results—including web links—appear via a drop-down menu. Click one or use the arrow keys to scroll through the list, pressing Enter when you find your match.



C WIDEN LAUNCHY'S SEARCH REMIT

Right-click the Launchy notification area icon and choose the "Options → Catalog" tab. Click "+" under "Directories" to add additional folders to include, then with the directory selected, click "+" under "File Types" to list file types to search. Finally, click "Rescan Catalog."

File Explorer

31 Customize Folder Behavior

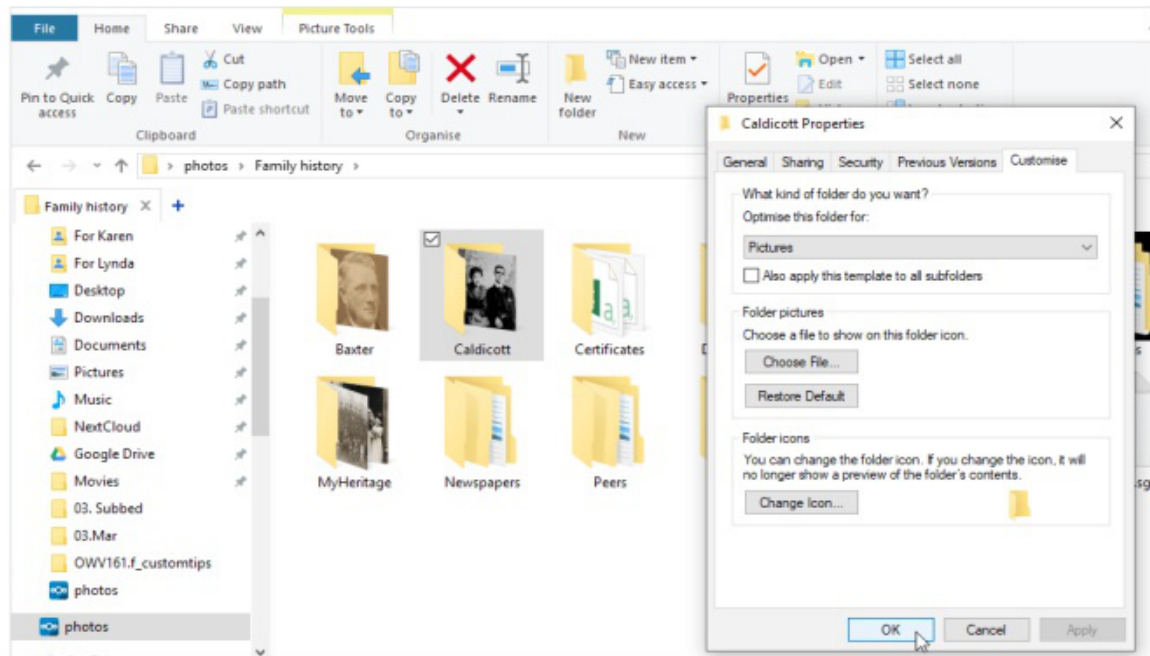
Windows can be instructed to treat folders in a specific way depending on the contents inside. Right-click a folder and choose “Properties → Customize,” where you can optimize it for a specific file type, such as pictures or documents.

32 Change the Folder Icon

You’ll also see an option to change the folder icon—useful if you want a more visual prompt as to the folder’s contents. Click “Change Icon” to browse files for any icons they contain (“shell32.dll” is selected by default, with lots of options). You can also select previously created or downloaded icon (.ICO) files—see the step-by-step guide on the page opposite for a way to extract icons from other files. Alternatively, click “Choose File” to choose a picture to display instead—this is perfect for photo folders, where you’d rather focus on one of the photos inside than have Windows display several of them at once.

33 Set up Individual Folder Views

Windows also remembers any individual customizations that you perform on a folder, so after opening it, switch to the “View” tab on the File Explorer’s Ribbon, where you can experiment with the “Layout” and “Current View” sections to apply settings that will remain specific to that particular folder whenever you reopen it.



Customize folders using icons or images to help provide a visual reference to their contents.

34 Adjust Icon Spacing

Further tweaks can be performed using Winaero Tweaker—navigate to the “Advanced Appearance Settings → Icons” section, where you can adjust the horizontal and vertical spacing of icons in both File Explorer and on the desktop, plus change the default font used to display names.

35 Tweak File Explorer Panes

File Explorer displays two panes—Navigation and Details—by default, but you can also add a Preview pane via the Ribbon’s “View” tab, plus restore Libraries to the Navigation pane by clicking it and choosing “Show Libraries.”

36 Set Up Quick Access

The Quick Access section of the Navigation pane is File Explorer’s best feature, bar none. You can drag frequently accessed folders into here to pin them for one-click access from any File Explorer location. You can also click and drag existing entries to rearrange their running order, or right-click to unpin them.

37 Clean the Navigation Pane

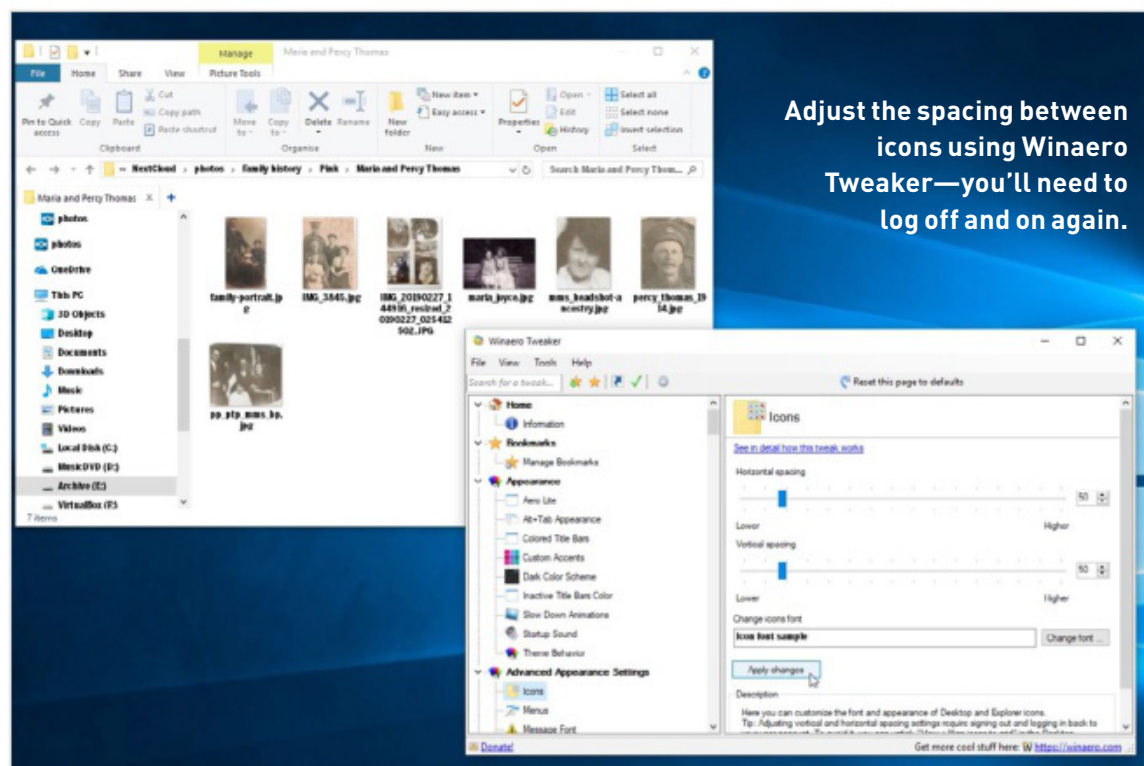
The Navigation pane can get cluttered with lots of entries you don’t use. The simplest way to review and remove these is to open up Winaero Tweaker to “File Explorer → Navigation Pane—Default Items.” Want to add your own links? Select “Navigation Pane—Custom Items” to do so.

38 Customize Navigation Pane Items

You can rename the “Quick Access,” “Libraries,” and “This PC” icons in the Navigation pane via Winaero Tweaker’s “File Explorer” section, too. You can also change their icons in the same way that you edit any folder icon.

39 Customize the “This PC” View

Given that most of us open File Explorer to “This PC” by default, it helps if you can tailor it to your exact needs. Fire up Ultimate Windows Tweaker, and navigate to the “Customization → This PC” option, where you can decide which user folders should be displayed, as well as adding various useful system shortcuts at the same time.



40 Add Tabs to File Explorer

Your web browser has tabs to reduce window clutter, so why not File Explorer? We've been using QTTabBar (<http://qttabbar.wikidot.com>) for the best part of a year to do just that. Once installed, tabs appear beneath the Ribbon—click “+” to browse for a new tab, or press Ctrl-N to duplicate the current tab.

41 Navigate Subfolders Quickly

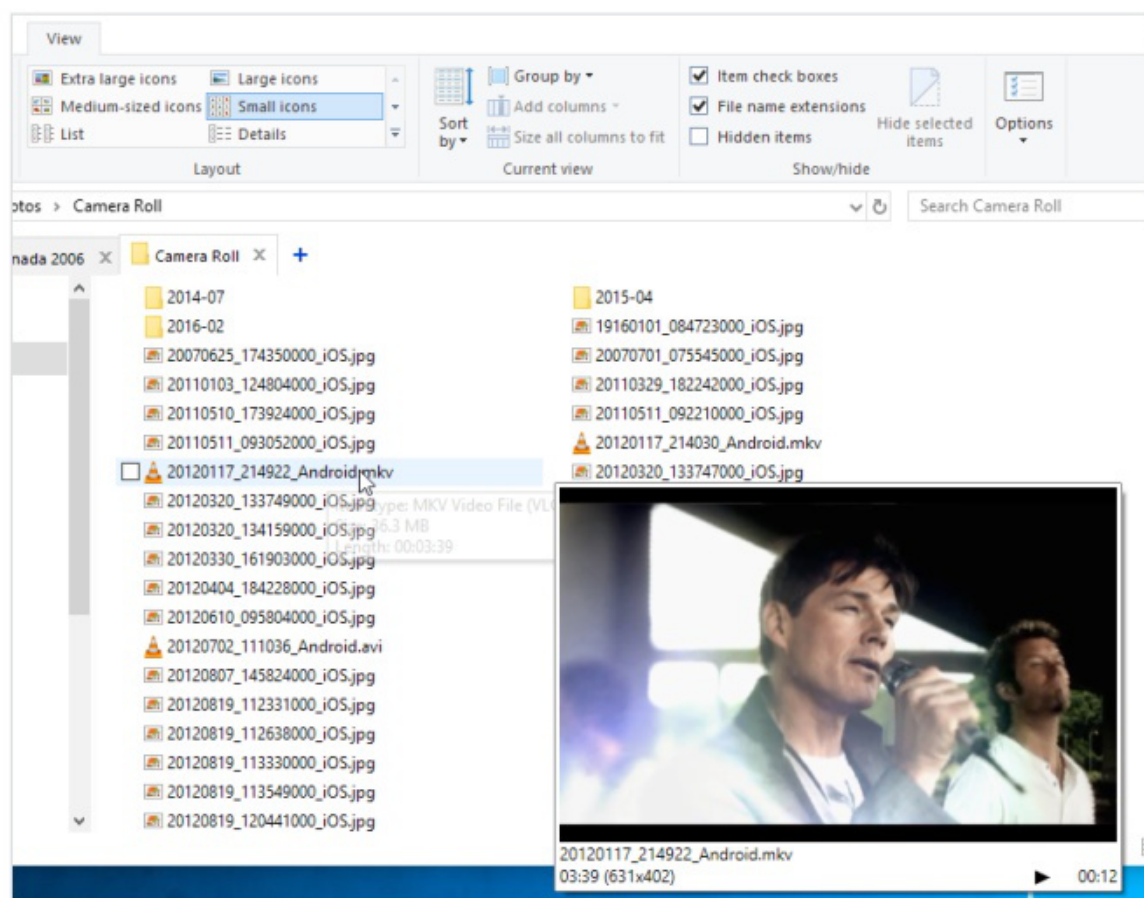
There's another fringe benefit to using QTTabBar: After installation, roll your mouse over a folder icon and click the drop-down arrow that appears over it to drill down through the folder's contents using a series of drop-down menus.

42 Pop-Up File Previews

QTTabBar also enables you to ditch the preview bar; instead, roll your mouse over a supported file type, and after a short pause a pop-up preview appears. You can configure the size of the thumbnail (and other QTTabBar options) by right-clicking an empty space on its tab bar in File Explorer, and then choosing “QTTabBar Options”—look under “Preview → Windowing.”

43 Customize Context Menus

The right-click menu is a handy place to stash useful—if not frequently needed—tools. You can add numerous entries to this using Winaero Tweaker's “Context Menu” section—you can access



Tabbed browsing and pop-up previews are just some of QTTabBar's many highlights.

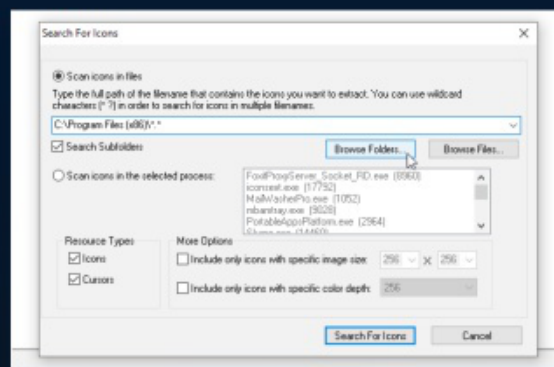
the new Clipboard History feature, for example, or restore access to classic appearance options in Windows 10 (see “Personalization”). It also contains system tools that enable you to do things such as claim ownership of a folder or reset its permissions to the default.

44 Clean Out the Context Menu

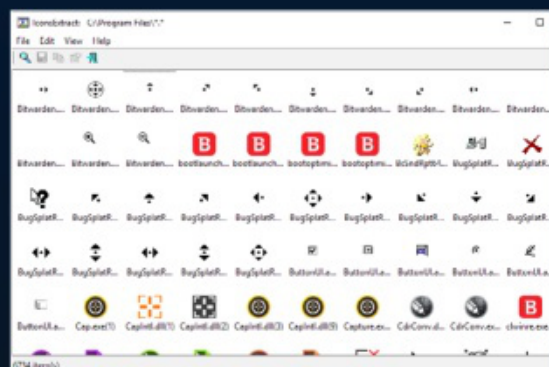
Select “Remove Default Entries” in Winaero Tweaker to clear out unused

entries added by Windows, such as BitLocker entries. Most clutter, however, comes from third-party tools. If you can't find options to remove them within those programs, use a tool such as ShellMenuView (www.nirsoft.net/utils/shell_menu_view.html) to review and remove unwanted entries. Doing so can be daunting, but ShellMenuView is comprehensive, and all its options are grouped by app, making them easy to detect and, if necessary, remove in bulk.

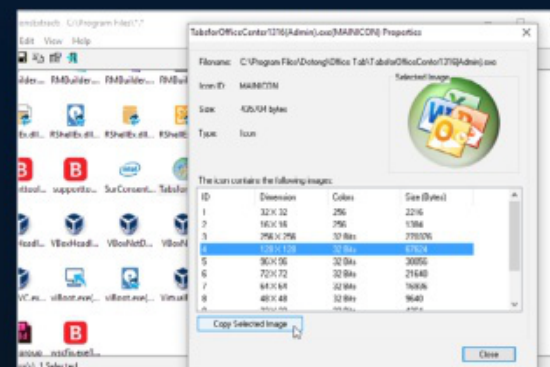
45 Extract Program Icons



A CHOOSE WHERE TO SEARCH Download Icons Extractor as a ZIP file from www.nirsoft.net/utils/iconsext.html, then extract its contents, and double-click “iconsext.exe” to launch the program. You have the option of choosing to search a specific file, all the files inside a folder, or a running process for icons.

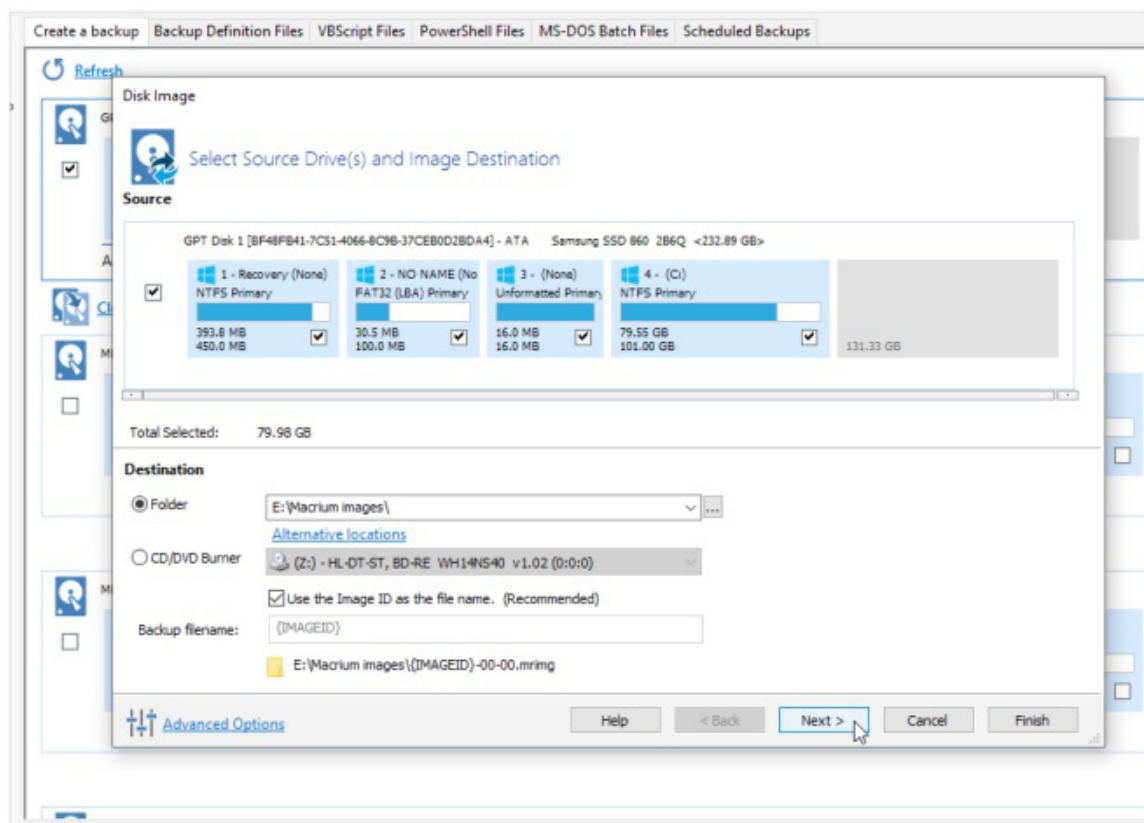


B SEARCH AND BROWSE Click “Search For Icons” and wait while the folder is searched—doing so can take some time, and a counter indicates how many matches have been found. You can click “Stop” at any time to halt the search and view the matches found so far. Double-click a match to view the available icons.



C BROWSE AND EXTRACT If a suitably large (128x128 or preferably 256x256 pixels) icon exists, you can either select it and click “Copy Selected Image” to copy it to the clipboard, or close the dialog box, right-click the icon, and choose “Save Selected Icons” to save it as an ICO file for use elsewhere.

Take Things to the Next Level



There are plenty of failsafes and reset options built into our tweak tools.

46 Take Precautions

We're now entering potential risk territory with some of these tips. Therefore, make sure you have some kind of system backup in place—either a rollback option such as System Restore or Rollback Rx (<https://horizondatasys.com/download>), or an up-to-date drive image using Macrium Reflect Free (www.macrium.com/reflectfree.aspx). Done that? Good, let's move on....

47 Customize Lock Screen

Can't tweak the lock screen to your satisfaction using the options found under "Settings → Personalization → Lock Screen"? Then take a look at the "Boot and Logon" section of Winaero Tweaker for more possibilities, such as not automatically selecting the last logged-on user by default, or adding a limit to how long the slideshow feature plays for.

48 Grab Lock Screen Images

If you're using the Windows Spotlight feature to display rotating background images, and you'd like a permanent copy of any or all of them, select "Find Lock Screen Images" in Winaero Tweaker, followed by "Get this one" under the current photo (if it's displayed) to save it, or "Get all images stored on this PC" to copy them to a desktop folder.

49 Apply the Aero Lite Theme

Aero Lite is a no-frills theme particularly suited for low-end PCs, such as 2-in-1 tablets. If you think it might help with performance—or want to see if its clean and simple lines appeal—open Winaero Tweaker and click "Enable Aero Lite (default)" under "Appearance → Aero Lite." You can undo it from here, too.

50 Customize Aero Lite

Once enabled, select "Window Borders" under "Advanced Appearance

Settings" to change the width and padding of windows—changes are performed in real time. You can also change the height of the window title bar and change the font—this requires logging off and on again, but also works with other desktop themes, too.

51 Change Windows' Start-Up Sound

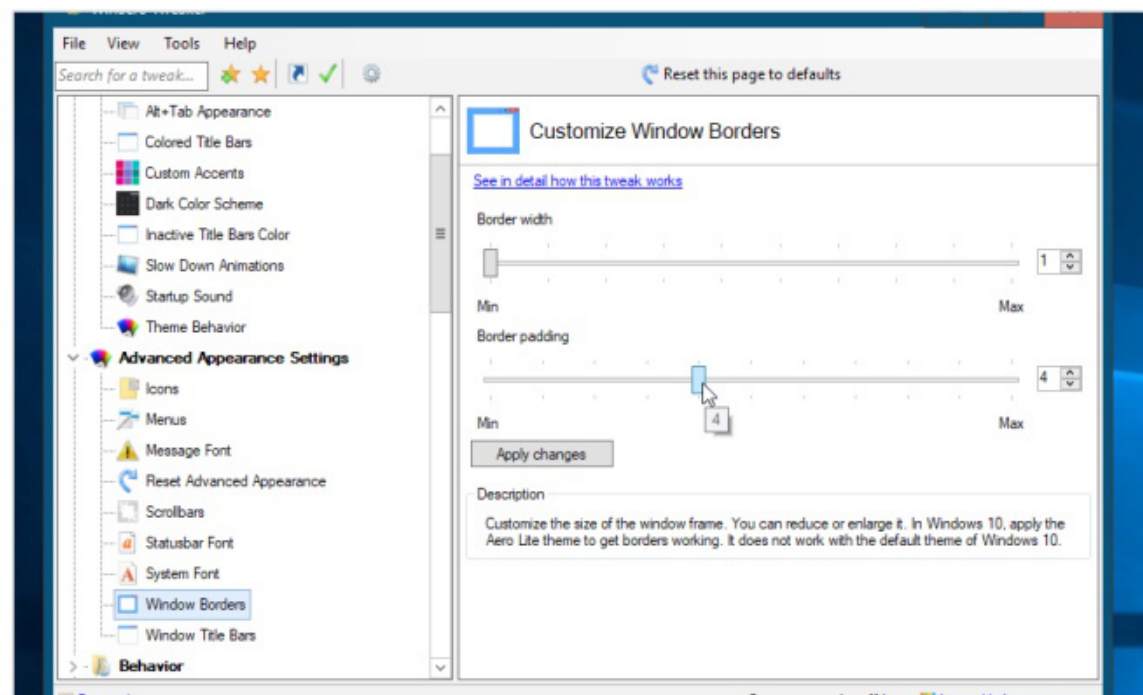
You can customize your Windows sound scheme by typing "sounds" into the Settings search box and selecting "Change system sounds." What you can't do from here is change the Windows start-up sound. Instead, navigate to "Appearance → Startup Sound" in Winaero Tweaker, where you can apply your own choice of WAV file in place of the default. If your chosen file is in another audio format, convert it using Pazera Free Audio Extractor (www.pazera-software.com/products/audio-extractor).

52 Switch System Fonts

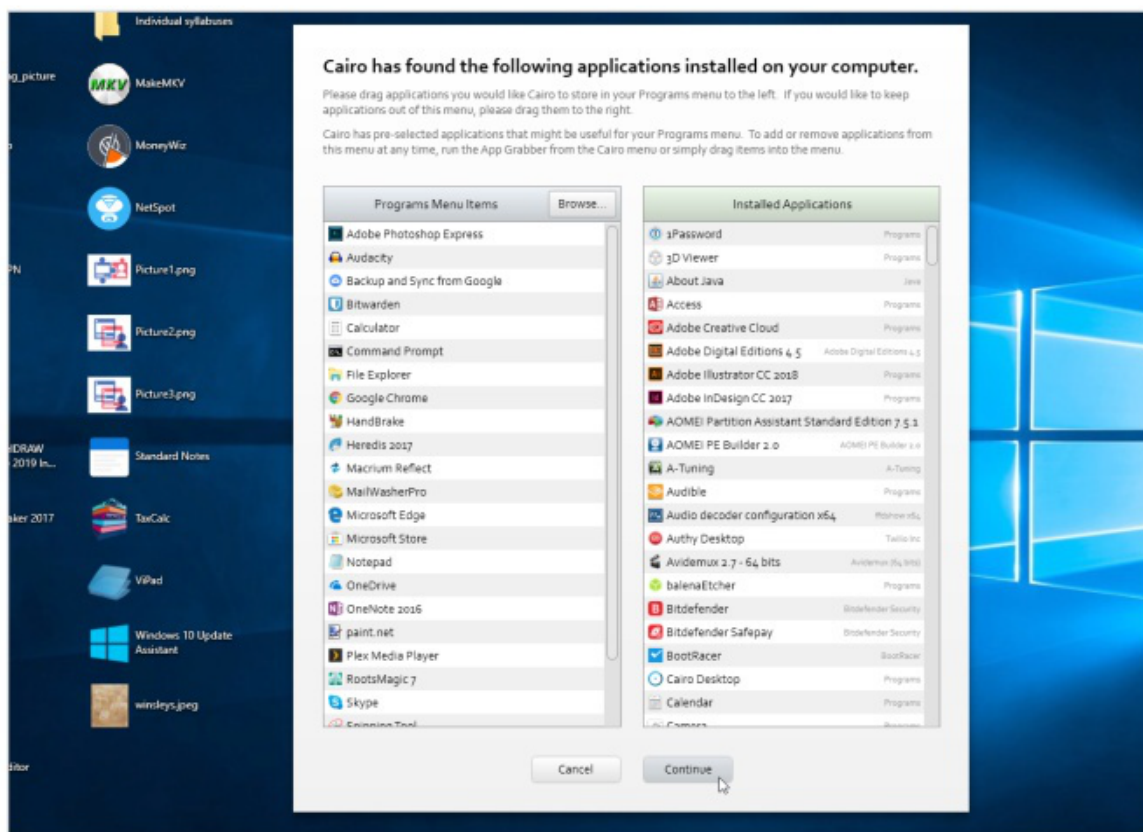
Tired of the rather conservative Segoe UI font used by Windows for its desktop components? Then swap it out for something more glamorous (but legible) via Winaero Tweaker's "Advanced Appearance Settings → System Font" screen. Log out and back in again to see the effect.

53 Reduce Window Clutter

You've added tabs to File Explorer, how about grouping application windows in a single multi-tabbed window, too? TidyTabs (www.nurgo-software.com) enables you to drag up to three windows



Give your low-end PC a breather by trying the svelte Aero Lite theme.



The Cairo desktop offers a completely different way of navigating and working with your PC.

on top of each other to group them, then use the tabs to switch. Upgrade to the Pro version (a measly \$9) and you can automatically group windows from the same application together, plus group more than three windows at once.

54 Get the Aero Glass Look If you're a tech-savvy Windows 8.1 user, head to www.glass8.eu to download Aero Glass for Windows 8 if you'd like to restore the translucent Aero effects from Windows 7. Aero Glass technically works with Windows 10, too, although we haven't

had much luck in getting any of the effects to work.

55 Try a New Shell The most radical change you can make to Windows is to replace the default shell with another one. One of the simplest to deploy is Cairo (<https://cairodesktop.com>)—during installation, leave the default settings, so it installs alongside File Explorer, not in place of it.

56 Set Up Apps After installation, Cairo opens

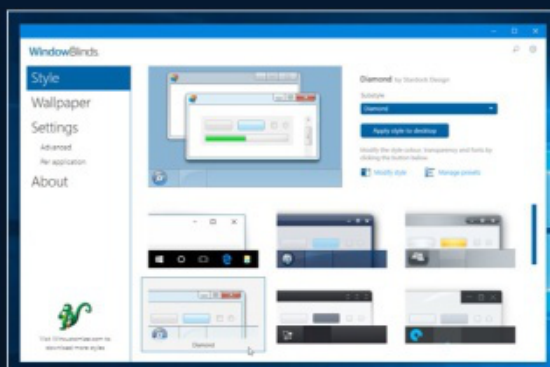
the App Grabber to enable you to choose which app shortcuts to add to the Programs menu at the top of the screen. Drag those you want into the left-hand pane, then click "Continue" to place them in subfolders such as "System Tools" or "Office." Click "Finish."

57 Use the Menu Bar Cairo's menu bar offers shortcuts to Programs, Places (user folders, This PC, Program Files, and the Recycle bin), Documents, and Downloads. There are various system tools and shortcuts on the right—click "<" to reveal your Taskbar notification area icons. Click the Cairo menu button in the top-left corner for a slimmed-down Start menu (plus access to Cairo's settings, or choose "Exit Cairo" to return to the regular desktop).

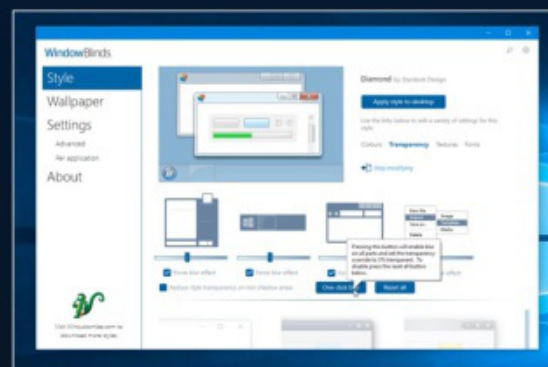
58 Navigate Folders with Cairo You'll see a list of files and folders on the desktop that correspond to those that are on your desktop. A floating bar enables you to change the folder shown using the navigation buttons to move up and down the folder tree, go back to the "home" desktop folder, or jump to a different folder.

59 Cairo's Dock Last, but not least, is Cairo's dock—its replacement for the Taskbar. It exclusively displays shortcut icons and open windows—click to open, right-click for more options, or "=" to open Task View for a preview of open windows.

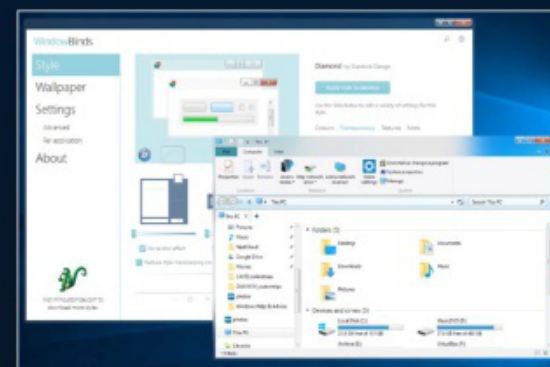
60 Transform Your Desktop with WindowBlinds



A DOWNLOAD AND INSTALL Download the trial version of WindowBlinds from www.stardock.com/products/windowblinds—after the program has installed, choose the 30-day trial, and enter your email address. Once activated, pick a style from the "Style" section of the program to preview it.



