IS INTEL ON THE ROPES?

NEW AMD & INTEL CPUs FACE OFF IN OUR UPGRADE DECIDER

apc

JAN 2020 #476

YOUR EXPERT GUIDE TO TODAY'S TECH

INTEL 10TH-GEN EXPLAINED

DISCOVER THE REAL GEMS IN THE NEW FAMILY

THE SMART WAY TO REINSTALL WINDOWS

- FIX SYSTEM PROBLEMS
- ELIMINATE JUNK
- SPEED UP YOUR PC

THE HISTORY OF THE PC

THE FASCINATING TALE OF HOW WE GOT HERE

THE MOST POWERFUL DESKTOP CPU EVER

AMD'S RECORD-BREAKING 16-CORE MONSTER

THE CHIP THAT CHANGES EVERYTHING

PLUS THREADRIPPER 3 *vs.* INTEL 10TH-GEN HEDT

UNHEARD OF PERFORMANCE FOR PROS AND CREATORS

FUTURE

DIY GUIDES & PRO-TIPS

- QUICKLY FIX A PHOTO
- MANAGE YOUR MAC'S STORAGE
- RUN A LINUX DESKTOP ON ANDROID

TESTED

THE FIRST PROJECT ATHENA LAPTOP

PLUS: SURFACE PRO 7

- APPLE 16-INCH MACBOOK
- BEST ULTRABOOKS HEAD TO HEAD

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- Central VPN Management
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

Vigor2926 LTE Series

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- 4G LTE Multi-WAN router with SIM card slot
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- SPI Firewall, 802.11ac Wave 2 Wi-Fi
- 16 x VLANs, 50 x VPN tunnels (including 16 x SSL-VPN tunnels)
- Central VPN Management
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

Vigor2620 LTE Series

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- 2 x VPN tunnels including SSL-VPN
- Central AP Management
- Support VigorACS 2 (Central Management System) for remote management

VigorLTE 200n

Ethernet WAN NBN Ready | Ethernet WAN UFB Ready | DUAL SIM | 2x VPN

- 4G LTE router with dual SIM card slots (SIM slot 2 for failover)
- 1x configurable GbE WAN/LAN port
- 1 x GbE LAN port
- SPI Firewall
- 802.11n Wi-Fi
- 2 x VPN tunnels including SSL-VPN
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Big trouble in Bluetown

Seeing Red

When they launched on November 26th, Intel's 10th-gen HEDT CPUs reigned supreme… for half a day. Six hours, actually. I can't recall ever seeing AMD and Intel launch new CPUs on the same day, but that's what happened. Intel first announced the embargo-lift time and date for 10th-gen Cascade Lake X – AMD then matched it exactly for Threadripper 3rd-gen. Same day. Same time. Shennigans were at play, the game was afoot. After AMD's launch date announcement, Intel, in a widely derided decision, then shifted its launch to six hours earlier in the day in a poorly judged decision to try get some nice quotes from sites and Youtubers who wouldn't be permitted to compare CLx to TR3 in the initial reviews. It backfired badly, with all the big name 'Tubers (Linus, Hardware Unboxed, Paul's Hardware, Gamer's Nexus, etc) laughing it off and slamming Intel for its antics.

Now that both side's cats are out of the bag, it's clear that with AMD TR3, HEDT dominance no longer belongs to Intel. And this follows just a few days after AMD's desktop 3950X obliterated anything Intel offers in that space. Only in mobile CPUs do Intel still maintain a slight performance edge, and there's not much in it.

Intel will very likely resort to its tried and tested market tactic of offering incentives, discounts and rebates. Its war chest is massive and it can keep that game up for a long time.

This is all Intel has left in the playbook to buy time for its engineers to come up with something competitive in terms of what matters – performance and value. That could take years. Meanwhile, AMD has its Zen 3-core products coming in the first half of 2020 – assuming it keeps to its schedule.

Intel has nothing left to compete. Unless you want to shine a spotlight on its Xeon Platinum 9282, with 56 cores. Though that one runs at a relatively low base clock (2.6GHz), is for servers, and, sells for around US$35,000. So, there's no game there.

In any case, Intel's 56-core engineering achievement with that CPU is about to be surpassed. AMD has also just lifted the lid on on the 64-core/128-thread (!!) Threadripper 3990X, which will hit the market by mid 2020, if not sooner. That one is interesting. AMD has taken its high-frequency variant of the 280 W Epyc 7H12 server CPU and will tailor it for the desktop market. Based on the price of that Epyc (US$6,950) the Threadripper version will likely be at least twice the price of the newly announced 32-core Threadripper, but still super-competitive compared to Intel offerings.

Intel's very public issues with achieving a functional CPU process below 14nm now take a backseat. AMD has capitalised fully on the 7nm process and is running with it. The debates are no longer academic. With TR3, AMD is now ahead on core count and high frequencies, its fast memory support is at least as good as Intel and in the ultimate apples-to-apples metric, IPC, it's also ahead.

Intel needs to catch up as much as AMD needs to maintain this momentum. I'm a tech fan, not a company vs. company fanboi, and these are incredibly interesting times. We all want performance and value, and now, after a long wait, the big guns are engaged in a fair fight that *we* will win.

BEN MANSILL
EDITOR
ben.mansill@futurenet.com

"Intel will very likely resort to its tried and tested market tactic of offering incentives, discounts and rebates. Its war chest is massive and it can keep that game up for a long time."

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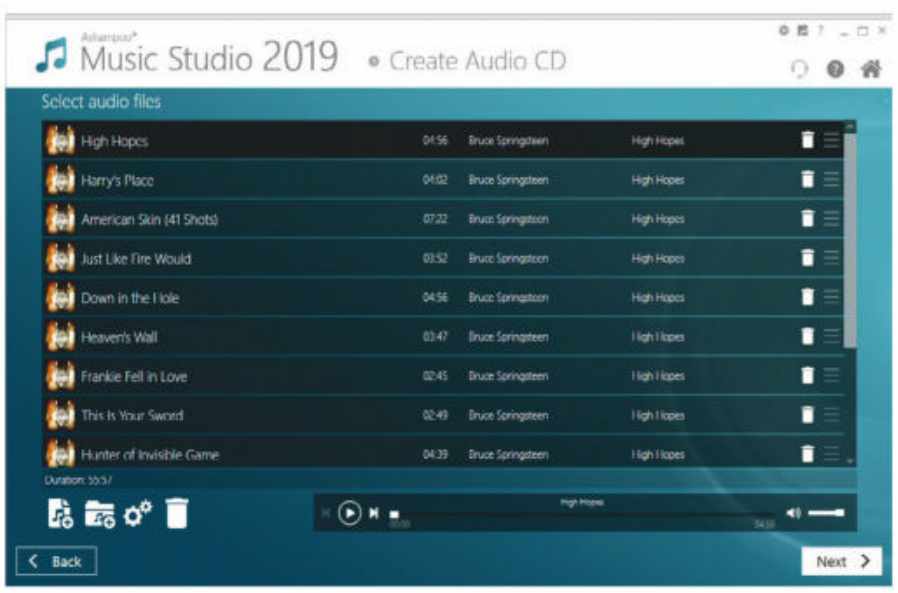

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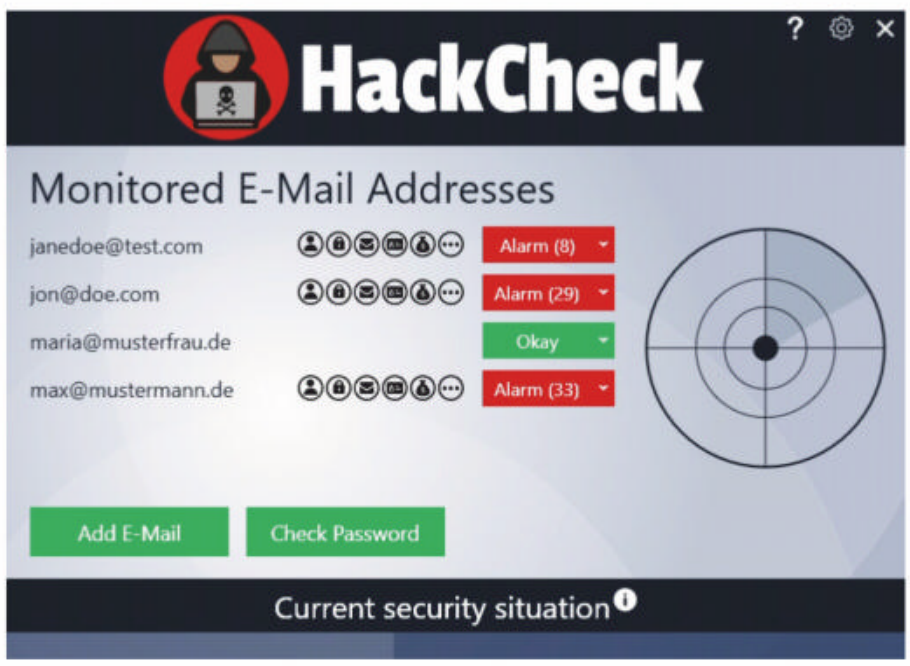

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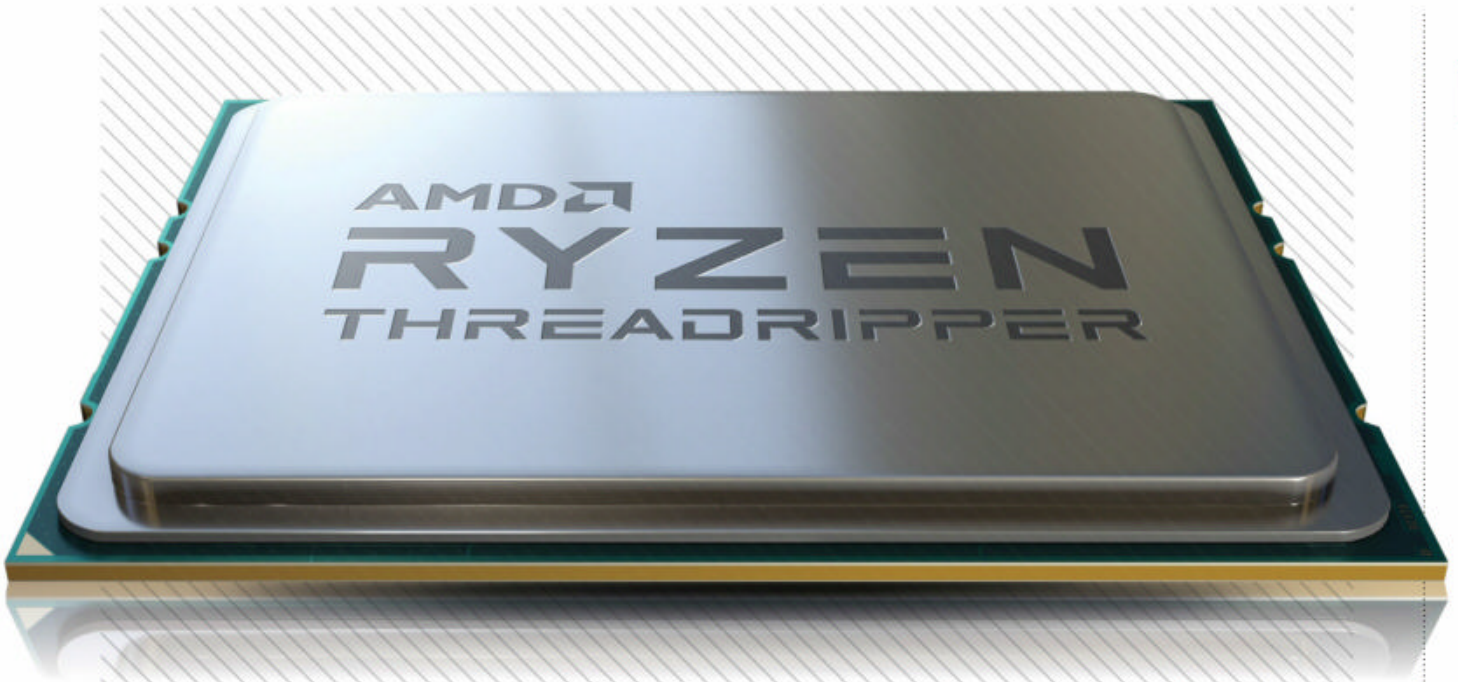
"AMD has completely redefined what a mainstream platform and PC is capable of." *page 30*



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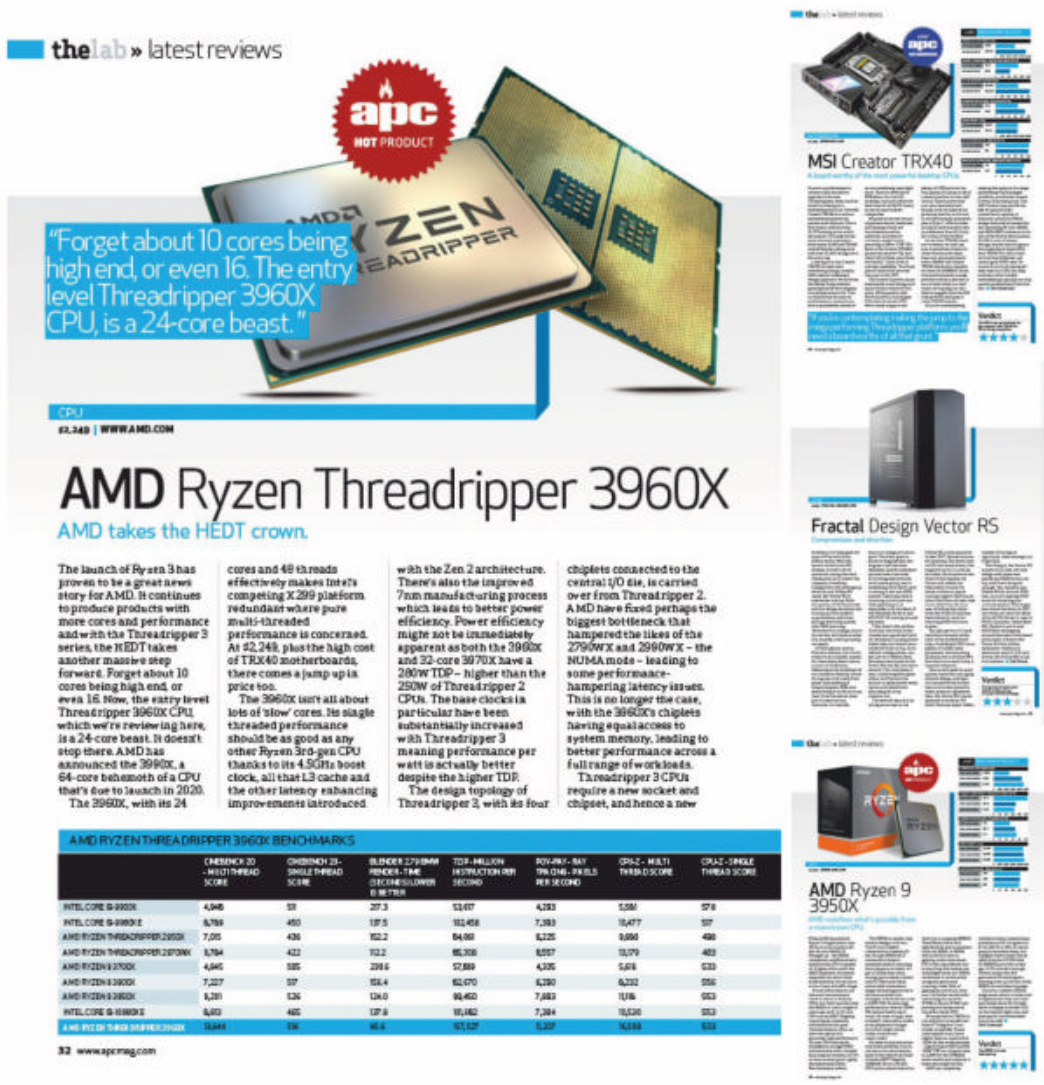

Inside APC

Find out all about *APC*'s editorial policies, test practices, how to read the benchmark results, and more.

APC is Australia's oldest consumer technology magazine – having been consistently in print for over 35 years, since our first issue way back in May 1980 – and we take that heritage and responsibility very seriously. While our focus is obviously on the personal computer – it's in our name, after all – the very definition of the PC has changed and shifted markedly since the early 1980s. As such, we touch on many other areas of tech, too, from smartphones and apps to peripherals, accessories, online services and beyond. We have two main goals: to track down the best of modern tech and also to help our readers make the most of it.

We're also an open church in terms of platforms. We know most people aren't wed to a single brand's products and use a variety of devices. And, like you, *APC*'s journalists want to know what's good in tech – no matter what platform it resides on.

INDEPENDENT REVIEWS

Championing technology doesn't mean we're unrelenting yes-men and -women, however, and *APC* aims to be as objective as possible in all our coverage. That means identifying the best products from multiple perspectives – the best performance, best value and best features and, ideally, the products that offer the best mix of these three.

As a matter of policy, reviews published in *APC* are not shared with product-makers prior to print. We will contact vendors under certain conditions; for example, if we have a problem testing a product that seems to indicate it may be faulty, or to invite a vendor to clarify how a particular feature works. If an *APC* reviewer has any potential conflicts of interest involving a brand, the review will always be assigned to another writer.

LABS TESTING

Despite being a small magazine with limited resources, *APC* still strives to conduct the most rigorous, objective scientific tests and benchmarks we can so as to make our reviews as unbiased as possible. We use a variety of tools and programs for this, including many freely available benchmark suites for assessing media encoding, general system performance, gaming and battery life.

In most cases, for the benchmark results published in *APC*, you can assume that higher is better. There are certain tests that deviate from this rule where the opposite is true; in those cases, we've flagged the results with a note explaining as such.

We use both tables and graphs for displaying results; the latter are our preference due to their ease-of-readability, but tables are more compact, so we use these in cases where thoroughness is preferred.

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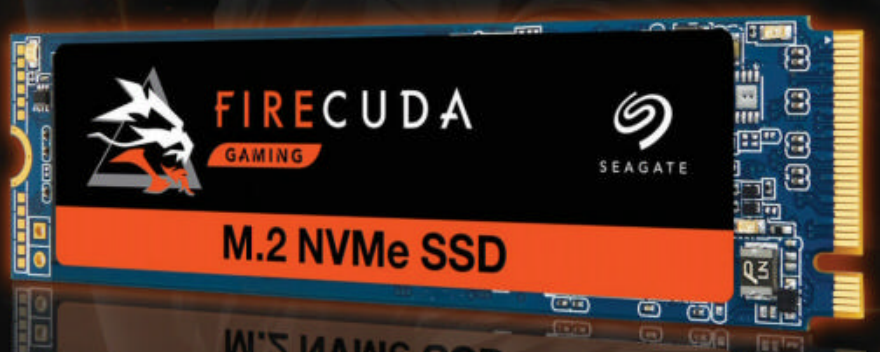

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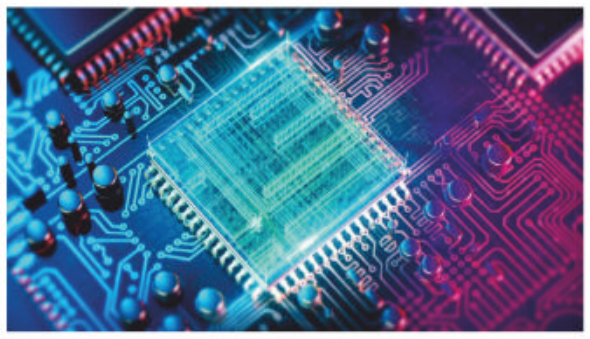
» HARRY DOMANSKI & BEN MANSILL BRING YOU THE NEED-TO-KNOW TECH NEWS



You will soon be able to hire your very own quantum computer from Amazon

AWS BRAKET – QUANTUM COMPUTING AS A SERVICE.

Naturally, quantum computers remain a very niche – not to mention hugely expensive – proposition, but there's no shortage of customers wanting to experiment with its power. The new AWS Braket service, revealed at the re:Invent 2019 conference, pairs up scientists and developers with quantum hardware providers and provides a unified development environment in which to operate.

New Android flagship phones in 2020 will use the Snapdragon 865 chipset

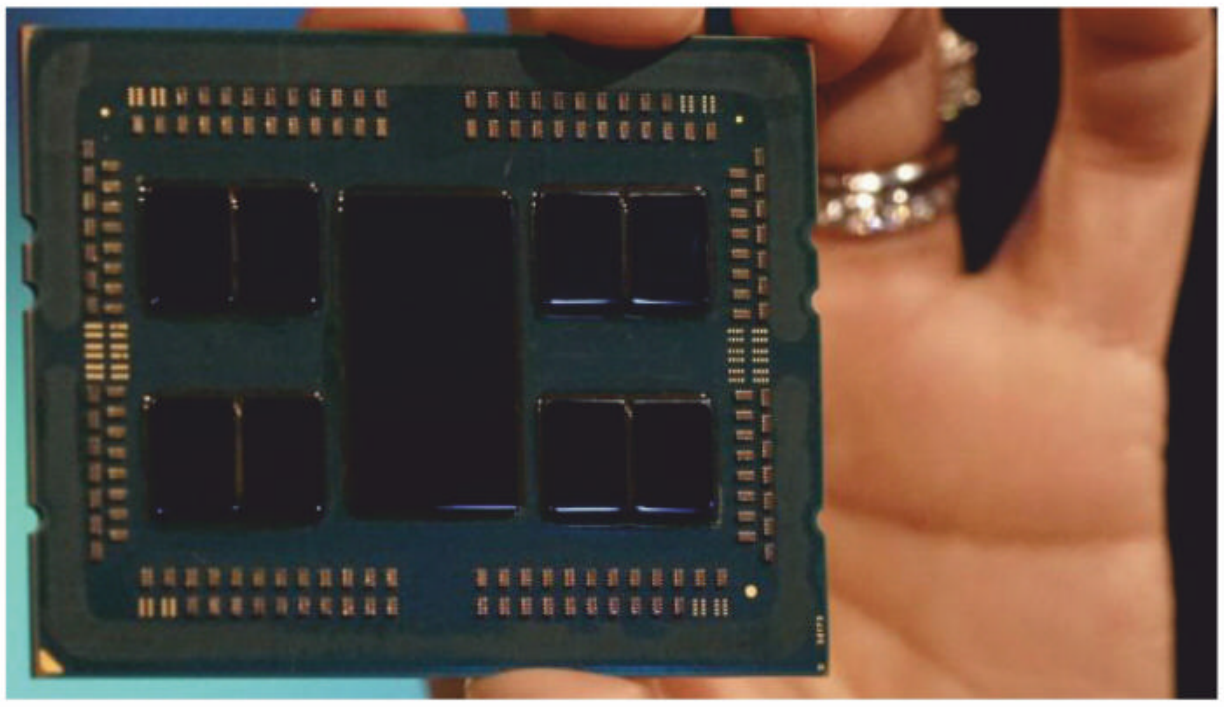
AND THE 765 COMES STOCK WITH 5G.

The Snapdragon 865 chipset (successor to the ubiquitous 855) was officially announced by Qualcomm at its annual Snapdragon Summit, with the company noting that it'll focus on 5G and AI capabilities. What's interesting is that there's going to be a second 5G chipset platform: the Snapdragon 765/765G. It'll have integrated 5G capabilities (highlighting the 865 chip does not), so hopefully we'll see some more affordable handsets get the new network standard.

Optus now offers the option to donate your data to children in need

CUSTOMERS CAN NOW DONATE UP TO 10GB PER MONTH.

Optus has begun to offer the ability for its customers to donate unused data to children living in poverty, ideally providing them with an increased capacity to work and study. Customers are able to select any amount up to 10GB to be donated from their monthly plan and can revoke the donation at any time. Optus will be providing free Optus SIM cards with unlimited calls and texts and the data that gets donated.



AMD announces 64-core/128-thread Threadripper 3990X

HOW – AND WHEN – WILL INTEL RESPOND TO THIS?

In an expected but much-anticipated announcement, AMD revealed that it has a 64-core 128-thread processor coming to market in 2020. The chip's beastly 280W TDP helps explain why AMD moved forward to the new sTRX4 socket, though, as the hefty processor will surely need a beefier power delivery subsystem.

The new Threadripper 3990X will likely drop into the newly-minted TRX40 platforms, but like the new Threadripper 3970X and 3960X, it won't be backward compatible with existing X399 motherboards.

Aside from noting that the chip will have an unbelievable 288MB of total cache, AMD didn't reveal any further details. However, given what we know about the Threadripper 3000 architecture, we know the chip will support PCIe 4.0, though the number of lanes it will expose to the user remains unknown.

The Threadripper 3000 series is based upon the same design as AMD's Epyc data center chips. As shown in the photo, the design will move from the four compute chiplets present on the Threadripper 3970X to an eight-chiplet design, just like the Epyc Rome processor. AMD says the Threadripper 3990X will arrive in 2020 but hasn't given a firm date.

Apple is buying Intel's modem chip business

CHIPMAKER SAYS IT SOLD BUSINESS AT A "MULTI-BILLION DOLLAR LOSS".

In a recent blog post, executive vice president and general counsel at Intel, Steven R. Rodgers explained that the chipmaker sold its smartphone modem chip business to Apple at a "multi-billion dollar loss", and was forced out of the market due to Qualcomm's patent licensing practices. He argued that the decision against the company should stand, saying: "We invested billions, hired thousands, acquired two companies and built innovative world-class products that eventually made their way into Apple's industry-leading iPhones, including the most recently released iPhone 11. But when all was said and done, Intel could not overcome the artificial and insurmountable barriers to fair competition created by Qualcomm's scheme and was forced to exit the market this year." Back in May, US District Judge Lucy Koh in San Jose wrote a 233-page decision in which she said that Qualcomm's patent licensing practices "strangled competition" in the modem chip market. Koh then ordered the company to renegotiate its licensing agreements to be more reasonable.

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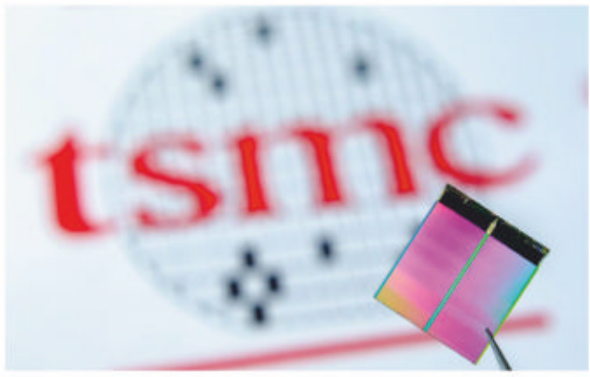


Chip-maker TSMC's prosperous 2019

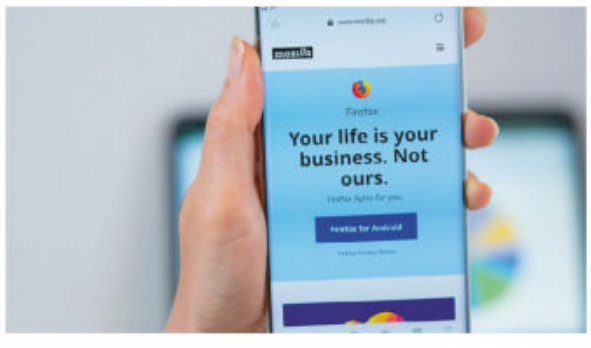
THE CHIP FOUNDRY IS NOW ASIA'S MOST VALUABLE COMPANY.

TSMC has became the most valuable company in Asia, with an 8.02 trillion New Taiwan Dollar ($385 billion) market cap. The company counts many leading tech companies as its customers – the likes of AMD, Nvidia and Apple all source at least some of their chips from TSMC – and demand for its semiconductors has been high, which is especially true of its 7nm chips.

Apple to launch new iPad, MacBook with miniLED displays in late 2020

THE WAIT COULD HAVE BEEN MUCH LONGER.

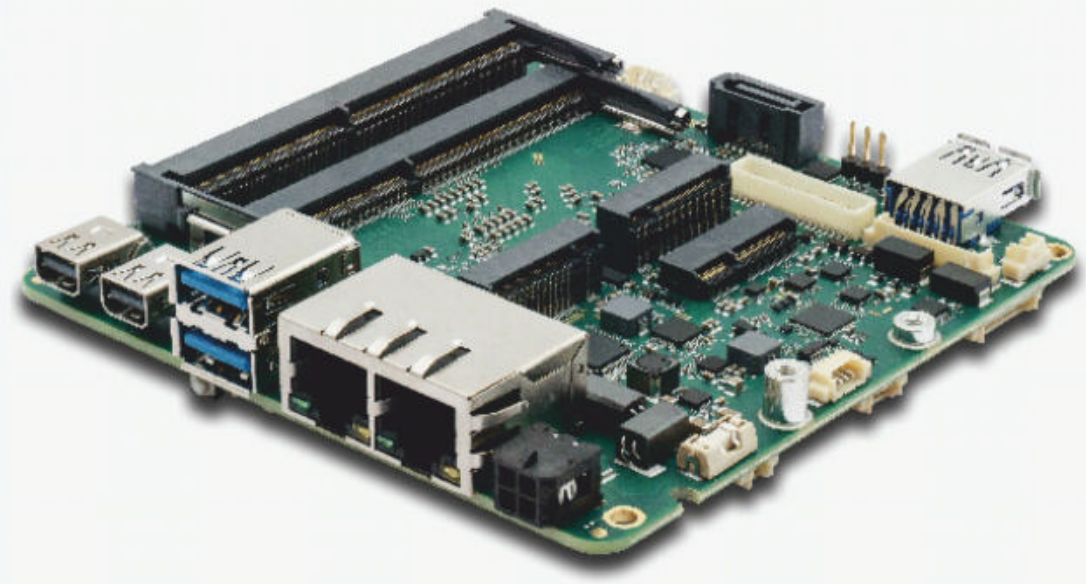
Rumours about an iPad Pro and 16-inch MacBook Pro with a MiniLED display have run rampant over the past few weeks. MiniLED uses more LEDs than OLED. These pixels are extremely tiny, which could give Apple the means of reducing the size of its products even further without sacrificing picture quality. According to industry insiders, the upcoming iPad Pro will arrive in Q3 of 2020 and will feature an A14X processor.



Mozilla drops top security tools over snooping fears

AVAST AND AVG EXTENSIONS FOUND COLLECTING USER DATA.

Mozilla has removed four Firefox extensions created by Avast and its subsidiary AVG after receiving credible reports that the extensions had harvested user data as well as user's browsing histories. The four extensions which have been removed are Avast Online Security, AVG Online Security, Avast SafePrice and AVG SafePrice. The snooping was discovered by AdBlock Plus' creator Wladimir Palant who sent a report to Mozilla.



AMD begins assault on NUC market

BROADENING ITS ASSAULT ON INTEL WITH A NEW LINE OF MINI PCS.

Intel's NUCs are small 'mini PCs' themselves, with fully-contained systems that often dip down to smaller than a litre. Intel designs and sells the motherboards for the barebone systems, and you can also order NUCs with components already installed, like memory and storage, from third-party retailers. However, the term 'NUC,' which is short for Next Unit of Computing, is an Intel branding for those small systems, so AMD has officially embraced 'Mini PC' branding, although a few of its partners are using NUC naming conventions for their products.

Unlike Intel's approach with NUCs, which involves creating the motherboards and selling them to third-party vendors that add their own differentiating features, AMD's Mini PC efforts consist of enabling an ecosystem of partners to use its Ryzen Embedded V1000 and R1000 processors as the linchpin for their own designs. AMD's R1000 series come as BGA-mounted SoCs, meaning they won't install in a normal desktop PC motherboard, and feature Zen+ CPU cores paired with the Vega 3 graphics engine.

Sundar Pichai is the new CEO of Google's parent company, Alphabet

LARRY PAGE AND SERGEY BRIN WILL CONTINUE TO BE BOARD MEMBERS.

Big things are changing in the Google and Alphabet world. Larry Page and Sergey Brin – the co-founders of both companies – published a letter announcing that Google CEO Sundar Pichai will be taking over as the new Alphabet CEO. "Going forward, Sundar will be the CEO of both Google and Alphabet. He will be the executive responsible and accountable for leading Google, and managing Alphabet's investment in our portfolio of Other Bets."

Page and Brin noted that "Alphabet and Google no longer need two CEOs and a President." As for their involvement with the companies, they note: "We are deeply committed to Google and Alphabet for the long term, and will remain actively involved as Board members, shareholders and co-founders. In addition, we plan to continue talking with Sundar regularly, especially on topics we're passionate about!"

Sundar has been leading Google as CEO since 2015, and he's worked with Page and Brin for over 15 years.