B MODIFY SKIN Click "Modify Style" to make changes—work through the "Colors," "Transparency," "Textures," and "Fonts" sections to customize it exactly the way you want it to look. Aching to recreate the old Windows 7 glass-like style? Select "Diamond" and choose "One click blur" under "Transparency."



C APPLY NEW SKIN Once you've finished making your changes in WindowBlinds, click "Stop modifying" followed by "Apply style to desktop." After a short pause, you'll see the Windows desktop update. Continue making tweaks—increase transparency using the sliders, for example—and apply them in real time. ↵

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4K Netflix. In the middle of nowhere. That's the sales pitch for 5G networking. But, as Jeremy Laird discovered, 5G is going to be much bigger than that...

A ZILLION INTERNET of Things devices all connected at once. Lagless cloud-based gaming. Cable-free connections for home Internet. Doctors operating remotely on patients. Smart farms. An end to traffic jams. And, yes, 10Gb/s in your pocket. All of that and way, way more is the promise of 5G. If it delivers—and it's a big "if"—5G is going to change our lives.

Simply put, 5G is just the inevitable progression of cellular wireless communication networks. It's the fifth such generation, hence the name. As for 5G's sales pitch, it goes like this: 5G will be vastly faster than previous networks; it will achieve dramatically lower latencies; and it will support a far larger number of devices connected in parallel.

The precise impact of all that will be complex. Early demos of 5G technology involving multiple

DREAM



gigabits of bandwidth delivered to smartphones have inevitably grabbed the headlines, as have teething problems that hint at real-world limitations for the new technology. But it will likely be the more nuanced capabilities of the new network, rather than YouTubers firing up Speedtest on their 5G handsets, that will have a greater impact on how we live and work.

For instance, future visions of a vast array of connected devices—including the so-called Internet of Things—will depend on it. Potentially world-altering technologies, such as autonomous cars, fall into that category. Similarly, much lower latencies will hugely reduce the need for wired connections to client devices of almost any kind. Wireless local delivery of really fast

4K Netflix from here? Well, possibly, but that's missing the really important things about 5G.

home connections will also change the core infrastructure of the Internet for domestic users. Rolling out new 5G home services should be far quicker and easier than digging up roads to supply optical fiber to every house.

At its best, 5G promises to be something of an end game. All the bandwidth you'll ever need, delivered with the lowest possible latency, pretty much wherever you are. Truly ubiquitous connectivity—in every sense of the word. If all that sounds great, it won't happen overnight. Nor will 5G deliver on everything it promises immediately, if indeed ever. So, while 5G networks are already being rolled out in the US and across the globe, like pretty much all previous generations of cellular, it's a piecemeal affair rather than a big bang.

We can all agree 5G is the next big thing in cellular comms. It's also fair to say it promises to radically impact digital connectivity on a much broader basis. So, let's kick off by investigating 5G's technical characteristics and how, ultimately, it works.

At the highest level you can divide 5G into two main elements, both of which are critical to delivering its benefits. Most obvious is the Radio Access Network. That's the collection of wireless access points to which client devices connect: small local cells, larger towers and masts, and dedicated in-building and home access points that connect users and wireless devices to the core network.

It's that core network that forms the other half of the equation. It combines the mobile exchange and data network that supports the network's functionality of voice, data, and Internet connectivity. For 5G, this core network is designed to hook in seamlessly with the Internet and cloud-based services, and include infrastructure and software expressly intended to not just increase bandwidth, but also reduce latency and lag.

The initial frequency bands for 5G will be around 600–700MHz, 3–4GHz, 26–28GHz, and 38–42GHz. In basic terms, that will add much more capacity compared to current mobile technologies, enabling more users, more data, and faster connections.

One significant new feature on 5G networks from a wireless access perspective involves a new class of small millimeter wave (mmWave) cells designed for short-range connections of roughly 10 to a few hundred yards. These local cells are designed to be positioned in clusters where there are high numbers of users, and complement the macro network that delivers the wide-area coverage. One of the earliest movers in 5G in the US, Verizon, has built some of these smaller nodes into street lighting in Chicago.

Larger 5G macro cells, meanwhile, use what's known as MIMO (multiple input, multiple output) antennas that have an array of elements to support more users and bandwidth. MIMO antennas are sometimes spoken of as "Massive MIMO," thanks to the really large number of antenna elements, but



Game streaming services like Google's Stadia will benefit from 5G's low-latency "edge" computing.

their actual physical size is comparable to existing 3G and 4G base station antennas.

Operators in the US will initially integrate 5G with existing 4G networks. The 5G radio system, known as 5G-NR, isn't compatible with 4G technology, but all early 5G devices in the US will use 4G for initial connections and control signaling, before hooking up to 5G for fast data where available. In terms of time to roll out, expect reasonably widespread 5G availability in 2022, and what you might call truly blanket 5G coverage by 2025 or thereabouts.

CLOSE TO THE EDGE

If wireless connectivity via the Radio Access Network is the most visible aspect of 5G, it's the upgrades it brings to the core network that will be critical for improving latency. Central to that is the idea of "edge" computing, which is all about bringing computing closer to the end user. In other words, instead of relying on huge public cloud computing infrastructure, located centrally and at distance from end users, the idea is to install "cloudlet" servers and other computing resources much more locally, to move the application or content close to the radio at the "edge" of the network.

It's a radical change. It can mean installing servers in 5G base stations to host content and run applications much closer to end users. For consumers, the impact would be felt in areas such as near-instant response when firing up video streams, or reduced lag in streamed games. But it's in enabling whole new usage cases that 5G's edge computing approach will have its biggest impact.

Which brings us to the broader subject of what 5G is for. The whole 4K-Netflix-up-a-mountain thing gets the basic idea of speed across, and represents one of the three main prongs of 5G, that of enhanced mobile broadband, but there's so much more to 5G. Next up is massive machine-to-machine connectivity, and support for an unprecedented number of devices. Whether it's sensors or IoT (Internet of Things) devices, the implication is billions of devices connected and communicating without immediate human intervention.

The third and final major usage model involves applications where low latency is critical. That means real-time control of devices, industrial robotics, car-to-car comms and autonomous

5G is a key technology in enabling an autonomous future for cars, and solving both safety and traffic problems.



driving, safety systems, smart rail networks, and, of course, gaming. If those are the three key 5G usage models, real-world applications will often straddle categories. An obvious example is, indeed, game streaming. For that you want lots of bandwidth. But you also want low latency.

The same convergence of factors applies to the emerging field of telemedicine. Delivering medical services remotely, even surgery, isn't a novel idea, but 5G promises to radically expand the range of medical services that can be delivered over the Internet. One more specific innovation involves something called the "tactile Internet." The idea is to combine a range of existing robotic, sensor, and haptic feedback technologies with the ultra-low latency of 5G, plus some predictive algorithms to compensate for what latency remains, to transmit touch over the Internet in real time. The upshot could change the way medicine is delivered.

MAKING CONNECTIONS

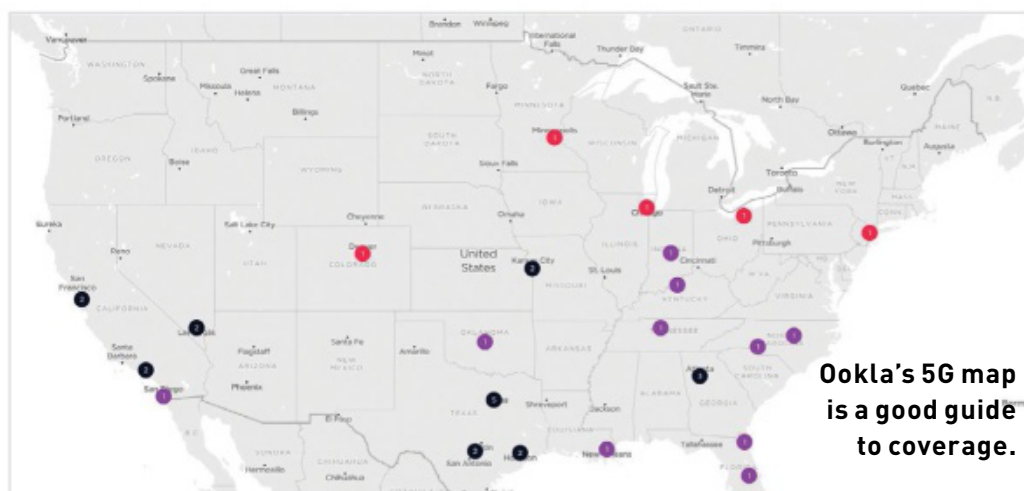
If that kind of technology is likely years away, the 5G-powered Internet of Things is much, much closer. Analyst outfit Gartner, for instance, reckons that by next year, over 20 billion devices will be connected to the Internet. That number is growing rapidly. Some research suggests 2025 could see as many as 100 billion connected devices, which is why 5G's support for a huge increase in connected devices is so critical. The IMT-2020 5G standard set by the International Telecommunication Union dictates a minimum requirement of at least one million connected devices per square kilometer. Yes, that's a minimum. Meanwhile the maximum number of connections supported by 4G tops out at around 100,000 per square kilometer.

Those are impressive numbers, but what will these devices be? Today's Internet of Things includes devices such as fitness monitors, and smart devices, like connected thermostats and light bulbs. But that's just the beginning. One obvious near-future example involves logistics and tracking. Currently, most couriers use a system of visible tags, which are optically scanned. It works pretty well, but leaves room for error. However, if every item or package had its own Internet connection, its individual position could be known in real time, even if it falls off the back of a truck.

In agriculture, meanwhile, 5G will enable a huge array of sensors to be located in the ground and in crops, on livestock, and on farm machinery. Combined with data from weather satellites and drones, farmers will have a far, far more accurate picture of when and how much to water, fertilize, and use pesticides. That will make farming more efficient and more environmentally friendly, by using chemicals only as and when needed.

Then there's the whole autonomous car thing. For truly self-driving cars to be possible, a very large array of innovations and technologies is required. Any fully autonomous car would need the capability to sense and react to vehicles and other hazards without communicating, especially

ROLLING OUT WHERE CAN YOU GET 5G IN THE USA TODAY?



In October 2018, Verizon beat other carriers to the punch by rolling out its Verizon Home 5G service in a handful of cities, including Houston, Indianapolis, Los Angeles, and Sacramento, and also offers a full retail service for mobile 5G users in a handful of cities. AT&T turned on 5G in 12 cities at the end of 2018, adding more since, but only offers the service to a select number of business customers. Sprint launched its network in May, and like Verizon has gone for a more limited initial offering in terms of locations, but with full availability to consumers. As we go to press, here are some of the currently available locations and services.

AT&T

What's on offer: Mobile 5G to a small number of business customers

Where:

- Los Angeles, California
- San Diego, California
- San Francisco, California
- San Jose, California
- Jacksonville, Florida
- Orlando, Florida
- Atlanta, Georgia
- Indianapolis, Indiana
- Louisville, Kentucky
- New Orleans, Louisiana
- Charlotte, North Carolina
- Raleigh, North Carolina
- Oklahoma City, Oklahoma
- Nashville, Tennessee
- Austin, Texas

Dallas, Texas

Houston, Texas

San Antonio, Texas

Waco, Texas

SPRINT

What's on offer: Mobile 5G to consumers and business customers

Where:

- Atlanta, Georgia
- Overland Park, Kansas
- Kansas City, Missouri
- Dallas, Texas
- Fort Worth, Texas
- Houston, Texas

T-MOBILE

What's on offer: Mobile 5G to consumers and business customers

Where:

- Los Angeles, California

Atlanta, Georgia

Las Vegas, Nevada

New York, New York

Cleveland, Ohio

Dallas, Texas

VERIZON

What's on offer: Mobile 5G to consumers and business customers, plus a separate home 5G service

Where:

- Verizon Mobile
- Denver, Colorado
- Chicago, Illinois
- Minneapolis, Minnesota

Verizon 5G Home

Los Angeles, California

Sacramento, California

Indianapolis, Indiana

Houston, Texas



5G is set to revolutionize the world of personal health.

in a world where autonomous cars will initially have to share the roads with human-driven vehicles, cyclists, and pedestrians. But the ability to send and receive large amounts of data with low latency will be a huge advantage.

An autonomous car would know about traffic problems miles away, because of the data it pulls in from other vehicles and the cloud. It will know where the cars in front and behind are going, and which lane they will be joining at the next set of traffic lights. It will know when the cars around it

HOW ABOUT THE HANDSETS?



The first full 5G handset: Samsung's Galaxy S10.

If you've motored through the main feature, you'll know that 5G is about way more than putting gigabits of bandwidth in your pocket, but that's still one of the most immediate benefits. So, which 5G-capable handsets can you buy right now?

Arguably the default option is the Samsung Galaxy S10 5G, available on Verizon, Sprint, and T-Mobile. It's a 6.7-inch beast with the same CPU and three of the same cameras as the regular Galaxy S10 and S10 Plus, but adds depth-sensing time-of-flight sensors front and back. Nice. The catch? It's \$1,299 for the 256GB version and \$1,399 for the 512GB model. Ouch.

Next is LG's V50 ThinQ 5G, available from Sprint for \$1,152. It's a 6.4-incher with a notch-style display, three cameras on the back, and 6GB of RAM. And that's it, bar pairing a Moto Z3 or Z4 with the 5G Moto Mod, which is a kludge.

By the end of 2019, a whole slew of handsets will be available, including the OnePlus 7 Pro 5G, Oppo Reno 5G, the Xiaomi Mi Mix 3 5G, and more.

As for Apple, rumor has it that its annual September refresh of handsets this year will not include 5G support. If so, that's not a huge surprise. Going back to the very first iPhone, which launched with 2.5G support, despite 3G services already being in existence, Apple has always taken a conservative approach to adopting new network technology. For most consumers, that probably makes sense. By the time 5G becomes widely available, Apple will have compatible handsets.

are about to change lanes on the highway before that begins to happen. The benefits to everything from traffic flow to safety are obvious enough.

On a more personal level, 5G-powered IoT gadgets will likely include smart clothing, prosthetic devices, and even ingestible health monitors. Here's one potential real-world example to consider. A start-up based in Utah, known as Veristride, has been working on smart shoe technology since 2012. What on earth is a smart shoe useful for? The feedback from its sensors can

For 5G networks, large cell towers, like this, will be augmented by smaller millimeter wave cells.



be used to do everything from helping people learn to walk again following major surgery or a stroke to predicting the onset of a serious illness based on nuanced changes in their movement.

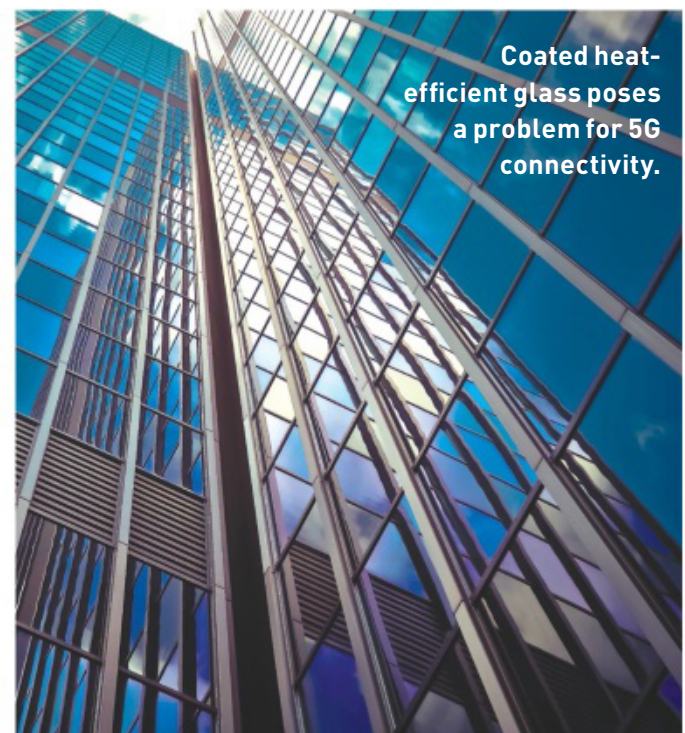
The list of emerging applications is immense when you combine the Internet of Things with 5G. Connected crime reporting, smart street lights, air quality sensors, parking spaces, garbage collection, home security and automation, factories with unprecedented levels of production oversight and efficiency—you name it, it's coming. And, yes, the refrigerator that reorders groceries when they run out is on the list, too.

UP TO SPEED

So, now we know how 5G works. We know what it's good for, and how it is and could be used. But what do we know about its real-world performance? Speed is one of the main selling points of 5G technology, but how fast is it? Inevitably, there is no simple answer. But there is plenty of hype. The sales pitch for 5G involves claims of speeds of at least 10 gigabits per second, making it about 100 times faster than standard 4G, and 30 times quicker even than upgraded 4G tech, such as LTE-A.

At launch, operators in the US are making much more modest claims. Think very low single digits in gigabits per second, and you'll have the right idea. That's still a very nice upgrade over the circa 100Mb/s of a conventional 4G connection. Of course, there are several 5G networks already in operation in US cities. So, early performance figures are available. Independent tests of AT&T's limited-availability network in Los Angeles returned figures of around 1.8Gb/s, while Verizon's more fully functioning and consumer-available service in Chicago was a little lower at 1.3Gb/s.

To put a tangible spin on the fastest of those speeds, you're looking at a 2GB file download in under 30 seconds. Or you could download multiple episodes of your favorite Netflix show in under a minute. Of course, the reality of 5G, just like any network generation, is that when it comes to speed, your mileage will vary. Among the early reviews of



Coated heat-efficient glass poses a problem for 5G connectivity.

the first 5G services in the US, some noted that speeds seemed to drop off behind plate glass. That's likely because of a combination of what's known as low-E glass and millimeter wave signals used to provide high-speed local 5G connections.

The problem is that many modern buildings now use low-E glass. That's glass with a special metallic coating that reduces heat radiation and thus provides improved insulation. Unfortunately, millimeter wave radio doesn't penetrate low-E glass terribly well. However, there are workarounds that can solve the problem, including active antennas fitted to window surfaces, but they do increase the complexity of implementing 5G, and it's not clear how much latency they introduce.

Speaking of latency, that's arguably an even more complicated question. 3G networks offer approximate latencies of around 65ms, while 4G clocks in anywhere from 30 to 50ms. For 5G, figures of just 1ms are being mooted. But that's a highly theoretical number. Ultimately, there's a limit to how far latencies can be reduced. The laws of physics, including the speed of light, make sure of that. That oft-touted 1ms spec for 5G buys you a little under 100 miles in each direction of a round trip in terms of the distance that can be pinged at the speed of light. Much, then, depends on the location of the physical client and the data source it's connected to.

By way of example of the physical limitations involved, the fiber-optic link between the Chicago and New York stock exchanges has been painstakingly optimized for low latency, even to the point of ensuring the paths of the cabling are as straight as possible. Even then, the round trip for pinging the opposite exchange could not be reduced below 13ms. The take home point here is that 5G can't remove the baked-in latencies associated with significant geographical distance.

In some ways, then, 5G has been overhyped. You're not going to get 10Gb/s and 1ms latency. Not today and, in most realities, not ever. But 5G is still going to change the world. It's going to make the Internet even more ubiquitous, power a whole new class of connectivity, and enable new applications that have yet to be dreamt up. It's not going to happen tomorrow, next week, or next year. But over the next decade, 5G is going to revolutionize not just the Internet, but the way we live and work. ⏻

HOME AND AWAY



5G handsets are grabbing the early YouTube and social media bandwidth, but 5G is actually far from just a mobile technology. Indeed, when Verizon launched its first 5G services last year, it actually implemented its home 5G product first, following with a mobile service later.

The immediate benefits of home 5G are obvious enough. It enables fast broadband to be delivered without the need to connect to a wired infrastructure. In other words, no more digging up streets to lay cables and fiber.

Verizon charges either \$70 dollars a month for a standalone service or \$50 to its mobile customers who have an existing plan of at least \$30 per month. The first three months are currently free, and there are no other up-front fees. For that you get claimed speeds of 300Mb/s. The service can also fall back to 4G connectivity if there are issues with the local 5G cells.

Early reports from customers suggest the performance claims are fairly realistic, while latencies in the very low double digits are often reported, meaning there's little if any penalty in that area versus a wired connection. If that all sounds good, the service's roll-out hasn't been entirely smooth. In fact, Verizon has put the brakes on adding coverage. Verizon said in January that it was waiting on new standards-compliant hardware before resuming the roll-out. However, some commentators reckon the problem is more serious.

According to a report by research analysts at MoffettNathanson, the effective range of the small millimeter wave cells is smaller than expected, so more cells will be required at greater cost to Verizon. Allegedly, Verizon has installed 200 cells in one of its initial locations, in Sacramento, California, but that covers just 10 percent of the city.



Yes, even farming is set to be revolutionized by the combination of 5G and the Internet of Things.



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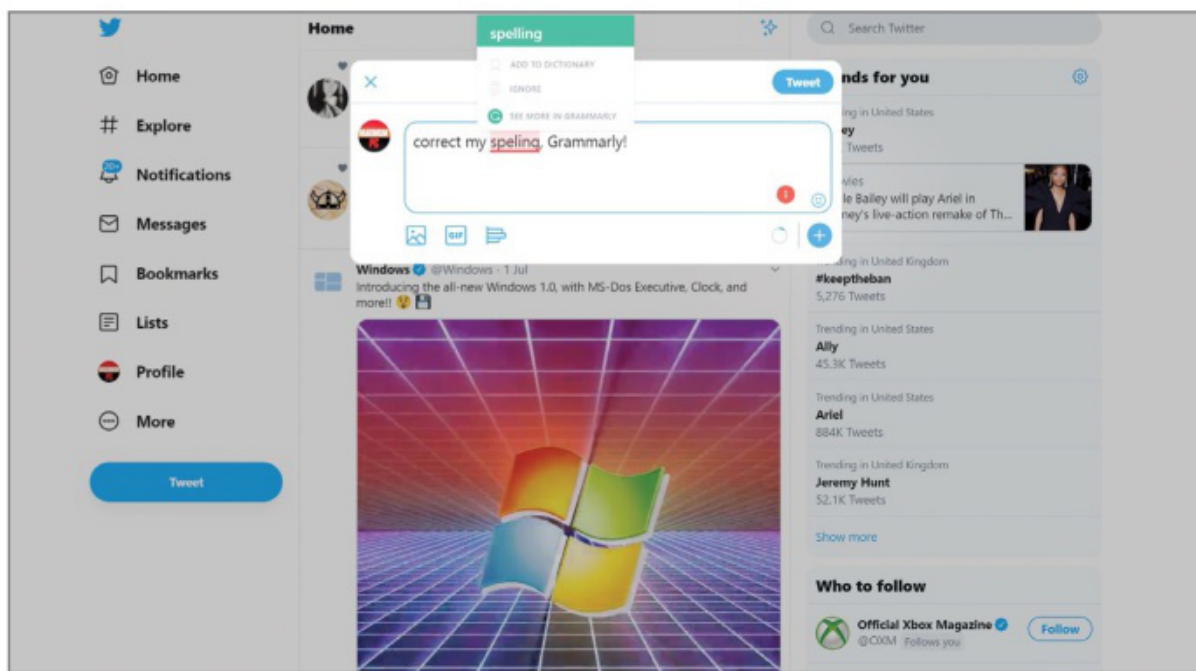
www.myfavouritemagazines.co.uk/pcgsubus

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HOW TO

STEP-BY-STEP GUIDES TO IMPROVING YOUR PC

TIP OF THE MONTH



CHRISTIAN GUYTON
STAFF WRITER

SUPED UP

I've been toying with the idea of a GPU upgrade, but decided to hold off until the new AMD and Nvidia cards landed. I'm glad I did; I imagine there's more than a few angry PC gamers trying to get their RTX 2070 cards refunded now Nvidia has officially revealed the Super variant, boasting moderately better performance at exactly the same price.

So, the original 2070 and 2080 have been marked for death, though the RTX 2060 Super won't be pushing out its predecessor. It was with mild annoyance that I noted the specs and benchmarking scores for the Super cards, as I was hopeful that the threat of new cards from AMD would kick Nvidia into overdrive. However, it feels like the Super GPUs only stand to secure Nvidia's position as top dog in the graphics market; there's no real innovation, just a mild performance bump, and a continuation of reliance on the ray-tracing USP.

Looking at the details of the new RDNA cards, it sadly looks as though AMD isn't attempting to shake things up too much either. One possible glimmer of excitement comes from Intel, which is promising to make an appearance in the GPU game next year. Will it go budget and compete with AMD, or go high-end in an attempt to bring down Nvidia? Only time will tell.

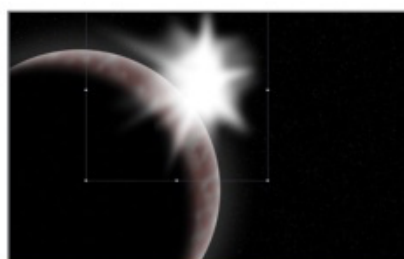
WRITE BETTER WITH GRAMMARLY

If you use your PC for word processing, you might be familiar with Grammarly, a program for simplifying and improving your writing. Well, there's a Chrome extension, too—install it, and it actively works to turn whatever typing you do online into concise, typo-free writing worthy of Hemingway himself. It works for messages, comments, documents, and even social media posts, and the standard version is completely free.

MAKE – USE – CREATE



54
Build a better home server with Docker



62
Design your own celestial bodies in Abode Photoshop



66
Build your own NAS box, with the magic of open source

© CREDITS TO COME

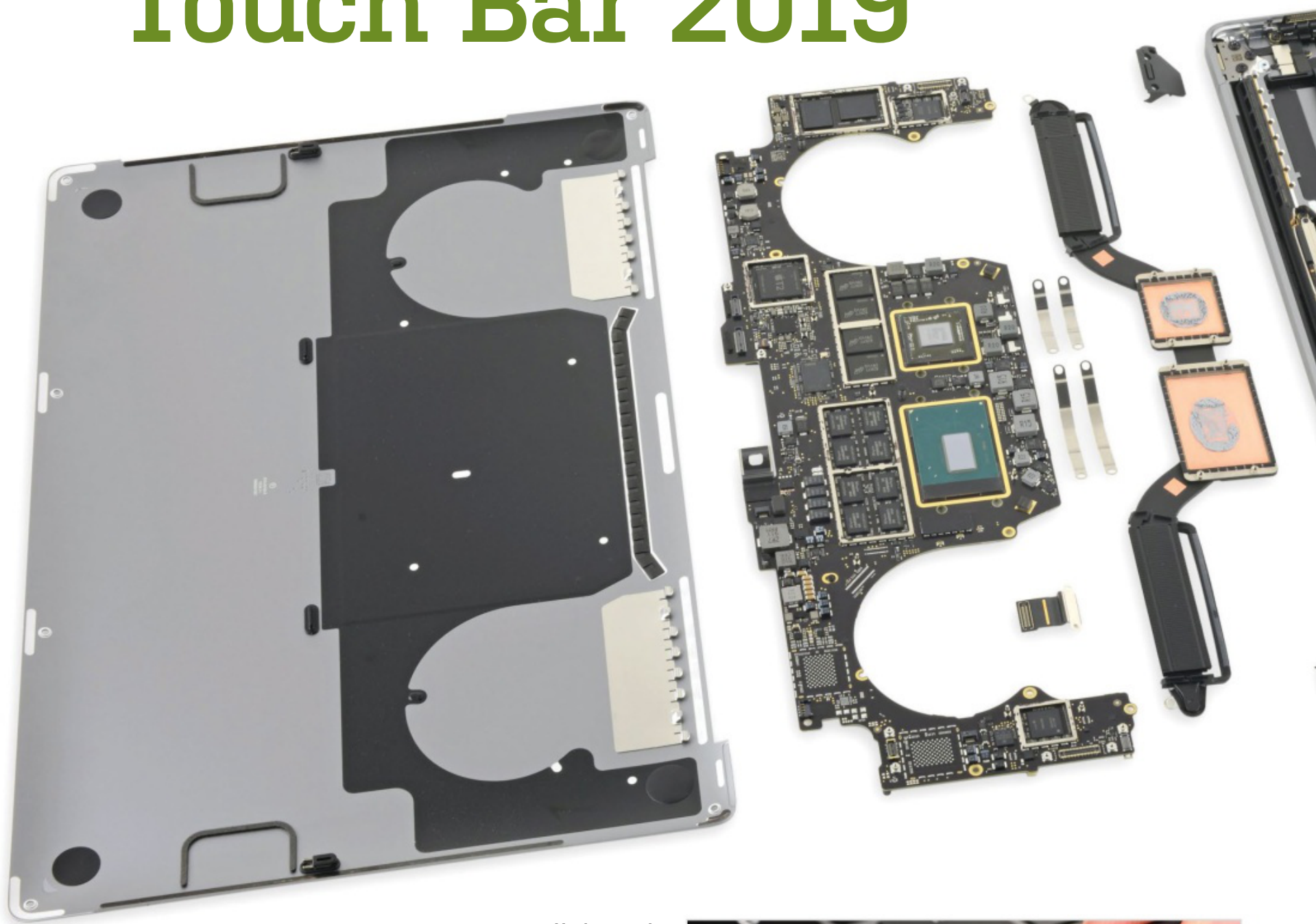
submit your How To project idea to: comments@maximumpc.com



AUTTOPSY

THIS MONTH WE DISSECT...

MacBook Pro 15-inch Touch Bar 2019

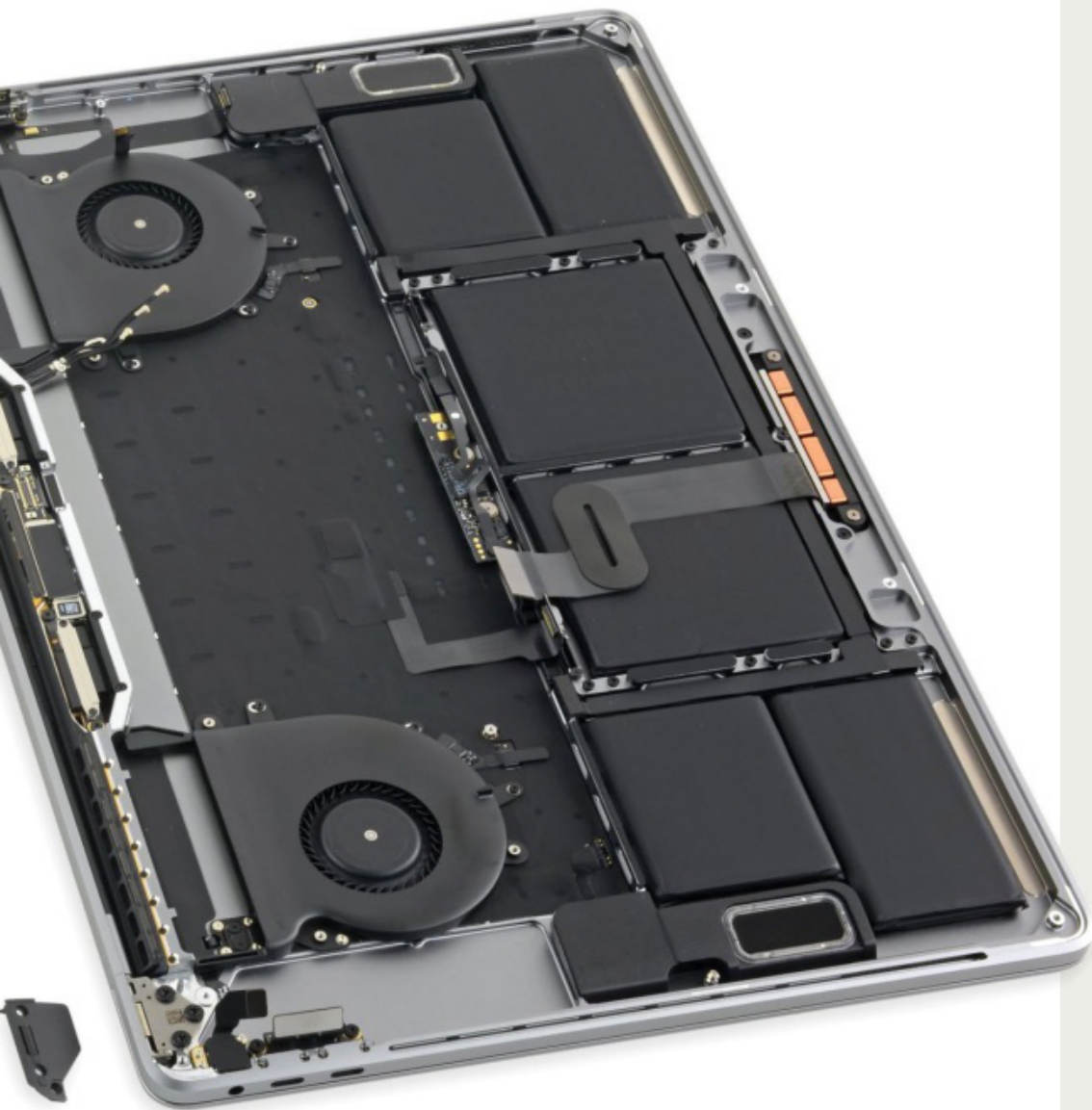


About iFixit

iFixit is a global community of tinkerers dedicated to helping people fix things through free online repair manuals and teardowns. iFixit believes that everyone has the right to maintain and repair their own products. To learn more, visit www.ifixit.com.

Underneath the dome switch are six metal pads. A keystroke registers whenever the top-center pad is shorted to any of the other five pads.





BACKGROUND

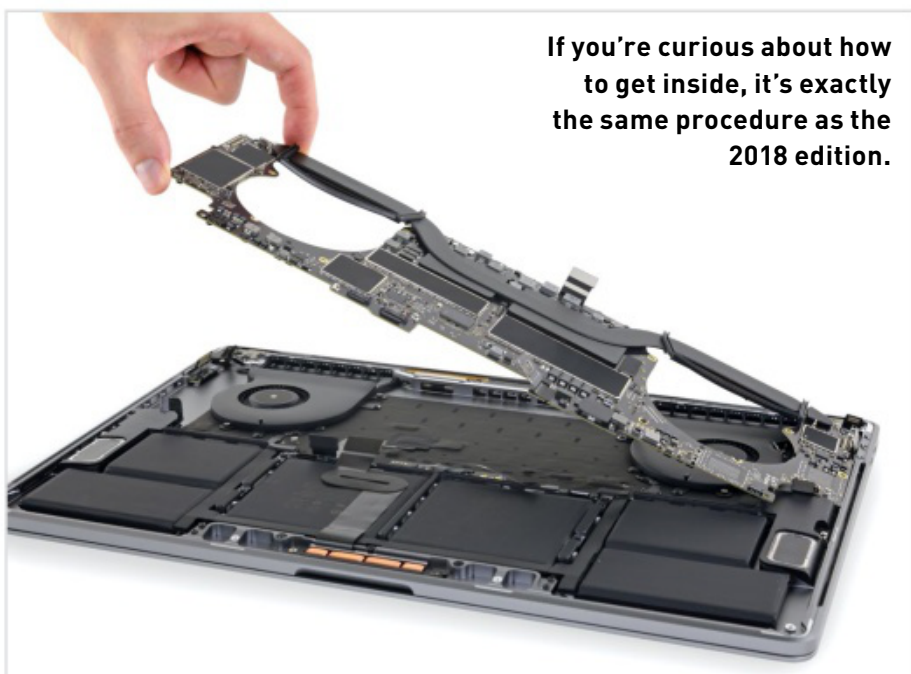
Apple's newest MacBook Pro is its fastest yet, featuring an optional eight-core processor—a first in a MacBook—and a mysterious new keyboard material. As it's unlikely that Apple's going to expound on this "material," and we're never satisfied with an unsolved mystery, it's time to take a closer look at the infamous butterfly keyboard.

MAJOR TECH SPECS

- 15.4-inch LED-backlit IPS Retina display with True Tone, 2880x1800 resolution (220 dpi), P3 wide color gamut
- 2.6GHz six-core Intel Core i7 (Turbo Boost up to 4.5GHz) paired with a Radeon Pro 555X
- 16GB of 2,400MHz DDR4 SDRAM
- 256GB PCIe-based SSD
- 802.11ac Wi-Fi and Bluetooth 5.0
- Four Thunderbolt 3 (USB-C) ports

KEY FINDINGS

- The butterfly keyboard landed on the MacBook Pro line for the first time in 2016. Designed to be super-thin, it proved controversial because of its extremely short throw—but soon proved unreliable as well. In summer of 2018, Apple launched a repair program and released updated models with a silicone membrane protecting the key switches. But problems have persisted. 2019's revision keeps the silicone membrane, but tweaks the materials in the metal dome and the plasticky material that covers it.
- Topping off 2019's butterfly switch is the key cap. A hinged white bracket is the "butterfly" mechanism controlling the key's motion. Nestling within that bracket is a transparent cover that flexes with each key press, while keeping contaminants away from the dome switch beneath.
- The switch cover in the 2018 model was semi-opaque, somewhat tacky, and felt like silicone. The new model is clearer and smooth to the touch. The 2018 model was either polyacetylene with aromatic urethane side groups, or a type of TPU (which seems more likely). The 2019 model is polyamide—commonly known as nylon.
- We also think the metal dome switch may have changed. It's like a tiny Snapple cap: Press down and it springs back up. If the dome is cracked or deformed, the key may behave erratically. If the prongs break or bend, the key stops working. These switches are also magnetized from the factory. Best guess as to their composition: ferritic stainless steel, with a thin polymer coating on the bottom.
- The fundamental problem with this laptop remains—with zero modular components, it means that if the slightest thing goes wrong, you'll be replacing half the machine. Even if the keyboard is perfect this time, you're taking a gamble on the rest. Our advice? Save your money.
- Repairability Score: 1 out of 10 (10 is easiest to repair). The trackpad can be removed and replaced with little drama. The processor, RAM, and flash memory are soldered to the logic board. Repairs and upgrades are impractical at best. The top case assembly, including keyboard, battery, speakers, and Touch Bar, is glued together, making those components difficult to replace. The Touch ID sensor doubles as the power switch, and is paired with the T2 chip on the logic board. Fixing a broken power switch may require help from Apple, or a new logic board. ⏻



If you're curious about how to get inside, it's exactly the same procedure as the 2018 edition.

Build a Better Home Server With Docker

YOU'LL NEED THIS

SERVER HARDWARE

Use whatever spare silicon works for you.

LUBUNTU

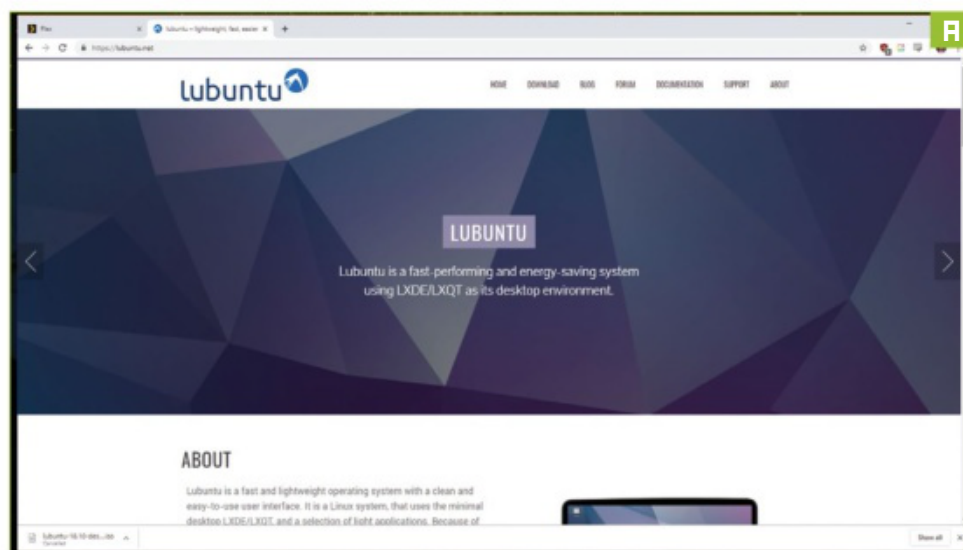
Grab it from <http://ubuntu.net>.

DOCKER COMMUNITY EDITION

You can find out more at www.docker.com.

EVERY GOOD HOME NEEDS A SERVER. It doesn't really matter what you intend to use it for. Whether you're throwing media around, performing backups, running game servers, or doing any other nebulous serving work, a dedicated machine is the best way to go about it—it leaves your main box free to work its hardest, and means those services are available whenever you need them. But the worst thing about a server is when it isn't there any more. If one of your software components forces a reboot, crashes the machine completely, or if it decides it likes system resources so much that it would like to take them all, everything else falls to bits along with it. Unless, that is, you manage your server properly.

Predictably, this brings us to Docker. Essentially, it's a way to compartmentalize everything on your server—each Docker container you run sits in its own sandboxed space, only reaching out as far as you let it, which means that while Docker containers can interact with each other, they're also able to be completely insulated. They're like little servers in their own right: If something goes wrong, just reboot the container. And it's so simple to get started.... —ALEX COX



1 PICK A PLATFORM

You're probably running Windows on your main PC, but while Docker is available for Windows machines, using it on Windows is not worth the effort. It sits much more comfortably on Linux, and as you're going to dig up some old hardware and run a dedicated machine for your containers, that's the way to go. Your first step, then, is to get that hardware (or a virtual machine, if you're just looking to test things out) running Linux. We used the desktop spin of Lubuntu 19.04—download it from <http://ubuntu.net> [Image A], write it to a USB stick with Rufus (<http://rufus.ie>), boot up your machine, and install it, ensuring you use a very strong password if you're likely to open the server up to the Internet in the future. You can run Docker just fine on a Raspberry Pi, but the power available to its individual containers may not be adequate to tease strong performance out of them.

2 SET THE CONNECTION

It's obviously a good idea to set up headless access to your server, so you can administer it from your main PC, and do away with the monitor and keyboard. Open up a terminal window, and run `sudo apt update` followed by `sudo apt install openssh-server` to install a decent SSH server; run `sudo systemctl status ssh` when you're done to check it's running. It's also handy to have a fixed IP address, so your server doesn't go walkabout if you reboot: While still at the desktop, you can set this by heading

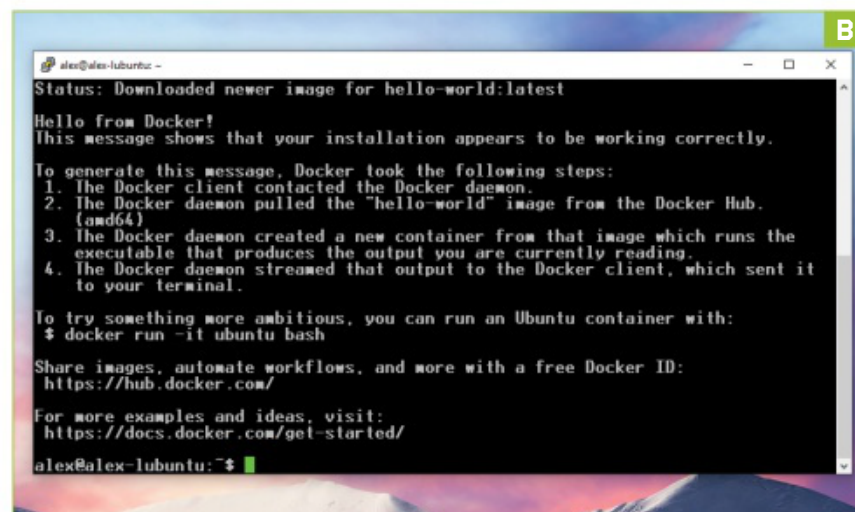
to the network manager via the icon in the top-right of the screen, selecting wired or wireless settings (depending on your connection), clicking the gear icon, and filling in the appropriate boxes. Reboot your server machine, and you should be ready to go.

3 HOOK YOURSELF UP

Frustratingly, the best SSH tool for Windows still seems to be the aging PuTTY (<http://putty.org>), though if you're cunning, you could also run the distro of your choice over the top of Microsoft's Linux Subsystem for Windows and access SSH from the command line. Head to your main PC, fire up PuTTY, and connect to the IP address you set earlier. On your first connect, select "Yes" to add the host key to PuTTY's cache, and log in with the username and password you set earlier.

4 DOING DOCKER

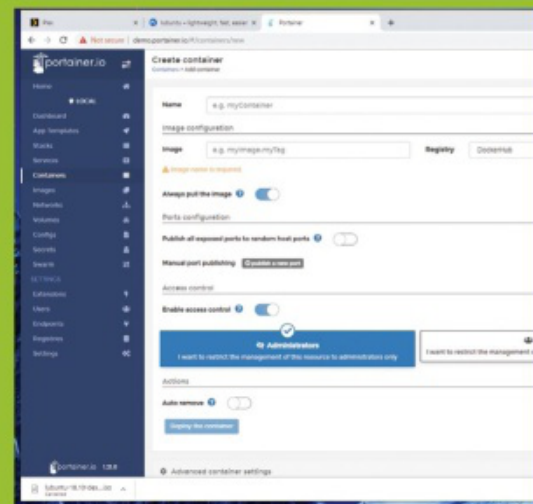
Next, install Docker, which, due to our awkward choice of OS, means grabbing an older version. Start by adding the Docker GPG key to your server with `curl -fsSL https://download.docker.com/linux/ubuntu/gpg | sudo apt-key add -` then add the Docker repository, so your server knows where to find the files, with `sudo add-apt-repository "deb [arch=amd64] https://download.docker.com/linux/ubuntu cosmic stable edge"`. Once



CONTAINERS UPON CONTAINERS

What's running on your Docker box? Given how easy it is to fire up a new container, the answer quickly becomes "quite a lot." Managing those individual software appliances is key to having an efficient time with everything. If you're using the command line, typing `sudo docker ps` lists all the processes that Docker is currently managing; once you've got that information, you can use `sudo docker kill` followed by the process ID to shut things down as required. Basics of management covered, then, but there's much more

to it than that. Creating a "docker-compose" file for all of your apps is a great way to make sure they're all configured properly (see <http://docs.docker.com/compose> for more on that) and to run a large collection of them with a single command. And if you want to see what your server is up to, there's a number of management containers that can help: The likes of Portainer, Grafana, and Prometheus can help you keep tabs on system resources and manage running containers with a point-and-click web interface.



that's done, update the package manager (`sudo apt-get update`), then check that your system is getting Docker from the right place by typing `apt-cache policy docker-ce` and scrutinizing the results. Happy? Fire off `sudo apt-get install -y docker-ce` to install the Docker Community Edition.

5 OUT OF CONTAINMENT

Docker tends to keep to itself, but it should now be installed, and its service should be running in the background—try `sudo systemctl status docker` to see if it is indeed running. It's important to note that the service, or daemon, is a separate entity from the command-line tool—the service will run when your system boots up, which means that once you've set up a Docker container, it'll stay active until you explicitly kill it. Let's try that now: Run `sudo docker run hello-world`—the command-line app will prod the daemon, which will first check for a local container, then (as it hasn't found one) head to Docker's servers, download the "hello-world" package, add it to its own database (allocating it the relevant storage and resources as it does so), then run it, spewing its output [Image B] to the command line.

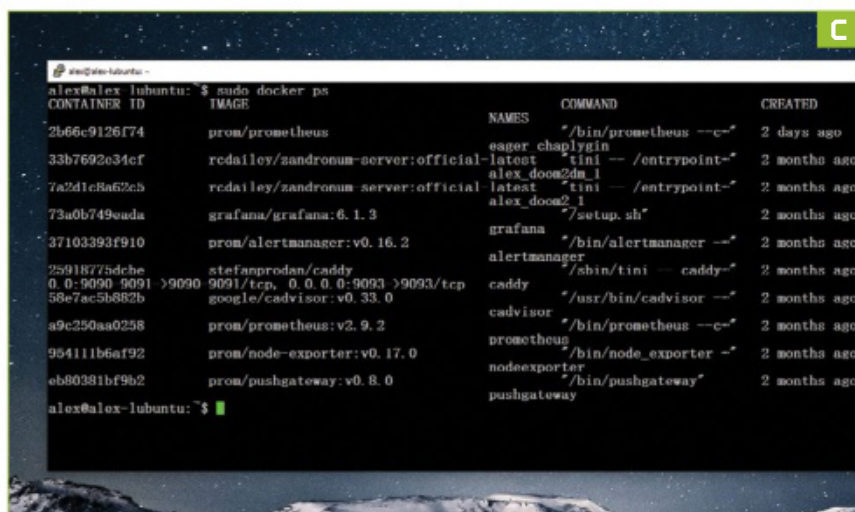
6 PICKING PORTS

Running a "hello world" does nothing for us, other than prove that Docker is working, but it's an example of how simple it can be to get a Docker container up and running. Let's install something slightly more practical to show off Docker's power: Try running the command `sudo docker run -d --name wiki -p 8181:8080 mkodockx/docker-wiki`. This tells Docker, in order, that we want to run something, we want it detached (`-d`) or running in the background, we want to call the container "wiki," and that we want to connect TCP port 8181 on our host machine to

8080 inside our container. Finally, we tell Docker where to find the image to use for our container. Just like that, your server is playing host to a full-blown wiki running on top of NodeJS—all the installation, all the folder structure, all the messing around with LAMP stacks is done for you. One command, and it's running. Connect to the appropriate port of your server in a web browser (in our case, this is 192.168.1.224:8181), and it'll be there—and if you wanted to run a second instance of the wiki, just run the same command, switching out the name for, say, "wiki2," and connecting it to a different port. Run `sudo docker ps` to see what containers you have running [Image C].

7 TAKE IT FURTHER

So, what to do with your new-found powers? Realistically, whatever you like. There's a vast catalog of tools available at <http://hub.docker.com>, some of which will likely be less useful than others. That said, you can pick up the likes of Plex (turning your server into a media hub) [Image D], OwnCloud (for convenient network file storage), OpenVPN (connect through your home network from afar), and much more—and there are other resources to check out, too, such as the excellent www.linuxserver.io. We're also running a pair of servers for Brutal Doom via <https://hub.docker.com/r/rcdailey/zandronum-server>. In this case, Docker is handy for setup and isolation, but since the server announces your IP address on a global browser, it does expose you somewhat, so you'll want to make sure your router's firewall is in good shape. ⏻



Set Up a Secure Shell Honeyypot

YOU'LL NEED THIS

A RASPBERRY PI

Version 2 or better.

RASPBIAN BUSTER

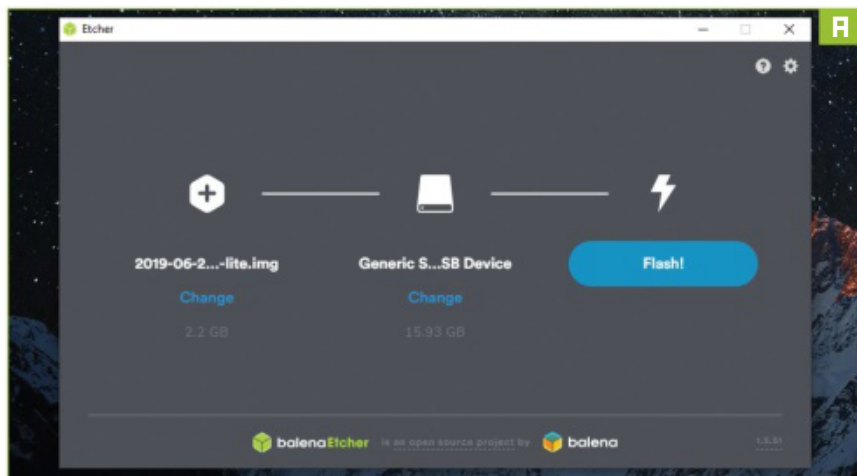
The latest spin on the Pi OS.

COWRIE

A great honeypot (see <https://github.com/cowrie>).

WHETHER THEY'RE OPPORTUNISTIC "SCRIPT KIDDIES," actual paid hackers on some Chinese payroll, or zombie computers compromised by malware, there's a huge number of forces trying to sniff around your network. A quick browse of your router's firewall logs (or those of Windows' own second-line-of-defense firewall) will likely make for worrying reading: Your ports are probably being scanned, probed, and poked to within an inch of their lives. There's little you can do, save for sleuthing out the snoopers and stopping them in real life (something we don't endorse). Instead, how about taking the path of least resistance, and just letting them in?

Crazy talk, right? Not so much. Setting up a honeypot, a sandboxed and safe area of your network, running on disposable hardware, which appears from the outside to be a juicy server worthy of exploitation, is an interesting idea with a nefarious side effect: Hackers can poke around and ideally feel as if they have accomplished something, thus thoroughly and fruitlessly wasting their time. If that doesn't make you feel good, your heart needs hacking. —ALEX COX



1 READY YOUR BOX

You may be familiar with Docker, particularly if you've read the tutorial on page 54. We're going to use it here to manage our honeypot, because it makes restoring a destroyed system as simple as a single command. And given that we're actively trying to make something disposable, destructible, and dedicated, the ideal platform is a Raspberry Pi; we tried the Pi Zero, but a combination of its ARM v6 processor, low power, and the staunch refusal of the latest Raspbian Buster to play nice drove us toward a RPi 3 Model B—don't let that stop you trying, but be aware that you may be in for some heartache. You may, if you don't want to draw attention to the rest of your network, run your honeypot on someone else's hardware: A VPS, or virtual private server, is generally cheap to rent, and grants you access to a full Linux shell. We're going to take the risk, but that's definitely an option.

2 INSTALL A HOST OS

First up, prepare your RPi. Grab a microSD card, head to www.raspberrypi.org, download Raspbian Lite (where we're going, we don't need desktops), then install it on the card [Image A]. Just for a change, use the excellent Balena Etcher (www.balena.io/etcher) this time. But don't pop the card in your RPi quite yet—ignore Windows' protestations about the card needing formatting, and open up the drive volume marked "boot." Create a blank text document in the root folder—we're going to use this file, in an area completely inaccessible to your honeypot, to preload your Wi-Fi credentials, so you can boot the Pi headless. Skip this step if you're attached by Ethernet. Open

the file, and insert the following (replacing <name> and <password> for your SSID and network key).

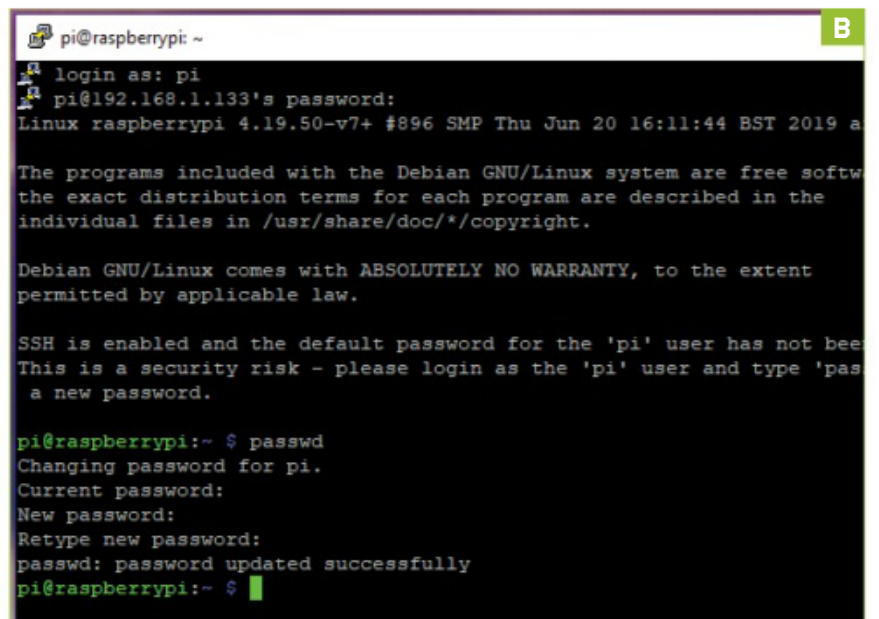
```
country=US
ctrl_interface=DIR=/var/run/wpa_supplicant
GROUP=netdev
update_config=1

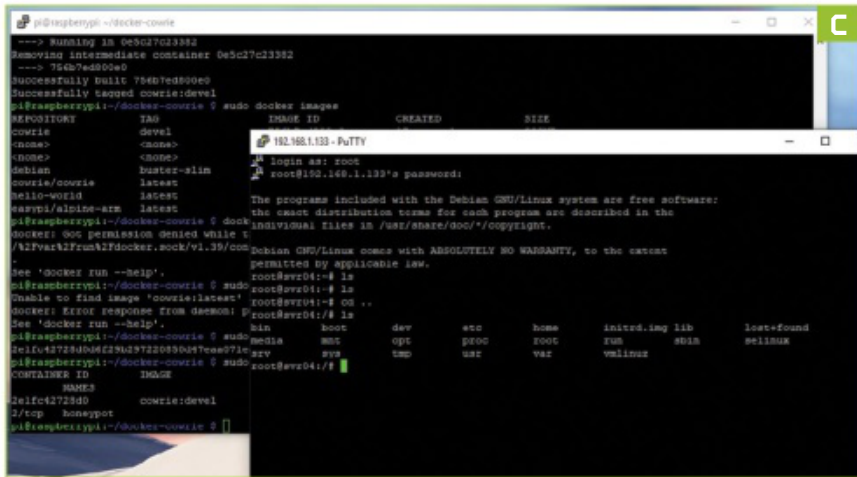
network={
  ssid="<name>"
  psk="<password>"
  key_mgmt=WPA-PSK
}
```

» Save it with the name `wpa_supplicant.conf`. Then create a second empty file (Ethernet users, you'll need to do this, too) called simply `ssh`, which tells Raspbian you want SSH (Secure Shell) switched on. Put the card in your Pi, power it up, and boot up your headless system.

3 FIND IT

You need to find the IP address of your Pi in order to connect—try using your router's web interface to see what's connected. You'll need this interface later, so now is a good time to get connected. Log in to your Pi via SSH using PuTTY (www.putty.org) with the username





“pi” and the password “raspberrypi.” Before we go further, let’s add a sliver of security and change that password [Image B] by running `passwd` and entering something non-default.

4 DO DOCKER

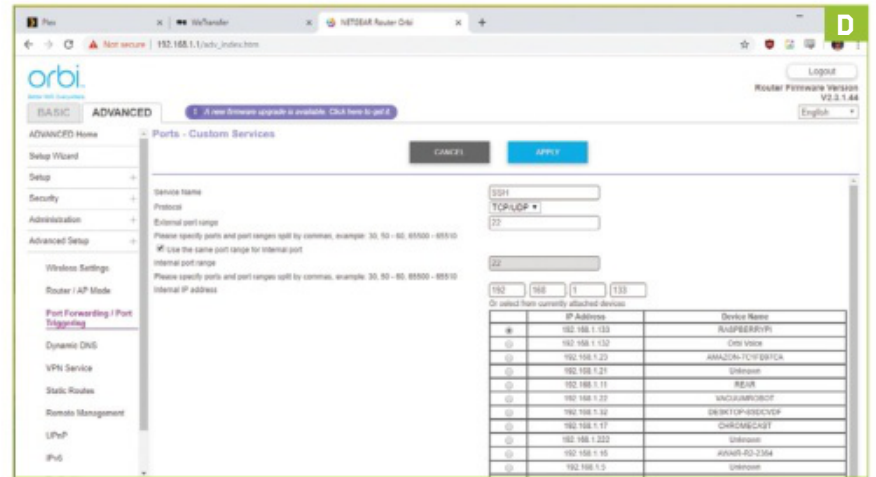
Now it’s time to install Docker—easy on the Pi, right? Kinda. At print time, with the recent upgrade to Raspbian Buster, Docker’s devs have yet to release a new stable version. No problem, though: We can use a little sidestep to get things working. First, run `sudo apt update` to make sure all your core packages are up to date, then run `curl -sL get.docker.com | sed 's/9/10/' | sh`, which pulls an install script from Docker’s servers, tweaks a couple of values, and runs it—this should install it without issue. Try `sudo docker run hello-world` to test it out.

5 PORT PROTECTION

Before we install our SSH honeypot, we need to change the default port that the Pi uses for SSH communication, lest we lock ourselves out. This is good practice whether you’re running a honeypot or not—hiding the entrance can make servers more resilient to attack. Run `sudo nano /etc/ssh/sshd_config`, scroll down to the line marked `#Port 22`, remove the octothorpe, and change the port number to something you’ll remember—2121 is a decent unused port, if you’re looking for inspiration. Hit Ctrl-X followed by Y to save and exit, then run `service sshd restart` to restart the SSH daemon. It should kick you from your PuTTY session, so log back on, this time changing the SSH port to match your new one.

6 TASTE THE HONEY

There are various honeypot containers that have already been put together by Docker users, but we’re going to go with Cowrie, a long-developed and mature honeypot coded in



Python—and we’re going to build a version specifically for the Raspberry Pi. Run `sudo apt install git`, then `sudo git clone https://github.com/cowrie/docker-cowrie.git` to download the appropriate files. Use `cd docker-cowrie` to enter the appropriate directory, then `sudo make all` to start the Raspberry Pi grinding away at the source code. This takes a while (particularly running on the ARM architecture of the Pi), but it’s necessary because there’s no up-to-date ARM package on the Docker Hub—and it ensures (all being well) that every file works on the hardware you’re running. When it’s done, run `sudo docker images` to check that it’s there.

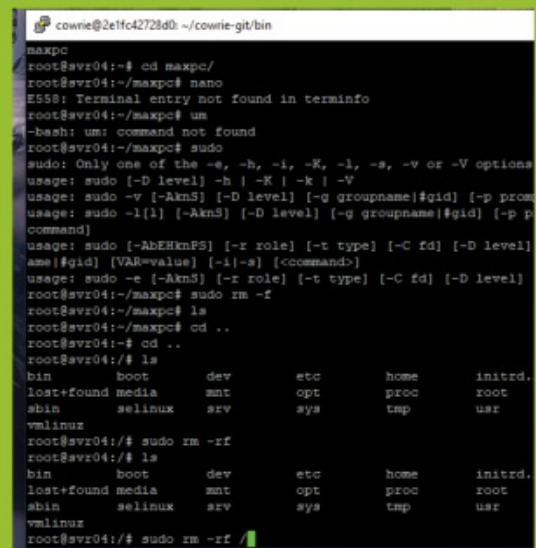
7 HACK ON IN

With the honeypot built, you can run your container with `docker run -d --name honeypot -p 22:2222 cowrie:devel`, noting the `-p 22:2222` portion, which maps the internal 2222 port that its SSH server runs on to 22 on your local machine. This means anyone looking for a standard SSH server will find your honeypot, rather than the actual SSH path to your host machine, which is why we changed it earlier. Test it yourself: Open a new instance of PuTTY, log in to port 22 of your Raspberry Pi, and you should see a login screen [Image C]. Using the username “root” and literally any password you like will get you into the simulated command line. Cause chaos, do what you like, because you’re in a safe space now. Isn’t that nice? The final step is to head over to your router’s port-forwarding page (and this is going to differ for every router, so we’ll leave the specifics to you), and pipe any incoming traffic on port 22 to the local IP address of your Raspberry Pi [Image D], thus capturing that horrible hacker traffic in the right place. 🔌

MONITORING YOUR HONEYPOT

Having a honeypot to keep hackers busy is one thing, but it’s far more interesting if you can actually see what those interlopers are up to. We can take that to the extreme: Let’s see exactly what was input into Cowrie with the exact timing at which it was input. The container keeps its own logs, and even includes a tool that can play them back in real time. Start by opening up a bash shell within your Cowrie container using `sudo docker exec -it honeypot bash`—this basically

gives you a command line running entirely inside the container. Then type the following without hitting Return: `playlog /cowrie/cowrie-git/var/lib/cowrie/tty/`. Now hit Tab, and you’ll see a bunch of files listed with awkward-to-remember hashed file names: Type the first couple of characters, hit Tab again to autocomplete, then hit Return to see that access played back. At first, you’ll only see your own basic fumbblings, but as the list grows, you may see some very interesting shenanigans....