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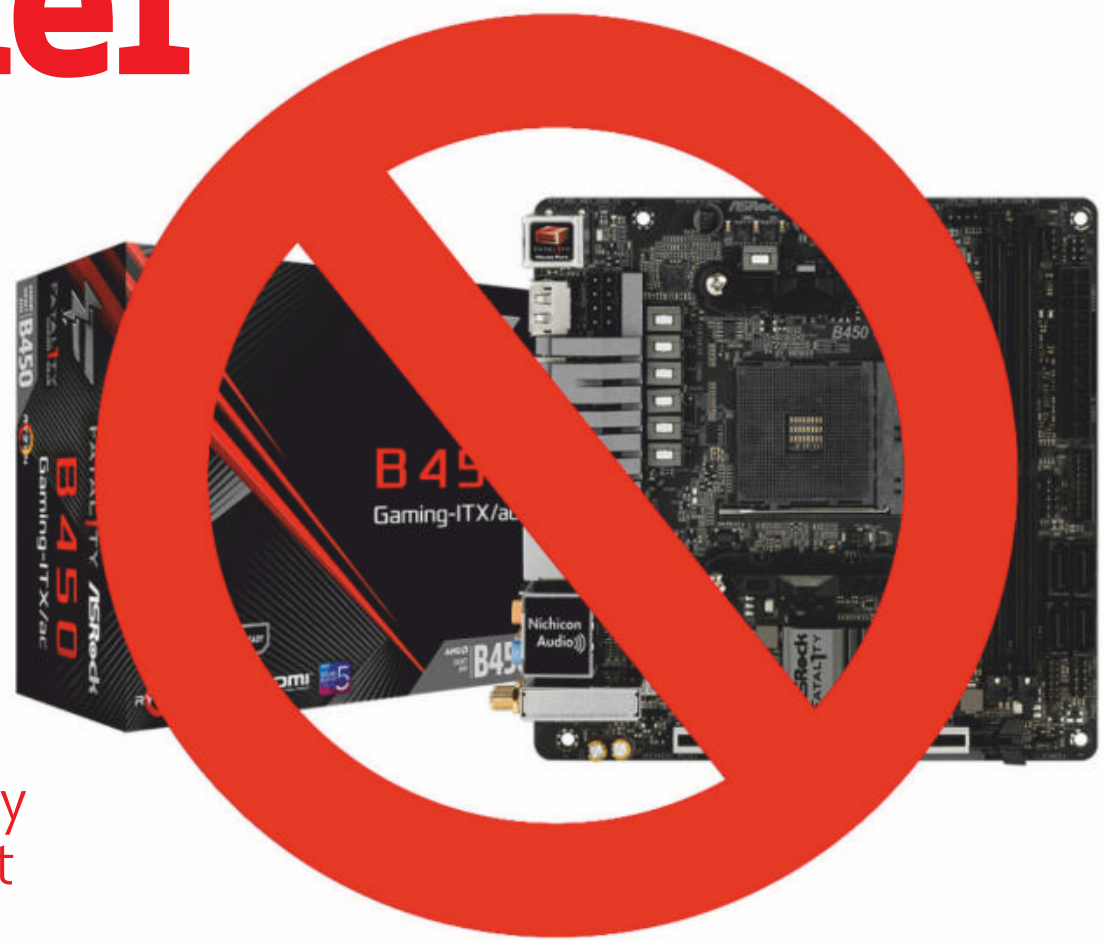

PCBye

It almost certainly won't really happen, but researchers want to ditch the motherboard.

University of California at Los Angeles researchers want to do the unthinkable: kill the motherboard. In a recent piece for IEEE Spectrum, the researchers said this act of technological matricide would enable the creation of more powerful systems that aren't constrained by the printed circuit board (PCB) used today, all thanks to a new silicon-interconnect fabric that can be used in the motherboard's stead.

The researchers, Puneet Gupta and Subramanian Iyer, said this change would enable the development of all kinds of systems. They contend that relying on PCBs makes it harder for companies to develop smaller devices like smartwatches while also inhibiting the growth of larger devices used in data centers. Their silicon-interconnect fabric is supposed to enable smaller and larger devices. They explained:

"Our research shows that the printed circuit board could be replaced with the same material that makes up the chips that are attached to it, namely silicon. Such a move would lead to smaller, lighter-weight systems for wearables and other size-constrained gadgets, and also to incredibly powerful high-performance computers that would pack dozens of servers' worth of computing capability onto a dinner-plate-size wafer of silicon."

Gupta and Iyer also said the silicon-interconnect fabric would allow chip makers to stop relying on "the (relatively) big, complicated, and difficult-to-manufacture systems-on-chips that currently run everything from smartphones to supercomputers." Instead they would be able to "use a conglomeration of smaller, simpler-to-design, and easier-to-manufacture chiplets tightly interconnected" on their fabric.

They note that relying on chiplets instead of SoCs isn't a novel idea. Intel, Nvidia and other semiconductor companies have explored the same concept. But the researchers want their silicon-interconnect fabric to go beyond the new packaging those companies are exploring to overcome what they view as fundamental problems with PCBs: their flexibility, their reliance on soldering and their size.

So how would they address those problems? It starts with "a relatively thick (500-µm to 1-mm) silicon wafer" to which "processors, memory dies, analog and RF chiplets, voltage-regulator modules, and even passive components such as inductors and capacitors can be directly bonded." That would also allow "micrometer-scale copper pillars built onto the silicon substrate" to replace solder bumps.

Those changes would "produce copper-to-copper bonds that are far more reliable than soldered bonds, with fewer materials involved," they said. But perhaps more importantly they would mean "the chip's I/O ports can be spaced as little as 10 µm apart instead of 500 µm" so one could "therefore pack 2,500 times as many I/O ports on the silicon die without needing the package as a space transformer."

Silicon would also be a better heat conductor than the FR-4 material currently used in PCBs, they said, allowing "up to 70 percent more" heat extraction when two heatsinks are placed on the sides of the silicon-interconnect fabric. Better heat extraction means better performing components that don't have to be artificially constrained because otherwise they'd get too hot to run safely.

> "Our research shows that the printed circuit board could be replaced with the same material that makes up the chips that are attached to it, namely silicon."

Those are just the benefits afforded to current form factors. The researchers believe silicon-interconnect fabric "should let system designers create computers that would otherwise be impossible, or at least extremely impractical," too. That's assuming development on the technology continues, of course. Right now they're addressing its potential, not promising it's ready to be used in the real world. **Nathaniel Mott**

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» GIZMOS AND GOODIES.

OSPREY TRANSPORTER

$149.95 | WWW.OSPREY.COM/AU

Christmas may be over for another year, but the Osprey Transporter will keep you feeling like Santa a little longer. There's three sizes in the range: 20, 25 and 30L, each with a slightly different access designs. The 20 and 30L packs feature a zip-top and flap while the 25L we looked at boasts a rolltop. It's essentially a giant sack for your stuff. There's a dedicated space inside for your 15-in lappy (the new Mac 16-in will easily fit), as well as more spots for documents and smaller items. Hidden on each flank on the outside are huge, zippered water bottle pockets. Yes, hydration is important, but we used one as a quick-acess space for our wallet and keys.

KOALA SUPER-GRIP PHONE HARNESS

~$35 | HANGTIMEGEAR.COM/

I can't be the only one to nearly drop my phone from a great height during my morning parkour to work. Hangtime Gear fortch has the sitch covered with the Koala, and the idea couldn't be simpler. It's a silicone mat (harness) that stretches over the edges of nearly any phone on the market (from the iPhone 6 to the Galaxy Note 10) and then attaches to clothes or backpack straps via a curly cord to a buckle. It's tough, too, so snagging won't be an issue; the harness itself will hold around 20kg before busting and the buckle releases at around 22kg.

KNEWKEY ROCKSETE

US$239 | KNEWKEY.COM

If any small part of you hankers for a keyboard that stands out from the rest, and Taiwan's all-out RGB + mechanical switch assault on the world is starting to feel samey – then perhaps this odd device fits your bill. The Rocksete from Knowkey – which is scheduled to start shipping early in the new year – is many things in one. Obviously in terms of appearance it's more than a little retro, and yes it does have backlighting, but a relatively classy white. It is also a Bluetooth speaker – because why not? The top area doubles as a laptop stand, and your phone or tablet can slot in here, too. Up to three supported devices can be switched between during use.

SEGWAY DIRT EBIKE

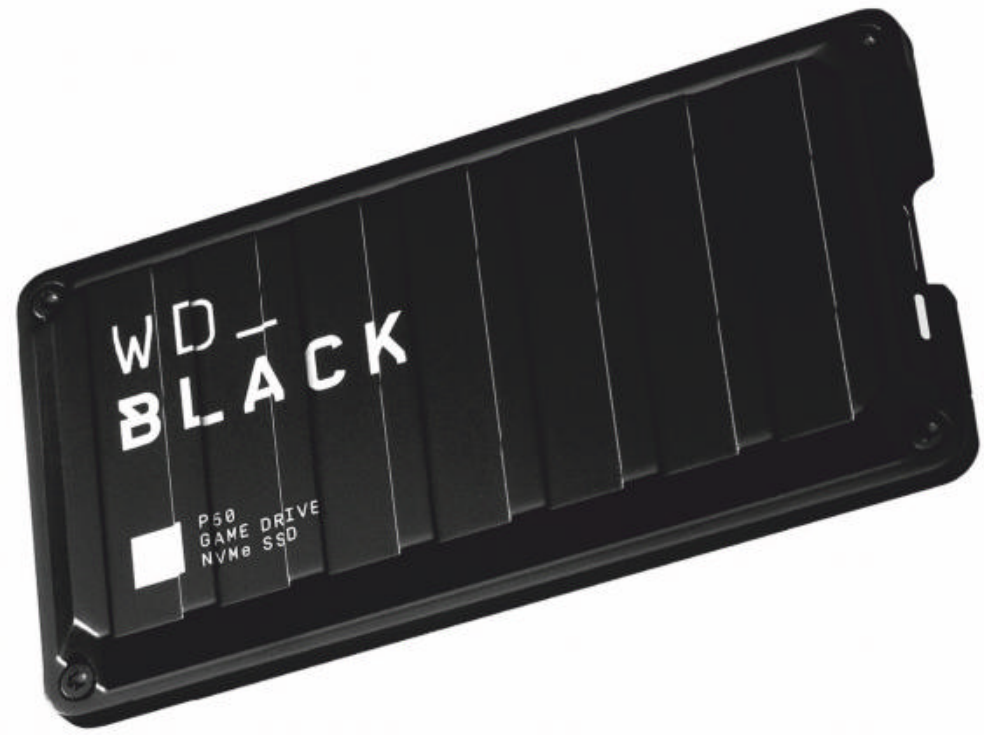
FROM $2,499 | IGG.ME/AT/SEGWAY-DIRT-EBIKE/X#/

Segway is generally considered the transport of choice for guided tours of people who like to take travel shots using their iPad, but the brand is keen on showing that it can do a lot more with a new electric dirt bike. The Segway Dirt eBike goes from 0 to 50 in 4 seconds, can reach a top speed of 75km/h and will last for either 65km or 120km, depending on the model you opt for. While this is a little under specced for proper dirt bikes, the two Segway Dirt eBikes weigh only 48 and 55kg, making them much more maneuverable than 100kg-plus petrol dirt bikes.

WD BLACK P50 GAME DRIVE

FROM US$150 | SHOP.WESTERNDIGITAL.COM

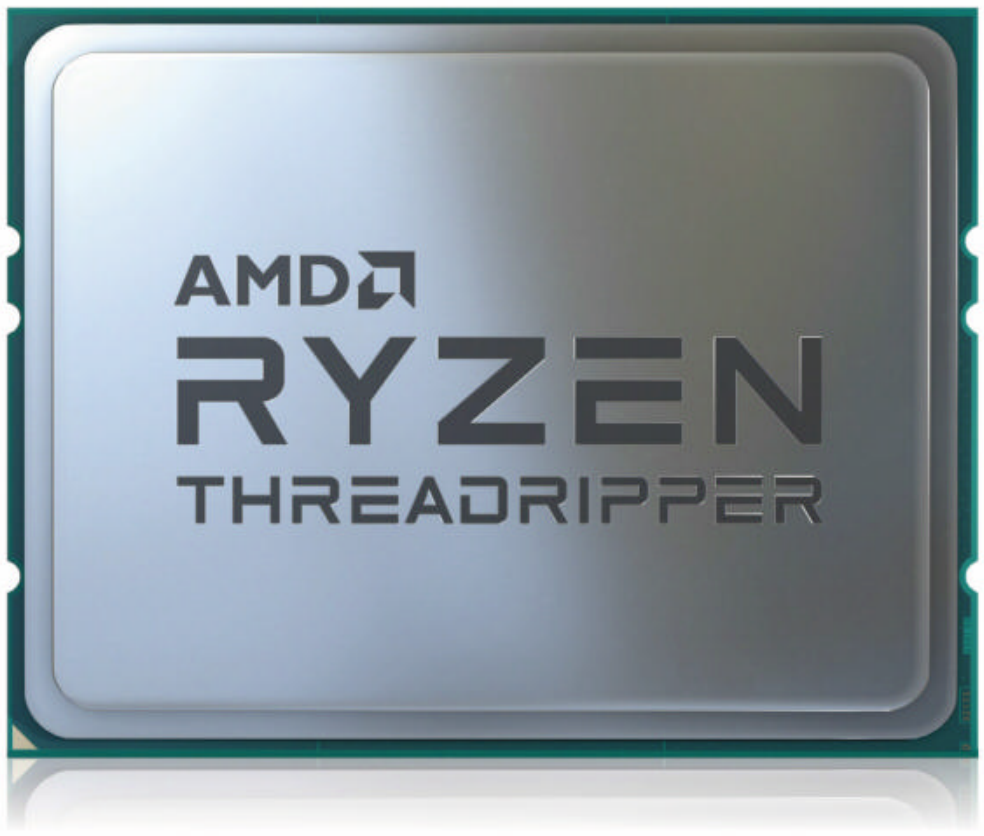
The USB 3.2 spec was announced back in February 2019, but it's only just starting to arrive on devices like WD's Black P50 Game Drive now. USB 3.2 is the third generation of USB 3 connection and basically adds an additional lane of USB 3.2 bandwidth to double the throughput from 10Gbps to 20Gbps. WD Black also uses an NVMe SSD that transfers information 4 times faster than SATA connected SSDs. In order to get the full 2,000MB/s speeds you'll need to have the latest USB 3.2 (Gen 2) interface on your PC, but even over USB 3.1 this drive should still be twice as fast as current portable SSDs.



GOPRO MAX

$799.95 | GOPRO.COM

GoPro's latest 360 camera includes on camera horizon levelling, stabilisation and hemisphere stitching, making the editing process for 360-video much simpler. The GoPro Max also gets a big app update that means you can edit 360-degree footage directly on your phone and share it as a spherical media file or cut and frame the parts you want into a 2D video file using the included over capture software. The new action camera is also smaller and lighter than its predecessor, which means it can fit on all of GoPro's existing mounts and it now has the ability to livestream a 2D video at 1080p.



Cores, cores and more cores

It's time for the software to catch up.

This month sees the launch of both Intel and AMD's high-end desktop platforms. Threadripper 3 in particular, as the name suggests, really increases the multi-threaded power available from a consumer level PC. Intel's 10980XE isn't exactly a sloth either with its 18 cores and high turbo clocks. The ever increasing number of cores available from the HEDT, and for that matter, the trend upwards in the number of cores available on the mainstream platforms begs the question: How many cores does the average consumer, gamer or PC enthusiast really need, and what's the point if software doesn't scale?

Having a CPU with a lot of cores looks good from many perspectives. But is a 16-core CPU twice as good as an 8-core one? We've got a 64-core CPU coming, but even with 32 cores, we see issues when benchmarking and testing. It all comes down to application scaling and multi-threaded support. Consumer level software has a long way to go, with much of it developed when a 64-core CPU wasn't on any roadmap. Professional software tends to be different, with things like rendering, CAD and scientific applications built to scale well with multi-socket and high core-count machines.

How much of this is relevant to a typical end user though? Even a prosumer or mega multitasker? A gamer, video encoder or developer (with exceptions) probably doesn't need more than 16-cores right now.

A year ago we'd have said multi-core performance on Windows was poor compared to the better optimised and MCM topology-aware Linux. That changed though with the release of the 1903 Windows build, which better allocated threads to the same core complexes, reducing the need to go via the I/O die, lowering latency, and therefore improving overall performance. Windows is getting better, but it's not perfect and it will be very interesting to see how it performs with an 8 x 8 core 3990X.

What about gaming? Over the course of our testing, we discovered that some games don't just fail to make use of a high core count, some games significantly regress in performance. *Metro: Exodus* is one where CPUs with 16 or more cores suffer from a performance hit. *Ghost Recon: Wildlands* is one that doesn't suffer at all, with a 24-core 3960X performing essentially identically to a 3700X or 3900X. Both games see the same behaviour on Intel systems. These variations across different games are tested on identical systems with identical drivers, meaning it's the game itself that causes these inconsistencies. If you're a gamer, stick with a 9700K or 3700X system and put the dollars saved towards a higher end GPU. You'll get better value for money and better performance too.

Threadripper is an amazing achievement, but it's only relevant if your software can make use of it. If your application can't make use of more than 16 or 32 threads, is a system with 64- or an eye popping 128-threads needed in 2019? Probably not, but we like the way things are going. CPUs with more cores will lead to improved software support and better performance. 'If you build it, they will come'. Come on then… We're waiting.

> "How many cores does the average consumer, gamer or PC enthusiast really need, and what's the point if software doesn't scale?"

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» SHAUN PRESCOTT DIGS INTO THE BIG TECH ISSUES.

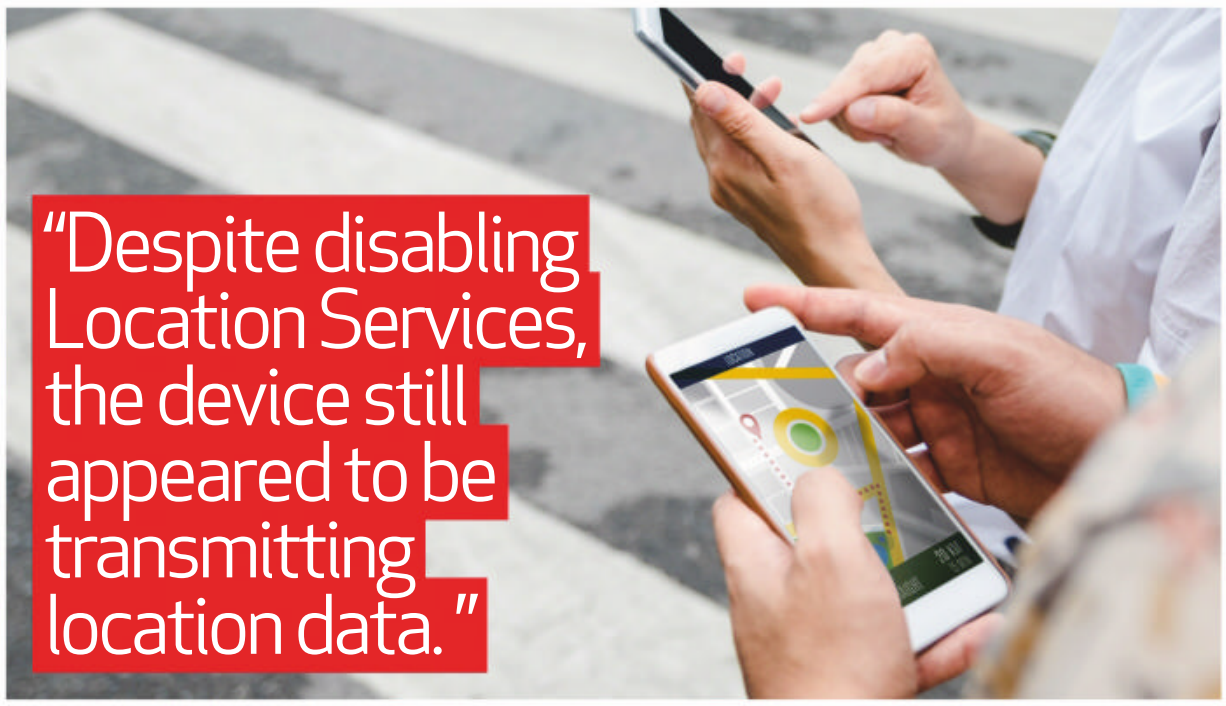
Apple's privacy credentials seem fine – but more disclosure is necessary

A recent "leak" in Location Services data demonstrates that the company needs to be upfront with users, writes Shaun Prescott.

As Google's invasive data collection practices become better known in the mainstream, Apple has positioned its iPhone brand as the best option for privacy conscious users. "What happens on your iPhone, stays on your iPhone" reads one of its recent advertising campaigns, and whether that's entirely true or not, it demonstrates that Apple wants to capture a portion of the market increasingly anxious about privacy.

So when it was discovered last month that the iPhone 11 Pro was sending out user location information, even when Location Services were entirely disabled, critics were rightly quick to pounce. Respected security reporter Brian Krebs broke the story, after discovering that despite disabling Location Services, the device still appeared to be transmitting location data. This breaches Apple's own privacy policy, but when Krebs contacted an Apple engineer on the matter, he was told that "the icon appears for system services that do not have a switch in Settings." In other words, this seemed to confirm that there were certain Location Services that it is not possible to toggle off (again, against Apple's own privacy policy).

Apple wasn't initially willing to offer any further explanation. But after several more publications picked up the story, the company explained that ultra wideband technology was the culprit. This is the technology behind Apple's AirDrop feature, some 5G functionality, and is rumoured to also play into an object tracking service Apple may roll out in the future (think tagging a set of keys and being able to search for it using your phone).



"Ultra wideband technology is an industry standard technology and is subject to international regulatory requirements that require it to be turned off in certain locations," Apple said in a statement sent to *TechCrunch*. "iOS uses Location Services to help determine if an iPhone is in these prohibited locations in order to disable ultra wideband and comply with regulations. The management of ultra wideband compliance and its use of location data is done entirely on the device and Apple is not collecting user location data."

It's about as reasonable an explanation as one could expect: there are locations where it is illegal to use ultra wideband technology, and so Apple needs to make sure the service is off if you happen to be in these locations. According to Apple, a future iOS update will allow users to deactivate AirDrop features, and therefore any ultra wideband technology related functionality on the phone, in order to allow a full deactivation of Location Services.

What it does demonstrate, is that some emerging technologies may rely on location functionality in order to operate – even software that doesn't immediately scream "we need your location data in order to function". While Apple's explanation is sound, it's worrying that it took the company several days to respond to criticism – and that it wasn't originally made clearer that turning off Location Services would still leave some (albeit legally necessary) Location Services operating. If Apple wants to boost its privacy credentials, making small harmless disclosures like this could only strengthen its position. ■

Share your stories!

If you have an interesting story about technology users, their experiences and the issues that affect us all (whether funny or serious), email us at **apcmag@futurenet.com**. All correspondence becomes the property of *APC* and is subject to editing. Letters must include writer's full name, street address, suburb, state and phone number to be considered for print publication. Address and phone details will not be published.

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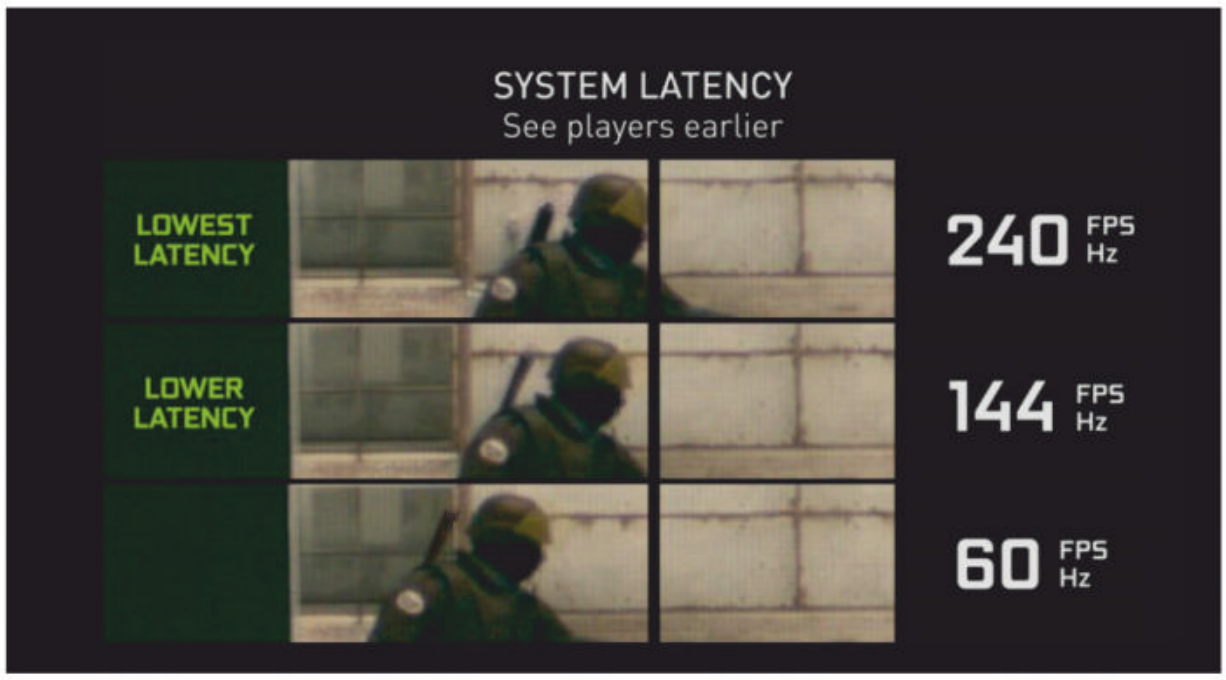
POLYCHROME SYNC

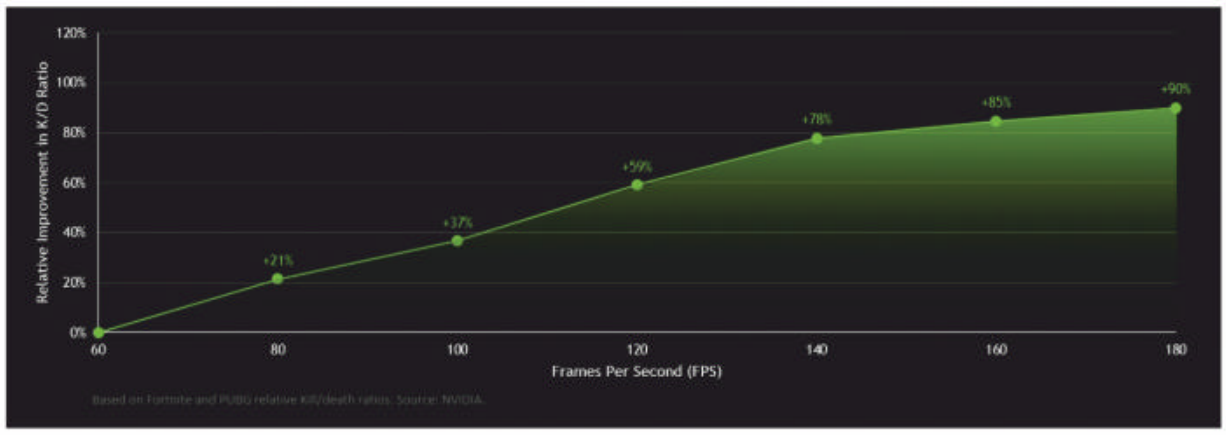
AMD RADEON RX 5700 XT

» JOEL BURGESS STEPS INTO THE FRAY.

Nvidia uses science to show the benefits of fast screens

The benefits of faster refresh screens in terms of gaming performance are often debated, but a new study from Nvidia says you'll be a better gamer with a faster monitor. Joel Burgess





There are many out there that have been advocating the benefits of high refresh rate, low latency gaming monitors for years now, and faster 144Hz displays are basically standard for FPS eSports pros – but we've often wondered how much benefit they offer the everyday gamer. Finally we have more than marketing spiels and bandwagon testimonials on how speedy screens actually improve gaming performance for everyone. While the research does come from Nvidia itself (which has a pretty obvious vested interest in promoting gaming GPUs and high-refresh screen technology), there's also perhaps no company with as much access to relevant data and there are some third party tech reviewers that have shown similar results.

Basically, Nvidia used data from an earlier study it did in March 2019 on how its GPUs affected kill-to-death (KD) ratios to show that higher screen refresh rates also significantly increase a players kill-to-death ratio. Nvidia plotted this data on a graph to show you have a 37% better kill-to-death ratio with a 100Hz monitor than a regular 60Hz screen, a 59% better KD ratio with a 120Hz display, a 78% better ratio at 140Hz and more than a 90% improvement for anything over 180fps. That's a pretty compelling reason to upgrade your gaming rig with a faster display.

These numbers seem massive, which is perhaps why Nvidia has provided a number of reasons for the strong correlation between higher latency and better kill to death ratios. Nvidia's blog post claims that faster refresh rates create notably smoother animations, which are easier for your eyes to track. Then the higher refresh rate reduces the size and effect of ghosting or partial object rendering which can lag behind moving objects and be distracting. Faster monitors will also have less pronounced screen tearing effects since there is less time between frames and therefore less of an opportunity to miss-align different frames. The last point that Nvidia stresses is that faster screens have a lower latency which means you will actually see players earlier if they emerge from behind objects on-screen. All of these features provide distinct advantages to gamers in competitive FPS titles and show how faster screens can have a significant impact on your performance.

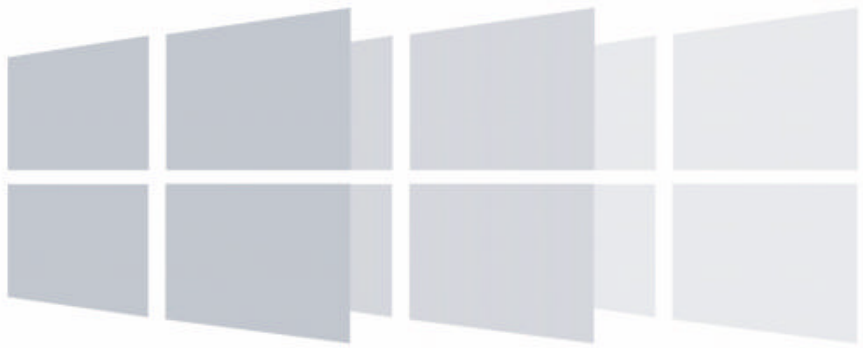
> "Nvidia has provided a number of reasons for the strong correlation between higher latency and better kill-to-death ratios."

The *Linus Tech Tips* Youtube channel ran a much smaller, but more detailed study on the effects of faster screen refresh rates on response time and shot accuracy in *CS: GO* back in June of 2019. This test found that response time was reduced by more than just the 12ms difference in latency between a 60Hz and a 240Hz displays, something that they suggested could be due to smoother visuals allowing for faster tracking and shorter response times. The study also showed that the shots taken on higher framerate settings were significantly more accurate and closer to the target on the whole than shots fired on 60Hz settings.

So there you have it, if you want to be twice as good at first person shooters, all you have to do is fork out for a much faster monitor. ■

numbercrunch

» WE LOOK AT THE NUMBERS DRIVING THE BIG TECH NEWS.



19H2

Is the next big Windows 10 update. Known as 19H2 as it has passed through the Insider testing rings, the final name is the Windows 10 November 2019 Update. Brace yourselves.

24%

Of Australian businesses plan to adopt 5G within three years. 37 percent are taking a "considered" outlook to 5G adoption, according to research by Tech Research Asia.

FORTNITE

171,000

Was the peak number of viewers of the official *Fortnite* Twitch channel as the popular multiplayer game sat there doing nothing last month. To cover server upgrades associated with the end of its first 'chapter', the entire game world was sucked into a black hole, which stayed for nearly two days before regurgitating a new level.

29%

Of the global smartphone market is entirely China, where over 100 million handsets were sold in the third quarter of 2018 alone.

7

Of the high-profile partners in the Libra Association – the teams building Facebook's putative digital currency – have quit the consortium. This includes big names such as PayPal, eBay, Visa and Mastercard.

360%

Is the shocking rise in tax-based phone scams being reported. There were 60,000 such incidents in the six months to January 2019, over three times higher than the previous six months.

howit'sdone

Fairphone 3

Ethical repairability FTW.

Removing the motherboard, we discover a bunch of spring contacts.

You can tear many of the modules apart as well – a real boon for fixing problems.

"Good things come in threes," the Dutch social enterprise must have thought when planning the Fairphone 3, its newest ethically made mobile device, sporting a modular and repairable design.

MAJOR TECH SPECS

- 5.65-inch IPS display with 1080x2160 resolution (427 ppi)
- Qualcomm Snapdragon 632 SoC
- 4GB of RAM and 64GB of storage
- 12MP f/1.8 rear camera and front-facing 8MP f/2.0 camera
- 3,060mAh battery
- Fingerprint sensor, headphone jack, and IP54 rating

KEY FINDINGS

- We start by removing the back cover – no tools needed. Compared to the bumper-like casing of the Fairphone 2 – as well as the two-piece "slim" version that replaced it midway through the product cycle – this is definitely an improvement. If you liked the added protection offered by the bumper, no worries – it's included in the box.
- Removing the battery is also easy as Android 9 – it lifts out using the notch at the bottom. With recessed contacts and sturdier plastic casing, it's a well-protected throwback we're happy to see. At 11.781Wh (3,060mAh at 3.85V), this juice box is not the biggest around, but it should get you through the day – and if it doesn't, you can carry a spare and swap it out. It beats the Google Pixel 3a in capacity (11.55Wh) but can't quite touch the iPhone Xs Max (12.08Wh), let alone the Shift 6m (16.3Wh). The underside of the battery bears an encouraging message: "Well done. You're what progress looks like." Speaking of which, it's time to make some more teardown progress. Onward!
- Fairphone decided to forgo the nifty display lock mechanism from the previous iteration, opting for standard Phillips #00 screws instead. There's even a tiny screwdriver provided. With the screws gone, we unsnap the display from the frame – revealing the same pogo pin connector plus breakout board configuration seen in the Fairphone 2. Note the map of the Democratic Republic of Congo here, illustrating the conflict-free sourcing of minerals such as tantalum, tin, tungsten, and gold.
- The Fairphone 3 comes with a family of modules: top module, camera module, and bottom module, much like in the Fairphone 2. The loudspeaker now gets its own closed module (as opposed to being part of the bottom module), and connects to the rear of the bottom module. If you hope to upgrade your Fairphone 2 with these modules, it's bad news: Modules and their inner parts are not compatible. But their housings are said to be produced from 50 percent recycled polycarbonate, so there's some reuse.
- Repairability Score: 10 out of 10 (10 is easiest to repair). Key components like the battery and screen have been prioritised in the design and are accessible either without tools or with a regular Phillips screwdriver. Visual cues inside the phone help with disassembling and replacing its parts and modules. Replacing complete modules is very easy. Going for their internal parts is also possible and requires a Torx screwdriver. Replacement guides and spare parts are available via the manufacturer's website. Most components inside the modules are individually replaceable, although some are soldered on. ■

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Head to head: Ultrabooks

Sophisticated and slim laptops that deliver exceptional performance for productivity and creative endeavours.