Build a Blog with Open Live Writer

YOU'LL NEED THIS

OPEN LIVE WRITER

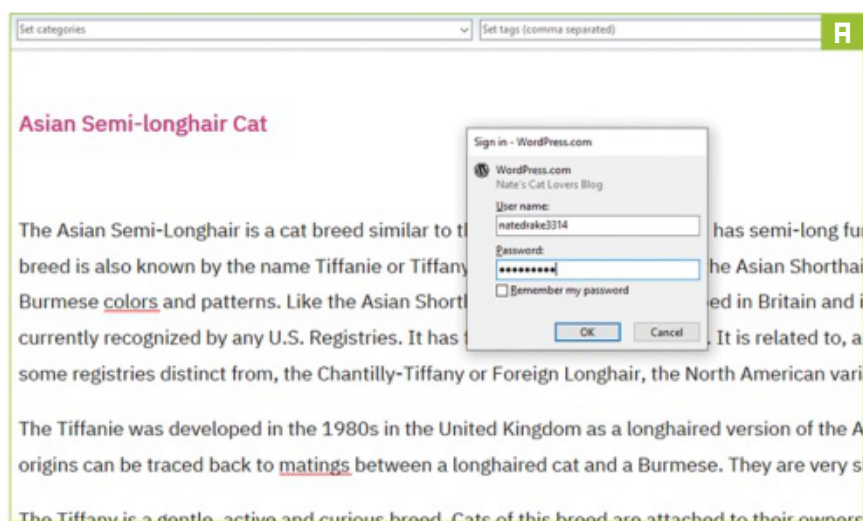
Download it from the Microsoft Store or directly from <http://openlivewriter.org>.

THE WORLD HAS YET to reach “peak blog.” Until it does, the Internet will continue to be swamped with bloggers sharing their obsessions, from exotic vacations to rare bottle caps. There are hundreds of platforms to choose from, many of which offer free tiers.

Open Live Writer is a lightweight, open-source fork of the popular Windows Live Writer. It’s designed to bring order to the madness of juggling various blogs. On first launch, you’re asked to connect your blogging account—a number of popular platforms, such as WordPress, Blogger, and DashBlog, are supported.

Once logged in, you can use the word processor-style interface to create and edit blog posts. The application supports basic features, such as changing fonts, adding pictures, and inserting hyperlinks, as well as more advanced tools, such as adding categories and tags, embedding videos, and scheduling posts for later publication.

Open Live Writer can support any number of blog accounts, enabling you to switch effortlessly between various platforms. Aside from consolidating your blogging, the app can also be used to prepare and save posts offline. In this guide, you’ll discover how to get started with Open Live Writer, as well as how to use some of its more advanced editing features. —NATE DRAKE



1 SIMPLE SETUP

Open Live Writer can be installed via the Microsoft Store or downloaded directly from (<http://openlivewriter.org>). On first launch, the app asks you to select which blogging services you already use. Click the radio button next to a service to select it. You can add further blogging platforms once setup is complete. The setup wizard now asks for the web address of your blog, along with your username and password. Click “Next” to continue. Open Live Writer immediately begins analyzing and syncing your blog. For certain platforms, the app offers to publish a temporary post. This is a fast and simple way for Open Live Writer to download your blog theme, enabling you to view posts as web users see them. Click “Yes” to agree. Once setup is complete, Open Live Writer prompts you to set a nickname for the blog (the default is the blog name). Click “Finish” to confirm.

2 YOUR FIRST POST

Once setup is complete, Open Live writer prompts you to create a new blog post. Fill in the field marked “Enter a Post Title,” then enter your post text below.

» You can access text editing options such as “Bold” or “Center Align” using the taskbar at the top. Click the “Picture” icon to add an image from your PC or the web. Highlight text and click the hyperlink icon to insert URLs; if a web address has been

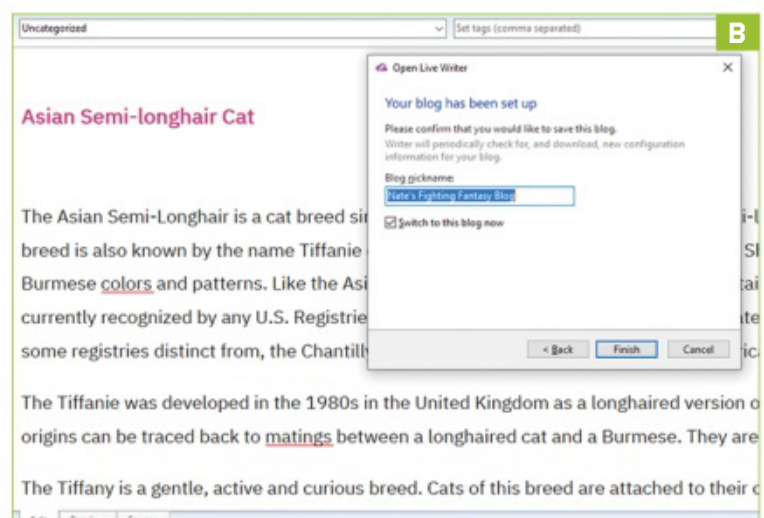
copied to the clipboard, it displays automatically. To save a draft, go to “File → Save.” From this submenu, choose “Save” to save a draft to your computer; to save a post to the online draft section of your blog, select “Post Draft to Blog.” If you choose this, you may be asked to sign in again [Image A]. Check the box marked “Remember Your Password” to avoid this in the future.

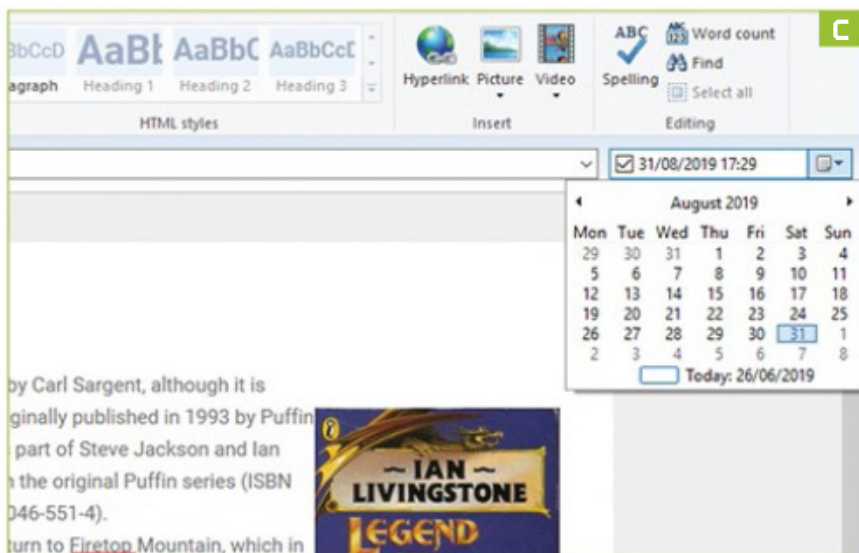
3 REVIEW AND PUBLISH YOUR POST

Once you’ve created your post, click the “Preview” tab at the bottom-left to see your blog as it would appear with your latest news. If you’ve previously chosen to save a post to online drafts, you can also view this in your browser by clicking the draft post title. Click the “Edit” tab to make any last-minute changes. Power users can edit raw page code via the “Source” tab. When ready, click “Publish” in the taskbar at the top. Open Live Writer automatically launches your blog in your browser once the post is uploaded, so you can review it.

4 ADDING MULTIPLE BLOGS

Open Live Writer supports multiple platforms and accounts. If you manage another blog, open the “Home” tab, click the name of your current blog in the





taskbar, then select “Add Blog Account.” This reopens the wizard you saw when you first launched Open Live Writer. Select your blogging platform and fill in your credentials as outlined earlier. By default, when you click “Finish” [Image B], the app switches automatically to the blog you just added. Click “File → New” to create a blank post. In future, be sure to select the correct blog from the taskbar at the top-left before clicking “Publish.”

5 SCHEDULING POSTS

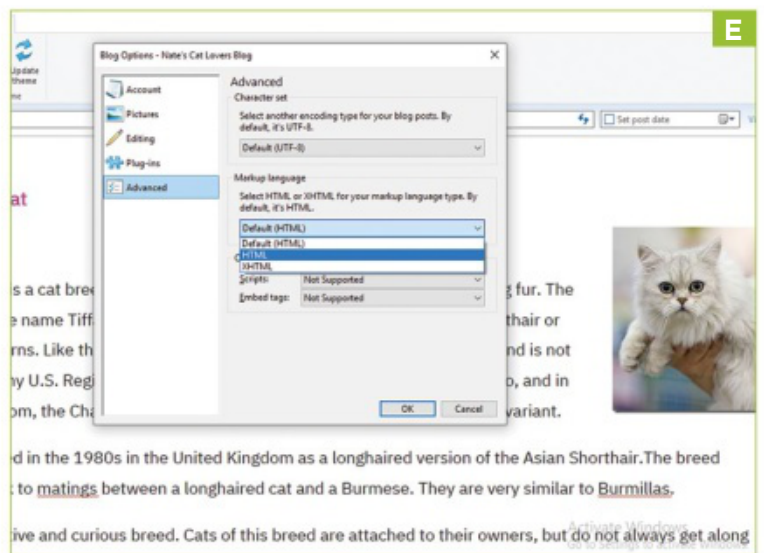
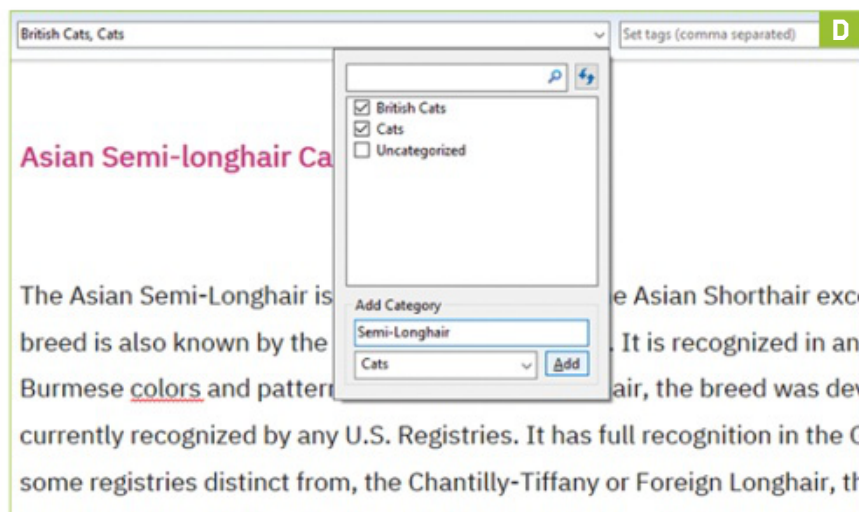
Open Live Writer supports publishing posts at a later date or time. To do this, visit the “Edit” tab and prepare your post for publication. Next, click the box marked “Set Post Date” at the top-right. A mini calendar drops down, enabling you to choose a publication date [Image C]. Click the “Time” field and use the up and down arrows to choose a specific time. Posts listed for publication are uploaded automatically to the “Scheduled” section of your blog platform. This means there’s no need for you to keep Open Live Writer running until the publication date.

6 SETTING CATEGORIES

Although categorizing blog posts is not essential, doing so is helpful for both visitors to your site and search engines, as they make your blog much easier to navigate. Open Live Writer supports creating categories from the “Edit” tab. Simply click the drop-down menu in the “Set Categories” pane on the left. From here, you can choose “Add Category.” If you’ve previously published a post with a category, such as “Cats,” you can set this as a parent for your new category—“Semi-longhair,” for example—using the drop-down menu at the bottom [Image D].

7 CUSTOMIZE BLOG PREFERENCES

You can fine-tune your blog settings even further by accessing “Blog Account” at the top-left of the screen. Choose “Blog Options” to view your account settings. From here



you can change your blog title using the “Blog Name” field. Use the “Pictures” section to choose between uploading images directly to your blog or via FTP. If you’ve recently changed your blog theme via the website, click “Update Theme” to reload this into Open Live Writer. Use the “Advanced” section to alter your blog’s default character set or markup language [Image E].

» If you need to make more radical changes, select “Dashboard” to open your blog configuration page in the browser. You can also view the comments section via the “Manage Comments” button. Remember that not all features are supported by every blogging platform, so some options will be disabled. ⚙️

EDITING TIPS & TRICKS

The overall look and feel of Open Live Writer is very similar to that of popular word processors, such as Microsoft Word. If you need to edit an existing post for any reason, simply go to “File → Open Recent Post,” then choose your previous entry. Open Live Writer only supports editing posts that were originally created in the app itself.

Highlight any text, then you can choose a new font from the drop-down menu in the taskbar. The fonts available should match those on your blog platform.

For more advanced editing, click the “Insert” tab. From here, you can add tables, insert maps, and even embed videos. You can hugely boost your posts’ SEO ranking by using tags. To start doing this, first select a tag provider, such as “LiveJournal,” from the drop-down menu at the bottom of the screen. Once you’ve made your changes, return to the “Home” tab, then click the “Publish” button in the taskbar. Your post is re-uploaded automatically.

Synchronize Your Life With Wunderlist

YOU'LL NEED THIS

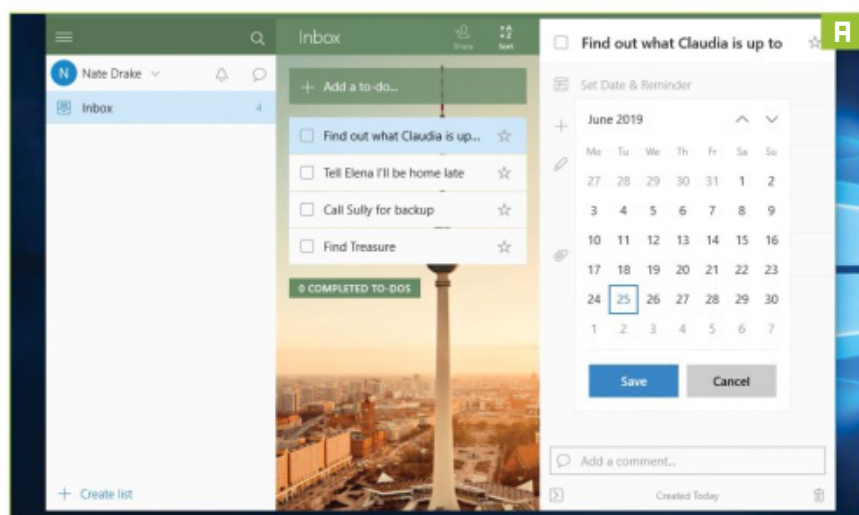
WUNDERLIST

Download the app from the Microsoft Store, or use the web-based version at www.wunderlist.com.

WHEN IT COMES TO MANAGING YOUR LIFE, Wunderlist offers a number of benefits over writing down everything you need to do on the back of an envelope. In the first place, when you sign up, you'll see that you can access Wunderlist via the dedicated desktop app or the website, so your to-do items are safely synched to the cloud. You can also have Wunderlist prompt you via push notification and/or email about important things you need to do.

If you're planning a major project, Wunderlist also supports dividing activities into subtasks and annotating them with your own notes. You can create as many lists as you want and even share them with friends and family for comments and completion.

There's a basic free version of Wunderlist, but for \$4.99 a month, you can upgrade to Pro. This enables you to assign an unlimited number of tasks to others, as well as create an infinite number of subtasks. This may be useful if you're planning a large undertaking, such as charity work or running a small business. Larger organizations can also benefit from Wunderlist—for \$4.99 a month per user, the Business version supports all the Pro features, plus centralized billing and team management. —NATE DRAKE



1 GETTING STARTED

Wunderlist is available on a variety of platforms; there is a web-based version (www.wunderlist.com), or you can download the app, which can be found in the Microsoft Store.

» To install Wunderlist, open the Microsoft Store, then type in "Wunderlist" and select "Get." Click "Launch"—on the first run, you need to sign in or create an account. If you don't want to use your Microsoft account, you can sign in via Gmail. Alternatively, access the web-based version of Wunderlist at (www.wunderlist.com). This guide focuses on the desktop application.

2 YOUR FIRST TO-DO LIST

Wunderlist displays your To-Do Inbox on the right. Tap "Add a To-Do" and input the name of the list you'd like to create. Once you've completed the details, press Enter to confirm. The item appears in your Inbox in the "To-Do" section. To rename an item, click it. A pop-up box appears. Click to highlight an item name to edit it. Press Enter to save changes.

» To mark a task as complete, click the checkbox beside it. The task is moved to "Completed To-Dos." Uncheck a completed task to restore it. To delete a task, right-click, and choose "Delete."

3 SET DUE DATES AND REMINDERS

Wunderlist supports both single and recurring reminders. The app can display notifications and/or send you an

email when an item is due. To set a reminder, right-click on a task, then scroll to "Due Today" or "Due Tomorrow." To set a different time, click a to-do item, then in the pop-up box that appears, select "Set Date & Reminder" [Image A]. For recurring tasks, click the arrow below the reminder's new due date. From here, you can choose "Never repeat," "Repeat every day," "Repeat every week," "Repeat every month," or "Repeat every year."

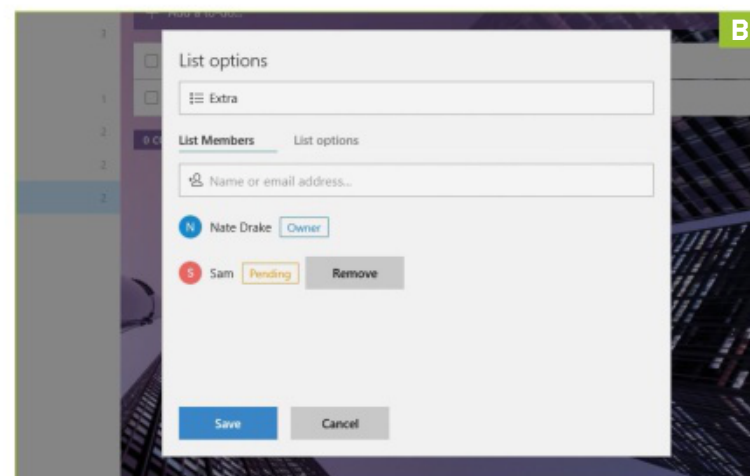
» To change notification settings, click your name on the left-hand side of the app, then click "Settings." Scroll to "Notifications." By default, both email and push notifications are enabled. Toggle the button next to each notification type to enable or disable.

4 SUBTASKS AND NOTES

Wunderlist enables you to add subtasks to each task you create. You can also add explanatory notes if you wish.

» Click the "To-do" list you want to edit. In the pop-up box, select "Add a Subtask." Type in the extra to-do item, then press Enter to create your subtask. You can add as many subtasks as you wish. Click the "x" beside a subtask to delete it.

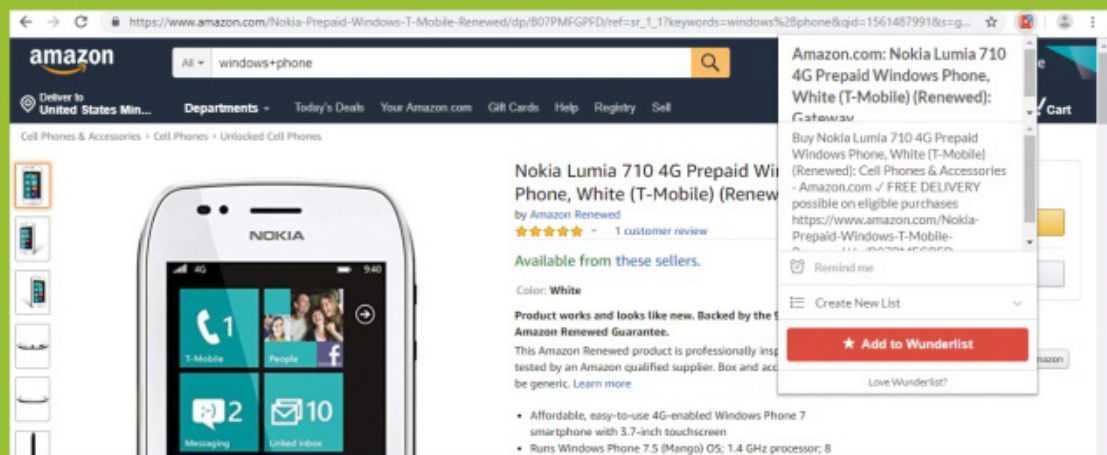
» To add a note to your task, click "Add Note" below the "Subtask" field. Write the note, then press Enter once you are done. This note is now added to your



BROWSER EXTENSION FOR CHROME

Google Chrome users can install the Wunderlist extension. This enables you to quickly bookmark items and save links to your Wunderlist account from sites such as Amazon, Gmail, and Outlook.com.

To add the extension, go to <https://chrome.google.com/webstore> and click “Add to Chrome.” Once installed, the Wunderlist icon appears to the right of your address bar. Click this, then log in to your Wunderlist account. Once this is done, click the Wunderlist extension icon again to automatically create a new to-do item from the current URL. Use the drop-down menu to choose which list you want to add the item



to. Alternatively, choose “Create New List” to begin a new list—“Christmas Shopping,” for example. The URL itself is stored in the “Notes” section for

each task. Click the link to launch it in your browser. At the time of writing, there were no extensions available for Microsoft Edge or Mozilla Firefox.

“To-Do” event. If you need to edit an existing note, you can do so by returning here.

5 SMART LISTS

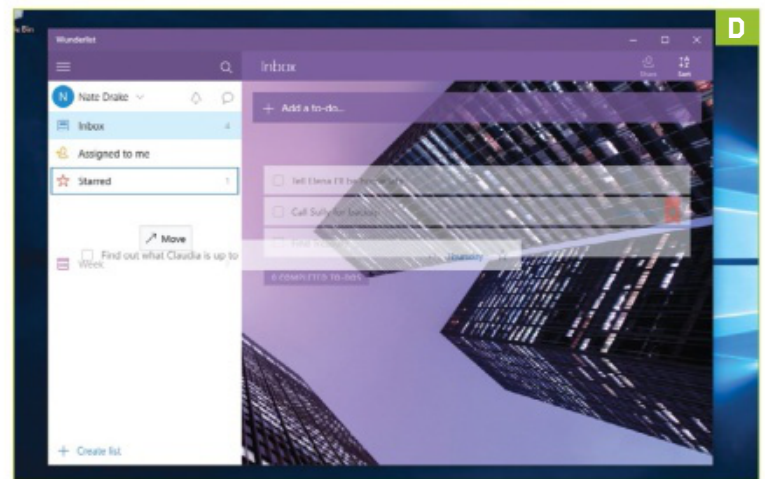
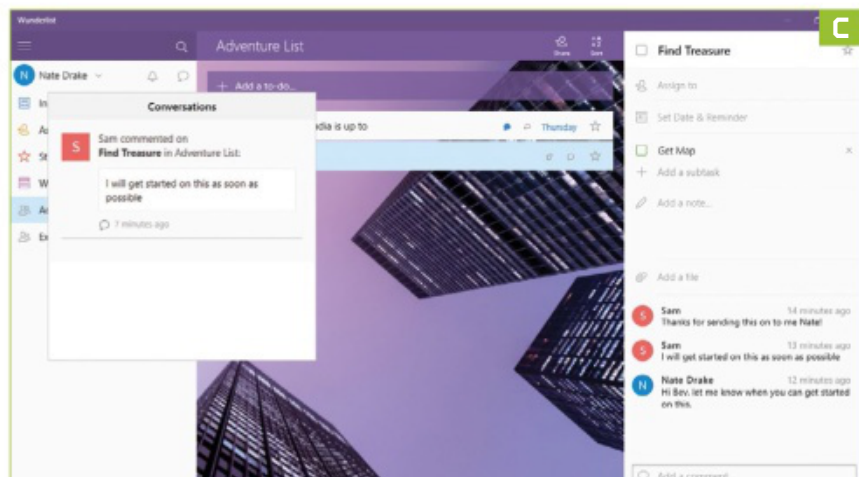
Smart Lists are a type of filter view, which group certain tasks together based on specific criteria. For example, all “Starred” to-do lists are grouped together, as are any tasks that have been assigned to you personally. Smart Lists appear at the top of the left-hand pane.

» To set up Smart Lists, go to your settings. From here, you can choose from “Auto,” “Visible,” and “Hidden.” “Auto” Smart Lists only appear if relevant. “Visible” smart lists always appear in the left-hand pane.

» You can choose which lists are displayed. By default, most options are set to “Auto.” The “All” section and “Week & Today Settings” are set to “Hidden” and “Show All To-Dos” respectively. You can switch between “Auto,” “Visible,” and “Hidden” for each option via the drop-down menu.

6 SHARING

You can add lists by clicking “Create List” at the bottom-left. These lists can be shared with friends, colleagues, and family members. To do this, select the list on the right-hand side. Choose the “Share” button. Enter your recipient’s name or email address in the pop-up box, then click “Save” [Image B]. An invite to view the list is then sent. While your recipient can see to-do items, they need a Wunderlist account to be able to edit them or mark them as complete.



7 ACTIVITIES CENTER

If you choose to share a list with a fellow Wunderlist user, you can collaborate on tasks together. Any tasks or subtasks completed by your contact appear in the Activity Center. Simply click the bell icon at the top-right of the screen to view notifications. Each time you open Wunderlist, a red number appears next to the Activity Center icon—this shows how many unread notifications you have.

» Click the “Conversations” on the left-hand side to view any comments made on tasks by collaborators [Image C]. Click a comment to view the entire conversation and add replies of your own.

8 OTHER FEATURES

If you have a large number of to-dos, Wunderlist supports organizing them into folders. Move your mouse over the to-do list you want to move, then drag and drop it into your chosen category in the left-hand pane—for example, “Assigned to Me.”

» You can add a task to the “Starred” list [Image D] by navigating to the “To-Do” in the inbox, and clicking the star icon beside the name of the task.

» If you would like to change the appearance of your app, first click your name, then select “Change Background.” From here, you can choose from a variety of images. Just click on your preference, and the background changes.

Design Your Own Celestial Bodies

YOU'LL NEED THIS

ADOBE PHOTOSHOP

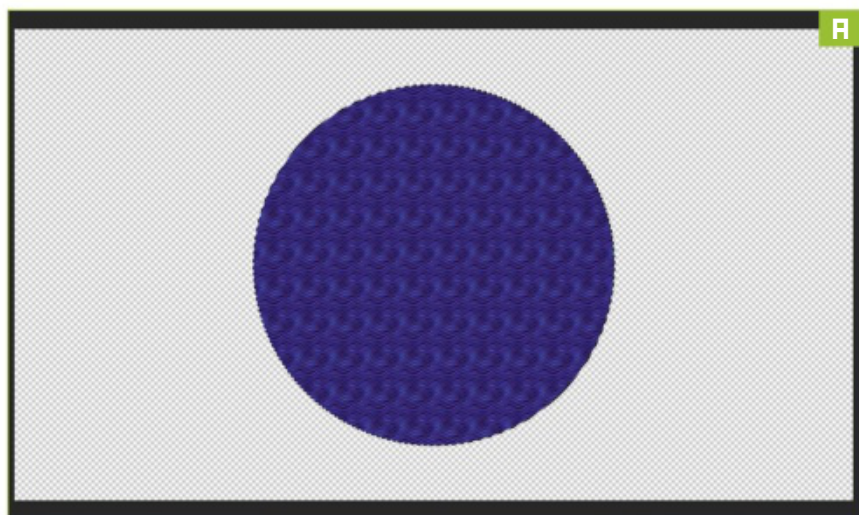
Subscribe to a suitable package at www.adobe.com.

THE FINAL FRONTIER IS NOT, as we'd previously supposed, a custom loop of hard-piped water cooling, but space itself. Until we can use miniature stable wormholes to employ the chilly temperatures of a hard vacuum to cool our CPUs (give it time, it'll happen), we have to resort to our imagination to conjure planetscapes around distant stars.

Photoshop is well placed for this kind of digital background painting, as it contains all the tools you need to create a reasonably lifelike solar system view. If you want to import your own textures, you can, but we've chosen to use the app's own features, and fix their shortcomings.

Good textures for a planet's surface can be anything from a rusty patch on the fender of a truck to a weatherbeaten sidewalk being forced apart by weeds. Anything can become a texture, and it will be especially challenging to find one if you want to have a network of cities visible on your planet.

If you're interested in rendering spaceships, this is the perfect sort of background to show off your creations. Otherwise, you can use it as a backdrop for text, or just as a relaxing screen wallpaper. —IAN EVENDEN

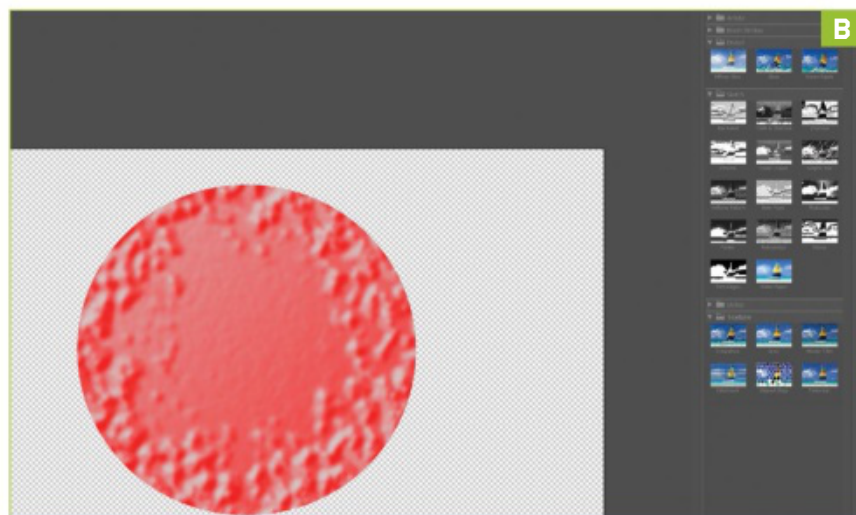


1 LET THERE BE LIGHT

Create a new document at an appropriate size—we've gone for 1920x1080 pixels—and create a new layer from the Layers palette, then delete the background layer, so you have a single, floating, transparent layer. For the first planet, use the Elliptical Marquee tool to create a circle (hold Shift) in the center of the canvas—use Smart Guides to find the center—and head to “Edit → Fill.” Click “Custom Pattern” and choose “Ant Farm” or “Water” (we've used the latter) [Image A]. The circle fills with your pattern, but it's repetitive and looks artificial—we'll deal with this later, but you could use a custom non-repeating texture image, drawing your circle on it, before cutting it to a new layer.