1 Matebook 13

$1,599, WWW.HUAWEI.COM

Huawei has been biding its time to take on the best Ultrabooks. But now, their time in the limelight is here. Like the Huawei MateBook X Pro before it, the Huawei Matebook 13 packs a ton of powerful hardware into a gorgeous shell, all while offering it at a price that's more than reasonable. Those discrete graphics are also worth a mention – the Huawei Matebook 13 may be one of the tiniest laptops out there to come with an MX150 GPU. It's not hard to see why the Huawei Matebook 13 is the best Ultrabook right now.

★★★★★

2 XPS 13

$2,038, WWW.DELL.COM

The Dell XPS 13 has been king of the Ultrabooks for years, and while it's been unseated by the Huawei MateBook 13, it remains one of the Ultrabooks to beat. This time around, Dell has moved the webcam from the bottom of the display back to the top, fixing one of the biggest flaws that held back the XPS 13 for years. Add the updated internal components to the mix, and the Dell XPS 13 still makes the best Ultrabooks list – even in the face of tough competition.

★★★★½

3 Matebook X Pro (2018)

$2,448, WWW.HUAWEI.COM

Sometimes an Ultrabook arrives that totally changes everything. When the 2018 model of the Huawei MateBook X Pro hit the scene, it did just that. This beautiful Ultrabook brings high-end components into an elegantly designed package that puts even the MacBook Pro to shame. It really is one of the best Ultrabooks on the market, despite its 2019 successor's attempts to best it with an Intel Whiskey Lake processor. It's still the 2018 model that's captured our computing cores.

★★★★☆

The best Ultrabooks are more than just status symbols. They're the ideal grab and go machines, which means that you can edit your photos, render your videos and power through your work, no matter if you're on a train, at a café, or in between classes.

Ever so light and compact, they now pack more power than ever before, coming equipped with the best processors and SSDs out there. They truly are powerful little devices that can help you breeze through projects like no one's business.

And, frequently, that power is paired with a pretty extraordinary battery life that may last you an entire work day on one full charge.

4

Spectre x360

$1,999, WWW.HP.COM

If an arresting Ultrabook housing 2-in-1 functionality and a ton of power satisfies what you're looking for, it's hard to find a better laptop than the HP Spectre x360. This slim and light Ultrabook isn't just filled with the latest Intel Whiskey Lake processors and plenty of RAM. It also might just be the most exquisite laptop you can buy today. The HP Spectre x360 won't just get you through your workload, but will also make you smart and stylish in the process.

4.5 stars

5

Surface Laptop 2

$1,270, WWW.MICROSOFT.COM

The original Microsoft Surface Laptop was a great Ultrabook, but had relatively weak internals and Windows 10 S. Fortunately, Microsoft rolled out the Surface Laptop 2 in late 2018, offering quad-core processors and the full-fat version of Windows 10. It's through these fundamental improvements that the Surface Laptop 2 is able to bring the purest Windows 10 experience to a laptop – and with the newer Laptop 3 machines just released, while brilliant, it's made pricing on the Laptop 2 so very appealing.

4.5 stars

6

Yoga C930

$2,799, WWW.LENOVO.COM

The Lenovo Yoga C930 has quite a few of the makings of the best Ultrabook – from an absurd 14.5 hours of battery life and dual Thunderbolt-enabled USB-C ports to internal components that will easily handle those daily productivity tasks. That's without even considering it's a 2-in-1 that offers form versatility so you can squeeze in some light gaming and movie-watching once you're done working. It has a few cherries on top as well, specifically the integrated self-charging stylus and the fab speaker system.

3 stars

thelab

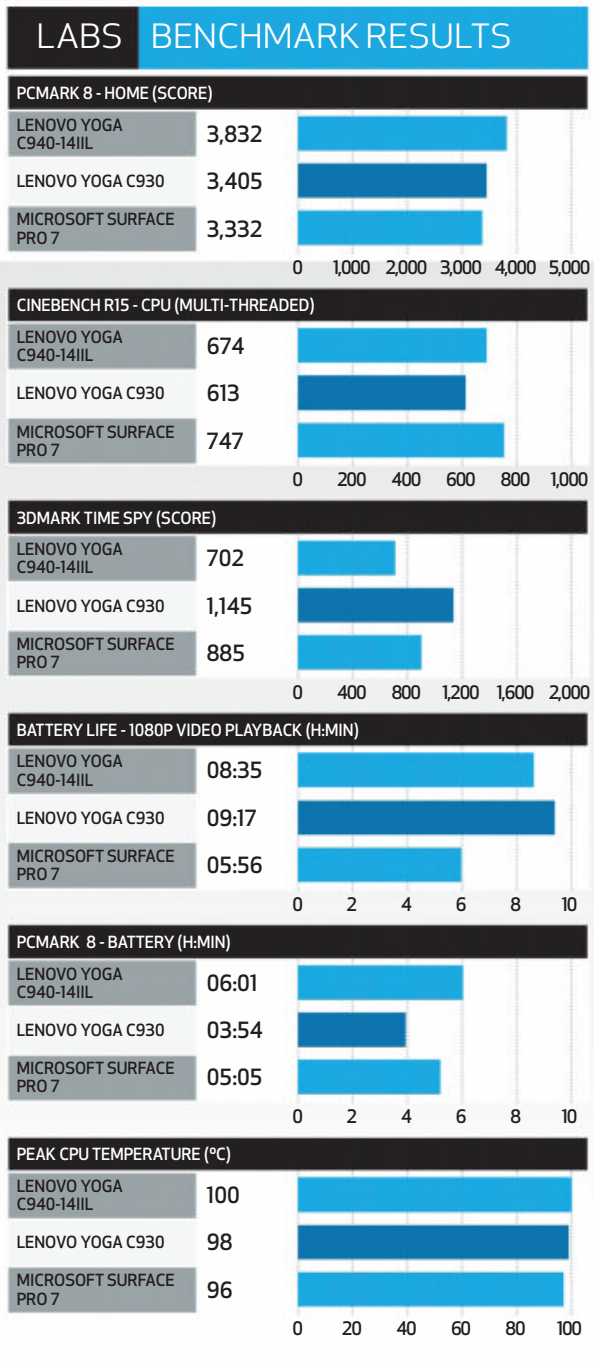
» LATEST REVIEWS

2-IN-1

$2,996 | WWW.LENOVO.COM

Lenovo Yoga C940

Lenovo's flagship convertible joins Intel's Project Athena cohort with 10th gen CPUs that improve AI processing and battery life.



We gave Lenovo's Yoga C930 five out of five in *APC*'s September edition (APC471), so this yearly update has some big shoes to fill. Like the Surface Pro 7 in this issue, the Yoga C940 is sporting one of Intel's latest 10th generation 10nm Ice lake CPUs that bring with it Wi-Fi 6, better AI processing and a new GPU. The C940 is supposed to be one of the first laptops to be certified under Intel's new Athena project – where Intel works with manufacturers to ensure the device has an all day battery life, instant on responsiveness and new low-power sleep states.

Lenovo is hoping to leverage the new Intel AI tech by developing a software called Q-Control which will use AI to monitor usage patterns and tweak system component power to optimise efficiency. While this software was not available at launch, Lenovo stated that it would be rolled out via its Lenovo Vantage hub before the end of 2019. Lenovo claims that this feature can extend the battery life of the FHD model to 17.5 hours. We haven't had the chance to actually test Q-Control's capabilities yet, but we expect its benefits to be more conservative under general usage conditions.

APC tested a Yoga C940 with a 14-inch FHD display, Intel Core i7-1065G7, 16GB of RAM and a 512GB PCIe SSD which retails for $2,996 at Officeworks. At the time of writing, Bing Lee was selling a Yoga C940 with a 14-inch UHD HDR display, an Intel Core i7-1065G7 CPU, 16GB of RAM and a 1TB SSD for just $3 more at $2,999. Considering the latter has a Dolby Vision Vesa HDR 400 certified screen and double the SSD storage, it would be silly not to go for the better model at this price, even if it will reduce the battery life.

The Yoga C940 was between five and 21% better than the Yoga C930 in all our CPU and general performance benchmarks, averaging out to around 10% across most tasks. If we put the Yoga C940 against the Surface Pro 7 with the same i7 CPU and 16GB of RAM the two largely perform at a similar level. The C940 was up to 10% better in general workloads while the Surface Pro 7 was up to 10% better on multi-threaded CPU tests.

One thing that was worth noting is that the Yoga runs hot, with the optimised CPU regularly hitting 100-degrees. We would usually say that pushing a CPU this hard would reduce the battery lifespan, but the C940 seems to have compensated by including a generous 57Wh battery that lasts more than six hours in PCMark 8 and eight hours and 35 minutes during 1080p movie playback. Sustained exposure to temperatures of 100 degrees and above is however likely to reduce the longevity of the processor.

Since the C940 has returned with the Yoga's clever Dolby Atmos speaker hinge, a decent keyboard, a fingerprint reader, a physical webcam shutter and a rear mounted stylus, the C940 is a good upgrade that adds battery life and better performance to an already solid convertible. Hopefully the forthcoming software improvements will add additional bonuses.

Joel Burgess

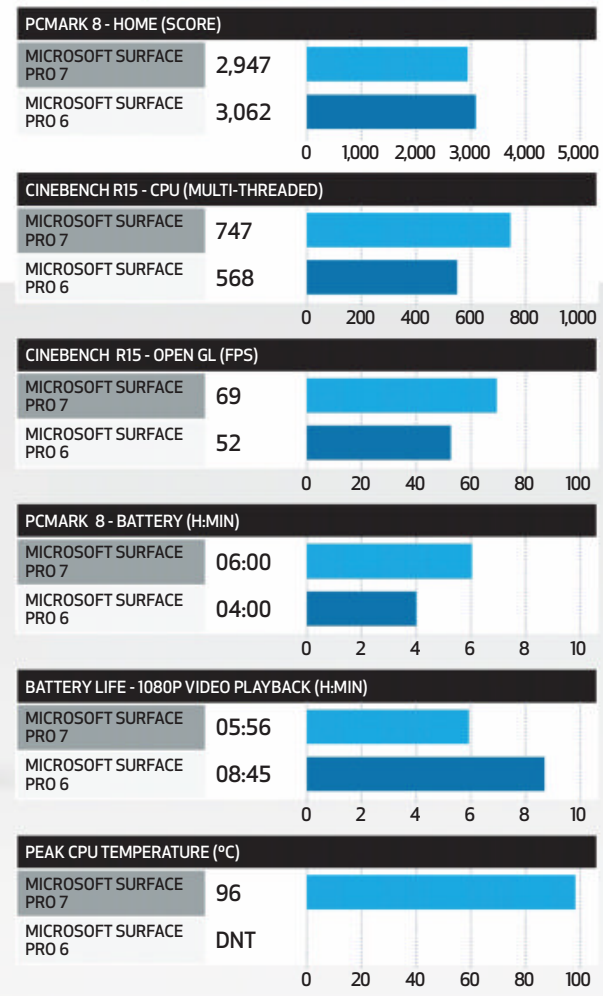
Verdict

The flagship Yoga 2-in-1 gets a performance bump, better battery life and some novel AI-powered features.

2-IN-1

FROM $1,249 | MICROSOFT.COM

LABS BENCHMARK RESULTS



Microsoft Surface Pro 7

Are there enough updates to justify a whole new model?

While all computer manufacturers do their best to keep some consistency between device updates, few take the commitment quite as seriously as Microsoft. Its latest Surface Pro 7 uses the same 12.3-inch, 3 x 2 PixelSense display at the same 2,736 by 1,824 resolution as its two most recent predecessors. It also fits into the same 29 x 20 x 0.9cm chassis and weighs an almost identical 790g.

If we then consider the Surface Pro 7 also offers the same four, eight and 16GB RAM configurations and identical 128GB to 1TB storage options, then the only real difference between the confusingly named (5th Gen) Surface Pro, its successor the Surface Pro 6, and the latest Surface Pro 7, is the processor.

On the Surface Pro 7 the CPU has been updated to one of Intel's latest 10th Gen processors and the majority of this device's novel feature-set are thanks largely to this update. Regardless of whether you get the Core i3-1005G1, the Core i5-1035G4 or the Core i7-1065G7, you will have access to the new faster Wi-Fi 6 802.11ax specification, allowing you to connect four times as many devices on a single network. These processors are also said to include noteworthy integrated GPU performance boosts and dedicated AI processing capabilities.

For most people the obvious distinction is that Microsoft has finally swapped out the Mini DisplayPort for a USB 3.1 Type-C interface, alongside its existing USB 3.1 Type-A port. This, unfortunately, isn't the updated USB 3.2 spec that was starting to emerge at the end of 2019, but it will at least be compatible with these devices with a 10Gbit/s max throughput.

> "Microsoft has finally swapped out the Mini DisplayPort for a USB 3.1 Type-C interface."

We tested the most powerful Surface Pro 7 with a Core i7-1065G7 CPU, 16GB of RAM, and a 256GB Hitachi PCIe SSD. In R15 multi-threaded CPU benchmarks, the Surface Pro 7 was 31.5% better than the Surface Pro 6 and 87.6% faster than the Surface Pro (5). This iterative improvement makes sense when you consider the Surface Pro 6 doubled the number of CPU cores from its predecessor, and the Surface Pro 7 uses more efficient 10mm Ice Lake processors.

The GPU seems to perform much better than that on the Surface Pro (5) getting 95% better performance on 3D Mark's Time Spy Benchmark and 11% better in Cinebench R15 Open GL framerates. This might seem like an unfair comparison, but the GPU actually got worse on the Surface Pro 6 going to an Intel UHD Graphics 620 from the Surface Pro (5)'s Intel Iris Plus Graphics 640.

While the Surface Pro 7 still has a 46Wh battery, the more efficient CPU and lower base clock speed should help it get closer to six hours in PCMark 8 battery benchmarks compared to 4 hours, and 4 hours and 20 minutes on the Surface Pro 6 and (5), respectively.

While there are some improvements to be had, the Surface Pro 7 essentially amounts to a new USB-C connection and a faster set of processors, which isn't really a whole lot of innovation. ■ **Joel Burgess**

Verdict

A highly portable 2-in-1 that offers a decent CPU performance bump to an already powerful and compact PC.

CPU

$1,219 | WWW.AMD.COM

AMD Ryzen 9 3950X

AMD redefines what's possible from a mainstream CPU.

When AMD launched its Ryzen 3 range back in June 2019, we were teased with the 16-core 3950X CP. Straight up – the 3950X completely redefines what a mainstream CPU is capable of. It lights a fire under the HEDT platform. It's almost obsoleted the entire Intel X299 platform. It's the jewel in the crown of AMD's range.

It's not often that we use the word 'revolutionary' when it comes to desktop CPUs, but that's exactly what the 3950X is. Just a couple of years ago, an 8- or 10-core CPU was an HEDT flagship, requiring an expensive motherboard and quad channel memory. Now, we have the option of a genuinely high performance 16-core CPU that can be installed in a budget B450 motherboard with a cheapie dual channel memory kit. It's no slouch when given lightly threaded loads either. Revolutionary indeed.

The 3950X is a multi-chip module design, with two 7nm 8-core chiplets connected to a central I/O die. You get 64MB of L3 cache which helps to minimise latency-inducing main memory accesses. It's got a 3.5GHz base clock, though particularly notable is its 4.7GHz boost clock which adds tremendous single threading prowess to its obvious multi core strength. It does all this with a 105W TDP. Sixteen high performance cores at 105W! We had just had to say it twice. Do note, though, that it doesn't come with a cooler, so be prepared to budget extra for a high-end air cooler or all-in-one water cooler.

It's time to talk about how this beast performs. As you can see in the benchmarks, most of the time it's in front of Intel's HEDT flagship 10980XE. Even with this CPU's price almost halved vs Intel's own outgoing 9980XE, Team Blue's best is still significantly more expensive than the 3950X. A 9900K still rules the roost in gaming, where maximum FPS is the requirement, but in anything that makes use of multiple cores, the 3950X obliterates it, all the while using less power and running cooler. Still, if gaming is your focus, then you'll be better served with something like an Intel 9700K or Ryzen 3700X and putting the money saved towards a faster GPU.

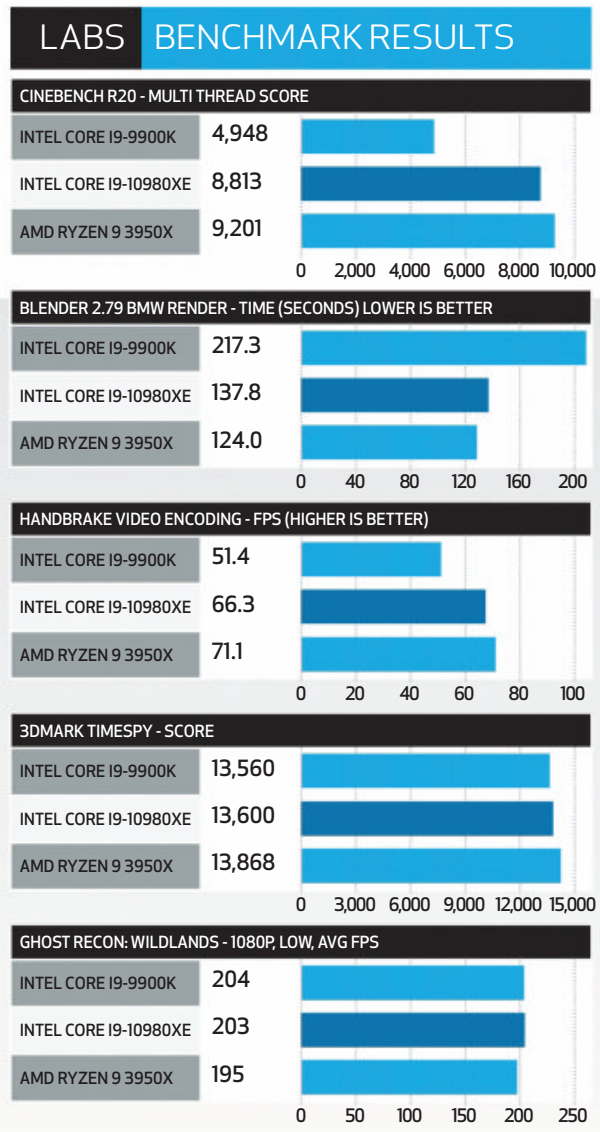
We expected the 3950X to run a bit hot, but an all-core load of 73 degrees C was totally acceptable. Power consumption was a little higher than we expected at 131W for the whole package – higher than AMD's quoted 105W TDP, but compare that to 229W for the 10980XE when loaded and suddenly it looks downright thrifty.

AMD has completely redefined what a mainstream platform and PC is capable of. At $1,200 for a CPU, it's never going to be called cheap, but compare that to what was on offer from the $2,799 Intel i9-9980XE just a few weeks ago. If 16 cores isn't enough, There's always the 3rd generation Threadrippers, starting with our review of the 3960X on the following page.

If you're a content creator, mega multi-tasker or make use of applications that can scale and utilise those 32 threads, there is simply no better CPU on the market right now, and perhaps for the foreseeable future as well. ■

Chris Szewczyk

LABS BENCHMARK RESULTS

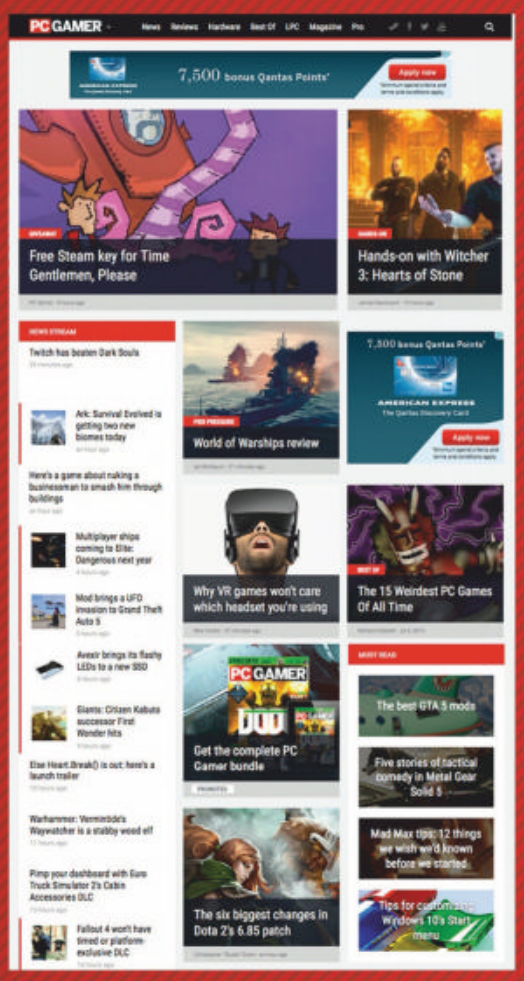


Verdict

The 3950X is the new desktop king.

★★★★★

SMARTER COOKIES ENABLED



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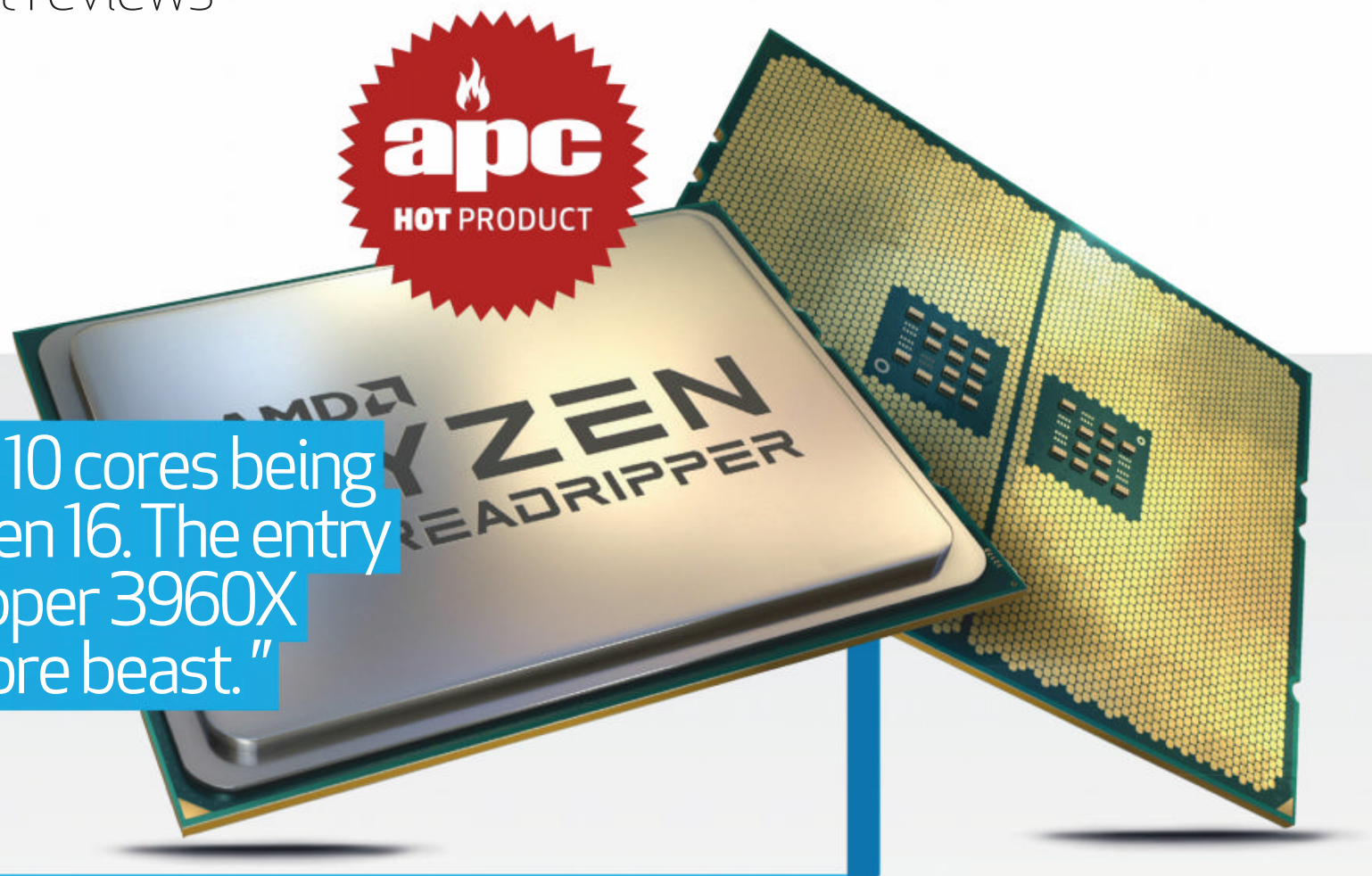


"Forget about 10 cores being high end, or even 16. The entry level Threadripper 3960X CPU, is a 24-core beast."

CPU

$2,249 | WWW.AMD.COM

AMD Ryzen Threadripper 3960X

AMD takes the HEDT crown.

The launch of Ryzen 3 has proven to be a great news story for AMD. It continues to produce products with more cores and performance and with the Threadripper 3 series, the HEDT takes another massive step forward. Forget about 10 cores being high end, or even 16. Now, the entry level Threadripper 3960X CPU, which we're reviewing here, is a 24-core beast. It doesn't stop there. AMD has announced the 3990X, a 64-core behemoth of a CPU that's due to launch in 2020.

The 3960X, with its 24 cores and 48 threads effectively makes Intel's competing X299 platform redundant where pure multi-threaded performance is concerned. At $2,249, plus the high cost of TRX40 motherboards, there comes a jump up in price too.

The 3960X isn't all about lots of 'slow' cores. Its single threaded performance should be as good as any other Ryzen 3rd-gen CPU thanks to its 4.5GHz boost clock, all that L3 cache and the other latency enhancing improvements introduced with the Zen 2 architecture. There's also the improved 7nm manufacturing process which leads to better power efficiency. Power efficiency might not be immediately apparent as both the 3960X and 32-core 3970X have a 280W TDP – higher than the 250W of Threadripper 2 CPUs. The base clocks in particular have been substantially increased with Threadripper 3 meaning performance per watt is actually better despite the higher TDP.

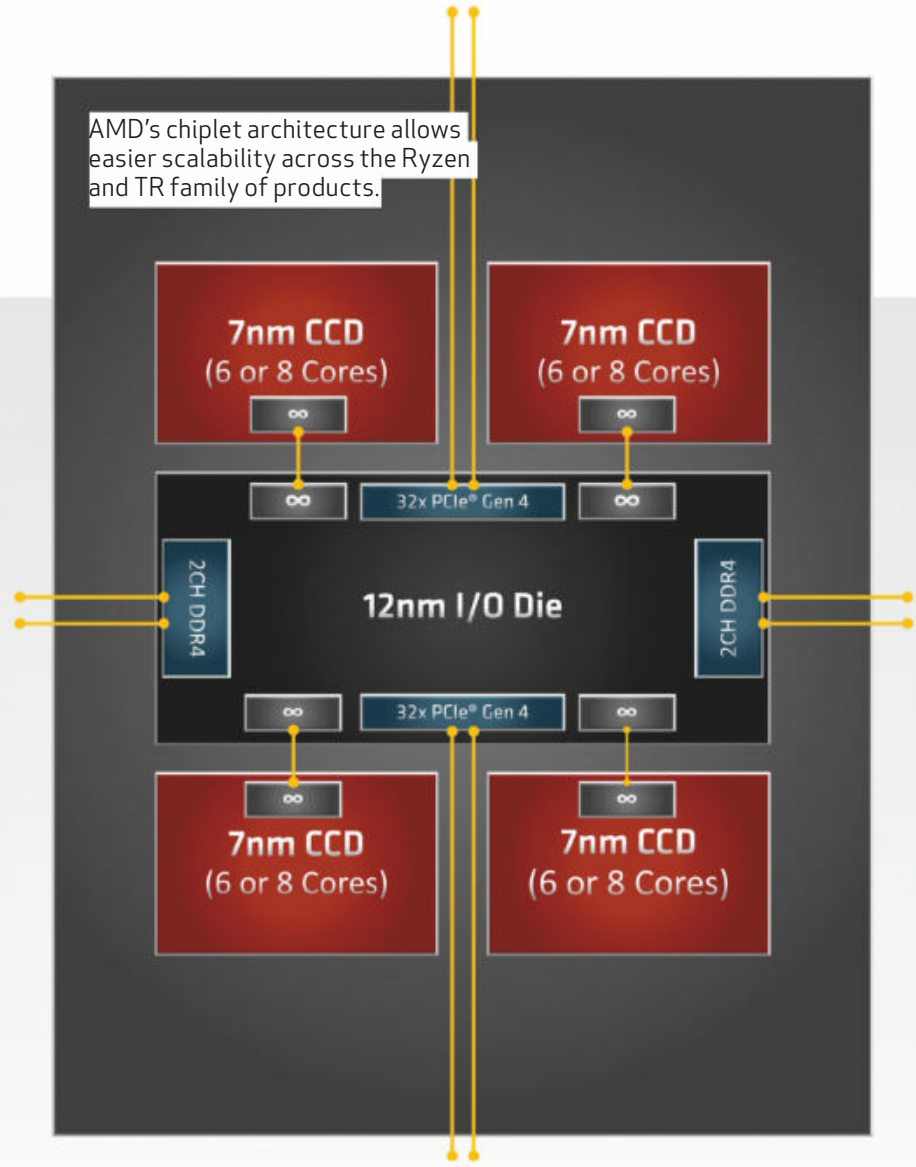
The design topology of Threadripper 3, with its four chiplets connected to the central I/O die, is carried over from Threadripper 2. AMD have fixed perhaps the biggest bottleneck that hampered the likes of the 2790WX and 2990WX – the NUMA mode – leading to some performance-hampering latency issues. This is no longer the case, with the 3960X's chiplets having equal access to system memory, leading to better performance across a full range of workloads.

Threadripper 3 CPUs require a new socket and chipset, and hence a new

AMD RYZEN THREADRIPPER 3960X BENCHMARKS

	CINEBENCH 20 - MULTI THREAD SCORE	CINEBENCH 20 - SINGLE THREAD SCORE	BLENDER 2.79 BMW RENDER - TIME (SECONDS) LOWER IS BETTER	7ZIP - MILLION INSTRUCTION PER SECOND	POV-RAY - RAY TRACING - PIXELS PER SECOND	CPU-Z - MULTI THREAD SCORE	CPU-Z - SINGLE THREAD SCORE
INTEL CORE I9-9900K	4,948	511	217.3	53,617	4,293	5,581	578
INTEL CORE I9-9980XE	8,789	450	137.5	102,456	7,393	10,477	517
AMD RYZEN THREADRIPPER 2950X	7,015	436	152.2	84,061	6,225	9,680	498
AMD RYZEN THREADRIPPER 2970WX	9,784	422	112.2	85,306	8,557	13,179	483
AMD RYZEN 9 3700X	4,845	505	230.6	57,819	4,335	5,616	533
AMD RYZEN 9 3900X	7,227	517	156.4	82,670	6,290	8,232	556
AMD RYZEN 9 3950X	9,201	526	124.0	99,450	7,893	11,118	553
INTEL CORE I9-10980XE	8,813	465	137.8	101,682	7,384	10,530	553
AMD RYZEN THREADRIPPER 3960X	13,644	516	85.6	157,027	11,207	16,599	533

> "If you're one of those with the applications and workflow to take advantage of it, then you'll find nothing better outside of multi-socket enterprise options."



AMD's chiplet architecture allows easier scalability across the Ryzen and TR family of products.

motherboard, some of which are very expensive indeed. They won't work in X399 motherboards, and similarly, older generation CPUs won't work in TRX40 motherboards. We're sad to see AMD abandon its long running commitment to supporting a socket across multiple generations, but the company says it was forced to change the pin arrangement to allow for more bandwidth between the CPU and chipset. At least coolers designed for X399 motherboards will remain compatible with TRX40.

If you're going to drop the best part of $3,000 on a CPU and motherboard alone you'll want it to perform like a beast, and the 3960X does exactly that. The Intel 10980XE is simply obliterated. The 3960X is in another league when it comes to multithreaded workloads. That isn't to say the 10980XE is a dud as Intel remains strong in lightly threaded workloads. That's not why you should be buying a 2019 HEDT though, especially when the mainstream desktop CPU platforms offer a better balance of performance when outright multi threading grunt isn't required.

A look at temperatures and power consumption didn't throw up any surprises. A CPU with a 280W TDP is always going to require very good cooling. A load temperature with a Nzxt 280mm cooler of 81c was about the limit of where we'd be totally comfortable. If you're planning to overclock, it appears that a full custom water loop is a requirement. Power consumption testing revealed a 268W reading when fully loaded vs 43W at idle. This compares to a 10980XE at 229W under load, and a 3950X at an impressive 131W.

AMD now utterly dominates the HEDT space, an unthinkable statement a couple of years ago. Threadripper 3 offers more cores, a better performance balance, a more feature-rich platform and better performance per watt and per core than Intel. A heavy multi-tasker, content creator or workstation user has no real alternative right now. Gamers should stick to the mainstream platforms which offer an equally good, if not better gaming experience for far less money. TR3 will game well enough of course, but that should not be its primary purpose.

The 3960X, along with its 32- and still-to-come 64-core siblings represents another reinvention of the high end desktop. Consumer level software developers have some work to do to take advantage of all that grunt after so many years of quad core hegemony. For most of us, it's complete overkill, but if you're one of those with the applications and workflow to take advantage of it, then you'll find nothing better outside of multi-socket enterprise options. The 3960X and TRX40 platform is expensive, but there's nothing like it on the market. If you're tired of waiting for your jobs to finish, you'll love Threadripper 3 and the 3960X.

Chris Szewczyk

Verdict

AMD's Threadripper 3960X obliterates Intel's entire HEDT lineup, and it's only the entry level CPU!

HANDBRAKE VIDEO ENCODING - FPS (HIGHER IS BETTER)	3DMARK TIMESPY - SCORE	TIME SPY EXTREME PHYSICS - SCORE	GHOST RECON: WILDLANDS - 1080P, LOW, AVG FPS	MIDDLE EARTH: SHADOW OF WAR - 1080P, LOWEST PRESET, AVG FPS	COUNTER-STRIKE: GLOBAL OFFENSIVE - 1440P, MAX, AVG FPS	GHOST RECON: WILDLANDS - 1080P, ULTRA, AVG FPS	MIDDLE EARTH: SHADOW OF WAR - 1080P, ULTRA PRESET, AVG FPS
51.4	13,560	5,106	204	252	381	89	160
66.4	13,383	8,603	196	216	336	87	151
63.7	12,978	6,352	151	179	235	80	127
46.0	12,132	6,541	117	182	247	67	136
52.8	13,315	4,572	195	218	355	84	140
67.5	13,738	6,717	193	219	341	84	150
71.1	13,868	8,428	195	219	340	85	149
66.3	13,600	8,649	203	216	330	85	140
89.9	13,222	12,862	195	202	326	87	149

CPU

$1,799 | WWW.INTEL.COM

Intel Core i9-10980XE

A refreshed refresh just isn't good enough.

It was as recently as early 2017 that Intel's high end desktop platform peaked at ten cores. Then everything changed with the release of AMD's 1st-gen 16-core Threadripper 1950X. Intel's response was the i9-7980XE – an 18-core monster sourced from its enterprise Xeon range. This kept Intel on top until AMD launched the powerful 32-core Threadripper 2990WX, which Intel countered with a refresh of the 7980XE – the 9980XE.

Now that the quicker Zen 2 Threadripper 3rd-gen is here, and with a 64-core model to come, AMD has dramatically upped the ante. Intel's response? Refresh the refreshed 9980XE into the 10980XE. Refreshing once raises an eyebrow, but twice is stretching the bounds of credibility, and that's where we are now with the i9-10980XE.

Though Intel refers to the 10980XE as a 10th generation CPU, there's really not a lot different architecturally between the 7980XE, 9980XE and 10980XE. All of them are based on the same Skylake-X silicon with its 18 cores and 36 threads, 1MB of L2 cache per-core and 24.75MB of L3 cache. All three CPUs share a 14nm manufacturing process. Intel's 10nm volume manufacturing seems as far away as ever.

That's not to say they are 100% the same, as there are a few differences both under the hood and more notably, with revised pricing. Where the 9980XE sold for $2,799, the 10980XE sells for a much more enticing $1,799. That alone makes the 10980XE significantly more attractive from a price/performance and price-per-core measure.

Compared to the 9980XE, lightly threaded Turbo Boost frequencies have increased, up to a maximum of 4.8GHz with a single core. There's also some additional subsets to the AVX512 instruction set. Intel calls these instructions DL Boost. These are aimed at accelerating deep learning and AI workloads.

AMD RYZEN THREADRIPPER 3960X BENCHMARKS

	CINEBENCH 20 - MULTI THREAD SCORE	CINEBENCH 20 - SINGLE THREAD SCORE	BLENDER 2.79 BMW RENDER - TIME (SECONDS) LOWER IS BETTER	7ZIP - MILLION INSTRUCTION PER SECOND	POV-RAY - RAY TRACING - PIXELS PER SECOND	CPU-Z - MULTI THREAD SCORE	CPU-Z - SINGLE THREAD SCORE
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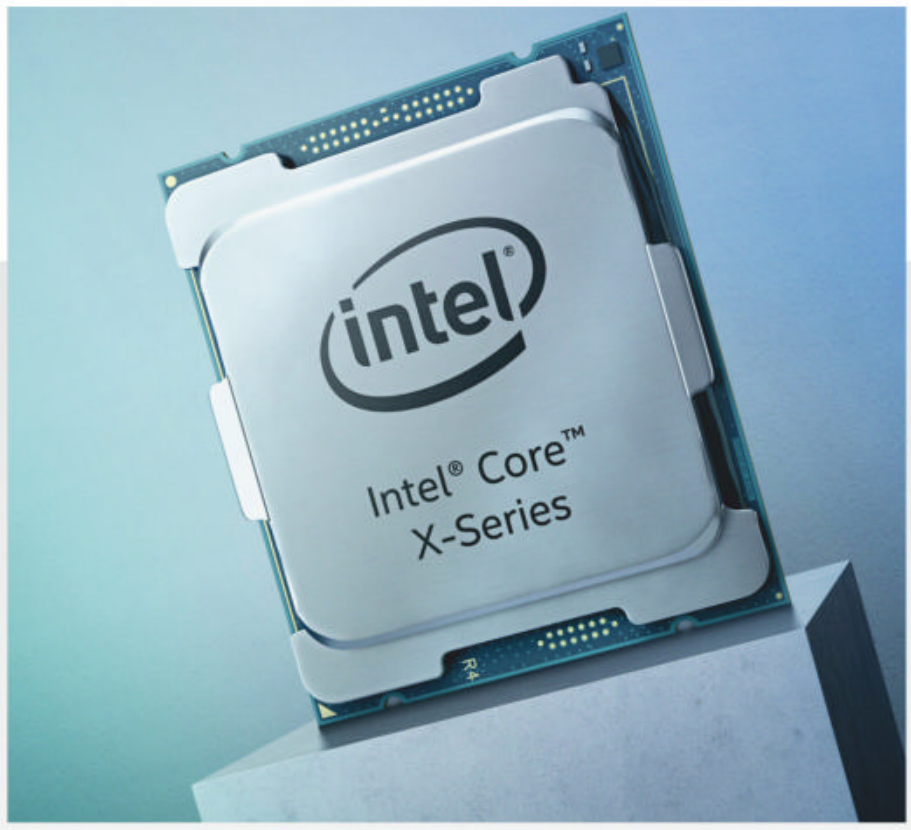

"It's somewhat more competitive under lightly threaded loads, but that's not why people should buy HEDT platforms."

The memory support specifications have improved, with the 10980XE supporting up to 256GB of DDR4-2933 memory, double the 128GB of DDR4-2666 capacity supported by the 9980XE. Cascade Lake-X CPUs get a modest PCIe lane increase too, though there's no sign of PCIe 4.0 support. All the models in the range support 48 PCIe lanes, which add to those coming from the motherboard chipset give you up to 72 lanes.

Speaking of motherboards, most manufacturers are releasing updated X299 models with things like Wi-Fi 6 and faster-than-Gigabit LAN included, which are welcome developments on 2019 HEDT-class systems.

The 10980XE at $1,799 has an added benefit of not forcing users to upgrade to an expensive new motherboard as first generation X299 motherboards will accept 10th generation CPUs after a BIOS update. So while Intel is price competitive in the HEDT market, unfortunately it's faced with the headache of competition from below as well – particularly from the excellent 16-core Ryzen 9 3950X. It's this CPU that's arguably the biggest competition for the 10980XE, and for that matter the likes of the 3900X vs. the rest of the 10th generation lineup.

With Intel struggling to compete with AMD's core counts, it's no surprise that the 10980XE is destroyed by the 3960X under highly threaded workloads. It's somewhat more competitive under lightly threaded loads, but that's not why people should buy HEDT platforms. Power consumption is also concerning – a stock 10980XE consumes around 229W under full load, compared to the AMD 3950X & 3960X's 131W and 268W respectively. This indicates Intel is on the limit of how aggressively it can clock Cascade Lake-X. The 10980XE has a lot of OC headroom, though, with its default thermals and performance per-watt already high you'll need some serious cooling to tame it when overclocking.

In summary, there's good and bad news for the 10980XE. First, the bad news. Intel is facing competition from AMD's CPUs from above and below across its entire HEDT range. Threadripper smashes it in performance, while the likes of the desktop Ryzen 3900X and 3950X are competitive while offering better value. The time for refreshes is over. Intel needs a new architecture and manufacturing process or its faces a very difficult couple of years ahead.

That's the bad news. The good news is that the 10980XE will provide a very strong and relatively affordable performance boost for users coming from the lower core-count 7000- and 9000-series processors, without the need to buy an expensive new motherboard. Software with AVX512 support will also benefit. Sadly there's not too much more than that. It's not a bad CPU in isolation, but the competition is simply too strong. How Intel follows this up over the next year or so will be fascinating to watch. ■

Chris Szewczyk

Verdict

The 10980XE isn't a bad processor, but the competition is simply too good. Intel needs something new.

★★★☆☆

HANDBRAKE VIDEO ENCODING - FPS (HIGHER IS BETTER)	3DMARK TIMESPY - SCORE	TIME SPY EXTREME PHYSICS - SCORE	GHOST RECON: WILDLANDS - 1080P, LOW, AVG FPS	MIDDLE EARTH: SHADOW OF WAR - 1080P, LOWEST PRESET, AVG FPS	COUNTER-STRIKE: GLOBAL OFFENSIVE - 1440P, MAX, AVG FPS	GHOST RECON: WILDLANDS - 1080P, ULTRA, AVG FPS	MIDDLE EARTH: SHADOW OF WAR - 1080P, ULTRA PRESET, AVG FPS
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46.0	12,132	6,541	117	182	247	67	136
52.8	13,315	4,572	195	218	355	84	140
67.5	13,738	6,717	193	219	341	84	150
71.1	13,868	8,428	195	219	340	85	149
66.3	13,600	8,649	203	216	330	85	148
89.9	13,222	12,862	195	202	326	87	149

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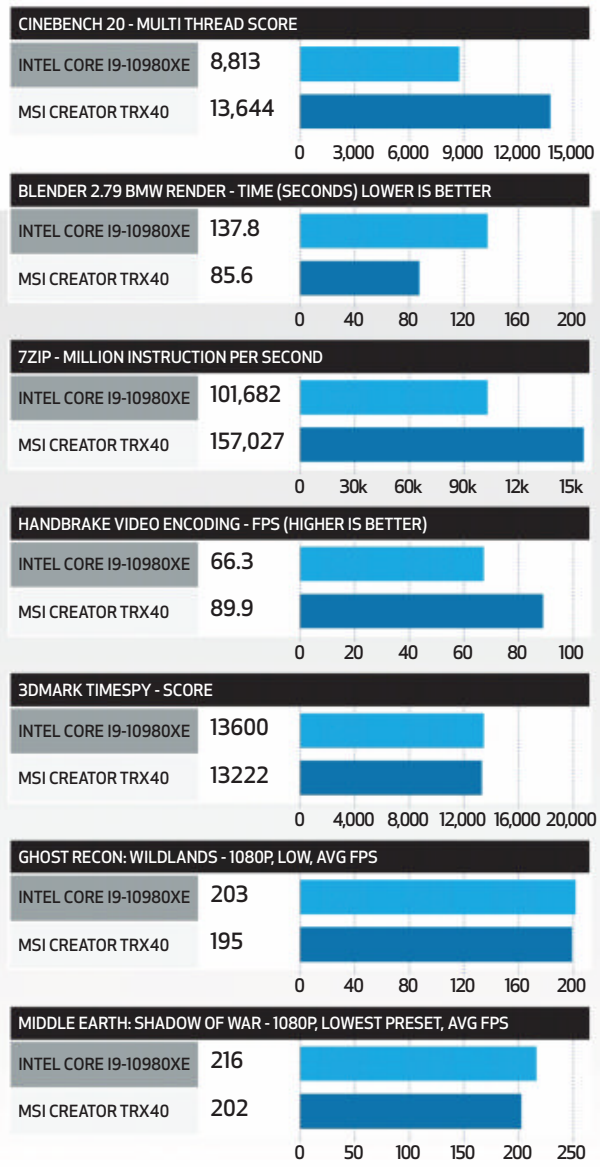
MSI Creator TRX40

A board worthy of the most powerful desktop CPUs.

LABS BENCHMARK RESULTS



If you're a professional or creator who's decided to upgrade to the new Threadrippers, then you'll no doubt be looking at a motherboard to suit. The MSI Creator TRX40 is a serious motherboard positively packed with features. But is this board, with its steep $1,279 asking price, worth the money? Actually it's far from the most expensive. With many X299 and TRX40 motherboards coming in at well over $1,000, things are a bit worrying.

Looking over the Creator TRX40 reveals some interesting things, notably MSI's almost utilitarian design approach. It's far from the flashy bling oriented gaming boards the company is typically known for. This is a board that focuses on performance, connectivity and expandability ahead of an overwhelming laser light show. There's a little bit of RGB above the rear I/O heatsink, but just a little bit! Note that it's an EATX board, so not all cases will be compatible.

It's great to see the return of genuine finned heatsinks and heatpipes that are functional as well as aesthetic. And they're certainly needed when powering a 280w+ TDP CPU. Each of the Creator TRX40's phases can deliver 70a, and there's 16 of them, plus three for the SoC. That's a lot of wattage capability. Two 8-pin power connectors provide the juice to the CPU.

The Creator is pretty much loaded with everything you'd expect from a board at this price. 10G Aquantia LAN, Wi-Fi 6 and four full length PCIe slots for multi-GPU. We're really happy to see plenty of USB ports on the rear panel. It's always a bit of a head scratcher to lose half of your Type-A ports once you use a keyboard and mouse, even on some of the premium boards, so it's nice to see MSI include nine ports plus a Type-C. MSI includes an add in card that provides an additional four M.2 slots, for a total of seven! Nice!

As the first TRX40 board we've tested, we can't say how it performs relative to other boards in its class, however, when partnered with a 3960X the Creator TRX40 absolutely smashes the Intel i9-10980XE. Given that motherboards usually perform within a percent or two of each other, we don't think we're going out on a limb to suggest that the MSI will perform similarly to other TRX40 boards.

If you're contemplating making the jump to the mega performing Threadripper platform, you'll need a board worthy of all that grunt. The MSI Creator may just fit the bill. It's packed with connectivity options, it features a powerful PWM design that will be needed for the upcoming 64-core 3990X and MSI's BIOS continues to be one of the best in the business. $1,249 is a lot of money though, and its hard to ignore the competition from MSI's own TRX40 Pro 10G, which isn't all that different, yet costs a good $350+ less. Of course if you're dropping all that cash on a CPU, you may well have little trouble rationalising a splurge on a top quality motherboard like this one. **Chris Szewczyk**

> "If you're contemplating making the jump to the mega performing Threadripper platform, you'll need a board worthy of all that grunt."

Verdict

This MSI is very good indeed, but the company's own TRX40 Pro 10G is strong competition.

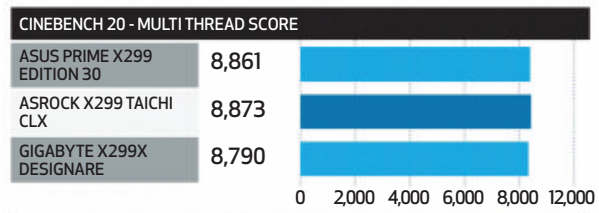
MOTHERBOARD

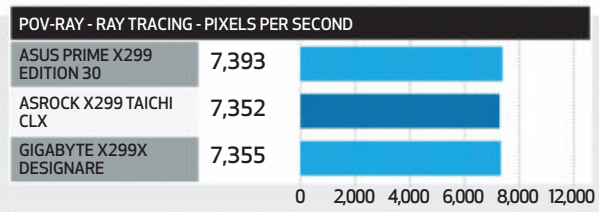
$1,179 | WWW.GIGABYTE.COM

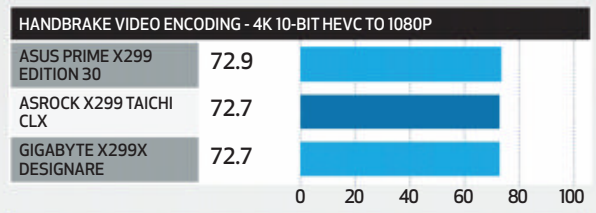
Gigabyte X299X Designare 10G

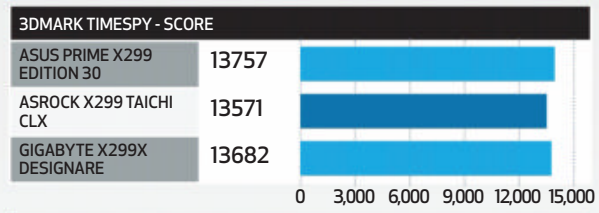
A creator's dream motherboard?

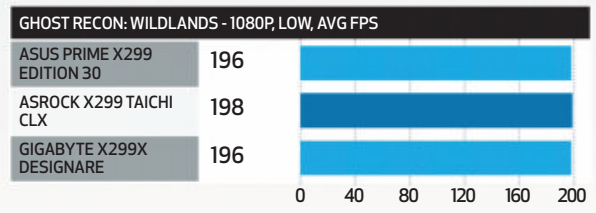
LABS BENCHMARK RESULTS











The X299 platform might be somewhat venerable in late 2019, but with the launch of Cascade Lake-X, motherboard companies are taking the opportunity to deck out their boards with the latest and greatest features on the market. The high-end models are all well north of $1,000 now, a price level that would have resulted in laughter and mockery just a couple of years ago. Premium X299 refresh boards might be expensive, but boy do they pack in some next generation features! Gigabyte's X299X Designare is one such board. It probably has the best specification of any motherboard we've reviewed to date.

A visual inspection of the Designare reveals some interesting things. Cascade Lake-X really sucks power and this board is designed with that in mind. A 12-phase VRM capable of delivering up to 840A is mated to finned heatsinks with heatpipes. If you're planning to overclock, you'll need a strong power system. You get four PCIe 16x slots that run up to 2x 16x and 2x 8x, useful if you're making use of multi-GPU grunt. You get eight SATA ports, three onboard M.2 slots and a typically excellent audio system as is often the case on Gigabyte's top boards. Overall the design is quite subtle. It's refreshing to see a very high end board not having to resort to 'gaming' style overload.

The Designare doesn't stop there though. It's a networking beast with Intel X550-AT2 dual 10G LAN and Wi-Fi 6. If you're running a lot of network attached storage then you'll love dual 10G! On the topic of storage, Gigabyte includes an expansion card to add four more m.2 drives, meaning the board can accept up to seven m.2 drives! The card is PCIe 4.0 ready for good measure. Throw in dual Thunderbolt 3 ports with DisplayPort passthrough and it's clear we're looking at one of the most expandable motherboards on the market. A creative professional won't do much better short of moving to enterprise products.

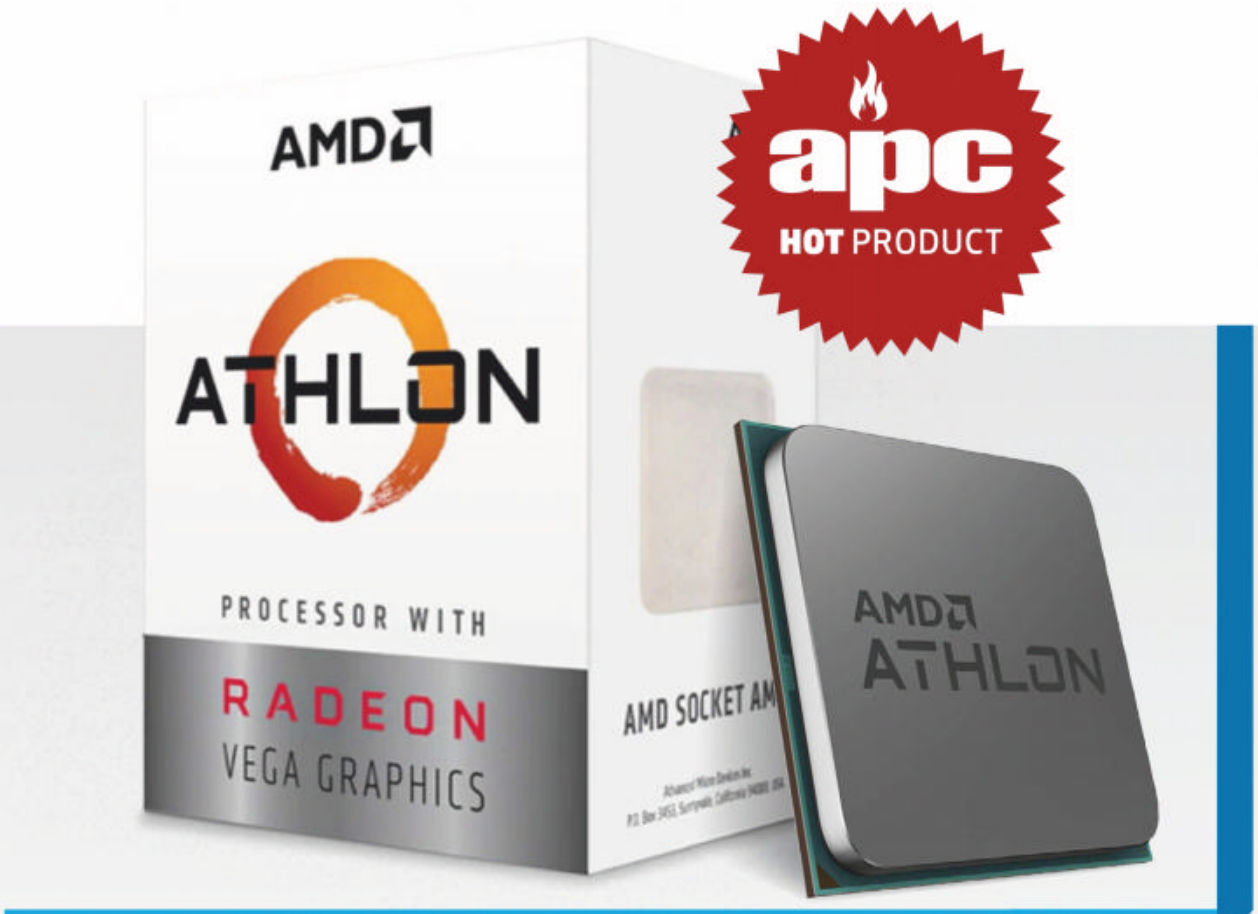
One of the only areas that seems to be lacking a bit is rear USB ports. You get a total of six, two of which are TB3/Type-C. Assuming you're using a wired keyboard and mouse, there's half of the type-A ports gone already. Surely a couple of extra USB 2.0 ports for basic devices wouldn't be too difficult to add.

As is often the case when comparing the performance of motherboards, the results are similar. We used an i9-9980XE and set the minimum Turbo clock to 3.8 GHz with no AVX offset to avoid any shenanigans. X299 is now a very mature platform and one or two percent difference here or there won't be noticed, and is typically within a margin of error.

The Gigabyte X299X Designare is a stunning motherboard, packed to the rafters with awesome levels of connectivity. If you're invested in the Intel ecosystem, you really won't find a board that packs a better set of features. We're sad that boards are creeping past $1,000, but with the likes of X550 10G LAN and a 4 way PCIe 4.0 m.2 add in card, some of that extra expense is well justified. ■ **Chris Szewczyk**

Verdict

The Gigabyte X299X Designare is perhaps the highest spec motherboard we've seen to date. It's got the lot.



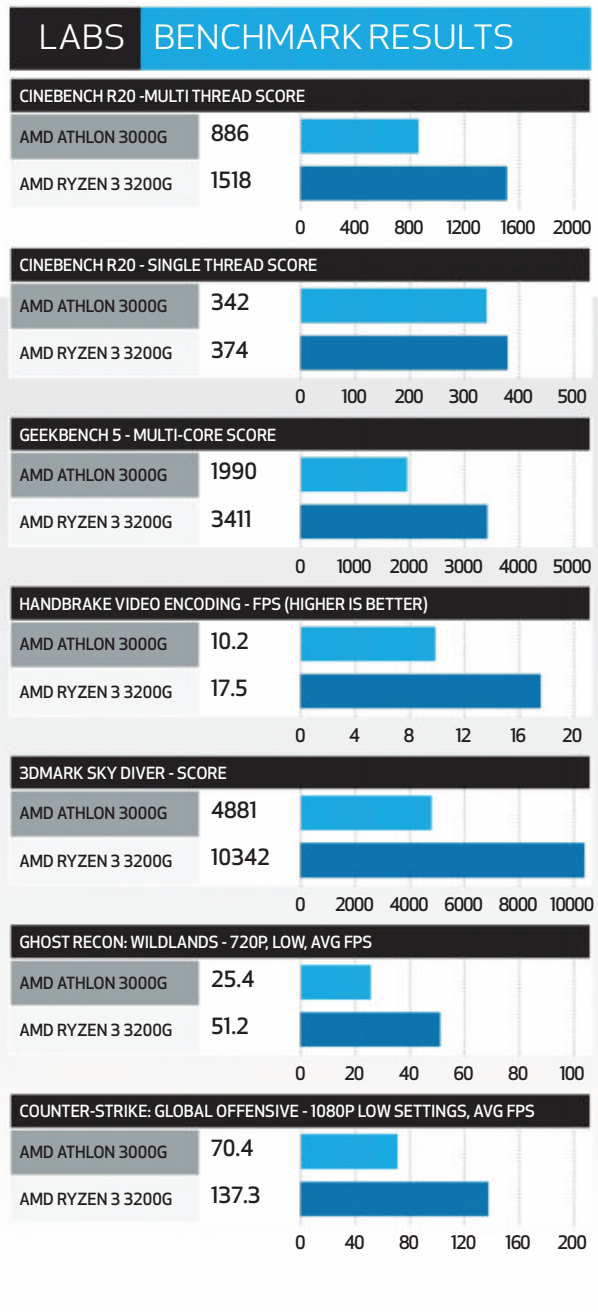
apc HOT PRODUCT

CPU

$79 | WWW.AMD.COM

AMD Athlon 3000G

Not everyone needs a thousand cores.



And now for something completely different. Much of this month's APC is spent covering the high end desktop processors. The simple truth is that not everyone needs a huge core count or high powered performance. Some folks just want a cheap and cheerful but still fully functional PC for general tasks. Enter the AMD Athlon 3000G. At $79 dollars it offers tremendous value for a basic PC.

The Athlon 3000G utilises older 1st generation Zen CPU cores, built on the 14nm process. It's a two-core/four-thread CPU with a 3.50 GHz clock speed. The 3000G doesn't have a boost clock, so 3.5GHz is the maximum it will run at. Perhaps the most interesting feature is the inclusion of an unlocked clock multiplier, making it a rather simple matter to gain some free performance with little effort. The 3000G comes with a basic cooler that's rated for up to 65W. Our test sample didn't come with this cooler, but since the 3000G has an impressive 35W TDP, it should remain quiet under all operating conditions. If you want to overclock it, an air cooler that's a bit beefier might be appropriate.

The 3000G includes a heavily cut down variant of AMD's Vega IGP. It's no match for any 2019 spec dedicated graphics card but is capable enough for simple 720p gaming with low details. By this we mean older games. Current AAA games are simply too demanding to run on a 3000G, but if you're more interested in browser gaming or something basic like a bit of *CS:GO*, it will do the job. Vega has a good set of multimedia capabilities making the 3000G a very attractive media server option.

As you can see in the test results, the 3000G isn't aimed at users who need performance. Its single thread performance isn't too bad but it's pretty slow under heavily threaded loads. We compared the 3000G to a Ryzen 3 3200G which is a genuine quad core with more powerful graphics. It trounces the 3000G, but remember its close enough to double the price with double the TDP. They aren't really comparable.

We simply couldn't let the 3000G go without trying to overclock it. We hoped to get over 4GHz fairly easily but found that full stability at 4GHz was difficult to achieve without moving over 1.4v. With a bit of time and effort, it should be possible. Our benchmarks ran at 3.95GHz at 1.4v. Not a bad free performance bump.

The Athlon 3000G is certainly not a speed demon processor. What's important to remember is its $79 price. At that level it's suddenly possible to build a dirt cheap budget PC that provides a computing experience you just can't get from a tablet or phone. Pair it with a budget A320 motherboard and 8GB of RAM and it's the kind of thing that a huge chunk of users will find perfectly adequate. Note that the A320 chipset doesn't support overclocking, so if you want to overclock the 3000G, you'll need something like a B350 or B450 motherboard. Just make sure your board of choice has an updated BIOS to support the 3000G. ■

Chris Szewczyk

> "We simply couldn't let the 3000G go without trying to overclock it."

Verdict

The 3000G won't win any speed records, but when it comes to bang for buck, it's hard to beat.

★★★★½

TRUE WIRELESS BUDS

$299 | WWW.JABRA.COM/AU

Jabra Elite 75t

Building upon greatness.

This follow-up to Jabra's excellent Elite 65t – one of the first sets of true wireless buds that 'just worked' – bundles together more than a dozen improvements in an effort to tackle with more-recent competitors. The upgrade has largely been a great success – as before, they're comfortable and fast to both pair and reconnect, but the 75t's more compact and discrete design also feels significantly tougher and more robust than its forebear's, and they're still exceptionally lightweight and well-balanced in terms of weight distribution. An extra 2.5 hours battery life, or 7.5 total, means they can effectively last a full working day, and the slimmed-down (and now USB-C) charging case somehow includes 3.5 additional full charges (28 hours) within it.

Audio quality is likewise first-rate, although by default it's tuned for extremely deep, rumbling bass. Thankfully, it's easy to adjust the sound profile to your specific tastes via a five-band equaliser in the Jabra smartphone app – and the 6mm drivers in each bud are flexible enough that we weren't able to distort them by pushing the EQ to extremes.

The 75t sadly still have a couple of the residual shortcomings from the 65t – specifically, if you want to use one bud, only the right one offers this, and these aren't a great set of earphones for gamers, where a little lag between the onscreen action can mess up lip-sync and be mildly distracting.

Those gripes aside, this is a very worthy upgrade, and one that brings Jabra back into the top tier. **Dan Gardiner**

Verdict

Successfully updates the Elite design to create one of the best 'no fuss' true wireless buds.

TRUE WIRELESS BUDS

$169 | BLUEANT.COM.AU

BlueAnt Pump Air 2

Decent sound in an average package.

The Pump Air 2s are certainly some of the smallest earbuds we've tried, and their sound quality is fairly decent in spite of this, but unfortunately they suffer in a few other areas. They are relatively affordable for true wireless 'buds, and this is certainly one of their more redeeming qualities, but that low price is felt when it comes to the cheap-feeling charging case, its micro-USB port and poor battery life.

The four-hour playtime on the units themselves can be forgiven considering their diminutive size, but for the bulky and awkward charging case to only contain an extra 11 hours of juice in total is disappointing.

As mentioned earlier, the audio is punchy and well-balanced, with solid bass and no signs of distortion at higher volumes. In fact, we'd be hard-pressed to find better fidelity in the true wireless market at this price, although if you don't mind a neckband, there are plenty of alternatives that top their performance. The connectivity, unfortunately, is another sore point for the Pump Air 2, with dropouts experienced on one or both of the 'buds all too often. They arrive with the choice of seven different silicon eartips, and their sweatproofing (IP54) combined with a very compact, lightweight (4g each) design lends them well to workouts. If you're prioritising audio quality above stability and are looking for a budget pair of true wireless 'buds, the Pump Air 2 are worthy of your consideration, but their weak battery life, poor charging case, and frequent signal dropouts make them hard to recommend as an everyday pair.

Harry Domanski

Verdict

Almost there, but niggling issues remain.

EXTERNAL STORAGE

$379 | SHOP.WESTERNDIGITAL.COM

WD Black D10 Game Drive

A little shipping container for your game data and media.

I say 'shipping container', because the rugged industrial style makes it look like one. Functionally that's also what it does, and as far as portable external storage goes, as WD and Seagate well know – the marketing battleground is all about styling with these things.

WD has five new drives marketed as game storage for PC, PS4 and Xbox One, varying in capacity and whether it uses an SSD or HDD. The model with the highest capacity is the 12TB WD Black D10, and we're testing the 8TB model here. We chose to look at the D10 because unlike the rest of the range, this one has active cooling so that makes it ever so slightly more interesting that the usual breed. It makes sense to cool a drive like this. At these massive capacities on a console users are likely to want to stream media as well as store games and saves, so the drive is going to spend more time spinning and reading – though, really, hard drives have been handling that without cooling for decades.

That said, the drive is a 7200RPM model and that means it does get hot. In testing the plastic shell warmed slightly to the touch, but it's not flush with the drive itself, and there's an abundant air gap between the drive and chassis that aids air circulation and, thus, keeps the outside cool. 7200RPM drives have a reputation for failing sooner than 5400RPM ones, and while I'm certainly not suggesting this one is particularly susceptible, these drives do live longer when they're kept cool. It's covered by a three year warranty.

Having a relatively fast drive means performance is relatively decent. WD claim speeds of up to 250MB/s, and in our testing we saw read and write speeds just shy of that, at 245MB/s. Connectivity is via USB Type-A, and that interface's 5GB/s throughput is well in excess of the drive's maximum performance, so that's not a bottleneck. Two USB Type-A ports are provided as useful charging ports, delivering 7.5W. An external power brick is required, and it's small enough to hide away keeping your gaming area clean.

Value is the big issue here, though. At around $380 it offers nothing that non-gaming-branded external portable drives can't handle. Indeed, you can buy a functionally identical 8TB 7200RPM WD My Book Desktop drive for just $250 and effectively have the same capacity and performance for $130 less, from the same company. It's a ridiculously excessive premium that WD, and Seagate too, add... because *gaming*.

So, it all boils down to styling, then, and that this is a 'gaming' device, which some may be ignorantly (and innocently) led to believe is the only option. Savvy console owners have external storage scoped and know what their choices are. As far as value goes, this shouldn't be one of them. ■

Ben Mansill

> "At around $380 is offers nothing that non-gaming-branded external portable drives can't handle."

Verdict

Good looks, decent performance from an actively cooled 7200RPM HDD, but the value is shockingly bad.

"When you want to eschew the tech for an old-school peephole, you can still look through the cover (with its one-way, privacy-protection flap) to see who's there."

apc HOT PRODUCT

DOORBELL CAMERA

$299 | WWW.TP-LINK.COM/AU

Ring Door View Cam

Great hardware and software make modernising your front door's peephole a breeze.