2 A VAULT BETWEEN THE WATERS

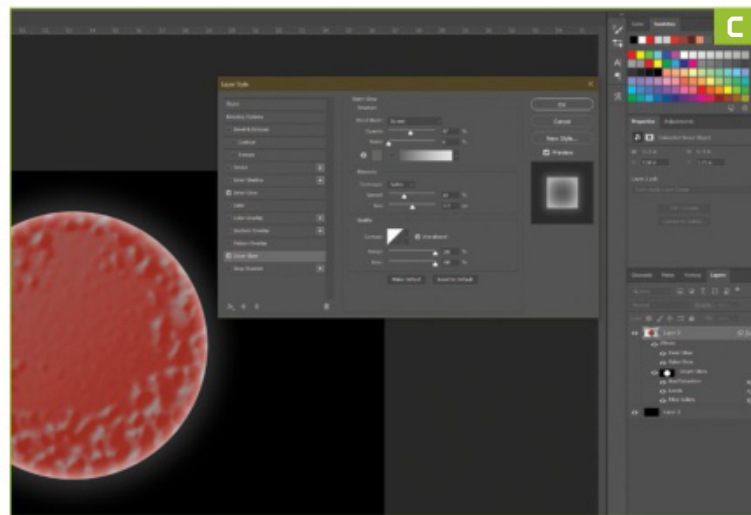
To break up the repetition, and to make the planet look more like a planet, use filters. It's worth converting the layer for Smart Filters (from the “Filter” menu) first—this allows you to come back and edit them later. Following this, and with the selection still in place, open “Filter → Filter Gallery.” We're going to build up three layers of filters, beginning with Stained Glass (from “Texture”). Add a new filter layer using the button at the bottom-right of the Filter Gallery, and add Diffuse Glow from “Distort.” Add a new layer and apply Bas Relief from “Sketch.” Play with the settings for all three until you've got something you're happy with. Ours looks like one of the moon's maria, and

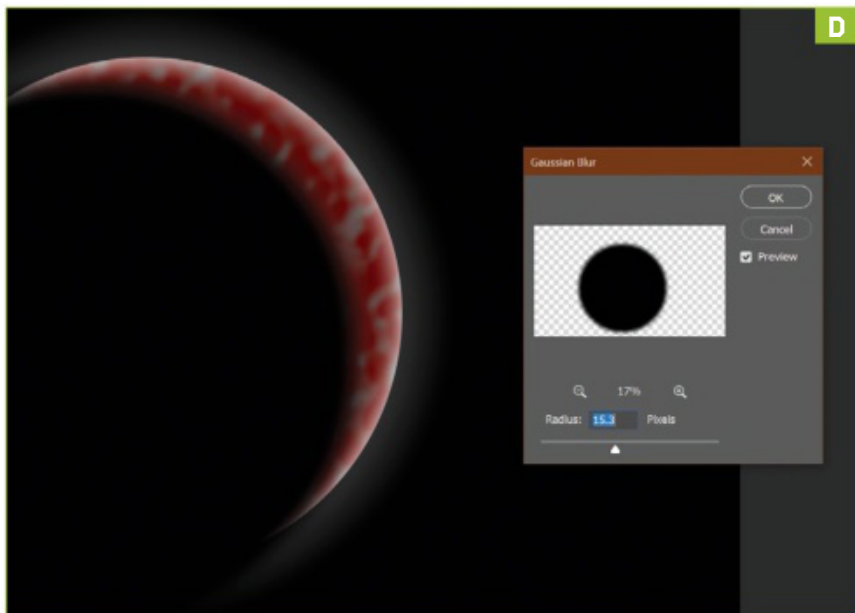


if we darken off the red color using “Levels” or “Hue/Saturation,” it'll look a bit like Pluto [Image B].

3 LET THE DRY LAND APPEAR

If your planet looks flat, use “Filter → Distort → Spherize” to give it some bulge—this is why the original circle had to be in the center, as Spherize works from the center out. When happy, create a new layer, fill it with black, and move it to the bottom of the layers stack. That's your howling void. Back on dry land, we're going





to add Layer Styles to our planet—double click its layer, and add Inner and Outer glows from the “Styles” window to give the impression of a diffuse atmosphere. Don’t make them white—we want them to transition from the darkness of space, so choose a mid-gray, and keep them soft and noise-free [Image C].

4 GIVE LIGHT UPON THE EARTH

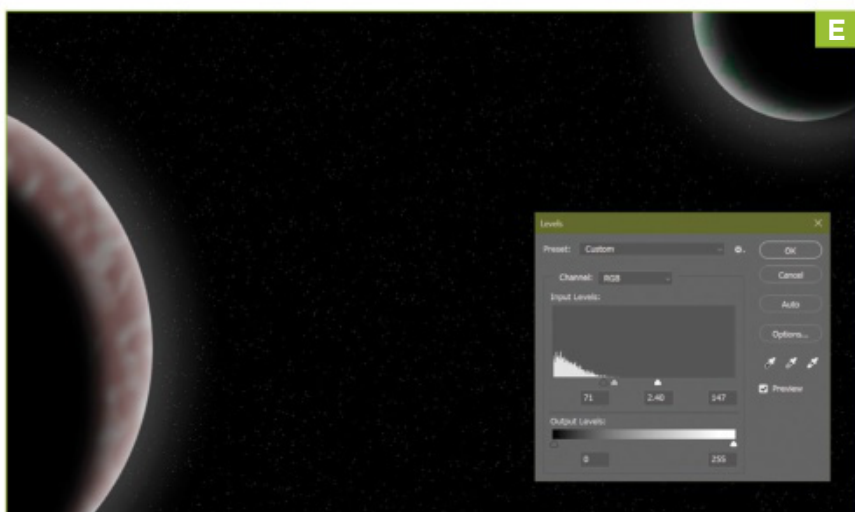
Or the red planet, anyway. The local star in this system is off to the top-right, so to create a planetary crescent, we can create a new layer, put it on top of the stack, and bring back the circular selection (“Select → Reselect”). On the new layer, fill the circle with black, then deselect, and use the Move tool to drag the circle to one side, revealing the planet. Use Gaussian Blur (“Filter → Blur”) on the layer to soften its edge (convert for Smart Filters if you want) and you get a nice crescent [Image D].

5 HE MADE THE STARS ALSO

To make a starry background, select the plain black layer at the bottom of the Layers palette, and use “Filter → Noise → Add Noise.” Use Levels on the layer to clip the black and white ends of the histogram—this reduces the number of dots, for a more realistic look [Image E]. It’ll still look wrong when the planet is in the center, so select the layers that make up the planet and shadow, and pull them to the bottom-left with the Move tool. Group these layers, and duplicate the group, and you have another planet to position and resize. Use Filter Gallery (editable as a Smart Filter) and Hue/Saturation to change its look, and Free Transform (“Edit” menu) to move and scale it.

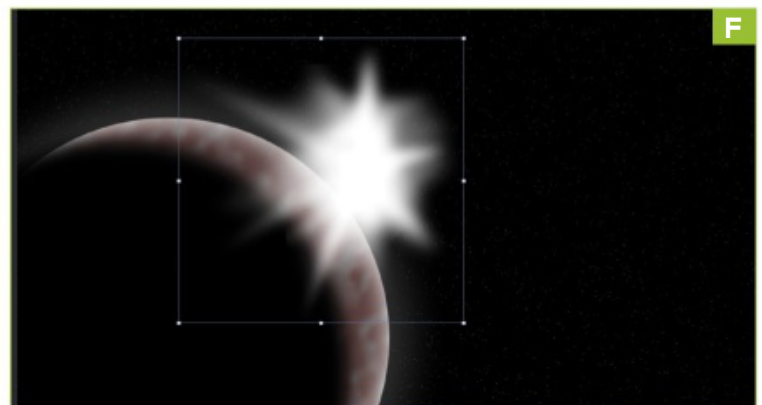
6 LET THERE BE MORE LIGHT

Finally, we’ll add a light source. Place a new layer at the top of the stack, and draw a rough star shape with



SMART OBJECTS AND FILTERS

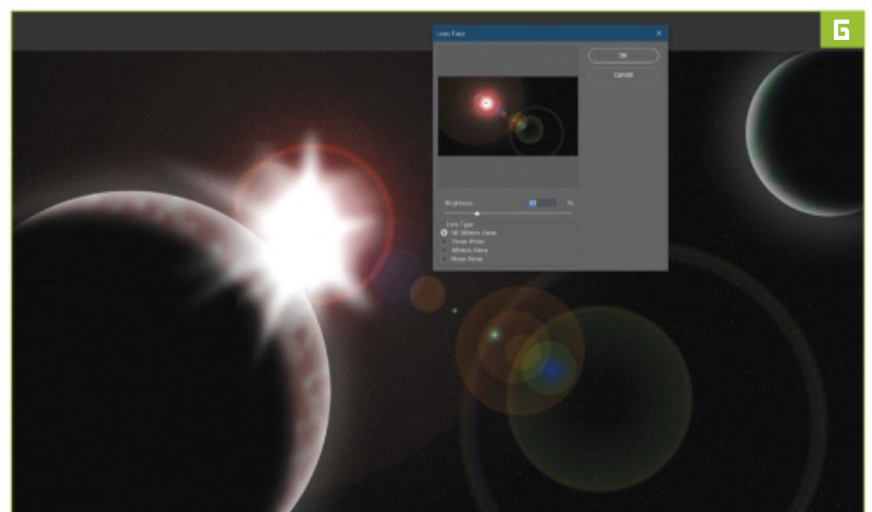
If you’re going to use your own textures, it’s worth loading them into Photoshop as Smart Objects rather than as straightforward raster layers, and making them in the highest resolution possible. A Smart Object provides a link to the source file, going back to it as a reference every time you manipulate it, so you can shrink it and enlarge it again without the loss of quality you’d usually associate with such a maneuver. Along with Smart Filters, this is one of Photoshop’s biggest steps toward non-destructive editing. A layer converted to use Smart Filters becomes a Smart Object in its own right, giving you the best of both worlds.



the Polygonal Lasso, filled with white. Deselect, and apply “Filter → Blur → Radial Blur” in Zoom mode and at 100% and Best quality. Then apply a Gaussian Blur. Duplicate the layer a few times (we did three), and use Free Transform on each to rotate it around until you have a bright-centered, diffuse light object rising above the large planet’s edge [Image F].

7 LET THERE BE LENS FLARE

If your space movie is directed by J.J. Abrams, it needs a little lens flare. Happily, Photoshop has a filter that can do that, in “Filter → Render.” If you try to use it on the layer containing your sun, however, you’re going to be disappointed. For a far better effect, use it on the black background layer with the noise on it. Run the filter, and see what different effects you can create in the tiny preview window. Our example is of the 50–300mm zoom type at around 85% brightness [Image G], but use whatever looks good. Now all the scene is waiting for is for you to place a 3D rendered spaceship in it. ⏻



Get Started With Google Drive

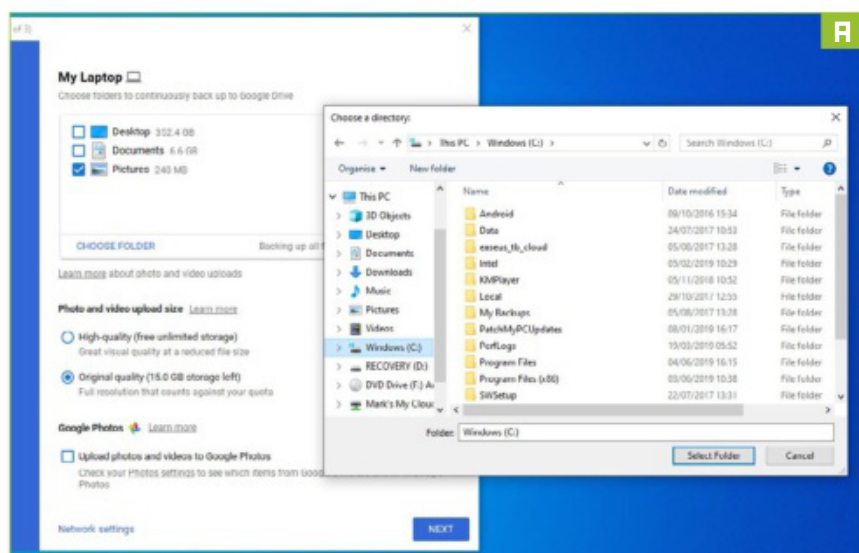
YOU'LL NEED THIS

GOOGLE ACCOUNT

If you don't have one, sign up at <https://drive.google.com>.

TALK OF "THE CLOUD" CAN BE CONFUSING if you're unfamiliar with the term, but it's really just a way of referring to storing files online. You may want to store a second copy of important files online to serve as a backup, for instance, or you may want to access your files from any computer connected to the Internet. Storing files in the cloud also makes them easier to share.

There are numerous cloud storage services to choose from, but perhaps the most well known is Google Drive. You can use it in a couple of ways, the first being to employ your web browser to explore, create, and edit files online. Perhaps more useful is to download the desktop software—called Backup and Sync—because this enables you to select a folder on your computer's hard drive that will be synchronized to Google Drive online, and you can sync with multiple computers, so the same files are available everywhere. —MARK WYCIŚLIK-WILSON



1 SIGN UP FOR AN ACCOUNT

Go to <https://drive.google.com>, and click "Go to Google Drive." If you already have a Google account, you can sign in and start using Google Drive, but if not, click the "Create account" link to get started. You're guided through the process of choosing a Gmail email address and securing it with a password.

2 DOWNLOAD BACKUP AND SYNC

When you are signed in to Google Drive, look to the lower-left of the page, and click the button labeled "Get Backup and Sync for Windows." You're taken to the download page, where you need to click the "Download" button in the "Personal" section. Save the file, then run through the installation. Launch the program, and you're invited to sign in to your Google account.

3 CONFIGURE BACKUP AND SYNC

Choose which folders you would like to synchronize between your computer and Google Drive. Backup and Sync automatically selects your Desktop, Documents, and Pictures folders, but you can deselect these. You can also add more folders with the "Choose Folder" button [Image A]. There's no limit to the number of folders you can sync, other than the amount of space available.

4 FILE AND PHOTO OPTIONS

By default, all files in your selected folders are backed up, but you can adjust this with the "Change" button. You can opt to only back up the image files in those folders, or click

"Advanced Settings" to specify file types to ignore. To avoid filling all your storage with photos and videos, you can opt to drop their quality to High, and you are given free, unlimited storage for them.

5 YOUR GOOGLE DRIVE FOLDER

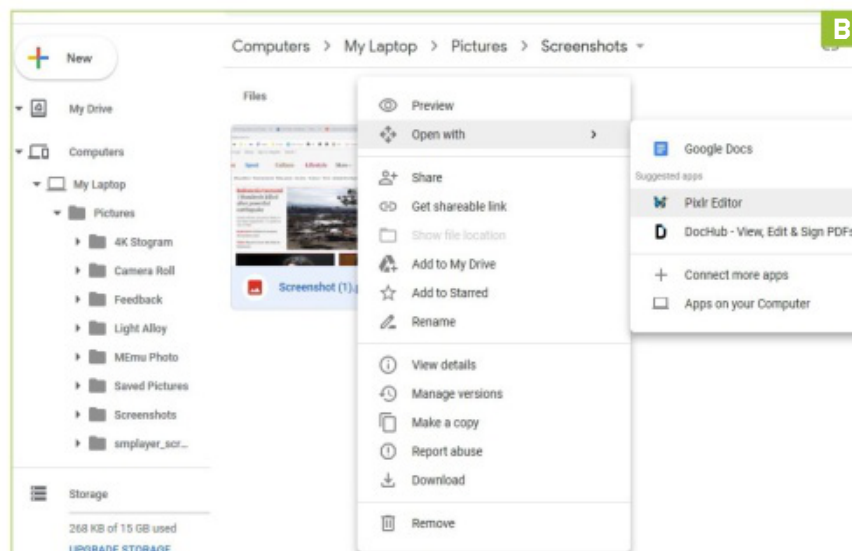
Click "Next," and you're prompted to choose a folder on your hard drive where Google Drive files should be stored. Any files and folders you add to this folder are automatically sent to Google Drive online, and any files you create online—or that are synchronized from other computers or devices, such as phones and tablets—are synchronized to this folder.

6 NAVIGATE FILES ONLINE

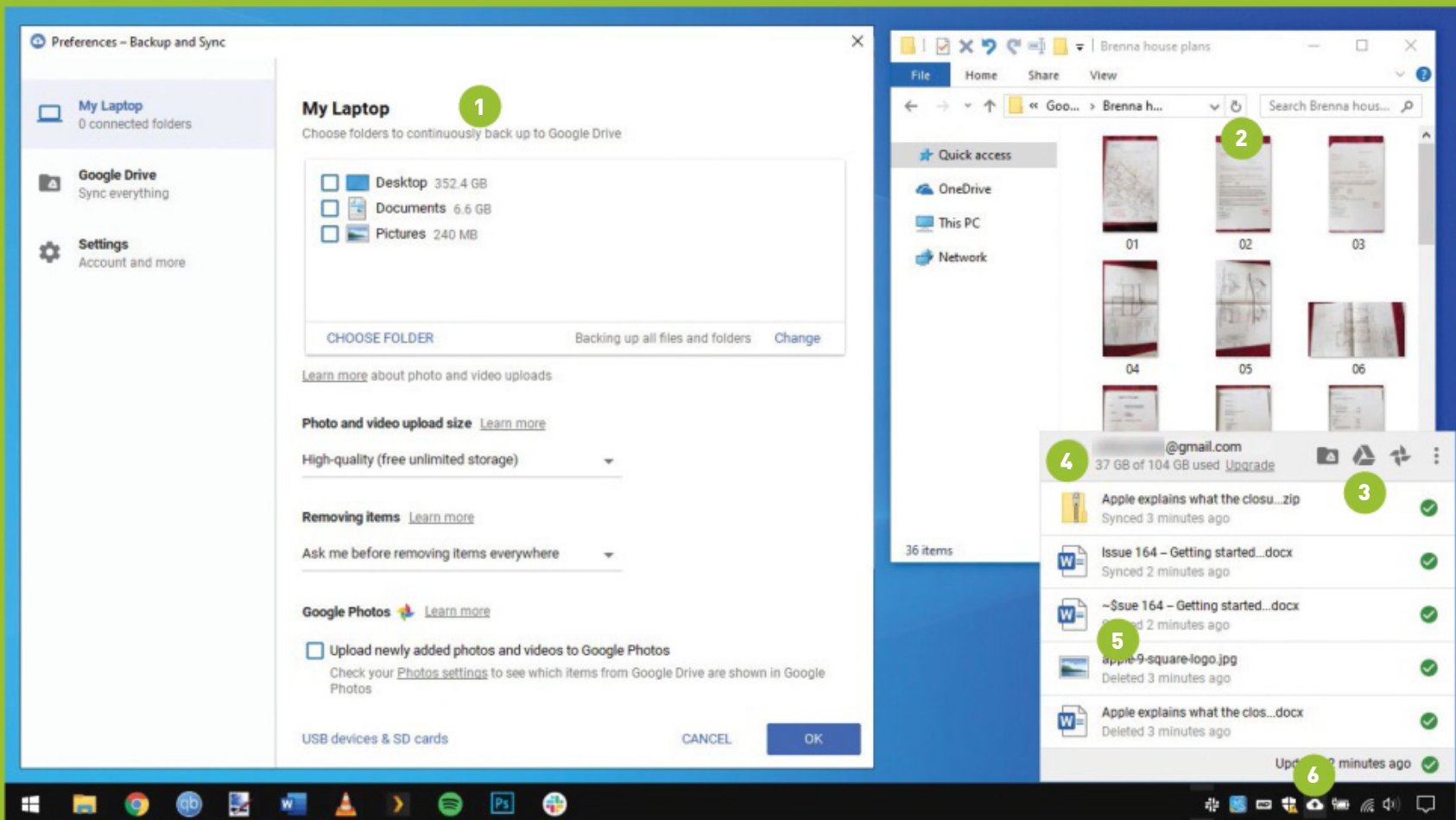
You can continue to create and edit files on your computer as normal, and any files you place in the Google Drive folder are then synchronized to the cloud. Many types of files can be viewed or even edited online. Visit Google Drive in a web browser, and you can navigate through your files. Double-click a file to open it, or right-click to choose an online app that can be used to edit the file [Image B].

7 SHARE FILES WITH OTHERS

One of the great things about Google Drive is that it enables you to easily share files with friends and family. On the Google Drive website, or on your computer,



DIVE INTO GOOGLE DRIVE



1. BACKUP AND SYNC SETTINGS

Configure which folders should be synchronized, or opt to back up your entire computer.

2. LOCAL GOOGLE DRIVE FOLDER

The contents of the folders you specify are synchronized between your PC and the cloud.

3. WEB SHORTCUTS

Shortcuts to the web-based version of Google Drive, as well as Google Photos and your local Drive folder.

4. AVAILABLE SPACE

There is a storage limit to which you need to stick. Here, you can see how much space you have used up.

5. SYNC UPDATES

Keep an eye on synchronization activity. How long files take to sync depends on size and connection speed.

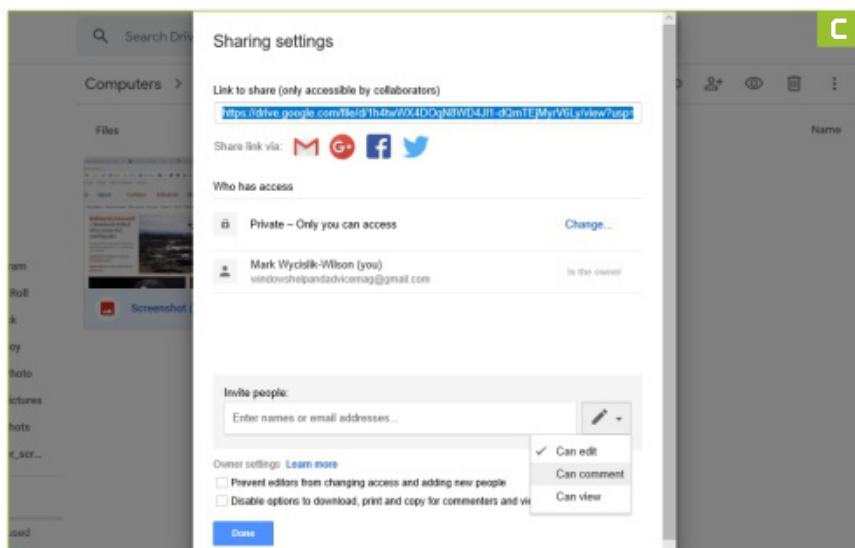
6. BACKUP AND SYNC

To synchronize files between your PC and Google Drive, you need to have this app running in the background.

you can right-click a file or folder, and select the “Share” option (in the “Google Drive” submenu on your computer) before entering someone’s email address. You can also add a note to be included in an email that is sent out.

8 ADVANCED SHARING OPTIONS

By default, people you share files with can edit them, but this can be changed. Having selected the “Share” option,



enter someone’s email address, then click the button to the right before deciding whether they should be able to view, edit, or comment on the file [Image C]. You can also click the “Advanced” link to see other options, such as making files publicly available.

9 EDIT FILES ONLINE

Google has a number of online tools to create and edit files—including a word processor and a spreadsheet. Thanks to these, you can edit files online without the need to download them and load them into specific programs. Despite being online apps, they are surprisingly feature-packed, and you should find that you are able to accomplish pretty much everything you would expect.

10 GET MORE STORAGE

You are given 15GB of space for free with Google Drive, but the time may come when you need more—and you need to pay for this. You can upgrade your storage by clicking the “Upgrade” link in Backup and Sync, or in Google Drive online. You can then select the amount of storage you want, and choose between paying on a monthly or annual basis.

BUILD IT

JONNI BIDWELL, CONTRIBUTING EDITOR



Home on the RAID

Build your own NAS box, with stuff you have lying around, and the magic of open source

LENGTH OF TIME: **2 HOURS**

LEVEL OF DIFFICULTY: **MEDIUM**

THE CONCEPT

OFF-THE-SHELF NAS units are easy to come by, but they're often underpowered, overpriced, or otherwise disappointing. Many of them run some kind of Linux (usually on quite modestly powered ARM hardware), and it's pretty straightforward to build a Linux box, and cram it with as many hard drives as geometry permits. You may even have enough spare parts lying around to get most of the way there (we did). You don't need anything special hardware-wise (4GB of RAM and a CPU sometime from the last decade is fine), but several large hard drives help. Many

consumer-level NAS devices come in attractive small form factors, and thanks to their low power consumption, don't require noisy cooling. So, we thought we'd try our hand at mimicking this.

If the prospect of using Linux makes you cringe, don't worry—we're going to use the fantastic OpenMediaVault, which (all going to plan) means you won't have to touch a command line, and everything can be controlled from a friendly web interface. Next-gen filesystems, RAID, and LVM don't need abstruse incantations (or sacrifices) at the terminal. Best of

all, OpenMediaVault can be customized and added to as much as you want. Read all about it at www.openmediavault.org. The Plex extension (available via the OMV-Extras.org repository) is particularly great, and will turn your NAS into a full-fledged DAAP media server. Beyond that, OMV can run Docker images, so you can host any popular Linux application you like, whether it's Nextcloud, Mastodon, BitTorrent, or anything else you care to name. OMV is also based on Debian Linux, so you can do pretty much whatever you'd do there with it.



REUSE AND RECYCLE

FRACTAL DESIGN was good enough to send us its Node 304 case for this build, which may be an aging model, but we were glamored by its teeny-weenyness. It's surprisingly difficult to find an ITX form factor case that can fit lots of hard drives in it; the Node 304 has room for six 3.5-inch drives, but is no bigger than two shoeboxes, so is ideal for hiding under the stairs. It's a little tricky to work with if you have a large heatsink, but it has excellent airflow, with two fans at the front and a large fan at the back. It's always tempting to opt for cheaper components, or even second-hand ones—and that's what we did, using an MSI-88X AC motherboard and an Athlon A10-7800K APU, circa 2014. Integrated graphics are certainly de rigueur here, because this device will probably run headless for most of its life. We used three 1TB Hitachi drives and a spare 240GB SSD for OMV. This is entirely overkill, because the initial installation is only around half a gigabyte, but we can use that space for something later. To get OMV installed, we used the cross-platform Etcher utility (<https://etcher.io>) to write the ISO to a USB stick. You can download said ISO from the OMV website. We got OMV to set our drives up as a RAID 5 array, having a total capacity of 2TB, and the ability to rebuild itself if any one of the drives fails. Power-wise, we used a Be Quiet! Pure Power 11, capable of delivering a totally unnecessary 650W. Again, we just used what was to hand, and so can you.

INGREDIENTS

PART		STREET PRICE
Case	Fractal Design Node 304	\$82
Motherboard	MSI A88XI AC	\$40 <i>(pre-owned)</i>
CPU	Athlon A10-7800K	\$50 <i>(pre-owned)</i>
CPU Cooler	Cooler Master Hyper 212 Black Edition	\$35
GPU	Integrated	\$0
Memory	2x 2GB Corsair XMS3	\$30 <i>(pre-owned)</i>
PSU	Be Quiet! 650W	\$100
Storage (OS)	Intel DC S3510 240GB	\$50 <i>(pre-owned)</i>
Storage (RAID)	3x Hitachi 1TB drives	\$105
OS	OpenMediaVault	\$0
Total		\$492

1

CASE IN POINT

THE FRACTAL DESIGN NODE 304 CASE is small, but perfectly formed. It takes a little bit of deft fingerwork in places, but if you don't use a crazy tall heatsink like us, there's actually plenty of room to work with. First, remove the thumbscrews and gently slide back the case's hood, before lifting it over the chassis and putting it somewhere out of harm's reach. Next, remove the white hard drive caddies, which are each secured with two thumbscrews and a top-facing regular screw. Before you proceed, look at how the SATA, fan, and ATX connectors are arranged on the motherboard, and think about how best to route cables. If you're going to use all three drive bays, think very hard about this, because it's difficult to envisage how little space will be left to accommodate anything once they're in place. Remove the 140mm fan from the rear of the case, otherwise getting the motherboard in will be tricky at best.



2

A TALL ORDER

WE OPTED TO FIT the CPU and heatsink before interring the motherboard in the case. This is usually the best way to do things, because it can be tricky accessing the heatsink mounting screws from outside. Unfortunately, the combination of large heatsink and small case made life a little sweary later on; the Node 304 can accommodate coolers up to 165mm high, and the Hyper 212 stands at about 160mm. You'll want to unclip the fan from the heatsink before fitting it, so that it doesn't obstruct access to the mounting screws. Depending on your CPU choice, a long screwdriver may be handy, because the mounting screws may end up pretty close to the (thoughtfully grooved) corners of the heatsink. Fitting it to the old FM2+ socket, in particular, required a little more force than we were comfortable with, but it's probably easier on newer CPU sockets. Reattach the fan, and don't forget to connect it to the motherboard.



3 POWER TRIP

ONCE AGAIN, this should be the correct order of proceedings, but it made life a little claustrophobic for us in the next step. Fit the PSU and screw it securely in place. The PSU's kettle connector is extended to the rear of the case with a well-designed right-angled cable that will lie alongside the motherboard. If your PSU's connector is close to its edge, though, this will be a bit of a tight fit. Don't be tempted to fit the PSU upside down to work around this—the resulting updraft of hot air into the case (actually aimed right at the hard drives) will properly mess up the airflow. The connector can handle being gently squished, and it may be worth connecting it before securing the PSU. Remove the central bar (or is it more of a beam?) that until recently held the drive trays in place. Fit the four motherboard standoffs in the corners, ready to support our tiny motherboard.



4 OF MEMORY AND MOBO

MEMORY IS THE EASIEST component to fry, so discharge any static you've accumulated by grounding yourself on a heating pipe (or use an antistatic strap connected to the case). Insert the RAM and ensure it's seated correctly. If your motherboard has a speaker, connect it now—its beeps may be useful if anything goes awry. Place the backplate over the mobo connectors and wrangle the motherboard into place. If your SATA data connectors are going to be hard to reach after the mobo is interred, connect those cables first. Ensure the backplate is fitted flush in the case, and screw the mobo in place. If you have a modular PSU, plug in the cables you need or discard the ones you don't. You'd run into space issues trying to fit a full-length graphics card and a modular PSU.



5 OUR MANY FANS

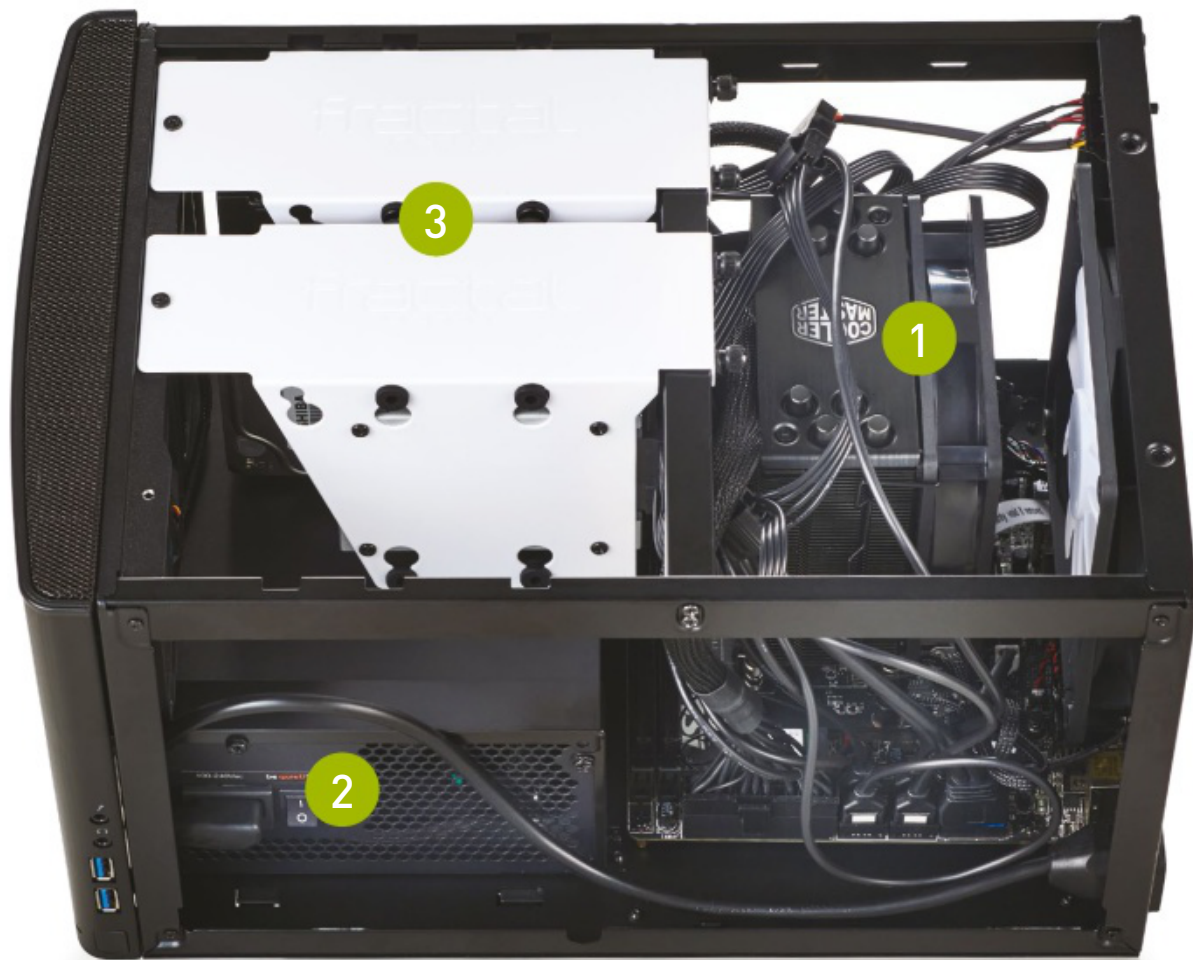
FIRSTLY ROUTE THE ATX POWER CABLE carefully alongside the heatsink and connect it to the motherboard. It looks like an alternate route is possible along the top of the PSU (beneath the front fans), but our cable was just too chunky, and didn't leave enough room to fit the drives atop it. Fit the case connectors (this can be tricky), and connect the CPU fan if you haven't already. Reattach the 140mm case fan, ensuring the orientation is correct, so it will vent hot air from the rear of the case. The two front fans connect to two of the three-pin connectors at the rear, and all connect to the PSU via the four-pin Molex connector at the back. There's a three-position switch on the case to govern fan speeds and balance temperature and noise. Make sure the cables don't interfere with any of the fans' ability to spin; secure them with the generously provided miniature cable ties if need be.



6 HARD DRIVIN'

EACH HANGING TRAY can hold two drives (2.5 or 3.5-inch). We only used two of the three trays (with our three hard drives and one SSD), which worked out pretty well, as it allows some extra breathing (or cable-stuffing) space. You'll need this space if you're fitting a long graphics card, too. It takes a bit of dexterity to fit a second 3.5-inch drive into each tray, but once you've got one screw in (use the large-headed ones for 3.5-inch drives), it's straightforward. Just be mindful not to bump drives into one another during installation. Once the trays are secured, put the lid back on the case, attach a monitor, cross your fingers, and power up your glorious NAS box. If it works, try to convince it to boot OpenMediaVault from a USB stick. The NAS should display its IP address once booted, at which point you can log in from your browser.





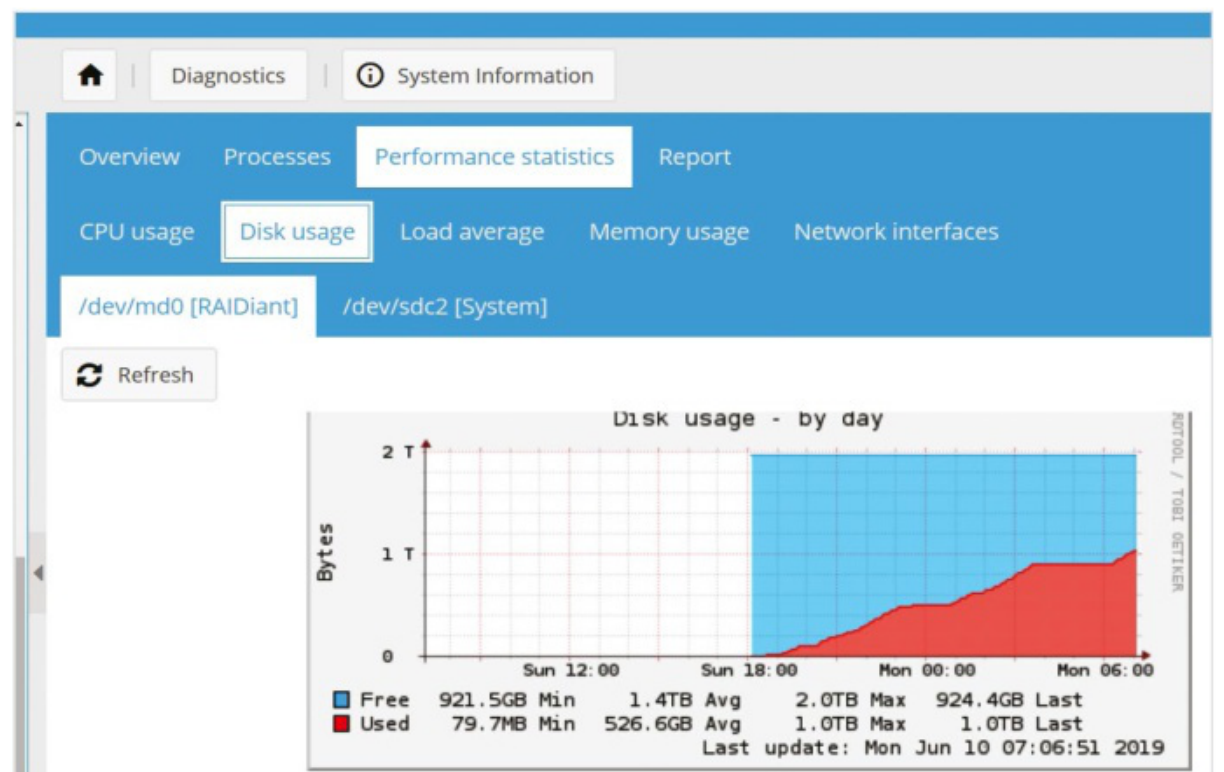
1 The Hyper 212 is one of the best budget coolers there is, and we liked that it just fitted into our case and no more. Just being a NAS doesn't require much of the CPU, so it shouldn't generate much heat. We never saw temperatures exceed 50 C, which was achieved while streaming hi-res movies with the Plex plugin.

2 Be Quiet! makes lovely PSUs, but 650W is far more than we needed—400W would probably have been fine. The fan ends up exhausting a little close to the ground, so carpeted floors are no friend of this machine.

3 Using old drives like this is a little risky, and consumer drives in general aren't meant for serious data storage. We just wanted the drives out of our main machine, and probably would survive if the data on them was lost. OMV can monitor SMART statistics, which can warn you about impending drive failure.

NAUGHTY BUT NAS

WELL, THAT WAS FUN. Except for the building part. Before you embark on such a project, consider this: Do you really need a case this small? Life is much easier when you have room to breathe. The final build was certainly messy, but perhaps with a differently arranged motherboard and PSU, it would be less of a plastic jungle. The fans in the Node 304 aren't the quietest creatures, but with them set on low, noise was tolerable, and idle temperatures stayed well below 40 C. Incidentally, if on first boot OMV tells you that it can't see the network (and the network cable is definitely plugged in), it's possible that DHCP negotiations just took a little too long. You can log in locally with the username "admin" and password "openmediavault" then type "ip a" (everything without quotes here) to see the correct IP. From then on, you can do anything you want by visiting that IP address in a browser, and using the slick web interface. As is customary with all things Linux, reading the relevant documentation is a good idea, but your first port of call should be "Storage → Disks" to wipe the drives (this is especially important if they have been involved in a RAID array before), and then create your RAID array. You have a few choices filesystem-wise—we went for traditional Ext4, but on a larger array, Btrfs might be a better idea. To be honest, we would wait for OMV 5.0 until you did that, because it will have much better support for the new filesystem's manifold bells and



whistles (in particular, its built-in RAID pooling and magical self-healing abilities).

It was a shame not to be able to fit the case with its full complement of six drives. Indeed, it's possible to run the OS from a USB stick, so we could have had a four-drive array (RAID 6 or 10), with two "hot" spare drives. That was all moot thanks to our motherboard's weak offering of just four SATA ports. RAID 5 is probably fine for our purposes, but on larger (or older) drives, the relentless reading that a rebuild (if the array fails) necessitates will probably kill another

drive as well as your redundancy. And by extension all your data. Oh yes—RAID is not backup, so back up your precious files. It left very little room behind the hard drives, and with the case full, there probably would have been airflow issues. Perhaps a modern CPU and smaller cooler (say a Ryzen 2200G with stock cooling) would be more suitable. It would also have been fun to use the experimental SnapRAID and MergerFS plugins (see June 2019 issue, pg. 17). But in the end, we were impressed with OMV, and pleased to make use of old hardware. ⏻

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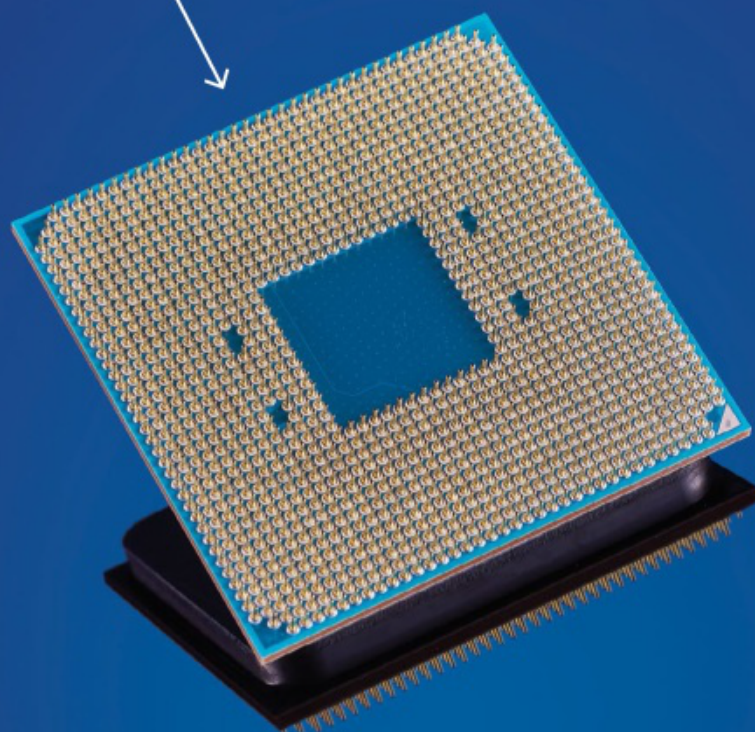
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AMD
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AMD Ryzen 9 3900X

AMD's third-gen Ryzen vies for the CPU throne

THE BUILD-UP to AMD's launch party for its Ryzen 3000 CPUs, aka third-gen Ryzen, aka Zen 2, has been huge. The Ryzen 3000 processors are the first mainstream CPUs to utilize a 7nm manufacturing process, and after flirting with the crown for the first two Ryzen generations, this could be the day AMD claims an outright victory. Will the Ryzen 9 3900X be the best CPU for gaming—and everything else? It's time to find out.

Zen 2 adds an improved L2 TAGE branch predictor, has a larger micro-op cache, doubles the maximum size of the L3 cache, and doubles the AVX floating point performance. There's also a third address generation unit, larger buffers, multiplication latency is reduced to three cycles, and there are wider buses to improve bandwidth. PCIe Gen 4 support is included, along with changes to the Infinity Fabric that links everything together, and there are improvements in memory compatibility. Wrap all of that up in a 7nm bow, then move the memory controller out of the main CPU chiplet and into a secondary IO chiplet, with the option to have dual CPU chiplets on higher-tier models. That's the Ryzen 3000 family, with the current king of the hill being the Ryzen 9 3900X: 24 threads spread out over two CPU chiplets. Whew!

So, how does third-gen Ryzen perform? That's the question we've been waiting to answer for several months. In particular, we want to see if AMD can truly close the gap. The good news is that gaming performance is improved by nearly 10

percent on average relative to the Ryzen 7 2700X. The bad news is that the Core i9-9900K is still about 10 percent faster overall. The other good news is that the difference in gaming performance between AMD and Intel CPUs really only matters at 1080p ultra with an RTX 2080 Ti—maybe you're aiming for 144fps and above. If you run a slightly slower GPU, even an RTX 2080 or 2070 Super, the gaming performance gap shrinks.

PICKING UP SPEED

That's not to say that Intel's CPUs aren't faster—they are. AMD loses in absolute gaming performance, again, but not by much. We wish that weren't the case, because even if AMD just tied Intel in gaming performance, it would make this a clean sweep. As it stands, the Zen 2 architecture improves performance compared to Zen+, but doesn't fully close the gaming performance gap.

The other side of the coin is non-gaming performance, and here AMD makes massive inroads against Intel. The Core i7-8700K was slower overall than the Ryzen 7 2700X last year, which is why Intel released the Core i9-9900K. That's an eight-core/16-thread CPU, and going up against the 12-core/24-thread Ryzen 9 3900X, it's not even close; AMD's 3900X is 21 percent faster than Intel's Core i9-9900K, at the same nominal price.

How much do those differences really matter? It depends on how you use your PC. 3D rendering and video encoding aren't things most people do on a regular

basis. The reality is that most non-enthusiasts and non-professionals likely wouldn't notice a difference between any of the Core i5/i7/i9 and Ryzen 5/7/9 products in day-to-day use. We have definitely hit a plateau in terms of what "typical" people ask of their PCs.

If you've been debating between an AMD or Intel rig for your next build, AMD is the better pick now. You can get excellent multithreaded performance, gaming performance is close enough that only benchmarks or extremely competitive gamers would likely notice (and then only with an extreme GPU, such as a 2080 Ti). Price and features are also in AMD's favor. You get PCIe Gen 4, a dedicated x4 PCIe connection for your primary M.2 SSD, more cores, even lower power use. What's more, you get all of that at equivalent or lower prices than you'd pay for Intel. If you're an enthusiast or professional, and your PC has a pre-Ryzen AMD or Intel seventh-gen or earlier CPU, now is a great time to upgrade to Ryzen 3000. —JARRED WALTON



AMD Ryzen 9 3900X

TO THE NINES Great multithreaded performance; PCIe Gen 4; comes with an excellent Wraith Prism cooler.

HARD TIMES Still beaten by Intel for high-end gaming; not much potential for overclocking.

\$500, www.amd.com

BENCHMARKS

	AMD Ryzen 9 3900X	Intel Core i9-9900K
Blender 2.80 Beta BMW (pps)	4,348	3,281
Cinebench R15 Single/Multi (Index)	203/ 3,086	221 /2,073
POV-Ray 3.7.1 Single/Multi (pps)	516/ 6,474	624 /5,477
Shadow of the Tomb Raider (fps)	128	150
Metro Exodus (fps)	91	95
Division 2 (fps)	145	152
Total War: Warhammer II (fps)	98	108

Best scores are in bold. Our test bed consists of an Asus ROG Crosshair VIII Hero Wi-Fi (X570) motherboard, 16GB of G.Skill TridentZ Royal DDR4-3600, an Nvidia GeForce RTX 2080 Ti, and a Gigabyte Aorus NVMe Gen 4 1TB SSD. All games are tested at their highest graphical profile, at 1080p.

SPECIFICATIONS

Base/Turbo Clock	3.8/4.6GHz
Cores/Threads	12/24
Lithography	7nm
Cache	64MB L3
Memory Support	128GB DDR4
Memory Channels	2
Max PCIe Lanes	16
Graphics	N/A
TDP	105W



The Zen 2 architecture is making great strides.



The grooved shroud with its curved section has resulted in more than a few "dented" jokes.

AMD Radeon RX 5700 XT

A compelling blend of 7nm technology, RDNA architecture updates, and a last-minute price drop

AFTER MONTHS OF WAITING and speculation, AMD's Radeon RX 5700 XT is finally here, joining the ranks of the best graphics cards. Sporting a new RDNA architecture that boosts performance while reducing power requirements, and with a price drop to keep AMD competitive with Nvidia's new RTX 2060 Super, expectations from the faithful have been high. This is AMD's first new GPU architecture since 2012, and the company has focused on improving efficiency, reworking the Compute Units to boost utilization and performance, and shifting to TSMC's 7nm process technology.

All three RX 5700 models use the same Navi 10 GPU, with the 5700 XT cards sporting fully enabled chips, while the RX 5700 disables four CUs and 256 cores. Clock speeds also vary, but the GDDR6 memory in all cases runs at 14Gb/s. The new Navi 10 GPUs end up with a die size slightly larger than the previous Polaris GPUs, with only a few extra CUs. However, each CU has been reworked with the new RDNA architecture, and the result is that even with fewer cores, the RX 5700 XT easily outperforms the Vega 64—and does so using substantially less power.

AMD says the new cooling is better than its previous-generation cards, but we're not fully convinced. It's not extremely loud, but that probably has more to do with the lower power requirements than any massive change in the cooling design. Idle noise and thermals tend to be about the same for most GPUs, but playing a game is a different matter. Compared to

the RTX 2060 Super, the RX 5700 XT runs just as quiet, but uses about 25W more power, and runs about 11 C hotter.

Just because pricing is the same on the RX 5700 XT and RTX 2060 Super, it doesn't mean performance, features, and API support are the same. AMD has opted not to support ray tracing here—there's no hardware-level RT acceleration and no Tensor processing clusters for AI and machine learning. Just as critically, even though it's possible to support DXR via drivers and shader calculations, AMD isn't doing that either (at least not yet). If you want an AMD GPU with hardware DXR support, you need to wait for Navi 20.

FAST VS. FEATURES

Performance is close enough that it shouldn't be the overriding factor when choosing between AMD and Nvidia. AMD is slightly faster and uses slightly more power, while Nvidia counters with features such as DXR support that AMD currently chooses to ignore. The RX 5700 XT easily handles 1080p ultra and even 1440p ultra. There may be individual games where settings will have to be dropped if you want a steady 60fps at 1440p, but in most games, the 5700 XT is hitting 60fps, and in some cases, even 100fps or more is viable.

There's plenty to like with AMD's new Navi GPUs and the RDNA architecture. Performance and efficiency are substantially improved relative to the previous-generation Vega and Polaris cards. Some of that is thanks to the

7nm manufacturing process, a good portion is thanks to the architectural improvements, and the reduced launch price is certainly a step in the right direction. The Navi GPUs have some features that could be worth exploring, including anti-lag, FidelityFX, and Radeon Image Sharpening (for games that don't directly include FidelityFX support).

The good news is that AMD is now competitive with Nvidia's lower-tier RTX cards, in both performance and pricing. It still can't touch the RTX 2080 and 2080 Ti, but it doesn't really need to right now. Some people might be willing to spend \$700 or \$1,200 on an extreme graphics card, but far more people will be interested in a \$350-\$400 high-end card. For those users, AMD's Radeon RX 5700 XT is a welcome addition. You may not get fancy ray-tracing support, but if you've been hoping for a new graphics card upgrade that doesn't require supporting Nvidia, this is currently the best AMD has to offer, and it's definitely worth considering. —JARRED WALTON

VERDICT



AMD Radeon RX 5700 XT

■ **NAVI** More efficient RDNA architecture; beats Vega 64

and 2060 Super; good performance at both 1080p and 1440p.

■ **UNOBTAINIUM** No ray-tracing support; higher temps and power than Nvidia; "dented" shroud looks weird.

\$400, www.amd.com

BENCHMARKS

	AMD Radeon RX 5700 XT	Nvidia GeForce RTX 2070
Tom Clancy's The Division 2 (Avg fps)	106/69	100/66
Assassin's Creed Odyssey (Avg fps)	69/54	66/56
Far Cry 5 (Avg fps)	127/103	125/93
Shadow of the Tomb Raider (Avg fps)	126/97	115/86
Middle Earth: Shadow of War (Avg fps)	107/69	108/77
Metro Exodus (Avg fps)	78/65	77/58
Total War: Warhammer II (Avg fps)	87/67	99/81

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB of G.Skill DDR4-3200, a Gigabyte Z370 Aorus Gaming 7, and a 1TB Samsung Evo M.2 SSD. All games are tested at their highest graphical profile with AA turned on, at 1080p and 1440p respectively.

SPECIFICATIONS

GPU	Navi 10
Lithography	7nm
Transistor Count	10.3 billion
CUDA Cores	2,560
Texture Units	160
ROPs	64
Core/Boost Clock	1,605/1,905MHz
Memory Capacity & Type	8GB GDDR6
Memory Speed	14GT/s
Memory Bus	256-bit

Nvidia GeForce RTX 2070 Super

A modest boost to performance

NINE MONTHS AFTER the RTX 2070 went on sale, yields have likely improved and Nvidia now has a reason to improve performance. The result is the RTX 2070 Super, moving up to the TU104 GPU with additional cores and performance. Silly branding aside (seriously, “Super” was the best name Nvidia could come up with?), there’s not much new to report. The GeForce RTX 2070 Super uses the same Turing architecture as the existing RTX cards, and the summary is that additional CUDA cores and higher clock speeds make it faster than the outgoing RTX 2070. Unlike the vanilla RTX 2060, which will remain on sale even though there’s an RTX 2060 Super, vanilla 2070 and 2080 cards are being phased out.

The 2060 Super has the advantage of being able to add more memory and thus increase bandwidth relative to the vanilla 2060. The RTX 2070 already uses a fully enabled TU106 chip, so Nvidia needs to look elsewhere if it’s going to improve performance by adding more cores. And “elsewhere” means moving to the larger TU104 chip that’s also in the RTX 2080.

The RTX 2070 Super’s reference boost clock is 1,770MHz, which is higher than even the overclocked 2070 Founders Edition boost clock of 1,710MHz. Since the 2070 Super has the same memory bandwidth and configuration, in practice the performance improvement ends up being around 10–15 percent.

The good news is that any added performance relative to the RTX 2070

comes without an accompanying increase in price. Even the 2070 Super Founders Edition sticks with a base price of \$499. Of course, RTX 2070 cards have gone on sale for as little as \$450 over the past nine months, but we’ll probably see the Super cards sell for less than the launch price at some point.

Performance is pretty much as expected. The 2070 Super is 6 percent faster than the 2070 FE at 1080p medium, but many games are hitting CPU bottlenecks. Only the most demanding games can’t reach 144fps average frame rates. 1080p ultra drops performance by about a third on average compared to 1080p medium, but the RTX 2070 Super remains comfortably above 60fps. Compared to the 2070 FE, it’s now 8 percent faster overall, which would make it about 15 percent faster than a reference clocked RTX 2070. It continues to perform well at 1440p ultra. Finally, at 4K ultra, the performance advantage over the 2070 FE increases to 10 percent.

Not surprisingly, keeping frame rates above 60fps at 4K ultra proves very difficult—not even the Titan RTX and RTX 2080 Ti can manage that feat in some games. If you’re serious about gaming at 4K, you’ll also want to plan on running high or even medium settings in some games if you want smooth performance. There’s nothing too surprising about the RTX 2070 Super. Enable a few more cores, increase clock speeds, and you get improved performance. It’s also

only 5–10 percent slower than the RTX 2080 (although the 2080 Super will change that).

In terms of value, the 2070 Super is a great option for people looking to build a high-end gaming PC. For those who haven’t felt the need to upgrade to one of Nvidia’s RTX cards already, though, we don’t think the 2070 Super is going to change things. The bigger issue is the future adoption of ray tracing by games and game engines. Maybe you don’t think you’ll ever want to play a game with DXR ray-tracing effects enabled, but at least you have that option with an Nvidia GPU. We’re likely still years away from widespread ray-tracing use within games, but the number of upcoming titles that support Nvidia’s RTX cards keeps growing. If you can keep using your current card a while longer, that’s almost always better than plunking down a wad of cash on a graphics card upgrade. And when the time comes to move on, there will inevitably be something better, faster, or cheaper. —JARRED WALTON

VERDICT



Nvidia GeForce RTX 2070 Super

✓ SUPER Close to a 2080 for less money; no more Founders Edition premium; same Turing features.

✗ POOPER Only slightly faster than an RTX 2070; nothing new to see here; Nvidia still needs a killer RTX game.

\$500, www.nvidia.com

BENCHMARKS

	Nvidia GeForce RTX 2070 Super	Nvidia GeForce RTX 2070
Tom Clancy’s The Division 2 (Avg fps)	117/78	100/66
Assassin’s Creed Odyssey (Avg fps)	69/57	66/56
Far Cry 5 (Avg fps)	131/103	125/93
Shadow of the Tomb Raider (Avg fps)	127/93	115/86
Middle Earth: Shadow of War (Avg fps)	114/83	108/77
Metro Exodus (Avg fps)	88/67	77/58
Total War: Warhammer II (Avg fps)	101/83	99/81

Best scores are in bold. Our test bed consists of an Intel Core i7-8700K, 16GB of G.Skill DDR4-3200, a Gigabyte Z370 Aorus Gaming 7, and a 1TB Samsung Evo M.2 SSD. All games are tested at their highest graphical profile with AA turned on, at 1080p and 1440p respectively.

SPECIFICATIONS

GPU	Turing TU104
Lithography	TSMC 12nm FinFET
Transistor Count	13.6 billion
CUDA Cores	2,560
Texture Units	160
ROPs	64
Core/Boost Clock	1,605/1,770MHz
Memory Capacity & Type	8GB GDDR6
Memory Speed	14GT/s
Memory Bus	256-bit

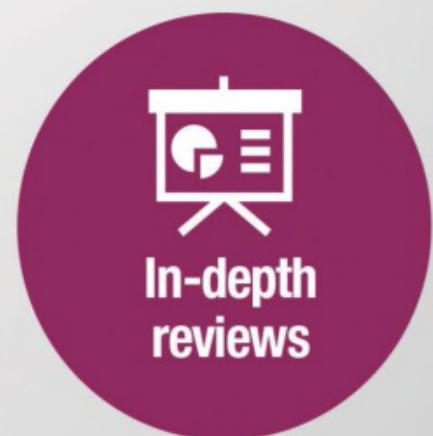
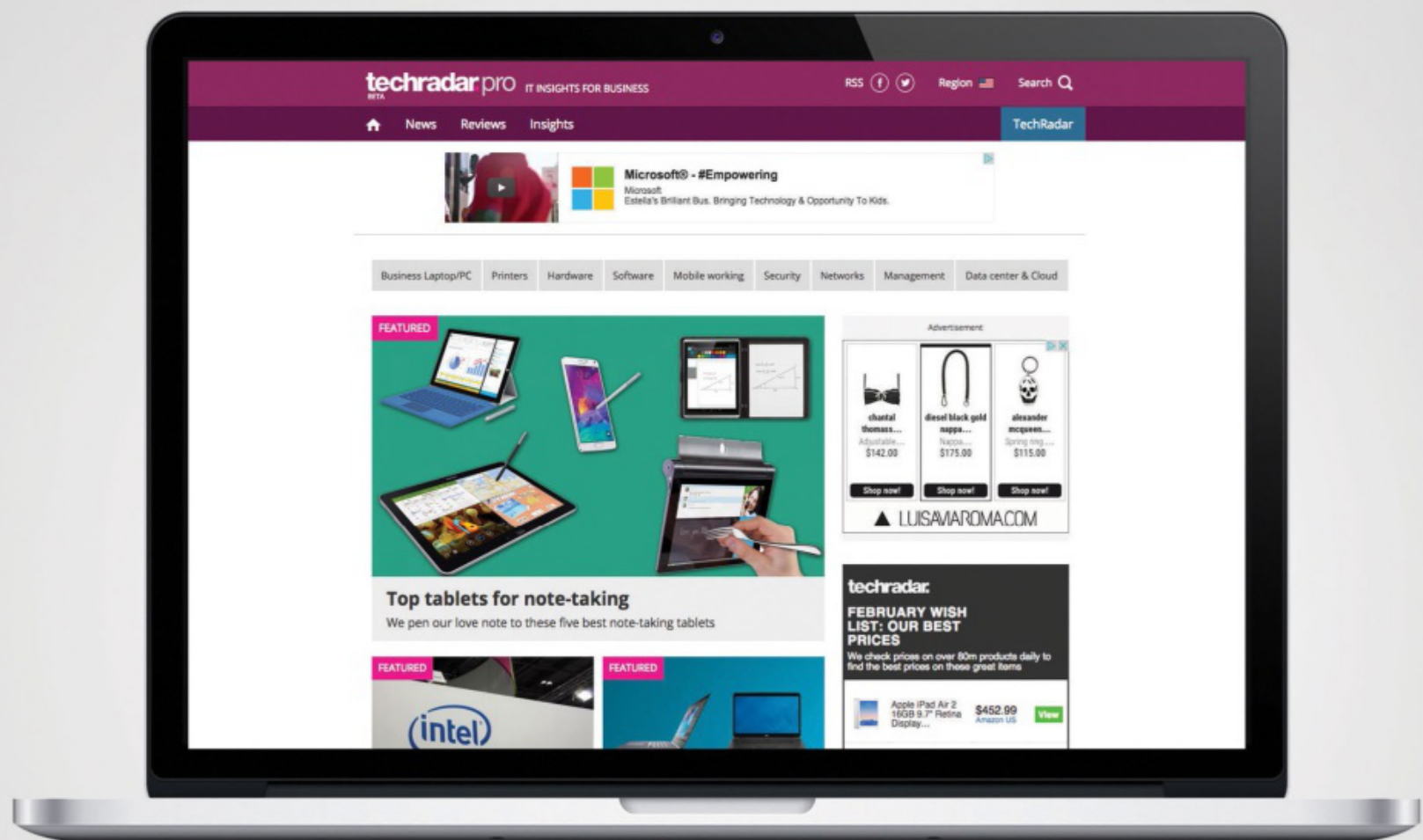


RTX 2070 *SUPER*

There's no Founders
Edition premium
here—you can buy
this card direct
from Nvidia.

techradar.pro

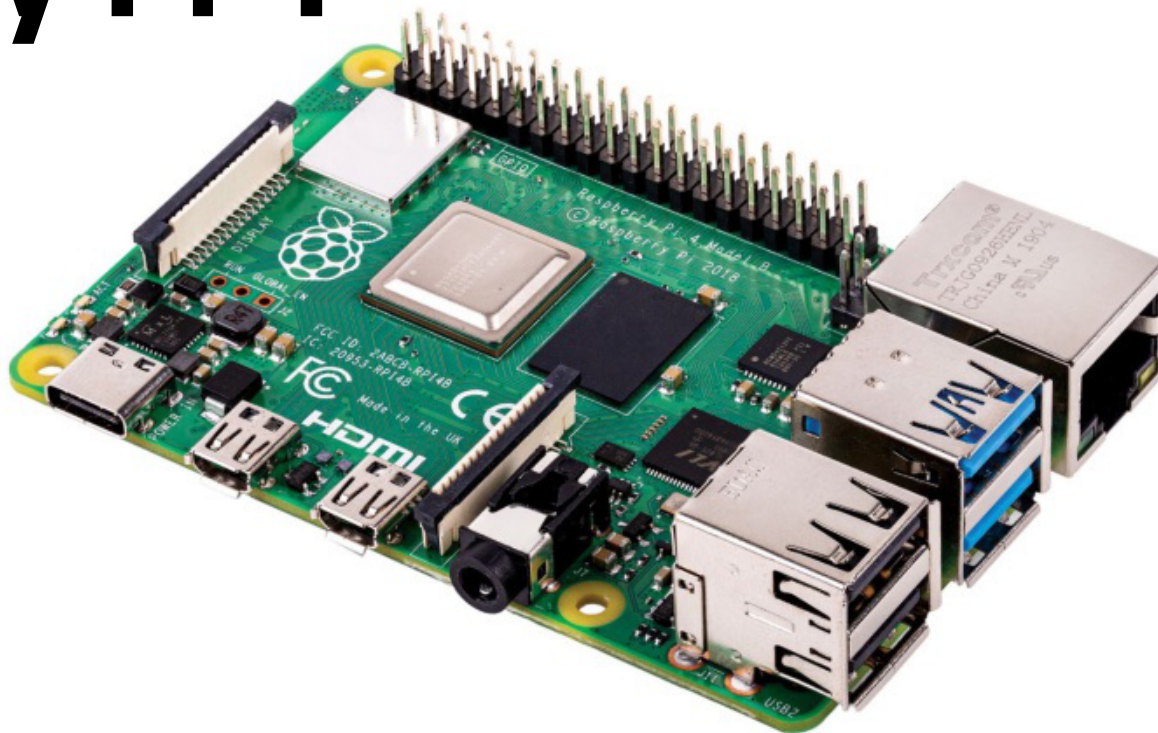
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Raspberry Pi 4 Model B

Everyone's favorite tiny computer is back—and it's better than ever



THIS ISN'T SOMETHING that we'd normally review. It's not a component, nor a game, nor is it a full-fledged multi-thousand-dollar gaming rig. But it's undeniable that the Raspberry Pi has only been improving in recent years, getting ever closer to becoming a proper desktop computer in its own right. The Pi 4 Model B is the newest iteration in the Raspberry Pi saga, taking the product from a basic programming education tool to a genuinely brilliant little PC.