Ring is more than a doorbell company nowadays. It offers security-oriented smart-home devices that work with some seriously slick software – a far cry from the Gen.1 products of yesteryear which had to contend with flaky smartphones and dodgy internet infrastructure. The company's new Door View Cam is launching into a much-more mature technological marketplace.

Unlike its predecessors, it installs into a door's peephole: a tool is provided to remove the existing lens. Next, you're faced with assembling the components. This might initially look daunting to all but the most experienced Ikea Jedi, however, the quick-start guide walks you through downloading the app and using a QR code to connect to the doorbell. The app then provides short, step-by-step, video guides to walk you through putting it all together. It takes about five minutes.

Once installed, the app takes you through the configuration process. This involves describing the camera's outlook (is it facing a busy hallway or a wall?), whether you want all motion to be detected or only significant motion (which checks whether an event is significant or a cat walked past) plus, whether there's an outer door/fly screen. You can reduce the areas of motion detection and add Privacy Zones which, for instance, block recordings of your neighbours' windows. You can also choose to record the audio from conversations near your door or not. Finally, it lets you invite other users to be notified.

To make full use of the monitoring you'll need to subscribe to Ring's Protect service, otherwise you'll only be notified of real-time events. You get a 30-day free trial of the $15-per-month Premium service which covers all Ring devices on particular premises. A $4-per-month Standard plan covers one device.

The app makes looking back through the day's recordings very simple thanks to a swipeable timeline and you can click Live View at any time. If an event occurs outside your door that you don't want to keep being reminded about (gardeners working, for instance) you can snooze motion detection for a few hours.

The very-wide-angle camera is crisp and clear with minimal, fishbowl-distortion. At night, the monochrome image offers comparable clarity. We were impressed at how little lag existed in two-way audio communications.

If someone doesn't press the doorbell, the impact sensor can detect if they knock instead. When you want to eschew the tech for an old-school peephole, you can still look through the cover (with its one-way, privacy-protection flap) to see who's there.

A second battery costs $49. However, a single charge will last six-to-twelve months depending on how frequently it's used and how sensitive the monitoring settings are. Ringer extensions (called, "Chimes") are $59 and there's a potentially-useful 'Pro' version for $79 that can also extend the range of the doorbell's Wi-Fi.

At $299 it represents great value for money and will be a god-send to those who don't want to miss posties and couriers, or who simply want to add some home security. Just remember that you'll need the monthly subscription to make the most of it.

Nick Ross

Verdict

A superbly designed product that takes home door cams to a new level.

★★★★★

CASE

$225 | WWW.CORSAIR.COM

Corsair iCue 465x RGB

Smart and cool.

Everything seems to be "smart" these days: phones, home appliances and yes, even smart cars. It was only a matter of time until case manufacturers jumped on the smart product bandwagon as well. Corsair's latest mid-tower chassis has just the right amount of RGB bling and great thermal performance as well. But how does Corsair define smart?

Measuring 467mm x 216mm x 465mm and weighing 8.16 kg, the Corsair iCue 465X RGB features steel and plastic construction with tempered glass panels on the front and left side. Painted in the buyer's choice of white or black both inside and out, this chassis comes with a two-year limited warranty.

Build quality and thermal performance aside, the case's biggest selling points are the new design, the Direct Airflow Path layout, tempered-glass panels and RGB lighting. The iCUE 465X RGB incorporates three of the company's latest LL120 RGB fans powered by the included iCUE Lighting Node CORE RGB controller.

Directly below the magnetic dust filter in the top panel are mounts for two 120 or one 140mm fans. Along the uppermost edge of the plastic front panel you'll find a pair of USB 3.0 ports, a headphone / microphone jack, plus power and reset buttons.

The front panel assembly attaches to the front of the case via long thumbscrews. A one-inch gap on both sides between the tempered glass and plastic frame provides a clear path for fresh air to be drawn into the chassis. The fan filtration system does a great job preventing most dirt and dust particles from entering your system.

Painted to match the exterior colour, the interior of the iCUE 465X RGB is very clean and well laid out. Corsair includes three installed LL120 RGB LED fans in the front, but none in the rear of the chassis. We found it a bit disappointing that Corsair didn't include a LL120 ARGB exhaust fan (or any fan for that matter) at this price point, given this chassis' emphasis on RGB lighting.

The Corsair iCUE Lighting Node Core controls all three included 120mm fans and has enough additional headers to power three more, all through the company's iCUE software.

Radiators and AIO coolers can be mounted in the top, front, and rear of this case. The mounting locations in the front of the chassis support 120, 140, 240, 280 and 360mm radiators.

The large intake vents in the front of the case, combined with a trio of 120mm intake fans, provided more than enough airflow to keep the components in our test system cool. CPU temperatures levelled off at 57 degrees Celsius over ambient. Running the tests again with two fans in front and one in the rear made no noticeable difference in thermal performance. GPU temperatures maxed out at 49 degrees Celsius over the ambient room temperature.

Corsair's iCUE 465X RGB is a great-looking case with the performance to match. With the right components and careful planning, this chassis is a solid choice for your next system build. The lack of a USB 3.1 Type-C port and odd 360mm radiator installation issue aside, the iCUE 465X RGB is a good value, a great performer, and should be at the top of your case consideration list. **Steven Lynch**

Verdict

Corsair's latest mid-priced mid-tower has the right amount of RGB and great thermal performance.

CASE

$299 | FRACTAL-DESIGN.COM

Fractal Design Vector RS

Compromises and direction.

It seems we're long past the days of Fractal's iconic Define series. With the launch of its Vector RS chassis, it's left a lot of questions among the tech community as to where the company is heading. Compared to the prestigious Meshify and Define R6 cases, the Vector RS is somewhat lacking. Both the quality of the materials and the design decisions fail to keep up with modern expectations, and those failings don't help justify that $300 price tag.

Yet before we consign this to the sin bin, let's look at what it is, exactly, that's grinding our gears.

At first glance, and on Fractal's website, the Vector seems to be a stylish chassis. Its clean sharp lines convey a sense of modernity, following in the footsteps of the dramatic Meshify series. Its angular roof, solid front panel, and melding of tempered glass, RGB, and metal bring it to life in a way that, from the site at least, give it some serious character. In real life, however, things are not so good. The black glass is prone to fingerprints, the angular roof less than desirable, and the standard painted steel that lines everything else attracts every mark going, and is something we're more used to seeing in the sub-$200 market. Some may find it stunning, but it's just not that appealing to us especially with the likes of the Phanteks Evolv X and NZXT H710i costing around the same.

Then there's the airflow. To be fair, the front of the chassis has a good half inch of ventilation running down either side, but there's not a whole lot front or top. In its default configuration, you get just two 140mm fans, the same ones found in the Define R5 and R6, and that's about it. The roof panel is also a solid tempered glass affair, but Fractal does include a replacement mesh option with additional mounting for a top radiator, too.

The interior layout is as strong as we saw in the Define R6, which launched in late 2017. Mostly because it's identical. For those keen on 3.5-inch hard drives, this supports up to 11, with six included, all mounted in the front of the chassis; the drives and caddie are removable to allow for better airflow or liquid-cooling support. But bear in mind that if you do take that route, there's no obvious way of hiding the cables from the front I/O and any fans behind it, once the towering HDD structure is gone.

You also get two 2.5-inch hard drive mounts on the back of the motherboard tray, a full-length PSU cover, plenty of rubber cable grommets, and mounting locations for a vertical GPU (for which you need to buy a separate adapter).

Once you're past the poor quality materials and aging interior design, and have circumvented the airflow issue with some powerful static pressure optimised fans, the Vector RS is quite pleasant to build in. We didn't find any major foibles outside of having to rigorously cable-manage our front fans.

The thing is, the Vector RS is just a two-year-old case design with some new panels and RGB thrown on top, and that's not good enough. You can pick up a Define R6 for around $200 now, so you're paying $100 more for some angular external panels. This might have been fine back in 2017, but when you have the likes of the H710i, Evolv X, Lian Li PC011-Dynamic, Silent Base 801, Enthoo Luxe II, and H510 Elite all nipping around the same if not lower price point, it makes the Vector RS feel utterly lackluster. Unless you absolutely need 11 3.5-inch drives, the Vector RS is one to be missed. ■ **Zak Storey**

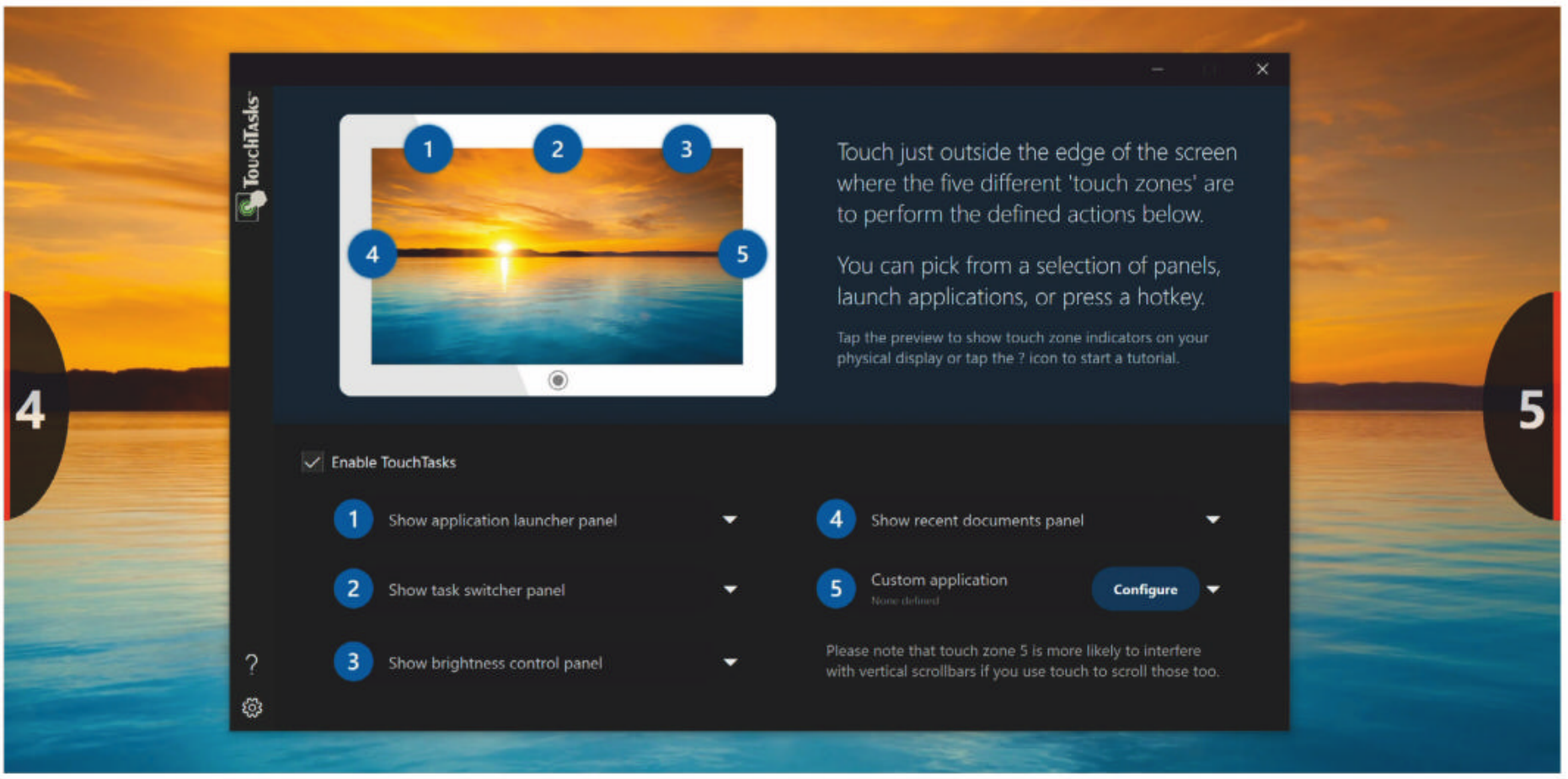
Verdict

Strong internal layout; poor default airflow; pricey; two-year-old internal design.

software

» APPS FOR ALL YOUR PLATFORMS

Windows SOFTWARE



Stardock Touchtasks

Longing for the touch-friendly days of Windows 8?

$7.99 | WWW.STARDOCK.COM/PRODUCTS/TOUCHTASKS

When Microsoft moved from Windows 8.1 to Windows 10, the company drastically changed tablet mode. Many still long for the fluid shortcuts and touch-centric design of Windows 8.1's tablet mode. Windows 10 works with touch, but it doesn't have the smooth shortcuts and gestures of its OS ancestor. In comes TouchTasks, a piece of software from Stardock designed to bring touch shortcuts to Windows. The concept is excellent, and I think Stardock could make it into a great piece of software with some tweaks and updates, but in its current state, it falls short.

Awkward touch targets that can be hard to find, making TouchTasks challenging to use. Additionally, Windows 10 and TouchTasks often compete for the same spots on your screen, making specific tasks difficult or nearly impossible. That said, some parts of TouchTasks are worth building upon.

TouchTasks allows you to create customisable touch shortcuts on your PC. There are five touch targets, each of which can be configured to perform specific tasks, such as opening an app, opening a navigation panel, or bringing up the touch keyboard. The idea of it reminds me of Windows 8.1 and when I used my Surface Pro 2 to jump around Windows with touch. Some of the additions seem inspired by Windows 8.1. I love the task switcher panel that allows you to jump between different apps quickly. It's reminiscent of Windows 8.1's Task view and takes up less screen than the Task view page of Windows 10.

The touch shortcuts can be customised easily within the app. You can even launch apps, though you'll have to jump through File Explorer and find the right exe file. It's a really nice idea, and I hope Stardock takes it another step further by adding options for swiping and more.

While TouchTaks is a good concept, it does poorly in terms of execution. Even though you can adjust the size of touch targets, finding them still feels hit and miss. I wish there were an option to swipe in from the edge of the screen because poking away at an invisible touch target is frustrating and inefficient.

In addition to the touch targets being hard to find, they compete with aspects of Windows 10. For example, if you're using a browser and want to use one of the three touch targets towards the top of your screen to return to your desktop, you might end up switching to a different browser tab instead. Tapping on the right of your screen can interfere with a scrollbar, and if you swap your touch targets to the bottom, you'll have to make sure not to touch the wrong part of your taskbar.

Stardock has a good track record of enhancing Windows 10, so there's a chance that TouchTasks will improve over time. I'd love to have the option to swipe in and out of shortcuts if possible. There are plenty of good ideas in TouchTasks, such as the customisable task switcher panel, but TouchTasks isn't worth it right now. **Sean Endicott**

Mac » APPS

The colour selectors are easy to use and offer up 'harmonies' of suggested colours to co-ordinate.

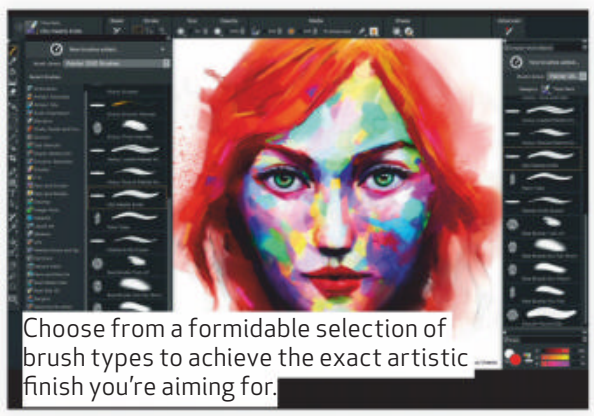
Corel Painter 2020

Create any artwork you can imagine with this powerful painting package.

FULL VERSION $429.99, UPGRADE $179.99 | PAINTERARTIST.COM | NEEDS MACOS 10.13 OR LATER

Corel has been bringing digital graphics software to the world since 1989, making it one of the longest-established developers offering these packages to the consumer and professional markets. With its Corel Painter 2020 suite, the company has refined the software and added smart new tools, further empowering digital artists of all levels to create stunning designs and blurring the lines between physical and digital artworks.

On first boot, the application can run a performance optimisation process to automatically adjust its settings to suit your hardware. The base requirements are quite modest – a Core 2 Duo CPU running macOS 10.13 or later, and 2GB RAM. There's a Brush Accelerator option in the preferences that, once run, will enable you to activate your Mac's dedicated GPU if it has one. Brush speed using the integrated graphics on our 2013 MacBook Pro 15 was respectable when using the basic graphics chip, but sped up noticeably once we activated the dedicated GPU instead. As ever with professional software, a faster Mac with more RAM will always do better.



Choose from a formidable selection of brush types to achieve the exact artistic finish you're aiming for.

Create a canvas of any size you like, choosing from the virtual papers supplied with the software. From there you begin painting, either using the mouse or trackpad, or more likely with software such as this, a tablet and pen. The tools on offer are powerful, and you will definitely get the most out of them by using a more advanced input method with features like pressure sensitivity, which is of course supported in the software.

BRUSH CONTROL

There are over 900 brushes supplied and these can be quickly chosen from the picker – there are far too many to list but they cover every conceivable thing you could need from brushes and pens to sprays, particles, textures, oils and much more. Naturally each one can be precisely configured in terms of the way it behaves regarding its size, feathering, hardness and much more. There's an intuitive colour selector with many nice little touches such as 'harmonies', a section that displays colours that complement the one you've chosen. The tool palettes can also float and snap to each other.

A handy layer system gives you Photoshop-style control of masking and layering, and there are advanced photo painting tools including auto-paint, where the software can turn a photo into an artwork. There are simpler apps that can do this, but not with the flexibility found here. While the toolset on offer is formidable, there is a learning curve for the less experienced in terms of the concepts and techniques at work, so creating something amazing will require skill. Luckily there is a good set of how-to videos available for free on Corel's website. ■ **Hollin Jones**

Point your iOS device upwards and Sky Guide will tell you what's hiding behind the clouds.

Sky Guide 8

Explore the universe with this fun app.

$4.49, OFFERS IN-APP PURCHASES | FIFTHSTARLABS.COM | NEEDS IOS 11 OR LATER

Sky Guide's mission is simple: to help you learn more about what's going on in the sky – and to help you have fun doing it.

It succeeds beautifully. From the moment you launch this app, you're greeted with calming celestial music (you can turn it off in settings). Sky Guide has three main sections. The main screen displays constellations, planets, moons, satellites, and other celestial bodies. Tap the compass and point your device at the sky, and Sky Guide displays those bodies currently in the location you're pointing at. If you have an AR-capable iPhone or iPad, tap the camera button and you'll see the view of the sky as seen by your device's camera, with constellations overlaid on it.

Version 8 uses Apple's Metal tech to make the whole thing silky smooth. It also improves tracking, low-light performance, and focus quality in AR mode. It's also added new asteroids and comets to its vast database.

When you see something you want to know more about, tap the 'i' and read all about it. Want to travel back or forward in time to see how the sky above you looked or will look on any given date? Just tap the time button and use arrows to navigate to the date you want.

LIGHT AND SOUND

Struggling with light pollution? You can adjust the brightness. Stars also make sounds, based on temperature and luminosity, and Sky Guide reflects that with its sounds. If you're looking for a particular celestial body, tap the magnifying glass and search for it.

The two other sections of Sky Guide are Features and Calendar. When you tap on the latter, it displays upcoming 11 astronauts into space.

Other features include a Today widget that shows you what's happening today, and a Watch app, plus notifications that alert you to passing satellites. But if you want even more, the Supermassive bundle (currently $30.99) allows high-definition zooming, 50x larger catalogues, and cinematic tours of the cosmos.

For anyone with an interest in astronomy, Sky Guide is a must.

Kenny Hemphill

Point your device at the sky, tap the camera, and Sky Guide overlays constellations on the camera view.

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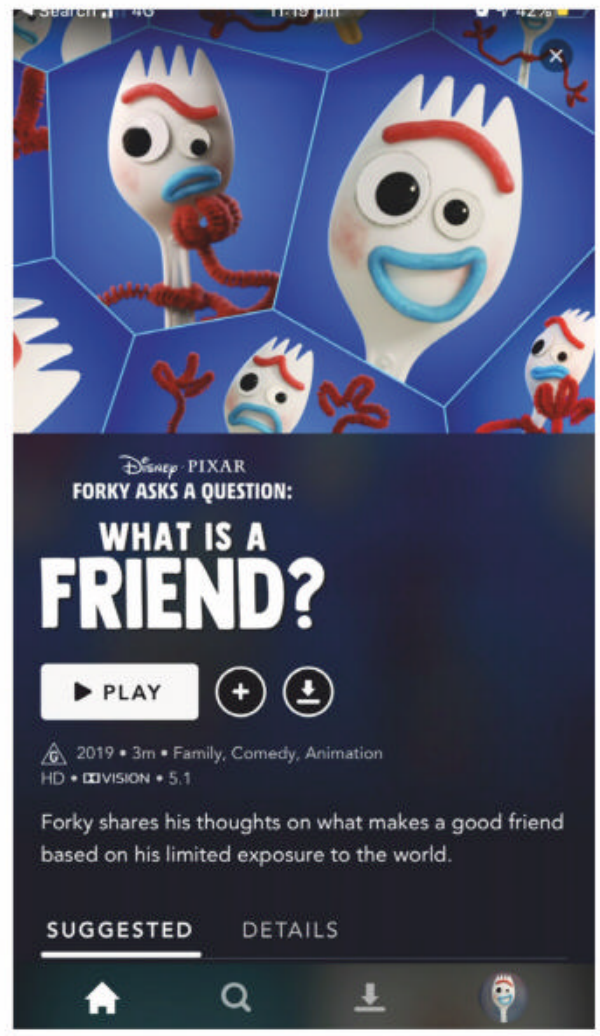
Disney +

Go see a Star War.

$8.99 A MONTH | DISNEYPLUS.COM

Now that Stan has lost all of Disney's back catalogue (but, sidenote, has maintained a tremendous library that gives local Netflix a serious run for its money), you'll need to migrate over to Disney + to watch *Star Wars* and your favourite *Marvel* movies without having to fish out the Blu-rays you probably also own. Disney + will, more than likely, have something you care about, whether it's a so-so new *Star Wars* TV series or every episode of *The Simpsons* ever released, and one account can be used across ten separate devices, which is fantastic. Putting aside whether or not Disney is openly damaging the entertainment industry with its gross, terrifying monopoly for a moment (although, sidenote: yes it is), Disney + is a good service with a great app. The clean UI is very readable, the search options are useful, and while I wish you could search in landscape instead of needing to switch how you hold your phone whenever you exit content back to the menu, that's a minor quibble.



Daily Haloha

You say goodbye, and I'll say Haloha.

FREE | WWW.DAILYHALOHA.COM

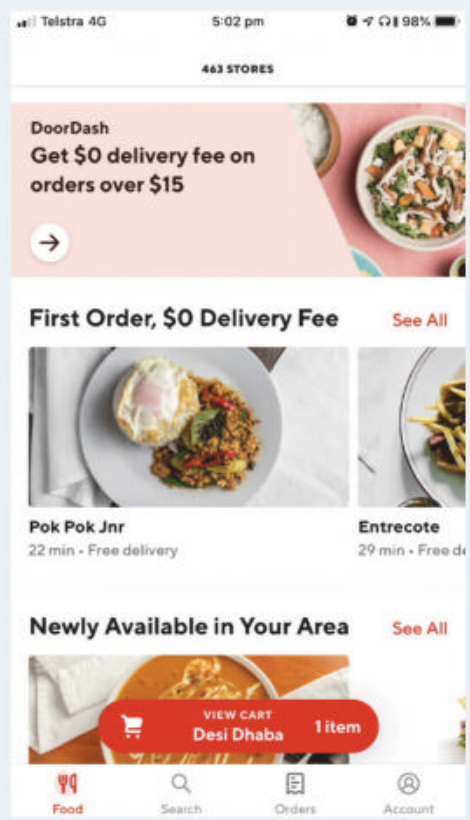
Daily Haloha's central philosophy is the idea that we're "all in this together", and that the simple act of sharing our cute answers to equally cute questions will make us feel a bit more connected. It's very simple – every 12 hours you're presented with a new fill-in-the-blank, like "one of my personal superpowers is ____" or "an action I can take to make today better is ____", which you answer. You swap answers with another user, and pick from a handful of reactions, which are then sent back to them. You can also view a log of every answer submitted. The app relies on the idea that making a complete stranger potentially smile once or twice a day is nice, and it absolutely is – I was surprised by how good I felt when I got a smile back for my asinine response to a question. Still, Daily Haloha is perhaps more harmless than actually helpful, and so far it hasn't revealed any grand truth of human nature or made me feel legitimately more connected to anyone. Regardless, it's a bit sweet.

Door Dash

Chew on this.

FREE | WWW.DOORDASH.COM

Food delivery service Door Dash is slowly making its way into Australia, with restaurants from Melbourne and Sydney now appearing on the app. If we're just talking about the app itself, and the user experience, it's honestly hard to fault Door Dash. At launch delivery is free on orders over $15, and all the information you could want on each restaurant is laid out clearly. There are helpful photos, the search functionality is great, and the UI is inviting. Plus, plenty of restaurants have already come on board. So far so food, but it doesn't take much digging before you might start to question whether this app, like Uber Eats and Deliveroo before it, are businesses you feel comfortable supporting. Door Dash is notorious in the US for underpaying workers and relying very heavily on tips; it's unclear what payments are like in Australia. There have also been reports of restaurants being signed up for the service against their will, not realising that the pick-up orders they're receiving are for app users until the delivery folks arrive. We might hold off until we hear more about the worker's experiences.



4MLinux 30.0

With more computers in the attic than on his workstation, Mayank Sharma keeps his eyes peeled for minimal distros.

FREE | HTTP://4MLINUX.COM

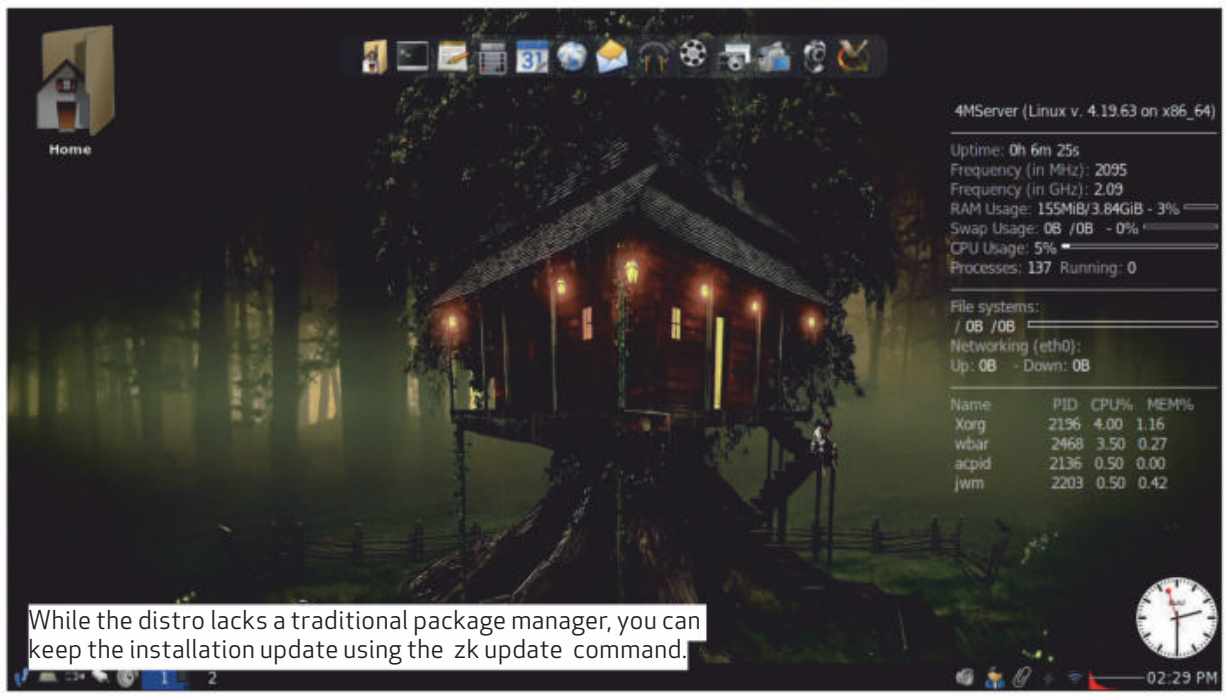
There are quite a few distros designed for older hardware. However, what sets 4MLinux apart is that you can mould it to your requirements. Each of the 4Ms in its name point a particular set of bundled apps. The distro has several system administration, monitoring and system rescue apps under the maintenance menu.

Similarly, it has a whole lot of multimedia apps to record, play, rip, edit, mix all kinds of audio, video and image files. The Mystery menu houses over a dozen popular, classic open source games including first-person shooters like *Doom*, *Duke Nukem 3D* and *Quake*. Finally there are miniservers, which is one of the reasons 4MLinuxis unique among its peers.

4MLinux employs Joe's Window Manager (JWM) and includes a panel, an applications menu, quick launchers, desktop icons, the wbar dock and Conky applet. JWM isn't the prettiest desktop but it's one of the lightest options for resource-strapped machines, and the 4MLinux developers have tweaked it enough to makeit look pleasing.

While you can get plenty of mileage from the distro straight out of the box, 4MLinux's package management makes it unique. Actually, 4MLinux doesn't include a package manager in the traditional sense of the word. Instead it rolls packages as add-ons that you can grab from within the Extensions menu. The collection is diverse and includes a large number of mainstream open source apps, including LibreOffice, Thunderbird, Firefox, Opera, VLC, VirtualBox, Wine and more.

You can download any of these apps with a single click, which is a lot more convenient than a traditional package manager. On the downside, you can't add any more apps besides the ones listed in the Extensions menu. This would have been a showstopper omission had 4MLinux been a desktop distro.



While the distro lacks a traditional package manager, you can keep the installation update using the zk update command.

> "The distro now includes OpenGL support for games right out of the box."

However, 4MLinux is primarily designed to resurrect old machines, and the ease with which you can flesh out the default install counts as a bonus. Once installed, the package is started from the same Extensions menu entry used for installation. If your computer lacks the resources to power an extension, you can uninstall it by simply removing its folder from the /opt directory.

The one feature that impressed us most about 4MLinux is its miniserver function. The distro includes a host of servers including a full LAMP server with Apache and MariaDB, as well as FTP, NFS, Proxy, and several others. While their inclusion alone makes the distro stand above its lightweight peers, 4MLinux also makes managing these servers pretty simple. You can start all the servers from the graphical menu, or only the ones you wish to use from the CLI. The distro also includes a web interface to help you tweak the configuration of these servers, along with tools such as Webmin and Adminer to manage the servers. Do note, however, that while 4MLinux is available for both 32-bit and 64-bit machines, the servers are included only in the 64-bit edition.

There are several notable improvements in this release, with the developer continuing to chip away the rough edges. For instance, the distro now includes OpenGL support for games right out of the box, and can automatically disable PulseAudio to avoid issues with some classic games. You can use all of the functions of 4MLinux, including the servers, from within the Live environment. Installation is handled by a custom CLI script and is slightly complicated. You'll first have to manually craft a partition for the distro using the Gparted partitioning tool from within the Live environment. Then fire up the installer and point it to this partition, which will then be formatted before installation.

You could argue that the 10th-gen Core is the successor to the Core 2 Duo from 2006.

10 IS THE MAGIC NUMBER

Intel's 10th-gen Core CPUs are here, and with them its 10nm production process. But, as Jeremy Laird found, the power of 10 is proving a little problematical.

It's been five long years since Intel's very first 14nm CPUs came to market. That's worth repeating. It's taken fully five years for Intel to roll out the 10nm successor to its 14nm production node. This from the company that has led the industry in manufacturing integrated circuits for decades. More than anything, it's Intel's advantage in chip manufacturing that has defined the company. But only now is it ramping up production of 10nm silicon as part of its new 10th generation of Core processors.

Of course, this is Intel, and nothing is ever simple. Strictly speaking, Intel trickled out a few dual-core 10nm chips in 2018. But if you can point us at an available retail product that uses these ultra-rare Cannon Lake chips, you'd be smarter than us. 10th-generation Core CPUs thus represent the first true availability of 10nm processors from Intel. Likewise, while Intel's new 10th-gen line-up does include both 10nm silicon and an exciting new microarchitecture, it also encompasses not just one but two 14nm designs based on existing microarchitectures. Intel 10th-gen, in other words, means a lot of different things.

That's just 10th-gen as we know it today. Don't be surprised if it becomes even more complicated. And that's just the products themselves. When it comes to branding, something Intel seemingly sees primarily as an opportunity to confuse its customers, the company is arguably achieving new lows with 10th-gen. The new nomenclature is so complicated and contradictory, it feels like you need a couple of MBAs, a law degree, and a PhD just to grasp the basics. But don't despair. There is some genuinely new technology buried beneath the brain-dead marketing. What's more, we're here to do the donkey work for you, and make sense of Intel's marketing madness.

Let's begin...

Before we deep-dive into all those new 10th-gen chips, there's an elephant that needs escorting from the path ahead. We speak of the extraordinarily long delay to Intel's 10nm production process, the successor to 14nm in all its many forms. According to Moore's Law, 10nm tech ought to have been in full flow by late 2016. After all, Moore's Law famously predicts the doubling of transistor density every couple of years, and thus essentially dictates a new process technology from Intel every two years.

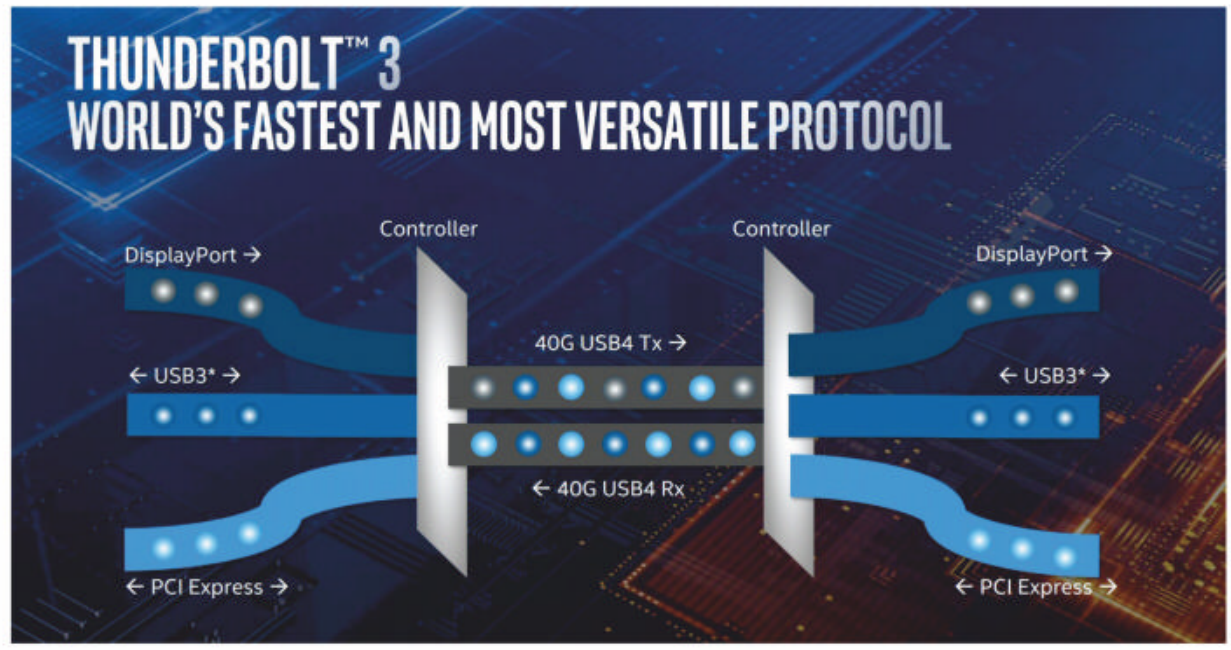
2016 sailed by, as did 2017. In 2018, Intel released a very small number of dual-core processors based on its 10nm node. But they were vanishingly rare and not true retail products. Even Intel described those initial 10nm products as "low volume." If we were cynics, we'd say they existed only so that Intel could claim that 10nm was in production and on sale.

Whatever, it's only now that 10nm CPUs from Intel are truly available, albeit with restrictions. At launch, 10nm is purely for mobile platforms. So, what happened? Inevitably, Intel hasn't been expansive in its explanations, but two fundamental issues have very likely been at play.

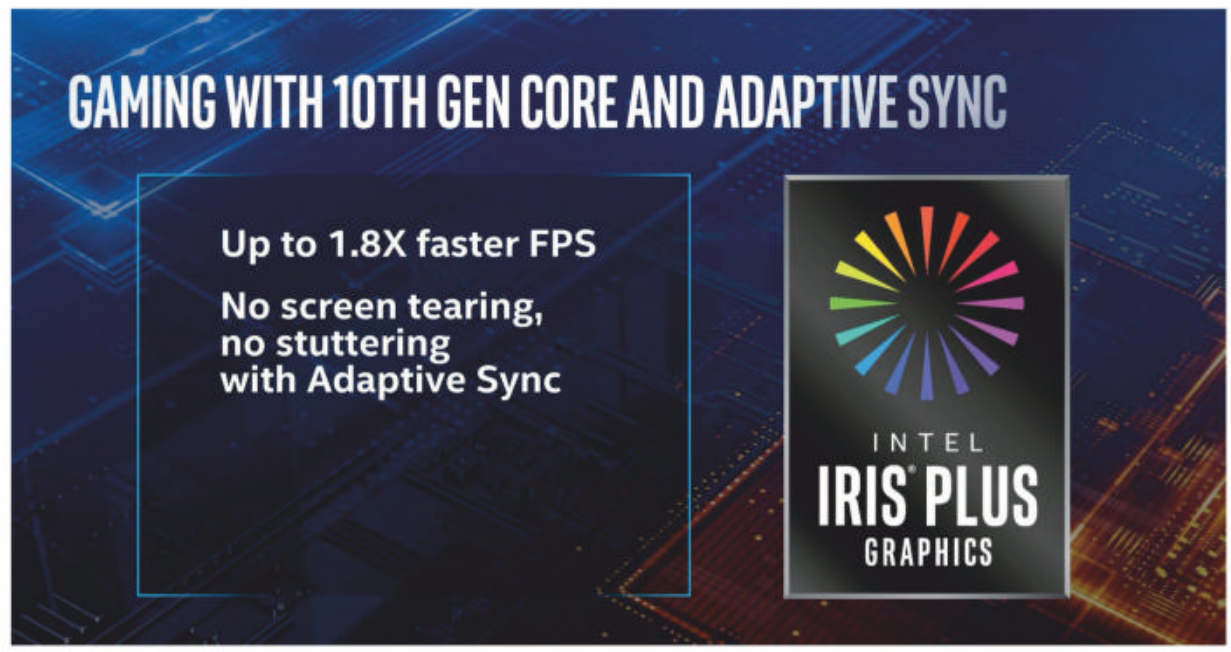
One: Intel was particularly aggressive with 10nm with regard to transistor density. For some time, the nomenclature attached to production nodes has become disconnected from the size of features in chips. In other words, the features inside a "14nm" Intel processor – the transistor gates, the logic cells, and so on – are not actually 14nm. By Intel's own figures, 14nm feature size actually ranges from 42nm through 399nm. That's the same for all major makers of integrated circuits. The node names have become labels, indicators of a given generation, rather than directly reflecting feature size.

Anyway, with feature size decoupled from the node nomenclature, the label "10nm" doesn't dictate transistor density. That's down to decisions made by Intel. For 10nm, Intel aimed for "hyper scaling" of density, in this case a 2.7x improvement in the number of transistors by area of integrated circuit. That compares with a scaling of 2.1x with the transition from 32nm to 22nm, and 2.5x improvement when 14nm came on stream.

Making matters worse, Intel went after this hyper scaling just as it was also running up against the limitations of its existing approach to producing chips using lithography based on ultraviolet (UV) light. It's the wavelength of the light used that informs the minimum size of features in a chip. UV light wavelength is in the order of 200nm. Using multiple masks and other tools, it's possible to produce feature sizes smaller than the actual wavelength. But with 10nm, Intel was pushing up hard against the limitations of UV light. 10nm is the end of the line for UV lithography. At the same time, the technology for extreme UV or EUV lithography, with wavelengths below 15nm, wasn't ready.



Integrated Thunderbolt 3 is part of the 10nm proposition.



10th-gen Core previews graphics technology that Intel will use to take on Nvidia and AMD.

"EVEN INTEL DESCRIBED THOSE INITIAL 10NM PRODUCTS AS "LOW VOLUME." IF WE WERE CYNICS, WE'D SAY THEY EXISTED ONLY SO THAT INTEL COULD CLAIM THAT 10NM WAS IN PRODUCTION AND ON SALE."

GENERATIONAL SHIFT

If that's the 10nm story, what about the 10th-gen narrative? While Intel's 10th-gen Core processors include new 10nm chips, there's much more besides. But we'll start with the 10nm hardware, because that's where the newest tech is found.

10th-gen chips that are 10nm also debut a new CPU architecture, known as Ice Lake. Depending on how you measure these things, Ice Lake represents the first extensively revised Intel x86 architecture since at least Skylake from 2015, and just possibly the first Intel Core chips in 2006.

For Ice lake, Intel has cooked up both a new microarchitecture for its CPU cores, Sunny Cove, and new graphics tech, denoted Gen11 Graphics. Together they form the basis of Intel's

key CPU and graphics technologies going forward. The latter half of the equation includes Intel's upcoming discrete graphics cards, which are likely to be based on the same architecture as the Gen11 integrated GPU in Ice Lake.

Ice Lake features start with a claimed 18 percent improvement in per core, per clock CPU performance compared to Skylake. Next up is a 2.5x increase in what Intel calls AI performance, the addition of AVX512 instructions, two times faster HEVC video encode, integrated Thunderbolt 3, DisplayPort 1.4a, and a whole lot more. In other words, Ice Lake is no simple die shrink with a few tweaks. It's the first major overhaul from Intel in a long time, worthy of the 10th generation tagline.

For now, Ice Lake is limited to mobile applications and is exclusively available in dual and quad-core variants for low and ultra-low power applications. Thus, Ice Lake is targeted at thin-and-light laptops and below, the latter encompassing even slimmer form factors, such as tablets.

Arguably less worthy of the 10th-gen designation are the other members of the line-up. For now, the most straightforward 10th-gen CPUs are the new HEDT (high-end desktop chips), the beasts based on Intel's workstation and server technology. Known as Cascade Lake-X, they're 14nm chips, ranging from 10 to 18 cores.

Feature-wise, they're dead ringers for their Skylake-X predecessors, which offered essentially the same microarchitecture and the same core counts. However, the big news with Cascade Lake-X is pricing. In short, Intel has pretty much cut pricing in half. The reason? AMD and the massively increased competition it is now presenting, especially in the form of its latest Ryzen 3000 series processors and the new third-gen Threadripper CPUs.

The final part of the 10th-gen puzzle, for now at least, is another set of mobile CPUs, this time based on existing 14nm production technology, an architecture derived from Skylake, and designated Comet Lake. Just like the Ice Lake chips we mentioned a moment ago, these Comet Lake processors are low and ultra-low power models, but along with dual and quad-core variants, Comet Lake also marks the first time that Intel has offered low-power six-core configurations.

Yes, you read that right. You can now buy a laptop based on a brand new 10th-gen Intel Core processor. And if it's dual or quad-core, it may be low or ultra-low power, it might be 14nm or 10nm, it might based on Skylake from 2015, or it might be a brand new architecture. Exactly how it makes sense that both of these families of CPUs, plus the HEDT multicore chips, are all designated 10th-gen is beyond our comprehension. But what we can say for sure is that it makes for a massive headache when it comes to actually recognising these CPUs in shipping products, particularly with regard to the mobile CPUs.

Allow us to elaborate. Traditionally, Intel has designated its low and ultra-low power chips with "U" and "Y" signifiers, respectively. By way of example, the eighth-generation Core i5-8265U was a quad-core low power CPU, with a 15W TDP, and a maximum boost clock of 3.9GHz, while the Core i7-8500Y was an ultra-low power dual-core model, with a 4.2GHz boost clock, and a 5W TDP. Is it a little confusing to have a dual-core Core i7 and a quad-core Core i5? Perhaps. But the U and Y designations at least made it clear what class of CPU you were dealing with, so there was logic of a kind.

But not with 10th-gen. Oh, no. In total, there are currently 19 different 10th-gen mobile CPUs to choose from. If we begin with the 10nm Ice Lake chips, the new nomenclature goes like this. Take the new Core i7-1065G7 as an example. It's a quad-core 10nm model with the most powerful "Iris" graphics option. Initially, the branding is fairly straightforward. The "i7" is Intel's established brand modifier indicating a high-performance model within a given range of CPUs. Next up, the "10"

DARE WE MENTION DESKTOPS?

Intel's 10th-gen CPUs are here. But wait—what about the desktop? For now, there are three different families of 10th-gen chips and none are mainstream desktop processors. So, what gives?

According to the narrative that has emerged over the last year or so, yup, the problem is 10nm. Rumors suggest that Intel is still having problems clocking the new process up, and also with yields. The first issue seems to be confirmed by the low clock speeds and relatively unimpressive TDPs of the first 10nm Ice Lake mobile chips.

By way of example, the quickest quad-core low-power Ice Lake CPU tops out at 4.1GHz, while the fastest of the new 14nm Comet family, also part of 10th-gen, hits 4.9GHz. In the ultra-low power area, Intel rates Ice Lake at 9W to Comet Lake's 7W. In some regards, those comparisons may be misleading. It's true that Ice Lake's Sunny Cove CPU cores bring more performance per clock, but the overall picture doesn't seem to be of a production process in rude health and delivering the typical benefits of a new node.

In a desktop context, of course, it's the clock speeds that are most worrisome. If the 10nm node really is the better part of a whole gigahertz behind 14nm in that regard, the 18 percent bump in per clock performance that comes with those Sunny Cove cores will be neutralized by the lower frequencies.

What with the well documented overall delay to 10nm – around three years – it's not surprising that rumors based on supposedly leaked roadmaps and suggesting Intel may skip 10nm for the desktop and go straight to 7nm have emerged. However, Intel has explicitly debunked such stories. A recent official statement from Intel said, "We continue to make great progress on 10nm, and our current roadmap of 10nm products includes desktop." Of course, "current roadmap" isn't quite the same as "definitely being launched." We'll believe 10nm mainstream desktop chips when we see them.

Ice Lake is great for laptops, but what about desktops?

THOSE NEW 10TH-GEN CHIPS IN FULL

In what is increasingly becoming an Intel tradition, the new 10th-generation Core processor family is nothing if not utterly baffling. So, here's every one of the new chips, along with their key specifications.

INTEL 10NM ICE LAKE-U SERIES MOBILE

	CORES/THREADS	BASE/BOOST (GHZ)	L3 CACHE	TDP	GPU UNITS	GPU CLOCK (MHZ)
CORE I7-1068G7	4/8	2.3/3.6	8MB	28W	64	1,100
CORE I7-1065G7	4/8	1.3/3.5	8MB	15W	64	1,100
CORE I5-1035G7	4/8	1.2/3.3	6MB	15W	64	1,050
CORE I5-1035G4	4/8	1.1/3.3	6MB	15W	48	1,050
CORE I5-1035G1	4/8	1.0/3.3	6MB	15W	32	1,050
CORE I3-1005G1	2/4	1.2/3.4	4MB	15W	32	950

INTEL 10NM ICE LAKE-Y SERIES MOBILE

	CORES/THREADS	BASE/BOOST (GHZ)	L3 CACHE	TDP	GPU UNITS	GPU CLOCK (MHZ)
CORE I7-1060G7	4/8	1.0/3.4	8MB	9W	64	1,100
CORE I5-1030G7	4/8	0.8/3.2	6MB	9W	64	1,050
CORE I5-1030G4	4/8	0.7/3.2	6MB	9W	48	1,050
CORE I3-1000G4	2/4	1.1/3.2	4MB	9W	48	900
CORE I3-1000G1	2/4	1.1/3.2	4MB	9W	32	900

INTEL 14NM COMET LAKE-U SERIES MOBILE

	CORES/THREADS	BASE/BOOST (GHZ)	L3 CACHE	TDP	GPU UNITS	GPU CLOCK (MHZ)
CORE I7-10710U	6/12	1.1/3.9	12MB	15W	24	1,150
CORE I7-10510U	4/8	1.8/4.3	8MB	15W	24	1,150
CORE I5-10210U	4/8	1.6/3.9	6MB	15W	24	1,100
CORE I3-10110U	2/4	2.1/3.7	4MB	15W	24	1,000

INTEL 14NM COMET LAKE-Y SERIES MOBILE

	CORES/THREADS	BASE/BOOST (GHZ)	L3 CACHE	TDP	GPU UNITS	GPU CLOCK (MHZ)
CORE I7-10510Y	4/8	1.2/3.2	8MB	7W	24	1,150
CORE I5-10310Y	4/8	1.1/2.8	6MB	7W	24	1,050
CORE I5-10210Y	4/8	1.0/2.7	6MB	7W	24	1,050
CORE I3-10110Y	2/4	1.0/3.7	4MB	7W	24	1,000

INTEL 14NM CASCADE LAKE-X SERIES HIGH-END DESKTOP

	CORES/THREADS	BASE/BOOST (GHZ)	L3 CACHE	TDP	GPU UNITS	GPU CLOCK (MHZ)
CORE I9-10980XE	18/36	3.0/4.8	24.75MB	165W	N/A	N/A
CORE I9-10940X	14/28	3.3/4.8	19.25MB	165W	N/A	N/A
CORE I9-10920X	12/24	3.5/4.8	19.25MB	165W	N/A	N/A
CORE I3-10900X	10/20	3.7/4.7	19.25MB	165W	N/A	N/A

"WHICH OF THE TWO 10TH-GEN MOBILE FAMILIES SHOULD YOU GO FOR. THAT IS A VERY TOUGH QUESTION TO ANSWER, UNLESS YOU EITHER DEMAND SIX CORES OR WANT THE BEST POSSIBLE INTEGRATED GRAPHICS PERFORMANCE."

indicates a 10th-gen Core processor. So far, so good.

The next two digits, the "65," identify both the specific SKU in question and its status as a low or ultra-low power processor, "5" in this case indicating low power – alternatively, "0" would signify an ultra-low power chip. Keeping up? Finally, the "G7" reveals the level of graphics power, with "7" designating the top tier of Gen11 graphics, with fully 64 execution units. If you've got all that, you'll no doubt immediately grasp that the Core i5-1030G4 is a quad-core 10nm ultra-

low power 9W Ice Lake processor with a top Turbo speed of 3.5GHz, and Gen11 graphics, with 48 execution units, right?

Now, while this is a break from the past, it follows a certain logic. So, all Intel needs to do is stick with that logic and we all have half a chance of keeping up. Except that isn't what happens. For starters, even within the Ice Lake series, there's a Core i7-1068G7, which breaks the "5" and "0" indicators for low and ultra-low power. But that's nothing compared to the confusion that occurs when you add the alternate Comet Lake 10th-gen mobile processors into the mix.

That's because Comet Lake retains the old "U" and "Y" designators. Thus the Core i7-10710U is a low power 15W 10th-gen 14nm processor with six cores, Gen9.5 graphics, and a top Turbo speed of 4.7GHz, while a Core i5-10310Y is an ultra-low power 7W quad-core chip, again with Gen9.5 graphics, and a maximum Turbo speed of 4.1GHz.

Quite how Intel imagines mainstream consumers can follow any of this, we have no idea. It's not entirely clear, for that matter, why Intel felt the need to offer two parallel low and ultra-low power CPU series within the 10th-generation line-up. However, we suspect that concerns over 10nm production capacity are at the heart of the matter.

The next obvious question is which of the two 10th-gen mobile families should you go for. That is a very tough question to answer, unless you either demand six cores or want the best possible integrated graphics performance. In the first scenario, only 14nm Comet Lake can deliver. In the second, you want an Ice Lake Processor with its fancy new Gen11 graphics. But for everything else? It's unclear at best.

On the one hand, Ice Lake offers a more efficient architecture that does more work per clock cycle. On the other, Comet Lake SKUs tend to clock higher. As for battery life, that's confusing, too. You might expect 10nm tech to be clearly superior for battery life, but the 10nm Ice Lake ultra-low power models, for instance, are rated at 9W, while the equivalent Comet Lake options are pegged at 7W.

In practice, your choice will often be dictated by other features, such as screen technology, chassis quality, and so on. But if you've narrowed down your options and are left with both flavors of 10th-gen CPU and little else to base a decision on, we'd lean toward the 10nm option for its stronger feature set. Extras such as integrated Thunderbolt 3 and support for DisplayPort 1.4a maximise connectivity options, particularly when it comes to adding future high-res displays.

GET READY FOR SOME DECENT GRAPHICS

Over one teraflop of pure compute performance, support for ultra-high resolution HEVC encode and decode, improved display pipelines, an enhanced rasteriser, variable rate shading, over double the performance in 3D rendering, and support for adaptive sync. This, ladies and gentlemen, is the elevator pitch for Intel's new Gen11 graphics technology, as seen in the new 10nm Ice Lake mobile CPUs.

In terms of actual in-game frame rates, Intel reckons that the fastest Gen11 integrated graphics core is typically around 80 percent faster than the Gen9.5 graphics found in eighth-generation processors, and sometimes over 100 percent faster. Much of that improvement is down to increased complexity. Gen11 graphics tops out at 64 execution units to the maximum 48 of its Gen9.5 progenitor. However, the 48-execution-unit iteration of Gen9.5 was limited to a small number of SKUs, whereas the 64-unit Gen11 graphics is found in nearly half of the currently available Ice Lake processors, including ultra-low power versions.

3D performance aside, Gen11 brings some other very nice enhancements. It supports two HEVC 10-bit video encode pipelines in parallel, and in terms of display output, Gen11 can drive three 4K screens at the same time – two via DisplayPort 1.4 HBR3, and another courtesy of HDMI 2.0b. Alternatively, it can drive dual 5K displays or a single 4K display at 120Hz. Nice. *Very* nice.

But what is the relationship between Gen11 and Intel's new discrete graphics chips, due next year and known as Intel Xe? Officially, we don't know. But our expectation is that Xe will be based on the same building blocks as Gen11, but with some additional enhancements, including hardware support for ray tracing. For those discrete cards, the indications are that initial SKUs will include GPUs with 128, 256, and 512 execution units. Given that Gen11 with 64 units is broadly good for 1080p gaming at 30fps and decent detail levels, the higher-end Xe chips, with nigh on 10 times the complexity, make for an interesting proposition.

Is 10th-gen Core where Intel finally gets in on the game?

Back on the desktop, of course, it's a lot easier. On the HEDT side, the pricing of 10th-gen Cascade Lake-X makes it a massive step forward in terms of value. You get double the cores at any price point compared to Skylake-X. As for mainstream desktop, there are no 10th-gen chips at all, for now.

Overall, then, this is the most interesting new generation of chips from Intel in a long time. But also the messiest. It includes Intel's first new production node in five years, and its most significant architectural overhaul in at least four years, not to mention debuting what will probably be the basis of Intel's graphical assault on Nvidia and AMD. But amalgamating the genuinely new 10nm products with a bunch of rebaked 14nm chips under a single 10th-gen banner, then cooking up some of the most baffling branding yet devised, is also a source of frustration. At this point, the term "generation" as Intel uses it means pretty much zilch. Still, you now know exactly what to expect from the CPUs Intel has deemed to describe as 10th-generation Core processors. For a while, at least. ■

THE HISTORY OF THE PC

In a world of competing processors and operating systems, John Knight explores how the PC began.

The PC. The personal computer. The IBM-compatible. Whatever you want to call it, somehow this machine has maintained a dominant presence for nearly four decades.

If you try to launch a program from the '80s to the 2000s, you have a good chance of getting it to launch – your PC has backward compatibility going right back to the '70s, enabling you to run pieces of history as though they were from yesterday. In fact, your computer is brimming with heritage, from

the way your motherboard is laid out to the size of your drive bays to the layout of your keyboard.

Despite the weight of all of this lineage, we have an extraordinary range of devices that somehow get lumped under the category "PC." Go back to the early '80s, and "PC" would evoke a desktop box from the business colossus IBM, but now the name doesn't belong to anyone, it still survives as "the PC."

Flip through any PC magazine and you'll see everything from bulky desktop computers to sleek business laptops; from expensive file servers to single-board devices only a few inches big. Somehow, all these machines are part of the same PC family, and somehow they can all talk to each other.

But where did all of this start? That's what we'll be examining: from the development of the PC to its launch in the early '80s, as it fought off giants such as Apple, as it was cloned by countless manufacturers, and as it eventually went 32-bit. We'll look at the '90s and the start of the multimedia age, the war between the chip makers, and the establishment of Windows as the world's leading operating system. Lastly, we'll examine the new millennium, initially dominated by Microsoft and the PC, followed by a slow shift to where we are now.

But before we go anywhere, to understand the revolutionary nature of the PC, you first need to grasp who IBM was at the time, and the culture that surrounded it.

THE LEAD UP TO THE PC

For decades, IBM was king, but the late 1970s brought a change in direction.

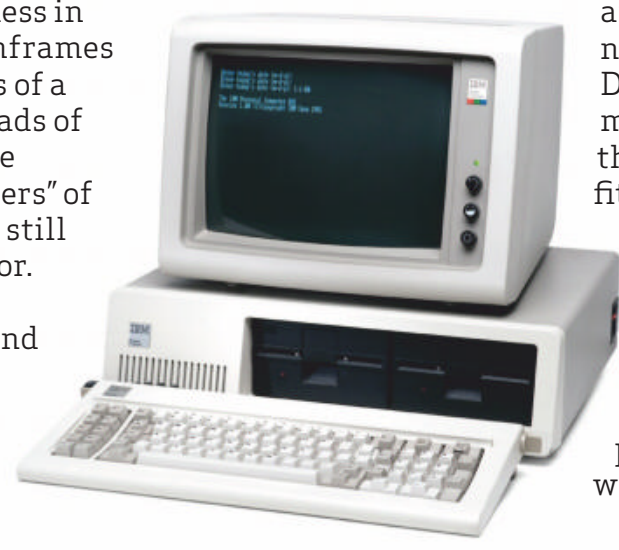
IBM was formed in the early 20th century by people who invented the kind of punch-card machines and tabulators that revolutionised the previous century. IBM introduced big data to the US government, with its equipment keeping track of millions of employment records in the 1930s. It gave us magnetic swipe cards, the hard disk, the floppy disk, and even ATMs. It would develop the first demonstration of AI, and be integral to NASA space programs. IBM has employed five Nobel Prize winners, six Turing Award recipients, and is one of the world's largest employers.

When it came to respected marques, you couldn't get much higher than IBM, and the top brass knew it – to say the corporate culture was stuffy would be an understatement. Company pride and loyalty was instilled in all workers. IBM bosses insisted on well-groomed salesmen, with dark suits, white shirts, and "sincere" ties – there was even an IBM anthem and songbook. IBM's mainframe computers dominated the '60s and '70s, and that grip on the industry gave IBM an almost instant association with computers in the minds of consumers. But trouble was on the horizon.

The late '70s were saturated by "microcomputers" from the likes of Apple, Commodore, Atari, and Tandy. IBM was losing customers as giant mainframes made way for microcomputers. As similarly large manufacturers were about to launch micros of their own, trying a new form of desktop computer was a way to fight back against rivals, but it would take a monumental shift in strategy.

IBM took years to develop anything, with endless layers of bureaucracy, testing every detail before releasing anything to market. Its chief business in the '60s was huge mainframes that filled entire floors of a building, and took squads of people to run, while the so-called "minicomputers" of mid-'60s and '70s were still the size of a refrigerator.

IBM was a long way from offering simple and (relatively) affordable desktop computers, and didn't even have experience with retail stores. Meanwhile, microcomputer manufacturers were developing new models in months, and there was no way IBM could keep up while sticking to traditional methods.



At last, the PC, the IBM 5150, is ready to take on the world.

ASSEMBLING THE CREW

In August 1979, the heads of IBM met to discuss the growing threat of microcomputers, and their need to develop a personal computer in retaliation. IBM president John Opel already recognised the potential in personal computers, but could also see the weakness in IBM's existing methods. In order to encourage innovation, IBM created a series of Independent Business Units, which were given a level of autonomy. One of these would soon be led by executive Bill Lowe, who would become the father of the PC.

In 1980, Lowe promised he could turn out a model within a year if he wasn't constrained by IBM's methods. Lowe's initial research led him to Atari, which was keen to work for IBM as an OEM builder, proposing a machine based on the Atari 800 line. Lowe suggested IBM should acquire Atari, but IBM rejected the idea in favor of developing a new IBM model instead.

This model was to be developed within the year, with Lowe given an independent team. This new squad, the Dirty Dozen, a group of IBM misfits, was allowed to do things however they saw fit to get the job done. The task was code-named Project Chess, with Lowe promising a working prototype in 30 days.

After talking to potential dealers, Lowe went for an open

Desktop Predecessors

The IBM PC 5150 wasn't the first IBM computer to be called "PC."

Contrary to popular belief, the IBM PC was not the first personal computer, nor was it the first desktop computer by IBM. Microcomputers existed long before "the PC," and as for IBM itself, desktop computers had already been developed, though in very different forms to the PC we know now.

In 1973, IBM developed a prototype computer called SCAMP, which emulated an IBM 1130 minicomputer in a "portable" (we use the term loosely) boxed form factor, with a small monitor and keyboard built in.

Perhaps of most interest in relation to the 5150 Personal Computer is 1975's IBM PC 5100. Before you start jumping up and down, here the "PC" actually stands for "Portable Computer." This was similar to the SCAMP, but designed for mass manufacture, using an IBM PALM CPU. A good 64KB model cost just under $20,000, and that's in 1975 money.

Finally, there's IBM's System/23 Datamaster, released just before the PC. This was a definite desktop computer, with a relatively compact footprint, but it ran an 8-bit Intel 8085 CPU, and had two 8-inch floppy drives. Interestingly, the System/23 used the new Model F keyboard before the PC.

architecture. While dealers were very interested in an IBM machine, it just wouldn't work if they had to operate within IBM's proprietary methods. If dealers were going to repair these machines, they needed to be made from standard off-the-shelf parts.

By August, Lowe had a very basic prototype and a business plan that broke away from established IBM practice. Based on this new open architecture, the PC would use standard components and software, instead of IBM parts, and be sold via normal retail channels.

DEVELOPING THE PC

Over the coming months, the Dirty Dozen grew exponentially in number and toiled away to transform the prototype into a world-class machine. They focused on giving the PC an excellent keyboard, which they delivered with the IBM Model F.

It needed to be durable and reliable, so each key was rated to 100 million keystrokes. It also needed to be tactile and ergonomic. IBM was renowned for quality keyboards, and would try to replicate the feel of older beamspring terminal keyboards with a new Buckling Spring technology.

These gave the keyboards the famous clacky sound and weighted feel that was popular with typists, giving a tactile feedback unrivaled at the time. The PC's keyboard alone would become the main selling point for a lot of customers, and IBM keyboards would be the best in the business for the next two decades.

Next, the crew turned to the CPU. IBM's own 801 RISC processor was considered (which would have been significantly more powerful), but for convenience and compatibility's sake, the team chose the Intel 8088.

By choosing an 8088 processor, technically the original IBM PC is only partly 16-bit. There is often confusion over why IBM chose to use the inferior 8088 CPU instead of the 8086 (especially with a so-called "x86" computer). Both are internally 16-bit, but the difference between the 8086 and the 8088 was the data path – the 8086 had a full 16-bit data path; the 8088's was 8-bit.

The 8088 was still quite fast, but was cheaper and could be bought in the large quantities the new PC market would demand. An 8086 would also require far more complex and expensive motherboards, and may not have been able to be produced in sufficient numbers to keep up with demand. A lot of the hardware likely to be used in the PC also had an 8-bit bus, so an 8088 would be better for compatibility.

IBM wasn't just a colossus in size, but also in sluggishness. Observers claimed it would take "nine months to ship an empty box."

As for the motherboard, RAM would be expandable up to 256KB, an optional 8087 math coprocessor would be available, and there would be five ISA expansion slots. Putting the machine together, launch models would have a choice of 16 or 64KB of RAM, space for two 5.25-inch floppy disk drives, and a cassette jack for tape storage. Buyers had a choice of monochrome or CGA graphics, and the Intel 8088 powering the system would be running at 4.77MHz.

With the hardware sorted, the burden of developing the operating system would be largely outsourced to Microsoft, with IBM offering consumers the joint-venture PC DOS. The final machine was dubbed the IBM Model Number 5150. This moniker would be immediately forgotten, for in the minds of the press, it was really IBM's Personal Computer that was about to launch.

Apple II
The great rival.

Without the Apple II, it's possible the PC would never have existed. Although a subject of debate, it's generally agreed that the Apple II was a primary influence on the PC. Many IBM engineers owned one – as did many customers, who found that they could easily do jobs, such as working on spreadsheets, that were nearly impossible on a giant mainframe.

Sporting an 8-bit MOS 6502 processor, with between 4KB and 64KB of RAM, it debuted in June 1977 for a base price of US$1,298. It had an incredible production run, selling from 1977 to 1993. Developed by Steve Wozniak, the Apple II stands in stark contrast to products developed by Apple's lesser Steve (Mr. Jobs). Chiefly, the Apple II is designed around an open architecture, with a removable lid allowing easy access to the motherboard and expansion slots. Much like the PC, the Apple II would be the subject of numerous clones over the years.

Even though the PC was newer, the Apple II retained advantages over the PC, such as having eight expansion slots over the PC's five, and much more convenient gaming, with bundled joysticks and games that loaded in seconds.

An open architecture? Easy access to expansion slots? Steve Jobs could never have designed such a thing!

THE 1980s: THE PC OFFICIALLY LAUNCHES

Rivals were unfazed by the old timer's new machine, but had no idea what was about to hit them.

A 386 with VGA – ask someone to think of classic DOS gaming, and this is likely the first thing that comes to mind.

After a 12-month development, IBM announced its new Personal Computer on August 12, 1981. The US$1,565 base model included 16KB of RAM, CGA graphics, and an input jack, relying on the user to provide a cassette deck (disk drives were optional and far more expensive).

Rivals such as RadioShack and Apple were unconcerned, as they had many times more dealers, large support networks, extensive software libraries, cheaper products, and models with better performance. Steve Jobs bought one to dissect and was unimpressed by some of its old-fashioned tech. In its hubris, Apple took out a full-page ad proclaiming "Welcome, IBM. Seriously." But it failed to recognise the weight a company like IBM carried with businesses.

Even though IBM's product was inferior in many ways to its cheaper competitors, businesses saw IBM as a safe bet, with excellent customer support. Within a year, the PC overtook the Apple II as the best-selling desktop computer. In 1983, two thirds of corporate customers standardised on the PC as their computer of choice, with only nine percent choosing Apple, and by 1984, the PC's annual revenue had doubled Apple's.

IBM surprised the industry by breaking its own traditions. Not only did it allow service training for non-IBM personnel, but it published the PC's tech specs and schematics to encourage third-party peripherals and software. Within a couple of years, the PC was the new standard for desktop computers, spawning a massive sub-industry of peripherals and expansions.

In 1982, the PC was updated to IBM's XT (eXtended Technology) standard, removing the cassette jack, and adding a 10MB hard disk. It was the first PC with a hard disk as standard.