All the software remains backward compatible, as does the shape of the little board itself; the Pi 4 can be easily dropped into any existing projects you might have if you're a Pi fanatic. The hardware also represents a significant step up. The processor is a 1.5GHz quad-core Cortex-A72 from Broadcom, an upgrade from the 1.4GHz A53 chip in the Pi 3 B+, while graphics are handled by VideoCore VI, as opposed to VideoCore IV. This enables the Pi 4 to support 4K resolution at 60Hz, or at lower refresh rates across two monitors at once.

The biggest step up is the RAM: While the Pi 3 B+ offered 1GB of LPDDR2, the Pi 4 comes in 1GB, 2GB, and 4GB models, all in low-power DDR4. We've got the 4GB version in for review, which costs \$55, but if you're looking for a more budget version, the 1GB will only set you back \$35. This version of the Pi is more capable than previous models—not quite able to fully replace a desktop, but expanding significantly on the possibilities presented by previous models. The 40-pin GPIO header from the Raspberry Pi 3 returns, too, ready for expansion and building purposes.

If you want to get going straight away, there's also a "desktop kit" available for \$120. This comes packing a 4GB Pi 4 Model B with Raspbian Buster pre-installed on a 16GB microSD card, two

1m Micro HDMI to HDMI cables, a USB-C power supply, a hefty printed beginner's guide, and a little plastic case for containing your Pi. It also comes with a wired keyboard and mouse in the quaint white and pink colors of the Pi. They're well-branded enough that our editor mistook the Pi case itself for the mouse during testing, briefly perplexed as to why the cursor wasn't moving.

PORT-ENTOUS

With full Gigabit Ethernet, onboard Bluetooth 5.0, and two ports supporting USB 3.0, the physical device itself is better than ever. Video is delivered via two Micro HDMI ports, and there's a USB-C port for power supply. Unfortunately, a hardware design flaw means that some smart charge cables will identify the Pi 4 as an audio device, and fail to supply power. While this is likely to be fixed at some point, it's something to bear in mind if you're looking to purchase a Pi 4 soon (or buy the \$8 power cable at the same time).

The teething problems don't end there, either. Raspbian Buster, the OS for Pi devices, has been updated for Pi 4, and while the OS itself functions as expected, there are numerous pieces of software that currently refuse to work properly. Some Python libraries are incompatible with the new version of the OS, while programs such as the popular RetroPie fail to run at all. These are problems that will be fixed in the not too distant future, though. RetroPie's developers have already stated that they are working on a new version of the software for Pi 4, and the Raspberry Pi Foundation itself

is committed to continual updating and improvement of the OS. As such, we won't hold it against the Pi 4 for now. Any new product is likely to encounter some post-launch software issues, and we can expect them to be ironed out in time. With that in mind, we feel pretty happy giving the Pi 4 a kick-ass rating; it's the best the Raspberry Pi has ever been, and we can't wait to see what crazy things people do with it. —CHRISTIAN GUYTON

VERDICT
9
KICK ASS!

Raspberry Pi 4 Model B 4GB

- ▣ **LIFE OF PI** Huge hardware improvements; 4K and dual-monitor support; USB 3.0 ports.
- ▣ **BLOWING RASPBERRIES** USB-C power supply issues; struggles with high-res video playback.

\$55, www.raspberrypi.org

SPECIFICATIONS

Processor	Broadcom BCM2711 Cortex-A72
Graphics	VideoCore VI with OpenGL ES 1.1, 2.0, 3.0
Memory	4GB LPDDR4
Ports	2x USB 3.0, 2x USB 2.0, 2x Micro HDMI, 1x Ethernet, 1x 3.5mm AVI, 1x MIPI DSI, 1x MIPI CSI
Connectivity	Bluetooth 5.0, dual-band 802.11 Wi-Fi
Power Requirements	3A, 5V
Dimensions	3.4 x 2.2 inches
Weight	0.1lb



Acer's new 27-inch 4K gaming panel ditches full-array local dimming, but it's still pricey.

Acer Predator XB3

Acer makes 4K, HDR, and 144Hz IPS goodness a tiny bit cheaper

FOR PROOF THAT the gaming monitor market is in total overdrive, look no further than the new Acer Predator XB3. It looks like a high-end precision panel for content product pros, with its sober suit and three-sided glare-reduction hood. But no, this is a full-on gaming panel, and just one of three such monitors Acer now sells in the 4K 27-inch segment.

The XB3 represents the tweener in the trio, above the Nitro XV3 and below the Predator X27. All three offer ostensibly the same proposition: a 27-inch 4K IPS panel with 144Hz refresh and adaptive sync. But drill down into the details, and you'll discover why the XV3 is yours for \$899, the X27 goes for around \$1,650, and this XB3 model lands at \$1,299.

Compared to the megabucks X27, the big downgrade with the XB3 is hinted at by the HDR400 spec versus the X27's HDR1000. The numbers imply a big gap in outright brightness—400 nits for the XB3 and 1,000 nits for the X27. But arguably the really significant difference is the XB3's lack of full-array local dimming. The X27 has a 384-zone backlight, a feature that's complex and expensive. The new XB3 has a big, dumb, conventional backlight.

In practice, however, local dimming is overhyped. At least, early iterations have proved underwhelming. Moreover, local dimming tech, and HDR support in general, is only relevant for HDR content. Granted, there are at least 60-plus PC games that support HDR, including everything from *Fortnite* to *Far Cry 5*, *Forza*, and *Final Fantasy XV*, but HDR is far from ubiquitous. For the record, the XB3's main advantage over the cheaper XV3 is full-spec Nvidia G-Sync rather than AMD FreeSync adaptive refresh tech.

Anywho, fire the XB3 up in SDR mode, and it's pretty much a dead ringer for the X27. So, the immediate impression is of plenty of pop and highly saturated colors, plus the tight pixel pitch that comes with a 3840x2160 native resolution on a relatively compact 27-inch panel.

The default factory calibration is a little wonky, with notable compression at the top end of the white scale, but that's easily dialed out, and the OSD menu is nothing if not comprehensive.

The 144Hz experience is as sweet as ever, even if you need one heck of a GPU to

make the most of it. Subjectively, there's zero input lag, and the pixel response in the lower range of the overdrive options is quick enough, and doesn't introduce any inverse ghosting nasties.

It's a damn fine gaming experience. If we have reservations, it's the scale of the proposition. At this money, you have a lot of options, many of them bigger and bolder. Ultimately, it's a question of preference. If you like the wraparound feel of a big, curved ultrawide monitor, this conventional 27-incher with a flat 16:9 panel could seem dowdy. But go bigger and wider, and you lose sharpness, detail, and precision. Until 8K gaming at 120Hz-plus becomes realistic, you're going to have to make a compromise somewhere.

What else? The all-plastic chassis looks and feels cheap, plasticky, and anonymous, especially at this price. The bar of configurable "mood" LEDs along the bottom of the lower bezel don't help much with that. The antiglare hood is a dubious accessory, too. On the plus side, it's easy to fit, but it doesn't do a great deal to reduce glare or improve aesthetics. The lack of USB-C is a downer for laptop-based gamers, too. —JEREMY LAIRD

VERDICT

8

Acer Predator XB3

GAME CHANGER Fabulous 4K IPS panel; superb combo of speed and precision.

GAME OVER Small for price; not true HDR.

\$1,299, www.acer.com

SPECIFICATIONS

Panel Size	27-inch
Native Resolution	3840x2160
Pixel Density	163 ppi
Panel Type	IPS
Maximum Refresh	144Hz
Response	4ms
Contrast	1,000:1
Display Inputs	DisplayPort, HDMI
Connectivity	USB-A hub
VESA Mount	100 x 100mm
Warranty	Three years



Get set for gaming on the go with the Triton 500.

Acer Predator Triton 500

Ready to go on the hunt...

ONE OF THE FIRST things we did upon unboxing Acer's newest gaming laptop was fire up the included software, PredatorSense (which, for some reason, has its own dedicated button on the keyboard). Like many programs of its type, PredatorSense collates a suite of tools useful to gamers: fan controls, automatic overclocking functions, temperature and voltage monitors, and so on. The first feature to catch our eye was the fan boost function, so of course we merrily clicked the "Max Speed" button. Oh, there it goes—the Triton 500 has launched itself out of the window, propelled by its almighty GPU fans.

So yes, it can be a bit loud. But that's only if you're really stressing the hardware. For day-to-day operation, we found that this laptop is actually fairly quiet—impressive, given that our review unit comes packing a GeForce RTX 2060 Max-Q and 16GB of dual-channel RAM. An RTX 2080 Max-Q version with twice the memory is also available, but at an appropriately steeper price. The model we've got is still a capable gaming machine, Nvidia's Max-Q design only clocking in slightly below the desktop variant of the RTX 2060, while implementing superior thermal design and improved efficiency. For storage, it's fitted with a 512GB M.2 drive, guaranteeing speedy load times in games. The eighth-gen Core i7 processor in this machine is nothing out of the ordinary, but it gets the job done.

In terms of physical design, the Triton 500 is easy on the eye. Acer's Predator brand logo illuminates on the rear of the

screen, while the backlit keyboard can be customized with an assortment of multicolored effects. In case you were in any doubt that this was a gaming laptop, the WASD and arrow keys are constructed from translucent blue plastic, as opposed to the clean white of the other keys. There's a huge amount of ventilation—on the sides, base, rear, and just above the keyboard—so while it might run loud, those fans are working hard to dissipate heat. On the whole, this laptop is well put together; it feels sturdy, but it's lighter and thinner than many of its ilk.

SCREEN TEST

The screen is undeniably a delight. It's a 1080p, 15.6-inch display, not the biggest we've seen, but comfortable enough for gaming on the go. Acer is quite proud to tout the 81.3 percent screen-to-body ratio, although the more impressive feature is the 144Hz refresh rate with 3ms Overdrive response time—perfect for fast-paced gaming. In practice, the screen is clear and sharp, showing both shadows and vibrant colors well. If the display isn't to your liking, though, there's support for up to three additional monitors via HDMI, Mini DisplayPort, and Thunderbolt 3 connections.

The included automatic overclocking functions in the PredatorSense menu do make a difference to performance, but it's fairly minimal. Running 3DMark's Fire Strike benchmarking software at the "Extreme" overclocking preset resulted in a score only 5 percent higher than the non-overclocked mode. The difference in noise was extremely noticeable,

however. The overclocking presets are also only available while the laptop is plugged in to an external power source, but this isn't really a deal-breaker.

There are a few annoying quirks of the Triton 500's design. For instance, the power button is located on the keyboard, just to the right of the delete key, making it all too easy to potentially hit in the heat of an intense competitive match [*stop flaying so much—Ed*]. There's a "Turbo" button located just above the keyboard for instant overclocking, but it's a bit finicky; our tests demonstrated that while the function improved performance in some games, it had little to no effect in others. The integrated webcam also doesn't have any physical security features, which is frustrating in a world of potential digital security risks.

It might be starting to sound like we don't like the Triton 500; that couldn't be further from the truth. These criticisms are minor imperfections, like scuff marks on the armrests of a comfortable couch. The Triton 500 feels good to use, plain and simple. It's not cheap, but if you're looking for a reliable gaming laptop, this could be the way to go. —CHRISTIAN GUYTON



VERDICT

**Acer Predator Triton 500
PT515-51-71VV**

STALKING PREY Solid

performance; pleasingly thin design; multi-monitor support.

NOT TODAY Automatic overclocking lacks luster; noisy fans; a little pricey.

\$1,800, www.acer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	1,030 (39%)
CrystalDisk QD32 Sequential Read (MB/s)	563	3,374 (499%)
CrystalDisk QD32 Sequential Write (MB/s)	133	2,530 (1,802%)
3DMark: Fire Strike (Index)	13,202	13,610 (3%)
Rise of the Tomb Raider (fps)	99	92 (-7%)
Total War: Warhammer II (fps)	62	62 (0%)
Tom Clancy's Ghost Recon: Wildlands (fps)	48	49 (2%)

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700HQ CPU, 8GB GTX 1070, and 16GB of DDR4. All game tests are performed at 1080p at the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-8750H
Graphics	Nvidia GeForce RTX 2060 Max-Q
RAM	16GB DDR4-2666
Screen	15.6-inch 1080p @ 144Hz
Storage	512GB PCIe NVMe M.2 SSD
Ports	Thunderbolt 3, 3x USB 3.1, HDMI, Mini DisplayPort, audio
Connectivity	Gigabit Ethernet, 802.11ac, Bluetooth 5.0
Weight	4.4lb
Size	14.1 x 10 x 0.7 inches

Razer Blade Pro 17 (2019)

The Blade Pro is dead, long live the Blade Pro!

RAZER HAS NOT NECESSARILY been quick in updating its heavy-hitting Blade Pro line—we last saw it a good two years ago—but the jump to RTX cards is far from a straight component swap. Outwardly, things have been significantly redesigned, with the soft-edged heft of the previous model replaced by a far more slimline body, both thinner and less wide than before, which brings the Blade Pro 17 into design line with the rest of the company's laptop pack. Not that the guts have been ignored; things have been seriously cooked up, in terms of both the RTX 2080 and hex-core i7-9750H in our review model, and strengthening its position as a laptop for people who love games, speed, and spending wads of cash in equal measure. This is a refresh, sure, but it's definitely a new Blade Pro. The real question is whether it's a success.

That visual upgrade certainly works in its favor. The bezel of the previous version has been chopped down to such an extent that it's hard to believe this carries a 17.3-inch panel; the closed case has a slick, unfussy profile that earns the "Pro" moniker about as handily as the specs do. There are downsides to the more conventional design—the RGB-ringed right-mounted touchpad of the previous generation has been swapped out for a boring (but pleasant) centrally-aligned glass number, the keyboard is no longer mechanical, and there's no volume roller, but the now centralized RGB-lit keyboard allows more room for a

pair of up-firing speakers, which belt out audio with impressive weight.

Between the bezels sits a matte FHD 144Hz IPS panel, which is initially baffling. Considering that both Razer's 13 and 15-inch flagships carry 4K panels, and this carries the "Pro" moniker, we'd have thought it a natural choice for a greater resolution than 1080p. Truthfully, we're not all that offended by the screen, though: It's bright, viewing angles are good, colors are absolutely awesome, and the 144Hz refresh rate is frequently tested, given the power that's driving it. A comparatively lower resolution might make this a lesser work machine, but it does wonders for its gaming potential.

VAPOR TRAIL

Forsaking wacky cooling designs, such as the pop-up ventilation seen on the Asus Zephyrus, and indeed shunning the large rear-mounted exhaust ports on offer from most other manufacturers, Razer has instead employed an internal vapor cooling system, which pulls in air from the front of the base, and outputs it through a pair of inconspicuous vents at the rear. It's tidy, certainly, though the four fans can get loud under heavy load. Bringing the heat is a ninth-gen Core i7-9750H running at 2.6GHz; continuing the theme of what Razer could have done, there's little doubt that a Core i9 could have been made to work and thrown out half as much performance again, but there's no true reason for one to be there

beyond luxury. This is a snappy enough chip for the job at hand.

The company has also (predictably) opted to put the graphics in the hands of the dialed-back Max-Q design of the RTX 2080, clocked at a boost of 1,230MHz. That's a good drop in speed from the desktop equivalent, but comparing its benchmark results to the similarly specced Asus Zephyrus S GX701GX shows that Razer's smaller, lighter cooling solution doesn't mean more throttling—the numbers here are almost identical, sometimes a touch better, and gaming on the Razer Blade Pro 17 is a true joy.

Although the price is somewhat horrific, Razer at least knows that this is an investment, making upgrading the RAM and storage options easy should you wish, and including 802.11ax wireless, USB 3.2, and a 2.5Gb Ethernet port for some forward-thinking connectivity. That's the caper to a redesign which, while lesser in some ways to its predecessor, results in one of the most handsome and capable big-screen laptops we've ever seen. —ALEX COX

VERDICT



Razer Blade Pro 17 (2019)

RAZER-THIN Gorgeous chassis redesign; great screen; effective cooling; excellent speed.

HEAVYWEIGHT Extremely expensive; some features lost.

\$3,119, www.razer.com

BENCHMARKS

	ZERO-POINT	
Cinebench R15 Multi (Index)	743	922 (24%)
CrystalDisk QD32 Sequential Read (MB/s)	563	3,228 (473%)
CrystalDisk QD32 Sequential Write (MB/s)	133	1,969 (1,380%)
3DMark: Fire Strike (Index)	13,202	17,244 (31%)
Rise of the Tomb Raider (fps)	99	113 (14%)
Total War: Warhammer II (fps)	62	80 (29%)
Tom Clancy's Ghost Recon: Wildlands (fps)	48	62 (29%)

0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

Our laptop zero-point is the Asus GL502VS-DS71, with an Intel Core i7-7700HQ CPU, 8GB GTX 1070, and 16GB of DDR4. All game tests are performed at 1080p and the highest graphical profile.

SPECIFICATIONS

CPU	Intel Core i7-9750H
Graphics	Nvidia GeForce RTX 2080 Max-Q
RAM	16GB dual-channel DDR4 2,667MHz
Screen	17.3-inch, 144Hz IPS
Storage	512GB NVMe SSD
Ports	3x USB 3.2, USB-C, Thunderbolt 3 (USB-C), SD reader, 3.5mm audio
Connectivity	2.5Gb Ethernet, 802.11ax Wi-Fi, Bluetooth 5.0
Weight	6lb 1oz
Size	0.78 x 10.24 x 15.55 inches



Sharper edges, tight design. It's hard not to love the Blade Pro.

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Corsair Nightsword RGB

Live by the sword,
die by the Nightsword

CAST YOUR MIND BACK one whole issue, and you'll remember our review of Logitech's G502 Lightspeed, a tremendous wireless reimagining of a mouse design, which has attracted enough reverence to stay a top-line choice for many years. Corsair's Nightsword isn't a G502, but boy, would it like to be. It's laid out in almost precisely the same way in terms of buttons and thumb shelf, it also features customizable weighting, and Corsair's engineers are no doubt looking very pleased with themselves for besting the G502's ludicrous 16,000 dpi sensor with an even sillier 18,000 dpi eye, last spotted in Corsair's Ironclaw wireless mouse.

As much as we'd like to shove this aside as some kind of wannabe clone of the king, though, it's also very much its own beast. It avoids some of the pitfalls the G502 fell into. Notably, the scroll wheel, which eschews switchable freewheeling for a comfortably resistant notched-only mechanism, is a whole lot better than that of its rival. The button layout is slightly closer, meaning less stretching and more in-the-moment immediacy. The shell is just slightly wider, and the thumb cradle a little deeper, making this more suited to larger hands.

It also doesn't do certain things quite as well. Despite its size, it seems to have been built, as is tradition, for a cartoon world in which little fingers do not exist. You'll be trailing yours on the desk. While there's a huge DPI-slashing sniper button, the Nightsword's upper side buttons are tapered to a point, making them indistinct and difficult to press. There are no side-click functions on the scroll wheel, which is nestled slightly lower in the shell than is entirely comfortable. And the weighting is concentrated on a single cluster around the sensor, rather than being spread over the whole body of the mouse. Whether the idea of mouse balance is a placebo or not, the fact is that placebos can work if you're told they do—and the Nightsword is smart enough

to recognize which weights have been put where, with Corsair's iCue software working out the center of mass, as well as helping to manage macros, lighting, and surface calibration.

For a moment, though, let's stop comparing apples to apples, and look at this fruit on its own. The Nightsword is an exceptionally pretty mouse, with RGB lighting delightfully presented through one palm light, from deep within the scroll wheel chasm, and through seven translucent windows around its base. These are covered in a circle-cut mesh, which (while entirely pointless) does add to the premium feel. It's heavily textured, with everything but the buttons on the top shell stippled for grip, some stickyish rubber grips on either side, and those main buttons (which are well dished and feel just great) are independent of the shell. It's also pretty chunky—even unburdened by the optional weights, the Nightsword is at the heavier end of the mouse spectrum.

In the guts we've got gaming-standard Omron switches, which we can't complain about one bit, and the Nightsword's sensor didn't falter even slightly in our tests. Neither did we expect it to. It's a custom version of a Pixart PMW3391, and it's great. There's no need to drive it as hard as it'll go, unless you're a lunatic with particularly exact wrist control, but it's perfect at lower resolutions, copes well with black and reflective surfaces,

and the adjustable lift height means it's suitable for anyone's style. We're not going to say the Nightsword is better than the G502, because that's a pinnacle mouse at a far higher price. We can't even call it better than the Ironclaw from which much of its hardware has been culled; it's probably on equal footing with its sibling. But the Nightsword is, in its own right, a quality, smart, and comfortable mouse with some serious chops—niggles be damned. —ALEX COX

VERDICT
8

Corsair Nightsword RGB

■ **NIGHTSWORD** Great lighting; mostly comfortable design; outrageous sensor; clever weighting.

■ **NIGHT SOIL** Some awkward buttons and positioning; reasonably expensive.

\$80, www.corsair.com

SPECIFICATIONS

Sensor	Optical
Sensitivity	18,000 dpi
Sensor Model	Pixart PMW3391
Polling Rate	1,000Hz
Programmable Buttons	10
LEDs	RGB, four-zone
Cable Length	6 feet
Weight	4.05–4.83oz

Roccat Noz

Budget-oriented cans with serious low end—hot or Noz?

THE HEADSET MARKET has changed a lot in the past few years, spurred on by streamers and YouTubers, and by the increasing popularity of esports. You know this, of course. But does Roccat?

We ask because this new Noz headset feels like a great budget offering from, well, a few years back now. Yes, it's unfussy and affordably priced, and it certainly has its plus points. But we can't help but think back to the days of Vine, ice bucket challenge videos, and Miley Cyrus's foam finger when we use the Noz. It would have earned an appreciative budget recommendation not so long ago, but times have changed.

Let's start with the spec sheet. There's certainly nothing wrong with the 50mm neodymium magnet drivers on paper, as they offer a 10Hz–20KHz frequency response, and have enough size to power an authoritative low end. Going beyond the usual 20Hz–20KHz range brings real benefits to the sound, although it's not specced out for hi-res audio. Those extra 10Hz way down beyond the limits of human hearing give the Noz's drivers the power to add thumping subharmonic bass frequencies you can really feel, even if you can't technically hear them.

At just 7.4oz, it's also an incredibly light headset, and we couldn't be happier that RGB lighting is an increasingly rare feature on headsets now—one area that the unintentionally throwback Noz feels bang on trend with. It's a decent looking headset for the price, unfussy and restrained, even compared to Roccat's pricier Khan.

At the back of the left-hand closed-back earcup, you'll find a mic mute switch and a volume thumbwheel, while at the other end of the cable, separate mic-in and audio-in mini-jacks can be combined into a single input. And, really, that's the long and short of the Noz's offering. Again, there's nothing inherently wrong with keeping things simple.

The trouble starts with the sound. In fact, momentarily before that. When you first don the Noz, you'll notice that "seashell effect" as the earcups close in over your ears. It's slight—just



a faint muffled reverberation as you hear outside noise—but it's there. Not to labor the point, but this used to be a problem we listened out for in headsets in 2012. Somewhere along the timeline, manufacturers cracked it with better contact-point materials, better earcup shapes, and a better fit using smarter hinges. But it's crept back in, just to a faintly perceptible degree, with the Noz.

And that affects the sound when you press play, be that in games, music, or movies. There's an imprecise character that colors the overall sound, especially noticeable in speech, which really is a shame, because Roccat is more than capable of delivering great-sounding, precise audio. Its higher-end Khan cans suffer none of the above issues, supporting hi-res audio, and bringing out more rumble and sparkle in compressed sound in the process. It hasn't dripped down to this set.

More's the shame, because that's really our only grumble with this model. Sure, it may not feel luxurious against your head, but we've endured much, much worse below the \$60 price point, and it's obvious that careful design and construction material selection has gone into this lightweight and adjustable design. It may not be the coolest or most breathable headset we've tested, but it

stays comfortable for hours thanks again to that skinny design and ample padding.

Can we recommend it? Not as it is. It feels one iteration away from genuine go-to budget headset contention. It doesn't sound like the driver architecture is at fault, but something about the shape and fit of the earcup chamber. You could do worse for the price, but Corsair's sub-\$75 offerings give a clearer, more precise sound. **—PHIL IWANIUK**

VERDICT

6

Roccat Noz

■ **ROCCAT ROLL** Good bass response; restrained design.

■ **JUST SAY NOZ** Muddy sound; seashell effect when worn.

\$55, <http://en.roccat.org>

SPECIFICATIONS

Driver Type	50mm neodymium
Frequency Response	10Hz–20KHz
Design Style	Closed back
Microphone Type	Electret condenser
Weight	7.4oz
Connectivity	Mini-jack
Cord Length	8 feet

Thermaltake Commander C35

Introducing the Commander-in-Grief

THE COMMANDER C35 is a big 'un. While it's only a standard ATX mid-tower case, it weighs a lot more than some of its counterparts, thanks to the steel and tempered glass. Yet when we peel off the protective film on the glass window and peek inside, we're not overly impressed.

There are a lot of visible screw points inside, along with the exposed circuit board of the front I/O, giving the initial appearance a slapdash look. It looks a bit better once we've assembled a build inside, but only marginally. The PSU shroud helps, concealing a lot of the potential mess under a layer of painted black steel. It's nothing new, though. Indeed, it's hard to see exactly what the C35 brings to the table when compared to other cases. It's not cheap, which forces it to justify its price tag with features that set it aside from the competition.

The most eye-catching of these are the two large ARGB fans mounted in the front. At 200mm, they are beefier than anything you'd normally consider for case airflow. The front of the case has an integrated dust filter behind the hexagon-patterned plastic panel, too. The on-board fan control unit connects to an RGB control button on the front I/O, allowing for quick customization of your PC's color scheme. These fans can sync with RGB tech from other manufacturers, enabling smooth color co-ordination. The fans are noisy at full speed, however. Their cabling is strangely long and winding inside the case, too, leaving a lot of slack to be managed—strange, considering that they come built into the case.

At the rear, there's another fan: a basic 120mm affair. No fancy lighting here, then. In fact, the rear fan looks annoyingly basic compared to the high-quality materials in the rest of the case; a cheap orange sticker bearing the Thermaltake logo almost adds insult to injury. There's ample space for fitting radiators, at least. The roof can take a

radiator with two 140mm fans, and the front can take another two 140mm fans, or three 120mm fans instead. Fitting a radiator to the front of the case demands a lot of work, though, as the fitted 200mm fans need to be removed first. Ideally, this case would suit a straightforward AIO-cooled build utilizing 280mm of radiator space in the ceiling. So, it's functional—but not particularly impressive.

Drive storage options are scattered haphazardly around. There are two flat mounts of 2.5-inch SSDs on the rear of the motherboard plate, which should be familiar to any seasoned system builder. The 3.5-inch HDD mounting panels (which can also accommodate a 2.5-inch drive, if preferred), on the other hand, are divided; two are positioned on the rear of the plate below the I/O, to the front of the case, but one sits flat on the bottom, behind the front fans. A large hole is cut in the PSU shroud to allow access, but it just results in a huge amount of negative space that is difficult to use effectively. A reservoir can be mounted in this hole for liquid-cooled custom loops, but otherwise it's poor use of space. A drive cage could have been fitted here instead, allowing for additional HDD storage space, while still leaving room for a coolant reservoir on top.

There are other concerns, too. The mounting pegs that support the PSU are hard plastic, not the rubber or foam we've seen in other cases to mitigate noise from vibrations. The RGB control button on the front I/O feels oddly cheap compared to the satisfying click of the power and

reset buttons, and the I/O only supports two USB 3.0 Type-A connectors. Cable management is at least straightforward, thanks to plenty of clips to secure cables. On the whole, it's not terrible; it's just hard to see what the C35 offers that we can't get elsewhere. —CHRISTIAN GUYTON



VERDICT
7 **Thermaltake Commander C35**
■ **COMMAND** Powerful front case fans; good ARGB features; plenty of clearance.

■ **UNMANNED** Loud fans; heavy and bulky; limited front I/O; unattractive interior.

\$110, www.thermaltake.com

SPECIFICATIONS

Form Factor	Mid-tower
Motherboard Support	ATX, mATX, ITX
Colors Available	Black
Window Available	Yes
3.5-Inch Support	3
2.5-Inch Support	5
Radiator Support	360mm front, 280mm roof, 120mm rear
Fan Support	2x 200mm front, 2x 140mm roof, 1x 120mm rear
Dimensions	18.2 x 9.2 x 21 inches
Graphics Card Clearance	16.1 inches (12.2 with coolant reservoir)
CPU Tower Clearance	7.1 inches
Weight	17.3lb



Total War: Three Kingdoms

Contains very little actual romance

AFTER THE STRIPPED-BACK nature of *Thrones of Britannia* comes the full-fat, heavyweight, no-holds-barred game. *Three Kingdoms* is as expansive as the name suggests, taking inspiration from a 14th-century historical novel chronicling the events at the end of the Han dynasty and the steps toward Chinese unification.