August 1984 brought IBM's next major release, the PC/AT (Advanced Technology). Sporting a 6MHz Intel 80286 (aka 286 – no one used the "80" prefix anymore), it came with 256KB of RAM, expandable up to 16MB. Initial models were limited to CGA and monochrome, but IBM's new 16-color EGA standard was soon introduced, allowing for 16 colors at 640x350. This was another step toward the PC we recognise now, with things like standardised drive bays, motherboard mounting points, and the basic keyboard layout we now take for granted.

The Compaq Portable made waves as the first proper IBM-compatible. If you could lift it.

THE IBM-COMPATIBLES

Although a hit with businesses, the first PC was too expensive for home users. The base model's price wasn't too outlandish, but it didn't include a monitor or floppy drive – a decent 64KB model with a floppy drive and monitor was more than US$3,000 (over US$8,000 in

If it weren't for that nasty keyboard, perhaps the PCjr could have worked out....

PCjr

The PCjr looked promising: an Intel 8088 CPU, CGA Plus graphics, and the kind of sound chips used by Sega consoles. IBM promised a home machine with PC compatibility, improved graphics and sound, and a lower price of US$1,269. Consumers adored the wireless keyboard, and it was IBM, the king of computing. Pundits thought the PCjr would destroy the competition, but on release it was universally panned.

A Commodore 64 was a third of the price, faster, with better graphics, and a huge software library. The PCjr's strange hardware and optimisations also meant it was only partially PC compatible, failing gamers and business users alike. What really riled consumers was the appalling rubber chiclet keyboard: A relatively expensive computer – from a company known for quality keyboards – was lumbered with something found on $99 budget micros.

Initial sales were a disaster, but a campaign of discounts, ads, and upgrades (particularly the keyboard) turned things around, making the PCjr a mild success. Nevertheless, its reputation was damaged – the PCjr was canceled in 1985.

today's money). Rivals smelled opportunity, and with an open architecture, it wouldn't be long before IBM clones would arrive.

Initially IBM wasn't concerned: While a PC could be mostly replicated with retail parts, the BIOS belonged to IBM, which guaranteed proper IBM compatibility. However, companies such as Award and American Megatrends reverse engineered IBM's BIOS, and companies such as Dell, Compaq, and HP then used cloned BIOSes to build clone machines.

The first clone came from Columbia Data Products with 1982's MPC 1600, but 1983 saw the landmark Compaq Portable, the first computer to be almost fully IBM compatible. Compaq used its own BIOS and provided a very different form factor to a desktop PC, with all the components in one box, including a small CRT monitor.

When IBM released its ill-fated budget PCjr in 1984, RadioShack made a clone, the Tandy 1000. It was far more successful than the PCjr, with better PC compatibility. After the PCjr's cancelation, existing software and peripherals came to be associated with the Tandy.

Far cheaper clones were eroding IBM's control of the market, with its share dropping from 76 percent in 1983 to 26 percent in 1986.

ENTER THE 386

At least IBM had the technological lead, but even that would be eroded when Compaq released 1986's Deskpro 386. Intel had recently released its 32-bit 80386 CPU, but unfortunately for IBM, Compaq beat it to market with a 386 machine boasting 1MB of RAM and MS-DOS 3.1. This was two to five times faster than a 286, with a base price of US$6,500. Compaq's machines were the very top of the line, and would steal IBM's title of business leader.

IBM fought back with 1987's Personal System/2 (PS/2), finally releasing a 386 to market; the most powerful model sporting a 20MHz CPU, 2MB of RAM, and a 115MB hard disk. This was a landmark computer, standardising on things such as a 1.44MB 3.5-inch floppy, and the PS/2 ports still used by mice and keyboards. However, the biggest leap was in the introduction of VGA graphics. On the desktop, this meant 640x480 in 16 colors, and a low-res mode of 320x200 in 256 colors, popular for gaming.

When it came to business, Apple forgot the adage, "No one ever got fired for buying IBM."

Despite the incredible advances, IBM continued to lose ground to the clones. Although the PS/2 line sold well for a time, IBM's machines were still too expensive for the general public. As the '80s progressed, the name "PC" started losing its association with IBM, and the public started referring instead to "IBM-compatibles."

Although the PC was sweeping America, in many regions worldwide micros were still wildly popular – Europe was particularly enamored of the Atari ST and Commodore Amiga. Where PCs were lacking in the GUI stakes, these Motorola 68000-based machines already had sophisticated GUIs and astonishing multimedia capabilities that would trounce PCs for some years – often at a fraction of the cost.

Nevertheless, the PC continued to grow and develop, with further advancements such as 800x600 SVGA (Super VGA) graphics in 1988. And the '80s had one last trick up their sleeve: In April 1989, Intel released the 486, the powerhouse CPU that would kick-start the next decade. The first computer to ship was IBM's 486/25 Power Platform in October, making it the most powerful machine on the market.

However, 486 machines wouldn't enter most households until the 1990s—286s were still the order of the day, and many brands were still making budget XT clones. Where a 386 was considered the height of sophistication, a 486 was witchcraft. Nevertheless, the '80s were a time of astonishing technological progress: We entered the decade with 8-bit micros and left with full 32-bit processors and SVGA graphics. It's unlikely such rapid progress will be repeated.

The OS Wars Begin

The battle for which company and OS will rule the PC starts with the beginning of the PC itself. Mention "DOS" and Microsoft DOS will come to mind, but there are plenty of variants. Enter Digital Research's CP/M-86. CP/M was the original "DOS," shipped with most non-proprietary machines. IBM originally planned to use CP/M-86 with the PC, but negotiations went sour when IBM wanted to pay Digital Research a one-time fee, rather than on-going royalties.

Meanwhile, Microsoft had purchased a clone of CP/M-86 from Seattle Computer Products, 86-DOS (aka QDOS – Quick and Dirty Operating System). This was re-branded to MS-DOS and IBM's PC DOS, available for the PC. After Digital Research threatened legal action, IBM gave customers the option to buy either CP/M-86 or MS-DOS/PC DOS. MS-DOS/PC DOS was the substantially cheaper option, and outsold CP/M-86 in overwhelming numbers.

IBM and Microsoft's MS-DOS/PC DOS partnership wouldn't last long, with the two products gradually diverging over the years, with different features and compatibility. PC DOS was designed for genuine IBM hardware, and as IBM compatibles took over the market, the more generic MS-DOS would become ubiquitous. Regardless, both versions would stay in production until the turn of the century.

IBM's PC DOS "By Microsoft" partnership didn't last long.

THE 32-BIT '90s
A decade when computers would adopt desktops and multimedia.

Previous versions of Windows were unsuccessful, but with 1990's Windows 3.0, the PC desktop was seen as a viable alternative to the Macintosh and Amiga. Windows 3.0 had a new interface, multitasking abilities, and mouse-driven productivity suites that freed users from the command line.

Meanwhile, IBM's OS/2 had been trying to establish itself as the respectable GUI for corporate America. By 1990, the alliance between IBM and Microsoft had essentially finished, with the two becoming rivals. Although newer versions of OS/2 would be more advanced, for now Microsoft had the technological advantage. IBM was still hampered by 286 machines, keeping OS/2 primarily 16-bit, unable to use the advanced features of the 386.

April 1992 finally saw OS/2 become 32-bit. In most ways, it was superior, with extensions to DOS, and Windows 3.x support in a stable environment. But while Windows targeted clone machines, OS/2 targeted IBM hardware, so it couldn't run on many clones where Windows ran perfectly. Furthermore, while IBM sold OS/2 as a separate product, Microsoft bundled Windows with new PCs.

Microsoft's dominance started with Windows for Workgroups 3.11 in August 1993. It had new 32-bit capabilities and proper networking. It devoured the business space, and 3.11 would be the environment many people grew up with.

THE MULTIMEDIA AGE

In the mid-'90s, every PC had a soundcard, CD-ROM drive, and tinny set of multimedia speakers. CD-ROM's 650MB of storage allowed more expansive gaming, with FMV cutscenes and CD-audio soundtracks. Schools bought edutainment packages with archived video and interactivity.

By now, the 486 was standard. Although 386s were still functional business machines, you needed a 486 to enjoy this era. Thankfully, hardware prices fell dramatically; while '80s PCs usually had Intel CPUs, rival manufacturers were on the ascent and lowering costs.

Although AMD CPUs were often from a previous generation to Intel's, its chips were more efficient and allowed higher clock speeds, giving similar performance at much lower prices. Cyrix was making a name for itself with 486-upgrade processors, providing a cheap upgrade route for 386 owners with a new CPU in their old motherboard.

1993's Intel Pentium brought the next generation of CPUs. Intel dropped the "86" to differentiate itself from other manufacturers, with "Pent" coming from the Greek "penta," meaning five (implying a 586 without saying it).

A typical '90s gaming PC, where a 3D accelerator would make you the envy of all n00bs.

The Pentium gave almost twice the performance per clock cycle as the 486, but early Pentiums were only 50–66MHz. Meanwhile, AMD was pumping out insanely overclocked 486s, such as the DX4-120 running at 120MHz, nearly matching early Pentiums. AMD's strong performance and low prices attracted manufacturers such as Acer and Compaq, whereas Cyrix's efficient designs caught IBM's eye, starting a partnership in 1994.

1995 saw the introduction of the ATX standard we use today, defining new mounting placements and features like automatic shutdowns. Unlike XT and AT, this change was brought by Intel instead of IBM.

August 1995 would see the biggest change to the computing landscape yet: Windows 95. On the technical side, Windows 95 was designed around 32-bit pre-emptive multitasking, compatibility with existing DOS and Windows programs, and new tech such as DirectX and Plug and Play support. But the real change was the interface. A taskbar, a "Start" button in the bottom-left, the "Maximize," "Minimise," and "Close" buttons at the top-right of the window.... We take these norms for granted now, but they started with Windows 95.

Windows 95 truly established the Microsoft goliath. Computing had become mainstream, and Microsoft was a household name. It was over for competitors: Commodore had gone bankrupt, Atari hit the wall, and Apple was barely surviving. IBM still had OS/2, with its newer Warp release from a year prior, but this only supported Win 3.x applications and sank into irrelevancy.

When Windows 98 arrived, it fixed many of the teething

The 386 and the 32-Bit Era

It's difficult to overstate the 386's importance. In short, the 32-bit 386 is where modern computing began. List the features of a modern OS, and for the PC, these abilities started with the 386, serving as the basis and minimum spec for the next generation of OSes in the '90s.

With the 386, PC operating systems immediately became more advanced, with a flood of Unix variants being ported to the platform. Advanced computing was previously dominated by expensive Unix workstations, but once the PC went 32-bit, they grew redundant, and big Unix companies such as DEC and Sun Microsystems started falling away. Until late 2012, a 386 could still run Linux (now it requires a decadent 486).

Put a squeaky millennial in front of a 16-bit machine and they won't know what they're looking at, but with a 386, they might stand a chance.

problems of Win 95, with a more stable system, better hardware support, and UI enhancements. This was also when the anti-trust lawsuits began, as Microsoft bundled Internet Explorer with Windows, itself already bundled with new computers. Now Microsoft would dominate not just PCs, but internet browsers too.

THE PERFORMANCE AGE

3D accelerator cards – such as 3dfx's Voodoo 2, Nvidia's Riva TNT, and ATI's Rage series – would be a defining feature of the late '90s. 3D acceleration brought a new era of PC gaming. Where previous games relied on the CPU for all rendering, these new graphics cards added a GPU (graphics processing unit), which took the graphical processing burden away from the CPU, allowing substantially faster gaming and stunning graphical effects.

Although 3dfx tried to corner the market with its proprietary Glide API, it eventually lost out to competitors who used market standards such as DirectX and Silicon Graphics's OpenGL. The ultimate card of the '90s would be 1999's Nvidia GeForce 256.

This point is where the CPU race is whittled down to AMD and Intel.

Until now, things looked great for Cyrix. The mid-'90s saw 5x86 upgrade chips for 486 machines, followed by the 6x86 in October 1995. The 6x86 out-performed mid-level Pentium machines for less money – Cyrix was becoming a technological leader rather than just a budget manufacturer.

Business was good until complex 3D games such as *Quake* uncovered Cyrix's embarrassing floating point and integer performance. Cyrix was great at spreadsheets, but terrible at gaming, which tarnished the brand. 1997's MediaGX helped improve things, with a system-on-chip design perfect for laptops and the budget PC market, but as Intel continued to advance, Cyrix did not.

IBM may have been struggling to sell desktop computers, but it made a killing with its new ultra-rugged ThinkPad laptops.

Newer-generation CPUs were really highly overclocked 6x86s – prone to high failure rates, still poor at gaming. The Cyrix-IBM partnership ended in 1998, and worse yet, Intel soon entered the budget market with its Celeron line. Cyrix was out of cash, and its tech was bought out by VIA in 1999, who gradually phased out the brand.

AMD, meanwhile, went from strength to strength. During the Pentium era, reverse-engineering Intel's processors became too complex, so AMD started designing its own style of processors, rather than follow Intel designs.

In 1996, AMD released the K5, the first Pentium rival, but 1997 brought true success with the K6. This was a proper rival to the new Pentium II, but could work in older Socket 7 motherboards. The K6 series was wildly successful, with its famous 3DNow! instructions, and cheaper prices. The successive K6-2 and K6-3 chips continued to rival advancing Pentium II and III models, and would eventually dominate most of the sub-$1,000 market.

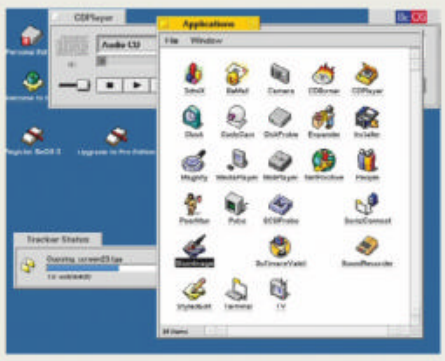
We would end the decade with 1999's K7 Athlon, the first retail CPU to break the 1GHz mark.

The '90s were a time of survival of the fittest, ending with one dominant OS and two CPU makers. Thankfully, the GPU market still had a few years of diversity remaining.

Other than the dull colors, Windows 95 is where the PC started to resemble the interface of today.

BeOS
The sleek alternative.

Be Inc. (founded by ex-Apple executive Frenchman Jean-Louis Gassée) launched the BeBox in October 1995, running its own operating system, BeOS. Optimised around multimedia performance for the masses, BeOS was intended to compete with both Mac OS and Windows. Lightning fast and free of the legacies of old 16-bit hardware, BeOS had features such as symmetric multiprocessing for multi-CPU machines, pre-emptive multitasking, and the 64-bit journaled file system BFS. Although the BeBox itself was unsuccessful, BeOS was ported to the Macintosh in 1996, and almost became the new system to replace Mac OS. Gassée's US$300 million asking price was too steep, however, and Apple went with Steve Jobs's NeXTSTEP OS instead. BeOS was then ported to the PC in 1998, along with a free stripped-down BeOS 5.0 Personal Edition, but it failed to gain more than a niche audience (Microsoft may also have worked against its adoption). Be Inc. was bought out by Palm Inc. in 2001. Despite numerous recreations, BeOS is now survived by Haiku, a popular open-source re-implementation with BeOS binary compatibility on 32-bit versions.



In an alternate universe of Betamax VCRs, where Al Gore was president, BeOS reigns across Macs and PCs.

BEYOND 2000

Microsoft totally dominates the start of the millennium, but this decade ends elsewhere.

After 2007's iPhone, Apple shifted industry focus to portable devices, becoming the world's biggest company in 2012.

The new century would start with Windows 2000 (arguably the best release of Windows) and Windows Me (arguably the worst). Win 2000 was based on Microsoft's NT platform, finally moving Windows away from DOS, while remaining mostly backward compatible with Windows 9x and DOS programs. 2000 had the stability of NT and the minimal aesthetic of the 9x series, without the bloat of future releases.

Later in the year, Microsoft released Windows Me (Millennium Edition) – still based on Windows 9x, which was still based on DOS. Often regarded as Microsoft's worst operating system, it somehow managed to be buggier and less refined than previous 9x releases. Whereas Windows 2000 is remembered as an underrated gem, Windows Me brings cold shivers down the spines of IT staff who lived through that scary time.

October 2001 saw the release of Windows XP, using the same NT base as 2000, with a revamped interface, and improved multimedia capabilities. While previous versions of Windows were pretty drab, XP was colorful. XP made piracy much harder, being the first Windows to have an activation scheme. The mix of relative stability and a friendly GUI made XP one of the most popular OSes of all time. Microsoft kept having to extend support for XP, right up until 2014, when it officially cut the cord. Despite this, there are still plenty of XP users, spreading digital disease across the Internet.

PLATFORM SHAKE-UPS

In April 2003, AMD released its 64-bit Opteron processor. This was the first major change to the x86 platform not made by Intel, and would be labeled either x86-64 or, embarrassingly for Intel, AMD64. Intel was forced into the position of modifying its processors for software compatibility with AMD's new specification. Although it would take a few years for the new spec to catch on, it would eventually become the standard in use today.

In May 2005, IBM sold its PC division to Lenovo in a deal worth nearly US$2 billion. As part of the deal, IBM would acquire a stake in Lenovo, and sell Lenovo goods under a marketing alliance – existing lines like the famous IBM ThinkPad laptops would be sold as Lenovo ThinkPads. Skepticism was high over the viability of such a merger but Lenovo went on to become the biggest PC vendor in the world, while IBM would focus on big-data markets and the cloud.

In June 2005, Apple announced that Macs would switch from PowerPC to x86 processors. Steve Jobs was disappointed in the progress of PowerPC CPUs, which were slower than Apple had promised consumers, too hot for laptops, and consumed too much power. Although the market was concerned, the Intel machines were faster than their PowerPC counterparts, and sales increased.

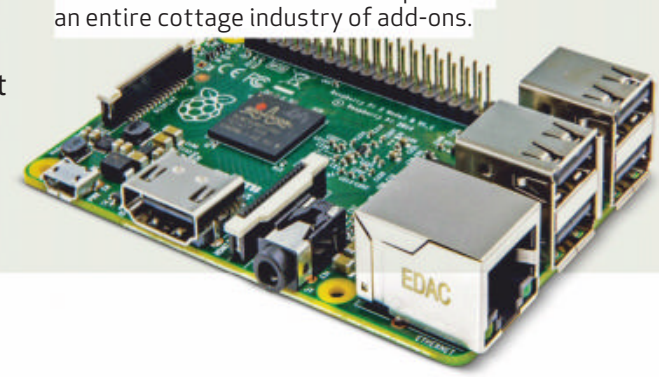
Between July and October 2006, AMD bought out graphics company ATI Technologies in a deal worth US$5.6 billion. Merging ATI's graphics tech with its existing CPU know-how, AMD was now taking on the might of both Intel and Nvidia with the manufacturing strength of combined technologies.

The Raspberry Pi Revolution

In February 2012, the successful Raspberry Pi was released, taking the industry by storm with a new form factor, often referred to as a single board computer (SBC). Made in Britain from a combination of cell phone and desktop parts, the Pi is barely larger than a credit card, for $35. The Pi was intended to get kids programming after the Raspberry Pi Foundation recognised a national decrease in programming skills, but it became more popular with hobby builders and the embedded computing industry.

Unfortunately for PC giants, the Pi ran Linux on an ARM CPU instead of Windows on x86. Due to its popularity, Microsoft ported Windows to the system a few years later, and manufacturers started producing rival machines. For the ARM crowd, there are products like the Asus Tinker Boards or Pine 64's RockPro64. For the x86 crowd, there are products like the Atomic Pi and the LattePanda series. ARM boards are generally cheaper and more efficient, while x86 boards can often run regular builds of Windows or Linux.

In spite of imitations, the Raspberry Pi still sets the standard and has spawned an entire cottage industry of add-ons.



To confused audiences worldwide, CEO Satya Nadella announces Linux-based Microsoft technologies.

THE VISTA HITS THE FAN

In January 2007, Windows Vista was released. Even though it was based on NT, Vista had a vastly different framework from previous versions, making for an essentially new platform. Vista was designed to be more secure, showcasing new features like intelligent RAM storage, and an updated GUI with effects like window translucency, but it was savaged by the press.

Windows Vista had bad backward compatibility, long loading times, and a stream of invasive warning messages. It improved with time, but the damage was done – computer manufacturers started shipping PCs with the option of XP. Microsoft would learn from its mistakes with the next release.

Windows 7 arrived in July 2009. Based on the same platform as Vista, it refined the codebase, bringing performance improvements, better stability, and a sensible interface.

To pick some highlights from a long list of new features, Win 7 had faster boot times, better multicore performance, easier networking, new virtualisation tech, and better backward compatibility. The UI changes were popular, including a new taskbar with more functionality, and the Snap function, which moved and resized windows when dragged against the screen edges.

Windows 7 would become the fastest selling OS in history, and around a third of PCs still use it. It's well regarded among IT staff, and many users are avoiding the switch to Windows 10, despite Extended Support ending next year.

In July 2012, Google's Chrome browser overtook Internet Explorer in usage share, and by April 2013, both Chrome and Firefox had a greater share of users than Internet Explorer, ending Microsoft's dominance of the browser market.

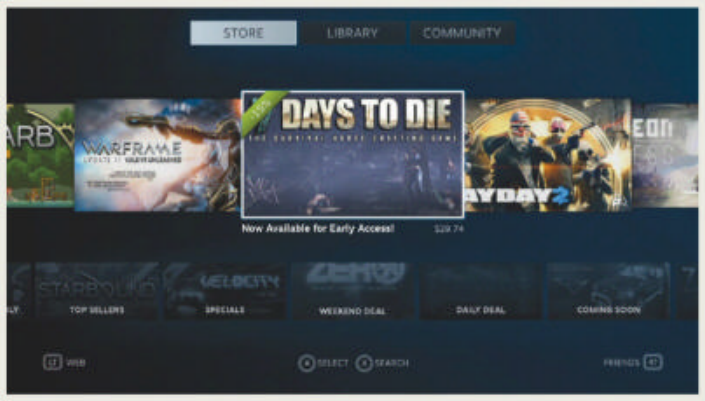
In October 2012, Windows 8 was released. Despite Microsoft's attempts to innovate, Windows 8 was critically savaged. As mobile devices were overtaking traditional desktops, Win 8 tried to have more of a "touch" interface, removing the "Start" button, and switching to a tile-based design. The result was a dreadful unintuitive compromise. Win 8 also introduced the Windows Store, a Microsoft-governed system for buying apps, in the style of Apple. This restrictive way of buying software drew criticism, especially from Valve, which started its own SteamOS in response.

Windows 8.1 addressed many of its criticisms, chiefly by bringing back the "Start" button and allowing users to boot a traditional desktop. But again, the damage was done. While Windows 7 is still in heavy use, Windows 8 is almost forgotten.

WHERE ARE WE NOW?

We end the decade with Windows 10 (released July 2015). Reception has been mixed. On the plus side, the interface is a more functional blend of Windows 7's traditional GUI and Windows 8's tile system, and Windows finally has virtual desktops (something featured in other OSes for decades). On the down side, forced system updates continue to infuriate users, there is a worrying amount of data collection, and the Microsoft Store undermines the open nature of the PC platform.

Microsoft still dominates the PC desktop, but is no longer a monopoly, with Apple having spent most of the decade wealthier than Microsoft. Niche OSes are growing in popularity.

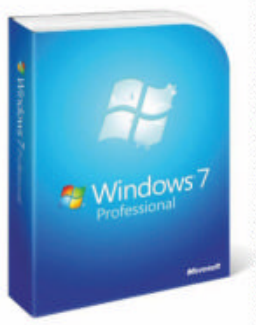


What About SteamOS?

When Microsoft released its proprietary Windows Store, Valve's Gabe Newell described it as a "catastrophe for everyone in the PC space." Valve felt that the Windows Store threatened Steam's existence, and decided to branch out with its own platform, using Linux as a base. First, Valve released the full Steam gaming client for Linux in February 2013, followed by its own platform, SteamOS, based on Debian Linux in December 2013. (Linux and SteamOS applications are generally cross-compatible.) However, SteamOS failed to gain much traction, and most of the user base would come from the regular Linux client.

Perhaps following the advice of id Software's John Carmack, Valve re-focused its attention from encouraging native SteamOS/Linux ports to perfecting Wine, the Windows compatibility layer for Linux. In August 2018, Valve released Proton, a modified version of Wine with a DXVK translation layer to convert between newer Direct3D system calls and Vulkan. It should be noted that Proton can be used for regular apps, not just gaming, so the more obscure games that can run, the more likely it will run any Windows apps without problems. Over half of all Windows games run out of the box, and that rate is growing steadily.

After Vista was poorly received, Microsoft won back consumer confidence with 2009's Windows 7.



Linux is creeping into everything from DVD players to the world's supercomputers. Microsoft has gone from calling Linux "a cancer" to proclaiming "Microsoft loves Linux," shipping Windows with a Linux kernel, and running its own Azure Sphere Linux distribution for IoT devices.

To focus on the PC, it isn't the dominant format it once was. IBM has long since left the market it created, and wisely so. Computing is more varied and takes many forms, from iPads to smartphones, from Chromebooks to weird Android devices no one can categorise. Computing has returned to a diversity like the '80s, but the PC no longer has the same supremacy – nor do the giants that established it, such as IBM, Intel, and Microsoft. ■

WINDOWS REFRESH

Ready to reinstall Windows? Are you really? Alex Cox and Nick Peers explain your options...

So, you use Windows. You're in a slowly shrinking but still three-quarters majority, so it's not a surprise: Windows users are ubiquitous. Almost as ubiquitous as people complaining about Windows, because macOS and Linux users do that, too.

Whatever your gripes, the thought of reinstalling Windows has likely crossed your mind at some point. Perhaps you've even gone ahead without thinking of the consequences. You might even have been left with a half-functioning machine that's missing many of your critical files and programs. Let's be clear at the start of this feature (one that's ostensibly about reinstalling Windows): Reinstalling Windows is generally a really bad idea.

Hear us out. Windows 10 is a much cleaner and more stable OS than its predecessors. There's no good reason to reinstall it unless you've managed to mess with its system files to the point of oblivion, or you've fallen victim to some serious malware that can't be expunged in any other way. If you're in the latter bracket, it's probably too late for your files – unless you've taken the correct precautions. With a proper process built into your everyday computer use, reinstalling is trivial and safe. Mostly pointless, but clean enough.

So, you could reinstall Windows, and we'll talk about it in detail, but we'll also show you other options. Before you throw everything away and start over, perhaps you'll want to clean everything up manually, or use Windows' own refresh tools, to leave your current installation in a better state. Maybe you'd like to try an innovative (and slightly silly) dual-boot, putting a clean Win 10 alongside your dirty one. You could be moving machines, and want to turn a fresh install on your new hardware into something akin to your current PC. It all sounds easy, but following the proper procedure is essential if you want to keep everything precious.

"Whatever your gripes, the thought of reinstalling Windows has likely crossed your mind at some point. Perhaps you've even gone ahead without thinking of the consequences."

Reinstall for fun and profit

Keep lists of installed programs, and their activation keys, to rapidly make your old PC feel like new again.

Reinstalling Windows 10 is a fairly trivial task. Put in the right media, boot from it, grind away the old OS, and replace it with the pristine bits of a shiny new install. This can be a painless, if time-consuming, procedure that leaves you with a like-new PC, or perhaps an even better one if you were unlucky enough to buy a PC burdened with preinstalled trashware.

Before you do this, make sure you've checked off a few prerequisites, all of which are good practice even if you're not planning to wipe everything and start again.

First, keep a record of your product key (if you have one – most likely if you've upgraded from a previous version of Windows), or make sure your digital licence is well looked after. If you've bought a PC in the last few years, you're probably using a digital licence rather than a key. Check Settings › Update & Security › Activation. If you see the message "Windows is activated with a digital licence," this means you're digitally signed, but you should link that license to your Microsoft account in case of installation issues or future hardware changes. Head to Settings › Accounts › Your Info, sign in with your Microsoft account details, and the message should change to "Windows is activated with a digital licence associated with your Microsoft account."

KEY INFORMATION

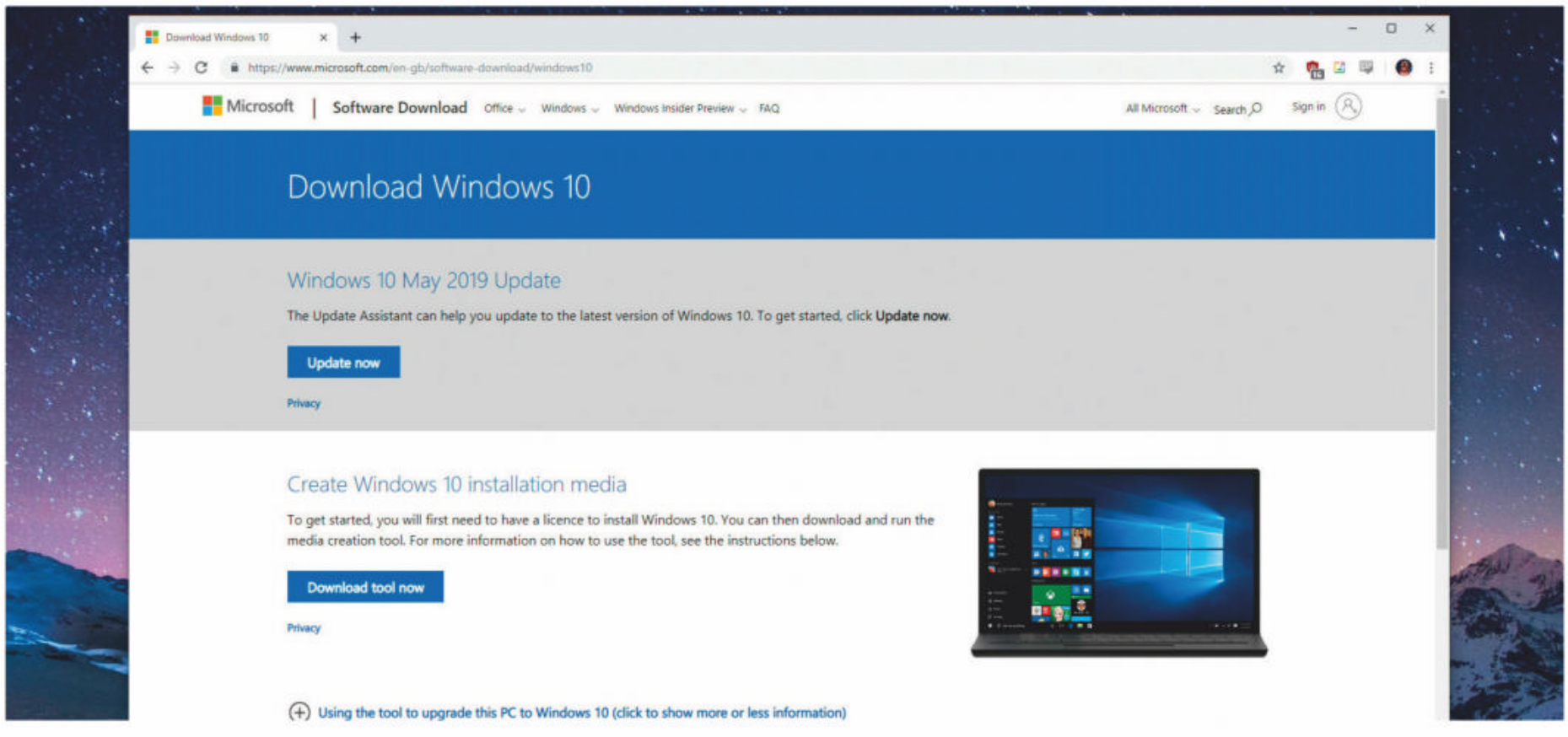
Next, dig out the keys for all your crucial software and keep them safe too, as you'll need to reinstate everything manually when performing a full reinstall. You can use PowerShell to make a list of your installed programs; run it as administrator, and type: **Get-ItemProperty HKLM:\Software\Wow6432Node\Microsoft\Windows\CurrentVersion\Uninstall* | Select-Object DisplayName, DisplayVersion, Publisher, InstallDate | Format-Table –AutoSize › C:\software.txt**

A list is created as a file called software.txt in the root of your C drive. Tweak if you want a different file name or location. Keep a copy of this elsewhere, in case you come to your reinstalled machine and realise there's something you've forgotten.

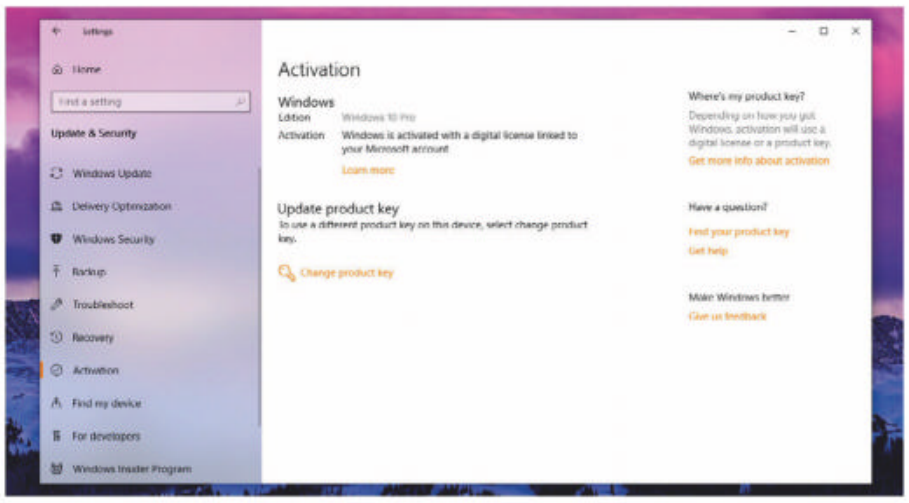
If you want to make your job easier, ProduKey (**http://nirsoft.net**) can dig up keys for many Microsoft apps and Windows; also consider using a lockable password manager, such as LastPass (**www.lastpass.com**), to not only keep a record of logins, but to store details about your software so it's always there when you need it.