The *Romance of the Three Kingdoms* novel contains nearly 1,000 characters and 800,000 words, and it feels like the game does, too. On the surface is the classic *Total War* structure: a turn-based strategy game in which armies and generals prowl the map, capturing cities and building them up, before rooting out enemies and rebellions, and a real-time tactical battle game when armies clash.

You're offered a choice: Do you play in Records mode, in which generals and other characters are quite powerful but need retinues of bodyguards to fight for them, or Romance mode, in which generals are supermen, capable of flattening an entire regiment of archers, and more politically astute characters can foment a war out of thin air? Romance mode feels more like the way the game is intended to be played, all the playful manipulations and *Tekken*-like one-on-one battles adding so much to the

experience on both maps. How long will it be before we can take direct control of our general as he (or she) duels with an enemy leader, picking up a gamepad to tap out combos and special moves?

For *Warhammer* or *Britannia* veterans, this is slower, as you spend more time on the strategy map and in the diplomacy screens—where a new button works out what it will take to get what you want from the other side, removing the need to make leaps in the dark. Now it's clear: gold, trade goods, and a daughter in return for a defensive alliance? Fine. Just beware that daughter doesn't come back in 10 turns as a high-powered enemy general.

The focus on individual characters may be an even larger change than the return of the game's full systems. You're asked to choose a character at the beginning, your choice dictating starting position and difficulty. From then on, you're not fighting other factions as much as other leaders, looking at their personality traits along with the disposition of their armies.

Things feel more familiar on the battlefield. The camera system hasn't changed, you still get some time to deploy before the battle begins, making use of the terrain, and the enemy AI is still straightforward enough to bog infantry

down with a well-designed army while your cavalry mop up archers and wheel around to slam into the back of enemy infantry. The focus on characters means the loss of a general is strongly felt, but it almost seems a shame to send a regiment after an enemy leader when you could send one of your own and watch the fireworks of a duel.

This series constantly evolves, never afraid to cut back or embrace new settings. The return to history—albeit a fictionalized version of it—after the *Warhammer* games has led to the developer throwing everything it can at *Three Kingdoms*. It's a huge game, completely open-ended, and with enough starting positions that you'll need a few centuries free to complete it. —IAN EVENDEN

VERDICT

8

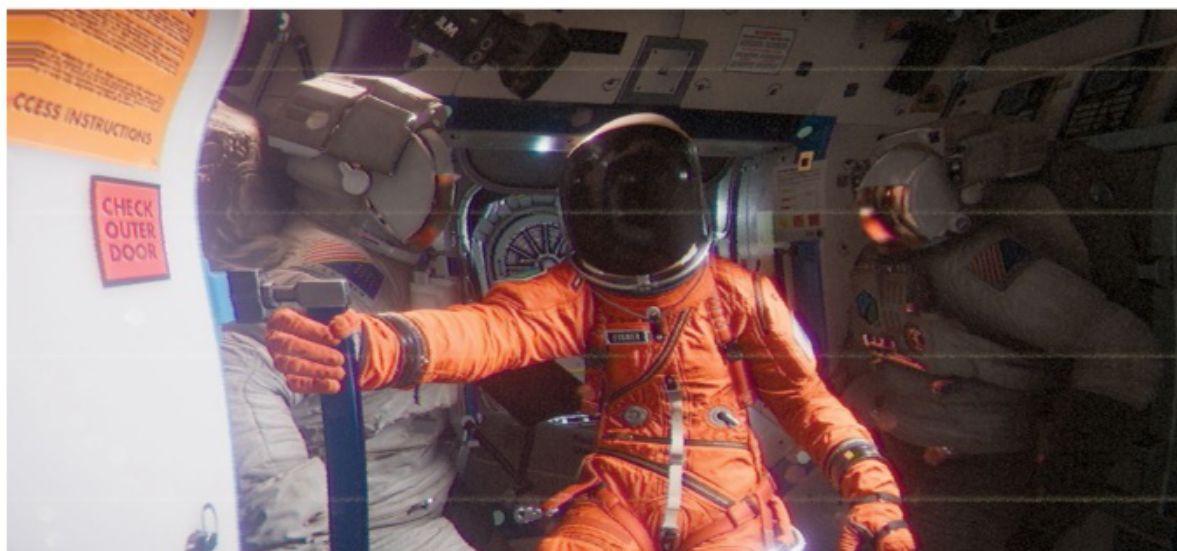
Total War: Three Kingdoms

ASPIRANT Sharply rendered mass battles with eye-catching character duels.

TYRANT Needs a monster system to play at 4K at Ultra 60fps.

RECOMMENDED SPECS i5-6600/Ryzen 5 2600X; 8GB RAM; GTX 970/R9 Fury X.

\$60, www.totalwar.com, ESRB: T



Observation

AIs can still scream in space

BRING HER. That's all you're told. But where? And why? The strange force interfering with the self-aware AI of the space station *Observation*, whisking it across the solar system and making all but one of its crew disappear, couldn't possibly have nefarious intent, could it?

Despite there being one human still alive on the *Observation*, it's the AI you play as, seeing and interacting with the world through security cameras in a rare example of a second-person game.

It's a subtle backdrop for a sci-fi thriller, almost silent apart from the hum of life support, and the click and whir of the cameras. Fisher, the surviving crew member, fights fires and carries out repairs with SAM the AI's help, getting you to open hatches and vent fumes. You jump between cameras, your point of view limited to their positions and arcs.

The cameras provide a distinctive visual style, as interference and distortion course across the feed. Exterior cameras allow you to inspect the outside of the station, the feeling of being millimeters away from the void almost tangible. Sections in which you fly freely through the station in a camera sphere allow the naturalistic lighting to shine, the cramped *Observation* and the calm flatness of

SAM's voice bringing to mind everything from *2001* to *Moon* to *Event Horizon*.

Some jobs are beyond Fisher, and SAM must go in alone. The *Observation* has a series of computer systems to manage its complex workings, and while some tasks, such as correctly firing jets to jettison a damaged portion of the station to save the rest, are a game of skill against the clock, others are more puzzle-like.

Occasionally, the game falls down in its signposting, the interactive object in the room not remotely clear, and Fisher chiding you as you sweep around with the camera. The thought of an AI sitting frozen in front of a puzzle, trying to grasp its mechanics the same way a human player would, can shake you out of the moment, but the puzzles are well designed, and the game is a patient teacher.

Exploring is a must, both to find clues to help complete the puzzles, and to dig out audio logs and other background information on the station's crew. It is possible to get lost, but a system of waypoints helps you to get around.

The plot takes you from uneasy suspense to actual horror, your limited power to interact with the world doing much to ramp up the tension. It's not a long game, but it does keep you playing—

the luckiest are those who can dedicate a day-long session to it. An AI should be unfeeling, but an AI played by a human can never be that way. When you fail Fisher, locking her out after a glitchy voice print analysis, or just failing to open a hatch on her count of three, you feel bad because you care about her, and don't want her to end up as just another frozen, floating piece of space debris.

And that's *Observation's* genius. The relationship between Fisher and SAM is a strong one, much like that between the characters of *Lone Echo*. And by setting simple goals, with complex solutions, against a background of austere white spaces as labyrinthine as the plot, it foregrounds the relationship in a hugely satisfying way. —IAN EVENDEN

VERDICT
8
Observation
OBSERVED Fascinating plot and characters drag you in.
RESERVED Too little signposting at times; easy to get frustrated.
RECOMMENDED SPECS Core i5-6600K 3.5GHz/Ryzen 3 2200G; 8GB RAM; Radeon RX 570 8GB/GeForce GTX 960 4GB.
 \$25, www.observationgame.com, ESRB: M

LAB NOTES

BO MOORE, HARDWARE LEAD



Cardboard Benchmark

If you don't have a spare case, use what's available

EVER BUILT A PC in a cardboard box? OK, what I'm talking about today isn't exactly a full PC build, but it was a fully functioning PC, and it lived in a giant cardboard box.

I'm not usually the one to do our CPU testing and reviews, but due to a number of unforeseen complications—namely Jarred planning a family vacation and then us finding out AMD's Ryzen 3000 parts would be launching in the middle of it—I found myself the unlikely benchmarker of the Ryzen 7 3700X and Ryzen 9 3900X. As I'm not a regular CPU tester (and I work from home), I don't have a full test bench area set up for the purpose. So, when AMD sent me the Ryzen parts to benchmark, I had to make do with what was available: the very box they shipped in.

You can see the cardboard test bench I assembled in the image, above-right. Sure,



it's not pretty, but it got the job done. And when I say "job," I mostly mean keeping my cats from pouncing on the extremely tantalizing spinning fans and sparkling lights. (Side note: AMD's Wraith coolers

She may not look like much, but she's got it where it counts.

are very pretty.) My test bench—er, box—served its purpose, though. I would run benchmarks by day, then close the top flaps to keep cats out at night. Never mind that the whole thing was probably a huge fire hazard (for the record,

I did keep it well ventilated while on, and unplugged while boxed up). Thankfully, my cardboard misadventures didn't set back the testing process at all, and we had our Ryzen 3000 reviews ready for launch.



JARRED WALTON
Senior Editor

The past month has been busy in the hardware testing labs. Between AMD's RX 5700 series, third-gen Ryzen, and Nvidia RTX Super cards, I've had my plate more than full. Ryzen looks good, but gaming performance still trails Intel by a small margin. The bigger problem has been AMD's launch drivers (19.7.1) for the graphics cards. We

ran into several performance anomalies—a nice way of saying that we encountered driver bugs and performance regressions. It's not clear what happened, but the 19.5.2 drivers were about 5–10 percent faster than 19.7.1 with an RX 590. Let's hope it's sorted soon, as another 10 percent out of the 5700 cards would be awesome.



JOANNA NELIUS
Hardware Staff Writer

Nvidia releases new RTX Super cards, AMD drops the prices of its new GPUs just before they hit shelves, and Intel announces it will have 7nm chips by 2021—I've been enjoying this subtle yet not so subtle "we gotta one-up each other" war. But I feel bad for those who bought a 20-series right before the Supers were announced; the 2060 Super

has on-par performance with the 2070 for \$100 less. The 2070 Super's performance is nearly the same as the 2080 for \$200 less. Of course, price varies from manufacturer to manufacturer, but the entire Super line, when comparing MSRP and performance to the original cards, makes the 20-series feel unnecessarily bloated.



Editors' Picks: Digital Discoveries

Executive editor, Alan Dexter, and staff writer, Christian Guyton, have been hunting for free software this month



VSDC FREE VIDEO EDITOR

I recently found myself needing to pull some old cine footage that had been transferred to DVDs. For numerous reasons, my normal video editor no longer worked, so I needed to find a tool (preferably free) that would help me complete the task in the kind of tight deadline that is completely normal for such things. After trying a few that either failed to see the files, produced corrupted images, or had the kind of interfaces that needed more time to master than I had, I settled on VSDC.

The interface comes from the intuitive, no-nonsense school of design. I was able to skip around the movie easily, and pick out the parts I needed. It did take a couple of attempts to get the output settings spot on, but once done, the quality was excellent, and the files sizes were manageable (not something that could be said of some of the programs I tried using).

Overall, I was impressed with how this tool performed. While I was very focused on a tight subset of what you'd usually want to do with a video editor, VSDC handled what was needed and was intuitive enough that I've left it on my machine for more fiddling when I get a few free moments.

Free, www.videosoftdev.com



HUNT: SHOWDOWN

Thanks to a recent free event, I gave Crytek's *Hunt: Showdown* a go. It's a strange beast, blending elements of horror, shooter, and battle royale games to produce a tense, atmospheric jaunt across the marshlands of 1800s Louisiana. It doesn't actually feel like a Crytek game, apart from the savage demands it puts upon your GPU. Even on the trusty 1070 Ti, the game really struggled at max settings.

Graphical fidelity aside, is it fun? Yes, but stressful. The gameplay is slow and ponderous, punctuated by brief bursts of intense action. Ten players are tasked with hunting a powerful demonic creature before escaping with the loot. Death is permanent, so the game demands that you recruit new hunters and outfit them with gear between sorties. Each hunter also levels up independently, unlocking helpful new perks as they grow stronger.

The catch? You're all after the same beastie, and there's nothing to stop you gunning down your fellow hunters. Weaker monsters roam the map, barely a threat, but depleting your limited ammunition. And you don't have to fight; you can venture out for a quick recon, then depart the match with your loot—and life—intact.

\$30, www.huntshowdown.com



Sonos Beam Soundbar

THIS IS MORE THAN just a soundbar. The Sonos Beam is a wireless, voice-controlled speaker, capable of pumping out brilliant sound quality that fills a room or even a house. It's packing four drivers, five amps, and a tweeter, laid out along the front of the bar to maximize range. There are five microphones, which can pick up voice commands from across a room, even while your music is blaring.

One of the biggest draws of the Beam is its ability to play music from virtually any source. Whether it's your phone or tablet, a network-connected drive, or your streaming service of choice (Spotify and Apple Music are obviously supported, but the Beam can also link to Tidal, Amazon Prime Music, Deezer, and more), this bar has got you covered. Of course, it can link to your TV or monitor, too, and dialogue jumps out with exceptional quality.

The Beam is easy to set up, supports HDMI for TV connectivity, and can be synced to Amazon Alexa devices for more in-depth voice control. iPhone users can also connect directly to it, and use their phone to issue commands to the Beam. The Beam connects to other Sonos products as well, should you wish to build a network of sonic mastery in your home.

Considering that it's relatively small (though weighty—you could knock someone out cold with this thing), the depth of bass is incredible. We were almost afraid of turning the Beam up to its maximum volume, lest we disturb the neighbors. **-CG**

\$399, www.sonos.com

LETTERS

WE TACKLE TOUGH READER QUESTIONS ON...

- > Best Coolers
- > Screen Calibration
- > Windows Security

Cool Winners

I am writing about your “Head to Head” article comparing cooling options. The bottom text shows the winner for each category. Clearly, “Air” cooling wins three of the five categories. The “All-in-One” one wins once (actually, it tied once).

Yet, you rate the “All-in-One” as the winner. How can this be possible?

This is a contradiction—why would you bother rating each category, then override your own rating?

—Jacob Simpson

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS:

While this may be a little confusing initially, if you turn your eyes to the “And the winner is...” box on the pages in question, you’ll find that we addressed this very issue, and explained why we favor all-in-one setups over air cooling. We don’t attribute equal weighting to the categories, or simply add up the wins; it comes down to what we feel is the best option overall. We break these head-to-heads into categories, so that if one area is more important to you, you can focus on

that—if you’re mainly after performance, for example, a custom loop is your best option. All three methods of cooling have their place, and there’s absolutely nothing wrong with air cooling (or, indeed, custom loops), but given the choice, we would recommend an all-in-one for the reasons stated.

Color Accuracy

A while back, you had a tutorial explaining how to use the basic version of the Datacolor Spyder5. For someone who would not only want to create a custom setting in their PC, but also calibrate the display itself (in this case, an HDTV, that would eventually be upgraded to a 4K UHD TV) via its own color management settings to accommodate multiple inputs (gaming consoles, TV, and so on), would the Datacolor Spyder5PRO be a better choice? Or would you instead recommend the X-Rite i1Display Pro or X-Rite ColorMunki Display? And, if I upgrade to a projector, would any of these choices work (I’m assuming the Spyder5PRO would not), or would I need

to look at a completely different calibration tool?

—Julian Parrilla Grajales

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS:

Hardware calibration devices are predominantly used by photographers and designers who need to ensure the images they’re working on can be accurately replicated—particularly useful when it comes to printing out the final image. Given the professional remit, it should come as no surprise that such devices command a premium (the SpyderX Studio costs \$500), although older units can be picked up for much less—which would be our recommendation if you’re not a professional image fiddler.

As to which of the ones you’ve listed is better, that largely comes down to what you can afford, your experience using them, the level of support needed, speed of operation, and what you’re actually using it for—the SpyderX Elite supports calibrating for motion work, for instance.

Projectors are a slightly different ball game, as

a traditional calibration device sits on the display’s surface, which in this case means it’ll block the image you’re trying to calibrate. The good news is that the latest models allow for this: The SpyderX Elite can be mounted in front of the screen on a stand, and can allow for the resultant shadow, while the X-Rite i1Display Pro and ColorMunki can calibrate projectors by placing them much further away, although we suspect the SpyderX quality will be better in this instance.

4K Video Editing

I want to build a desktop to monitor 4K videos off my Mavic 2 Pro drone. I didn’t see anything current when I searched the archives. Do you have a component list for a good build? I was thinking somewhere from \$1,500 to \$2,000 without monitor(s), if that will do a good job.

—Larry Pence

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS:

We’ll look at piecing together a rig like this in a future “Build It,” but if you’re eager to get building, our recommendations would

submit your questions to: comments@maximumpc.com

be a fast processor with plenty of cores, and as much RAM as you can muster; at least 32GB (64GB would be ideal). A graphics card could potentially help out on the rendering front, depending on the software you use, plus plenty of storage. Our mid-range build at the back of the magazine, with a lot more RAM, isn't a bad place to start.

Security as Standard

I need help determining how to build my next PC for Microsoft's "Standards for a highly secure Windows 10 device." You have probably seen the Windows Security settings, but under "Device Security," Windows tells you how it manages the security that is built into your device.

I've spent time looking around for motherboards that can support everything Microsoft wants in order to hit all of the security requirements, but I don't want to pay many dollars and be disappointed that the product doesn't check all of the requirements.

This is where I think you can help—you most likely have access to all kinds of motherboards and hard drives, so you can test them to see what Microsoft Windows 10 is going to check in the "Device Security" section. There is also a question of BIOS settings that I'm not too familiar with, so maybe you can help with that also. This might be a good article for your readers.

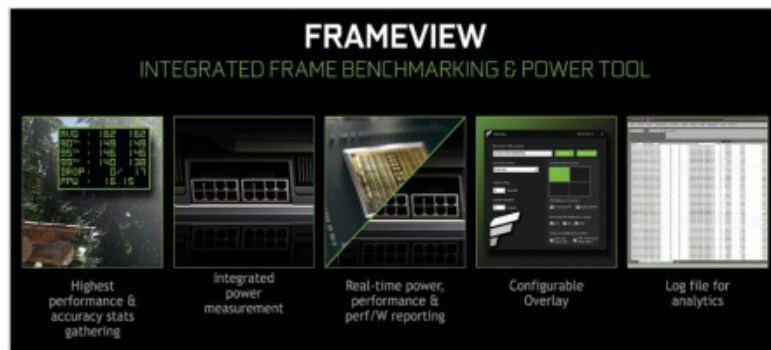
Here is the link from Microsoft: <https://docs.microsoft.com/en-us/windows-hardware/design/device-experiences/oem-highly-secure>.

—Gary Kalwaytis

STAFF WRITER, CHRISTIAN GUYTON, RESPONDS: When it comes to hardware security, it's a lot more straightforward than it may initially seem. Essentially,

[NOW ONLINE]

NVIDIA LAUNCHES A FRAME RATE CAPTURE TOOL FOR EASY GPU BENCHMARKING



Integrated power measurement sets this one apart. So, you did your research and figured out which is the best graphics card for your setup, bought it, and installed it in your PC. Now what? Playing games is the natural thing to do at this point, and a new frame rate capture tool from Nvidia will help you analyze performance to make sure your shiny new card is working as it should be.

It's called FrameView, and it's essentially a modified version of PresentMon, with some extra features added by Nvidia. For example, you can track power usage with FrameView, but you can't in utilities like FRAPS and AMD's OCAT (Open Capture and Analytics), so it's a nifty perk.

Read the full article: <https://bit.ly/2XGQJUe>

the motherboard needs to be equipped with a connector for a Trusted Platform Module 2.0 (most recently released mobos have one) and UEFI MAT compatibility. The BIOS needs to be fully up to date and equipped with an eighth or ninth-generation Intel processor, or an eighth-gen or later AMD chip. All the security settings (including secure boot) need to be enabled in the BIOS. The system also needs to have an activated and up-to-date copy of Windows 10 installed, to ensure that Data Execution Protection can function properly. In the "Device Security" tab of Windows settings, "Core Isolation" must be running and "Memory Integrity" must be turned on.

Retro Pleasure

I wanted to let you know how much I enjoyed John Knight's "So Retro!" article in the June issue. It was

refreshing to read an article for the sheer joy of reading something, and learning some very interesting history, versus reading an article for research for a potential future purchase or build, to help troubleshoot a problem, or to learn about a utility I've never heard of before and how to use it.

It's not that I don't find these types of articles helpful, because I do, and they are the main reason I subscribe to your magazine. In fact, the majority of my purchases and utilities I use are a result of articles or reviews in your magazine. However, it was nice to read an article primarily for pleasure. It was also nice because, being an older reader, I grew up seeing the systems he talked about come to market and I owned a couple of them.

It was ironic that right after reading the article, I saw a two-hour program on

the History channel titled *Game Changers: Inside the Video Game Wars*. Although the program focus was different from John's article, it mentioned a couple of the gaming systems that his article talked about. It was nice to have some "insider knowledge" about these systems prior to watching the History channel show.

Kudos to John, for such an interesting article, and to your magazine for publishing it.

—Michael Craddock

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: We do try to mix entertaining reads alongside the more traditionally beneficial pieces, so we're glad you enjoyed it. For those of us of a certain age, taking a trip down memory lane with the benefit of hindsight makes for an interesting perspective.

Red Shift

I downloaded RedShiftGUI to my Windows 10 1903, but it doesn't work. I tried all the compatibility settings possible, but no go. What type of system did you get this "old" dog to run on?

—Derek Hamilton

EXECUTIVE EDITOR, ALAN DEXTER, RESPONDS: We've just tried this on three PCs in the office, and had no problems with any of them, including my system running the latest Insider build. Without more information, we're limited in how to respond, but we can recommend another course of action, albeit one that isn't so user-friendly. Windows 10 comes with its own blue-light-banishing tool, called Night Light. Select "Settings" from the "Start" menu, click "System," and you'll find the option to turn on Night Light under the "Display" menu. Control how and when it works by clicking the Night Light settings.

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THE BUILDS



BUDGET



MID-RANGE

INGREDIENTS

PART		PRICE
Case	BitFenix Nova TG	\$85
PSU	Corsair VS450 80+ White 450W NEW	\$42
Mobo	ASRock B450M R4.0 AM4	\$65
CPU	AMD Ryzen 5 2600X NEW	\$160
GPU	EVGA GeForce GTX 1660 XC Black 6GB NEW	\$220
RAM	8GB (2x 4GB) Geil Evo Potenza @ 3,000MT/s NEW	\$37
SSD	120GB Crucial BX500 2.5-inch	\$20
HDD	1TB Seagate Constellation ES 3.5-inch	\$36
OS	Ubuntu Desktop Linux 18.04 LTS 64-bit	\$15

Approximate Price: \$680

CHANGES ACROSS THE BOARD were minimal for the budget build this month, so it's unlikely you'll see much difference in performance. The key alteration was the switch from the conventional Ryzen 5 2600 to the 2600X version, with its expanded overclocking potential. The 2600X was inexplicably cheaper this month, even though neither item was on sale with any of the big online retailers. The max boost frequency is 0.3GHz higher, and despite swapping out to Geil's Evo Potenza RAM, the overall performance should be slightly superior to last month's setup. The 2600X also comes with a beefier cooling solution; the AMD Wraith Stealth is replaced by the taller Wraith Spire. We've also shifted from Gigabyte to EVGA on the GPU front; we're down from two fans to one, and the boost clock is a little less impressive, but the EVGA GTX 1660 XC Black is quieter and currently the cheapest GTX 1660 card on the market.

INGREDIENTS

PART		PRICE
Case	Fractal Design Meshify C	\$90
PSU	550W Cooler Master MasterWatt 550 80+ Bronze	\$55
Mobo	MSI B450M Gaming Plus NEW	\$102
CPU	AMD Ryzen 7 2700	\$200
Cooler	AMD Wraith Max NEW	\$40
GPU	Sapphire Radeon RX 5700 8GB NEW	\$350
RAM	16GB (2x 8GB) Team T-Force Vulcan Z @ 3,200MT/s NEW	\$70
SSD	250GB Samsung 970 Evo Plus M.2 PCIe	\$75
HDD	1TB Seagate Constellation ES 3.5-inch	\$36
OS	Windows 10 Home 64-bit OEM	\$100

Approximate Price: \$1,118

WE DIDN'T REALLY WANT to admit it, but yes, an AIO cooler for this build was overkill. We're out to make some savings this month, and a pricey cooling solution represented the perfect place to trim the fat in this build. To that end, we've opted for AMD's high-end air cooler, the Wraith Max, which comes with RGB lighting and near-silent fan operation, while still providing sufficient heat dissipation for all but the most savage of overclocking attempts. We're putting that cooler on to a different board, too: the MSI B450M Gaming Plus, a slight upgrade from last month's B450-A for just two dollars more. The key change here, though, is going from Nvidia to AMD with our graphics card. For no extra cost, the RX 5700 provides slightly better performance and an extra 2GB of VRAM for your system. Right now, it comes bundled with a three-month pass for Xbox Game Pass on PC, too.



UPGRADE OF THE MONTH



SAPPHIRE RADEON RX 5700

The RX 5700 XT might have been the star AMD card this issue, but its little brother shouldn't be disregarded. We'll touch more on the RX 5700 next month, with a full review, but for now, just be assured that it's a quality GPU that modestly outperforms the GeForce RTX 2060 for exactly the same price. That's all that needs to be said; gains only range from 5–15 percent with various games and graphical settings, but that's an improvement that costs not one dollar more. Sapphire is a trusted manufacturer of Radeon GPUs—XFX and Asus are good options, too. **\$350, www.sapphiretech.com**

© AMD

AT THE TIME OF WRITING, we didn't have access to the RTX 2080 Super cards—expect to see one in this build next issue. For now, though, Zotac's twin-fan offering of the original RTX 2080 is significantly discounted, so we'll be swapping to that from last month's MSI GPU to save a sweet 80 dollarroos. Given the 2080 Super will have the same baseline price point as the 2080, and won't be likely to go on sale anytime soon, snapping up a discounted high-end card like this is a good call right now.

While the Gigabyte Aorus RGB SSD remains great value, we decided to use the spare cash from the GPU to splash out, going for Samsung's 970 Evo M.2 drive. While we lost 12GB of storage, Samsung remains the king of SSD write speeds, netting us an extra 300MB/s of maximum transfer rate for just \$20 extra. We've also changed up the RAM, going with Ballistix for a small saving.

As usual, there's no call to trade out our CPU and motherboard here. ASRock's Phantom Gaming 6 has been the best-value X399 mobo in the game for a while, and Threadripper prices are staying stalwart, even in the face of Ryzen 9. Upgrading the processor in this build would throw a significant price hike into the overall system; bear in mind that if you've got the extra 400 to upgrade to the 2970WX, splashing out at extra 80 on a superior motherboard is almost always a worthy investment.

For more of our component recommendations, visit www.pcgamer.com/hardware/buying-guides/

INGREDIENTS

PART		PRICE
Case	NZXT H700i	\$190
PSU	850W Corsair TX-M Series 80+ Gold	\$110
Mobo	ASRock X399 Phantom Gaming 6	\$240
CPU	AMD Threadripper 2950X	\$830
Cooler	Cooler Master MasterLiquid ML360 RGB AIO	\$130
GPU	Zotac Gaming GeForce RTX 2080 8GB NEW	\$620
RAM	32GB (2x 16GB) Ballistix Sport LT Red @ 3,200MT/s NEW	\$156
SSD	500GB Samsung 970 Evo M.2 NVMe NEW	\$140
HDD	2x 3TB Seagate BarraCuda Compute	\$160
OS	Windows 10 Home 64-bit OEM	\$100

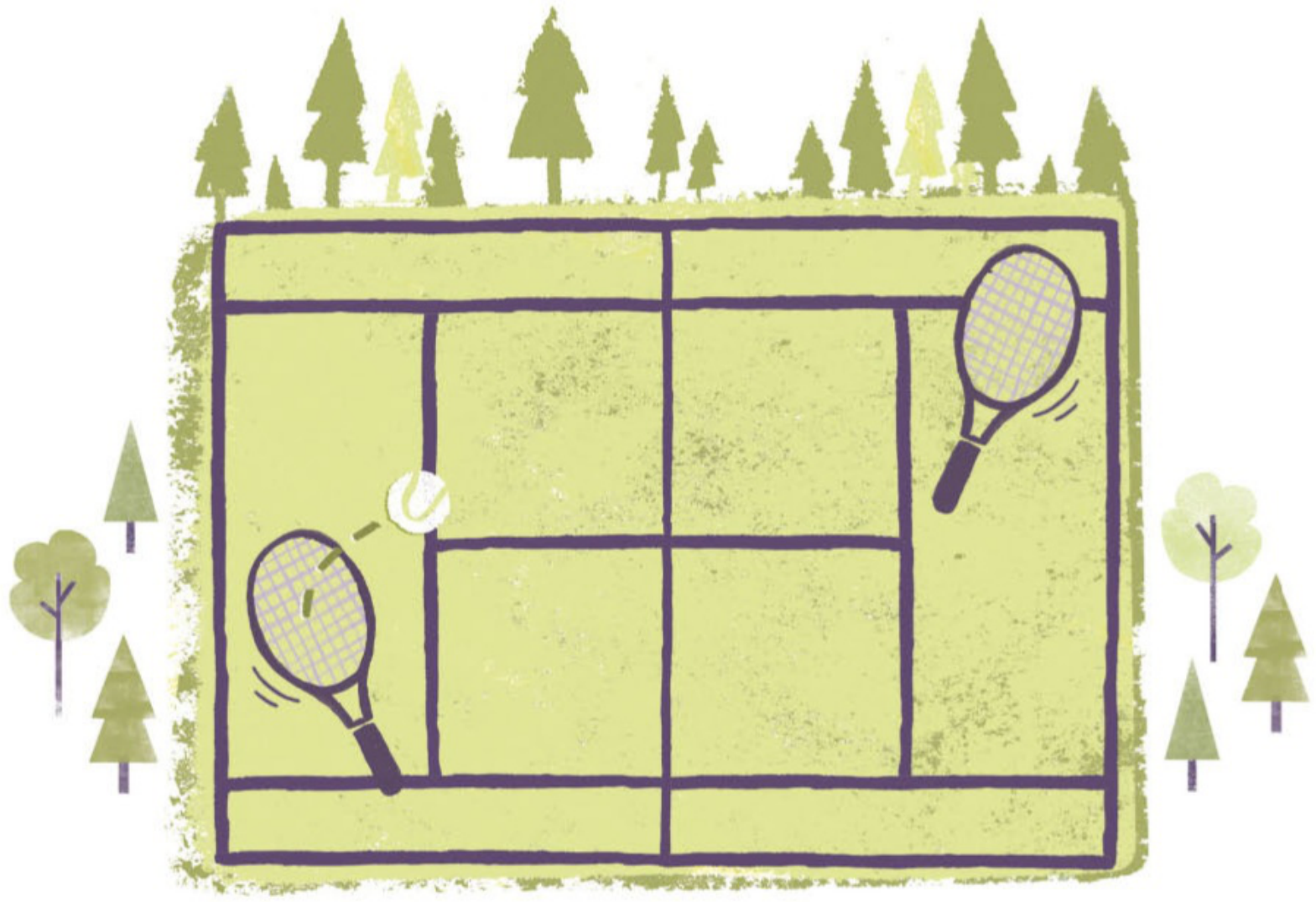
Approximate Price: \$2,676

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