You can't back up programs (Windows' file structure doesn't work like that), but you can (and should) back up every other little thing. Backing up your hard drive using something like

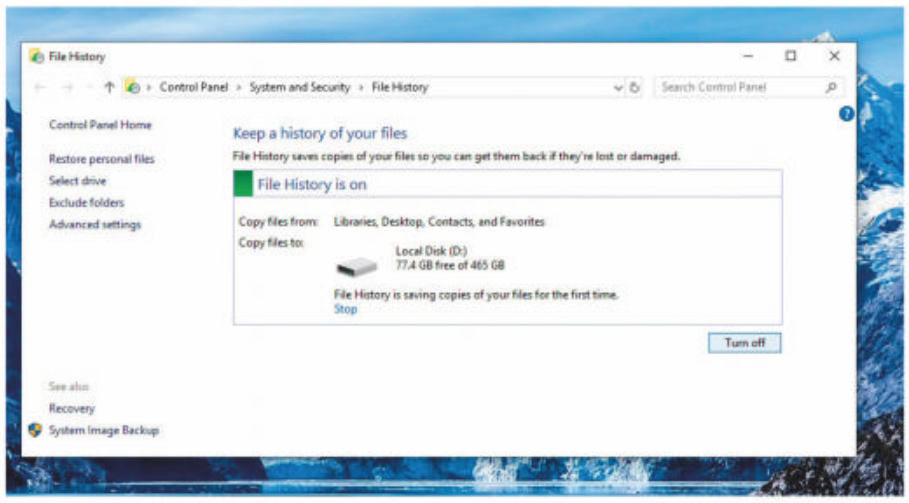
> "Dig out the product keys for all your crucial software and keep them safe, as you'll need to reinstall that too."



Microsoft is happy to dole out the code for Windows 10, but you'll need a proper licence if you want to use it fully.



Ensure your licence key is properly linked to your Microsoft account before you begin reinstalling Windows.



File History isn't just about keeping versions – it's about keeping everything, and can be a real lifesaver.

Macrium Reflect might seem like a solid idea, and it's the best way to make sure you don't miss anything, but a compressed copy won't give you access to the files you need once it's made, and it's pointless if you're reinstalling to fix a broken system – instead, consider Windows File History to perform rolling backups of crucial folders as you use your machine. It's slow to start, but if this is something you set up to run invisibly as you use your PC (and, ideally, back up to different hardware periodically), you always have a backup ready when you need one. Try to include driver installation files in your personal folders, to be caught by File History – and consider creating a second, manual backup of all of your important files. Check them both for integrity before you pull the trigger.

One last consideration: DRM. It's a menace, but never more so than when you have a bunch of DRMed files that are tied to an account that limits PC authorisations. Kill your current install, and you might not be able to get that authorisation back – you could even lose access to all the things you've bought; DRM is cruel like that. So, make sure any management app, such as iTunes, has been de-authorised before you leave your current install behind.

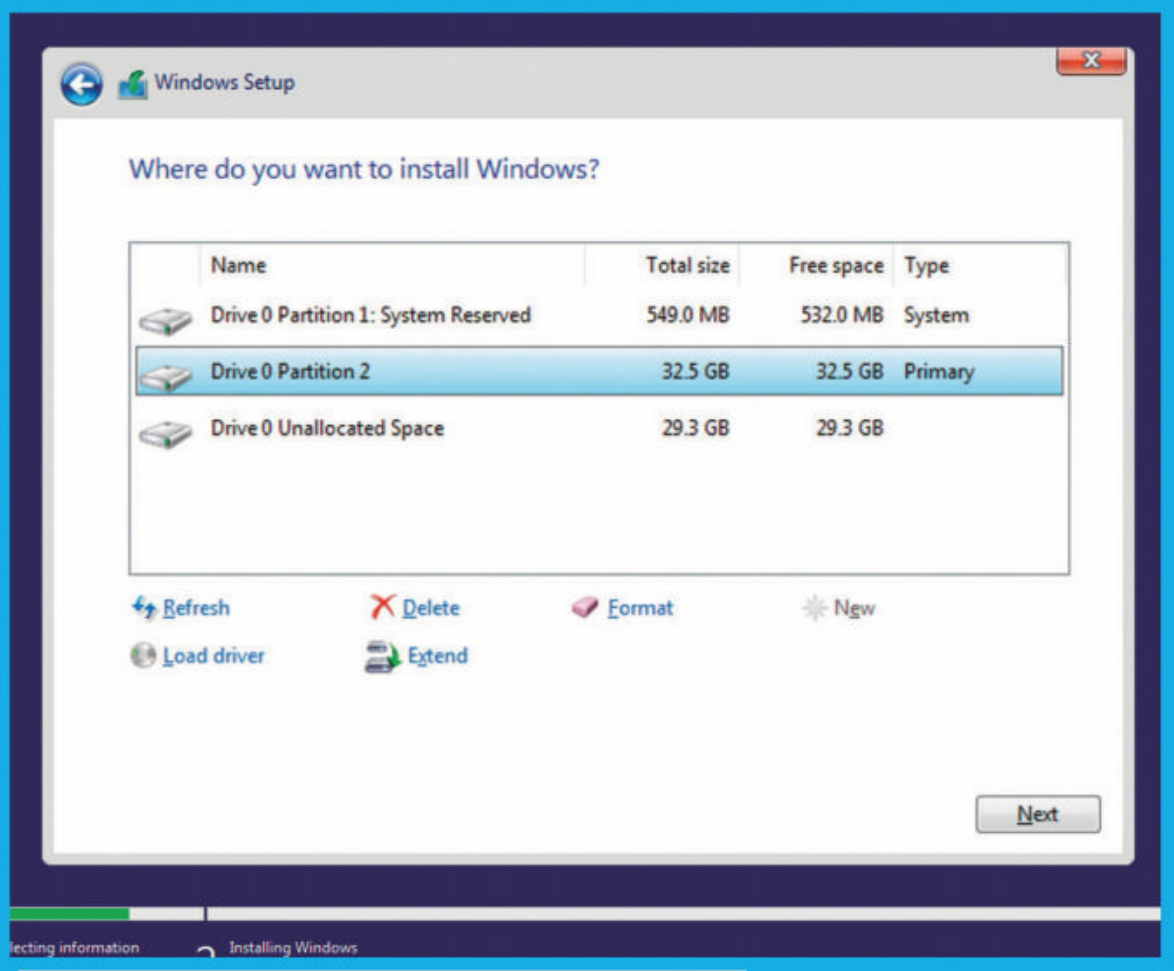
INSTALLATION ART

With all this done, go ahead and reinstall. You can create your own installation media by heading to **www.microsoft.com/en-us/software-download/windows10** and using the media creation tool to put the latest update of Windows 10 on a USB stick ready for installation. Over the page, we show you everything you need to reinstall your operating system, but a couple of notes first: You'll want to select Install Windows Only, because the Upgrade option will leave your PC basically as it was; and you can skip inserting a product key – you can do this later, or your PC will activate itself when you sign in to your Microsoft account.

Multibooting Windows 10

One of the factors that contributes to our pessimism surrounding reinstalling Windows is that we desperately don't want you to lose anything. We're kind like that. But there is another, slightly frivolous way to do a reinstallation if you've got working hardware to play with: you can turn one Windows installation into two. If you have a second drive that is able to support a Windows 10 installation, or enough access to your current Windows 10 installation (and enough free space) to be able to trim down its drive using Disk Management then create a new clean partition, you can install a second copy of the operating system alongside the first. Simply select a custom install, and then point Windows 10 at that spare disk space – it should then do the rest for you.

It's questionable whether you'd technically need a second Windows licence to do this – you can only possibly use one instance of Windows 10 at a time if installed this way, so it shouldn't be an issue, but the Microsoft EULA does suggest that only one instance is allowed to exist. Take that as you will. You'll likely need to switch off BitLocker before partitioning your drive, and if you use Windows in this way, you'll want to do this anyway, since an unlocked filesystem on your original install can be easily accessed on your new one. Copy everything to a safe new location, make sure you've got everything, and you can ditch the original install – and if you're likely to use the new installation as your main copy of Windows, you'll need to make sure it's first in the boot order. It should be by default, but you may need to poke around in your BIOS/UEFI settings to select the correct drive, or set it through the Advanced system settings link from the Control Panel's System tab.



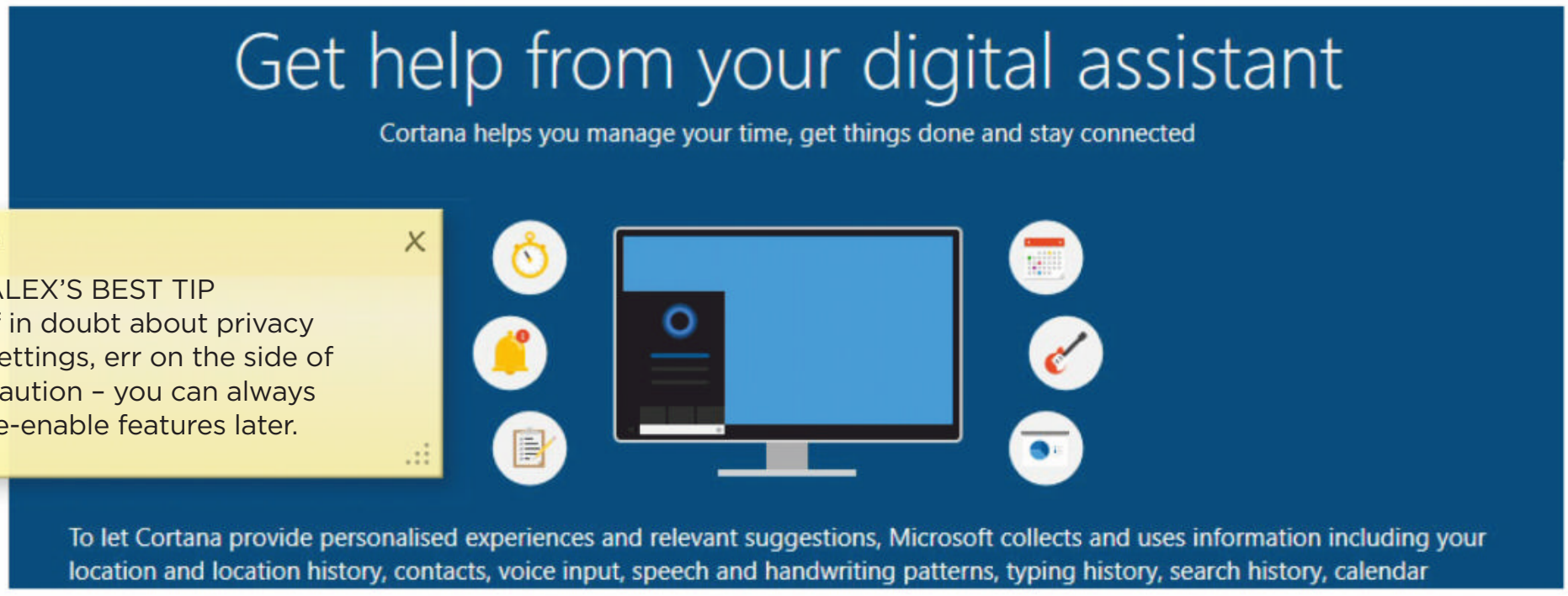
Just select the correct partition and install away. But make sure it definitely is the correct one before you start.

Learn how to reinstall Windows 10

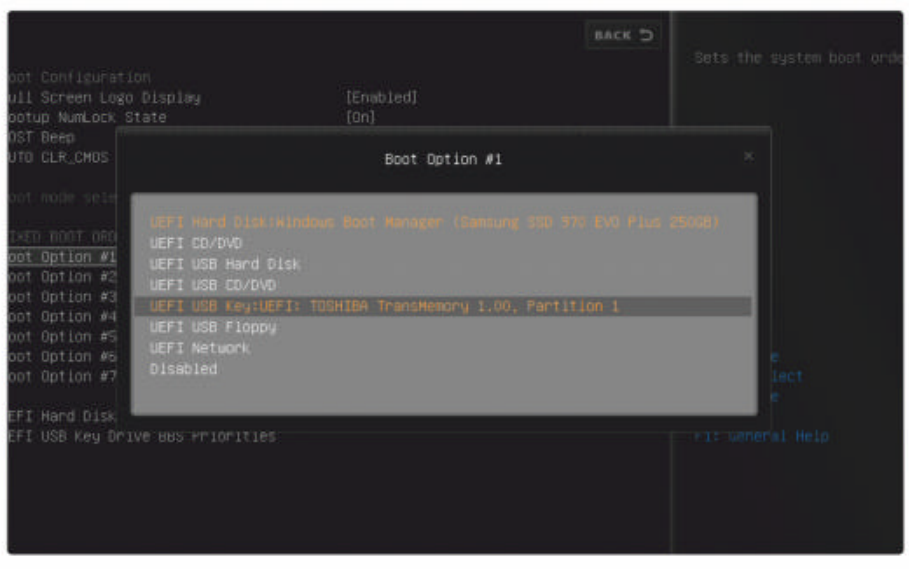
Create brand new installation media and then reinstall the latest version of Windows 10 from scratch on your hard drive.

The act of reinstalling Windows 10 can feel daunting. Never fear: we're going to step you through the entire process from booting from your Windows installation media to running carefully through the post-install setup options.

If you've not yet done so, visit **www.microsoft.com/en-gb/software-download/windows10** and click Download tool now to download and run the Media Creation Tool. Insert a blank DVD, or plug in an unused USB flash drive (8GB or larger). After launching the tool, accept the licence terms, then choose Create installation media… and follow the prompts (use recommended options when asked) to create your flash drive or generate an ISO file. If you choose the ISO file option, click Open DVD burner at the end to write it to your blank DVD. Once your installation media has been created, read on.

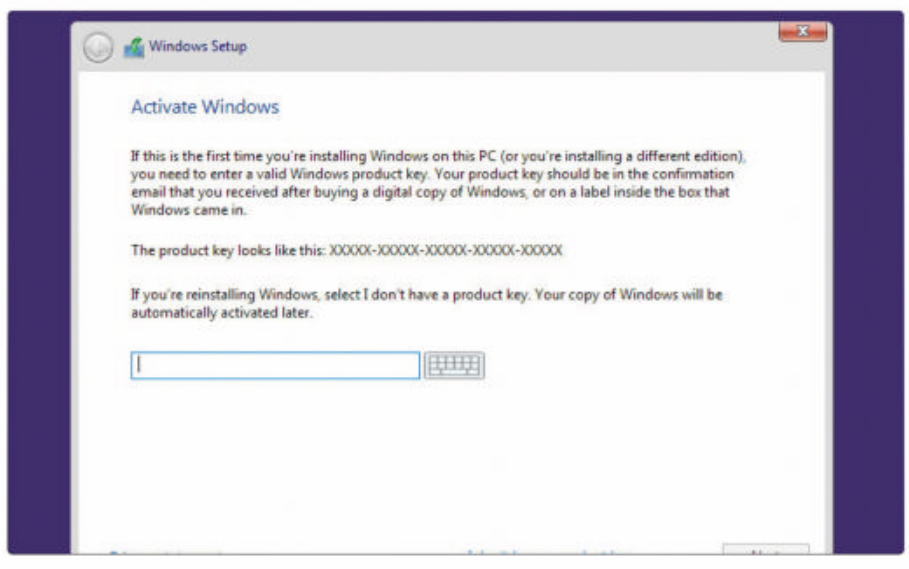


Step-by-step | Install Windows 10



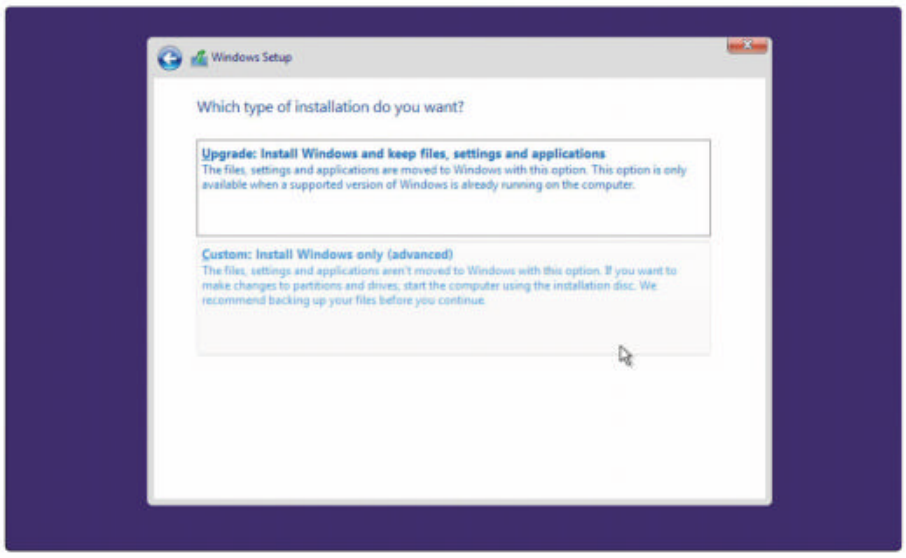
1 Boot from installation media

Insert or plug in your Windows installation drive (choose a USB 3.0 port for your USB flash drive for maximum performance) and then start or reboot your PC. If it doesn't automatically start the installation process, reboot again, but this time look for a message about choosing a boot device (typically the F11 or F12 key). Tap this, then choose your DVD or USB drive to boot from it.



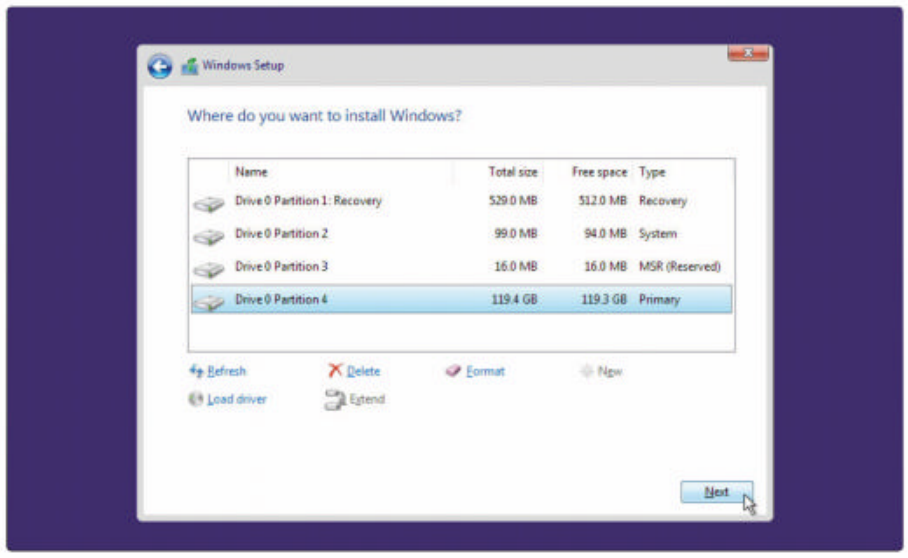
2 First steps

At the first screen, verify that the language, time and currency format and keyboard are all set to the correct location, such as English (Australia). Click Next, followed by Install Now. When the Activate Windows box appears, click 'I don't have a product key' unless you're using a local account rather than a Microsoft one, in which case enter the product key and click Next.



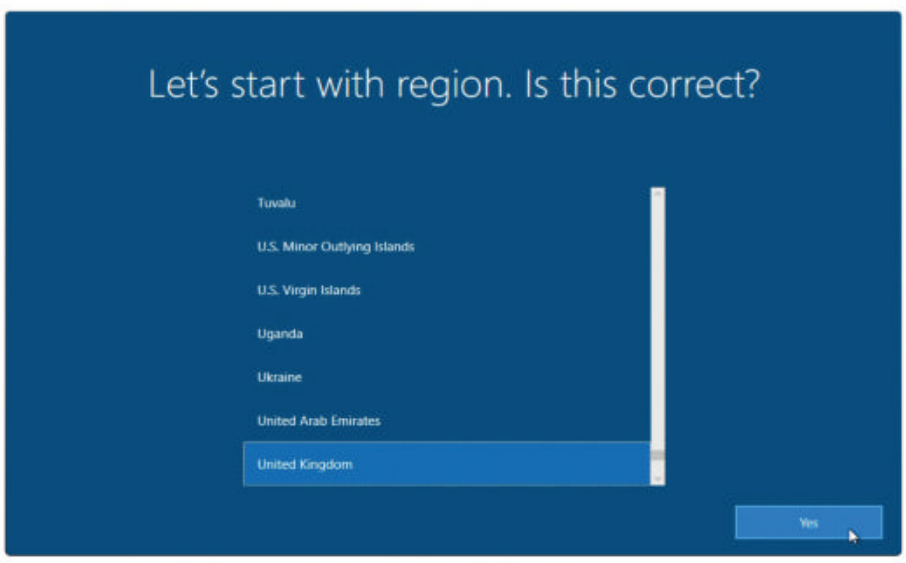
3 Choose installation type

Select your edition of Windows 10 (typically Home or Pro, not Home N or Pro N) and click Next. Tick to accept the licence terms and click Next again. Choose the Custom: Install Windows only (advanced) option. At the next screen you'll see your current drives and partition layout. Be sure to identify the correct partition containing your current Windows installation.



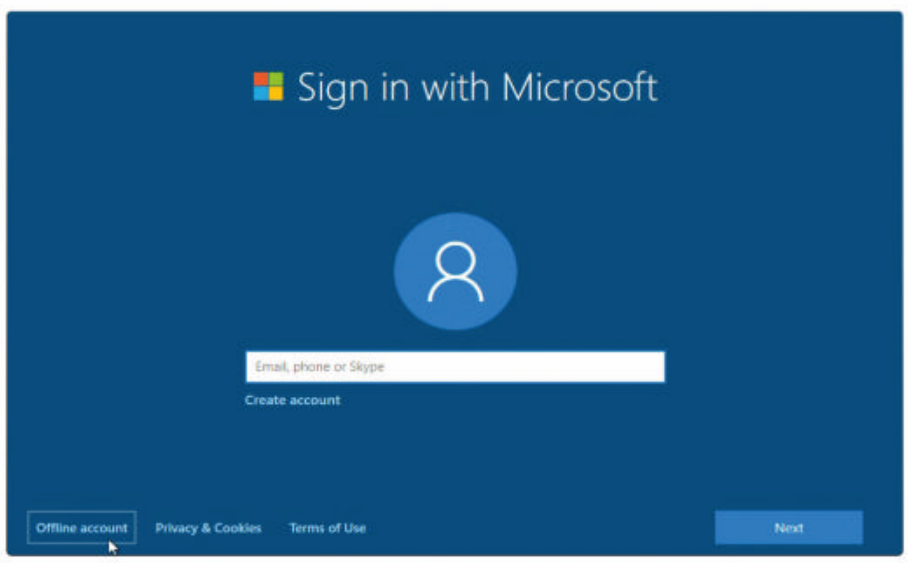
4 Set up drives, copy files

If you click Next now, Windows should detect your existing installation and offer to move it to a Windows.old folder; assuming you've backed everything up beforehand, a better option is to select the partition and click Format to wipe it (after acknowledging the warning), then click Next. Windows will move on to the file copying and installation stage. Sit back and relax.



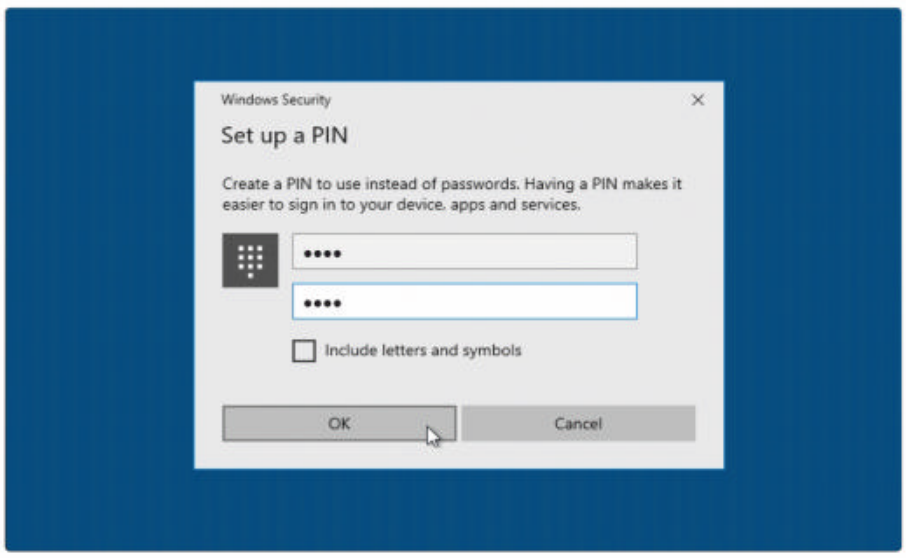
5 Basic setup

Once the 'Installing Windows' phase is complete, your PC will reboot. Step one is to confirm the region and keyboard layout are both correct – it should be the same as you selected in step two. Click Yes to confirm each, followed by Skip to avoid adding a second keyboard layout. If you're connecting wirelessly, you'll next be prompted to select and connect to your Wi-Fi network.



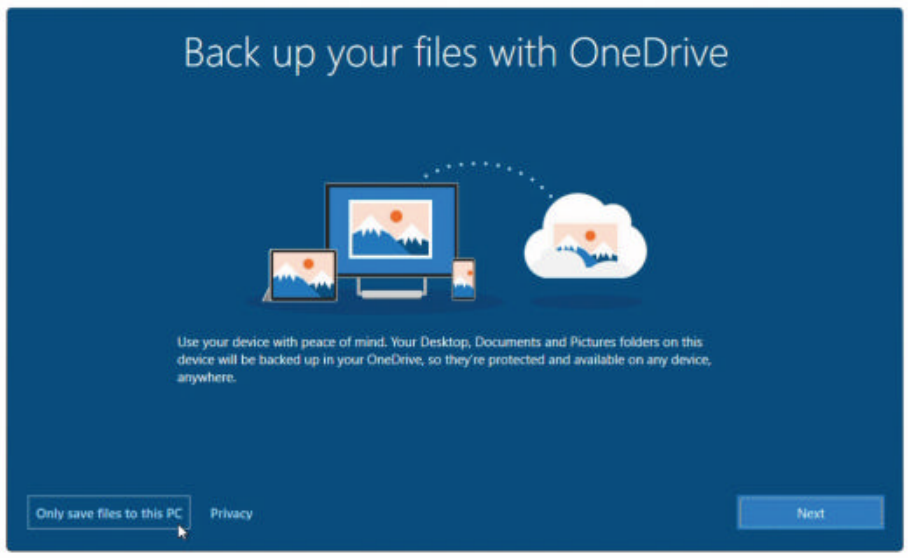
6 Choose account type

Most people will want to choose 'Set up for personal use' when prompted, so select it and click Next. You'll now be prompted to sign in with your Microsoft Account – the same one you previously used for Windows on this PC. If you entered a product key and don't use a Microsoft Account, click Offline Account followed by No to create a local one instead.



7 Set up PIN

After signing in, click 'Create PIN' to simplify future sign-ins with a numerical code rather than your password. Click OK. You'll be asked to switch on activity history – click Yes only if you use Windows on more than one device. You'll then be given the opportunity to link your Android or iPhone to your PC via the Continue on PC app. Click Next to move on.

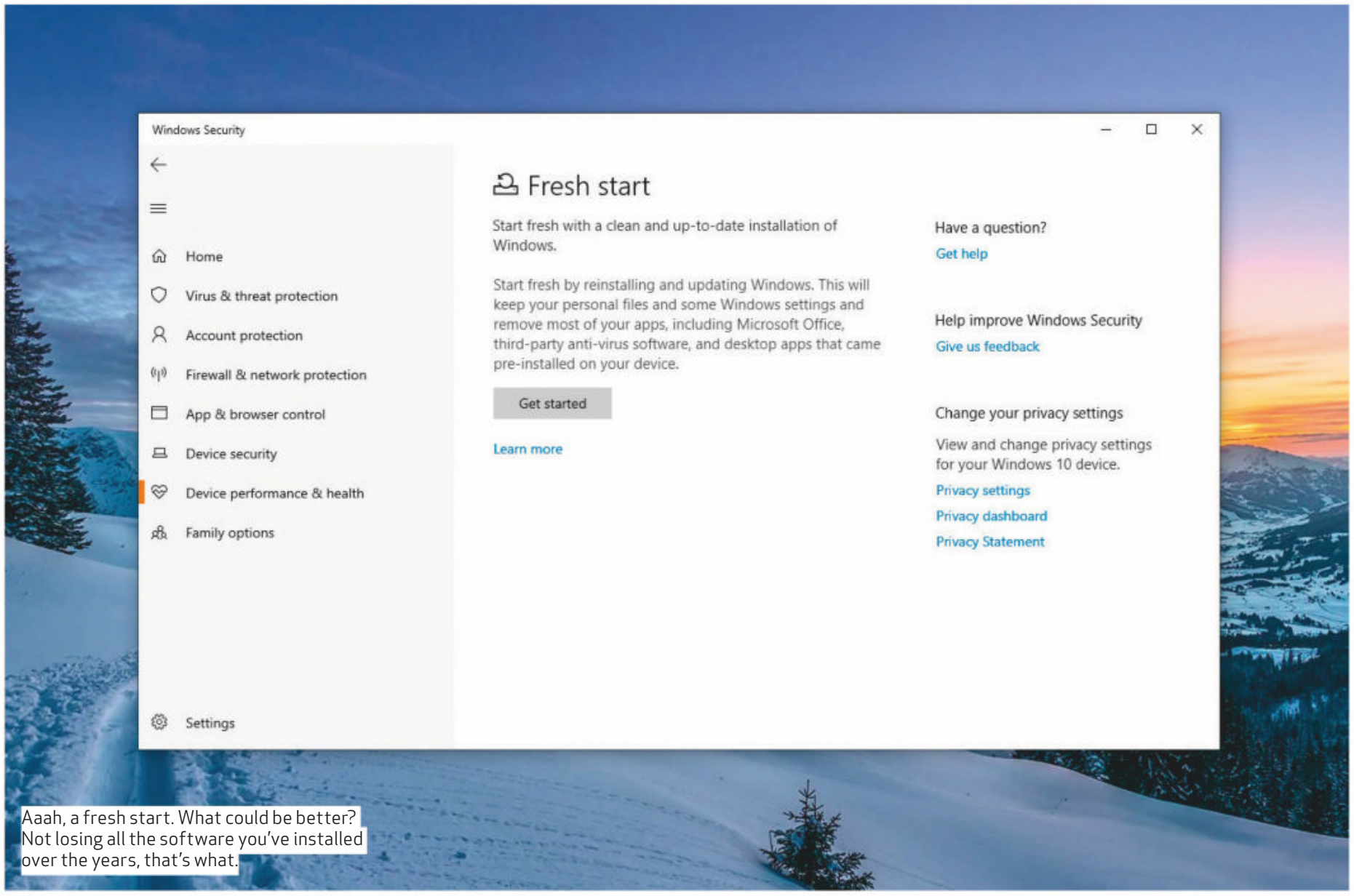


8 Manage privacy settings

Next, if you want to prevent OneDrive from becoming your default save location, click 'Only save files to this PC'. The rest of the wizard will allow you to choose whether to use Cortana, online speech recognition and various other privacy related features. Read each one carefully before selecting your choice to complete the post-install setup process. ■

Refresh, restart, recycle, reinstall

Confused by whether to refresh, reset or reinstall? Windows 10 has multiple options, and they're changing all the time.



Aaah, a fresh start. What could be better? Not losing all the software you've installed over the years, that's what.

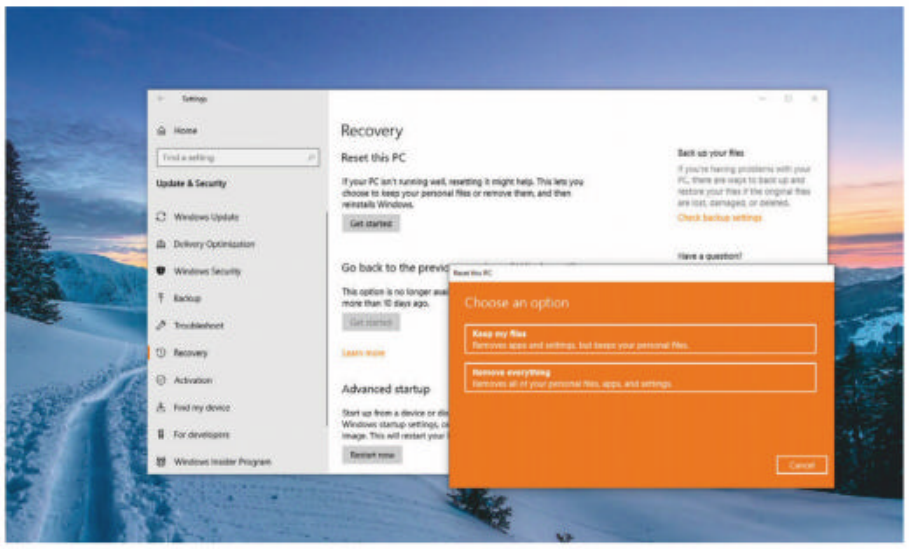
If you've gone to the trouble of creating new installation media for any version of Windows 10 past the Creators Update, you'll probably feel a bit silly when you discover that Microsoft tucked a 'fresh start' option into its later Win 10 editions.

Using it takes any Windows 10 installation back to the basics of a Windows install, even removing any preinstalled software your manufacturer might have included, and stripping away all your drivers – and it doesn't require any special media. It's basically a clean install without you having to directly perform the actions of reinstallation. You'll find it in a corner of Windows Defender Security Centre, aka Windows Security – select Device performance and & health, then Additional info, before clicking Get started to begin. Again, make sure you're backed up, as this is only slightly less destructive than formatting your hard drive. Handily, the fresh start procedure leaves a little note of all the things you've destroyed on your desktop, just so you can kick yourself later.

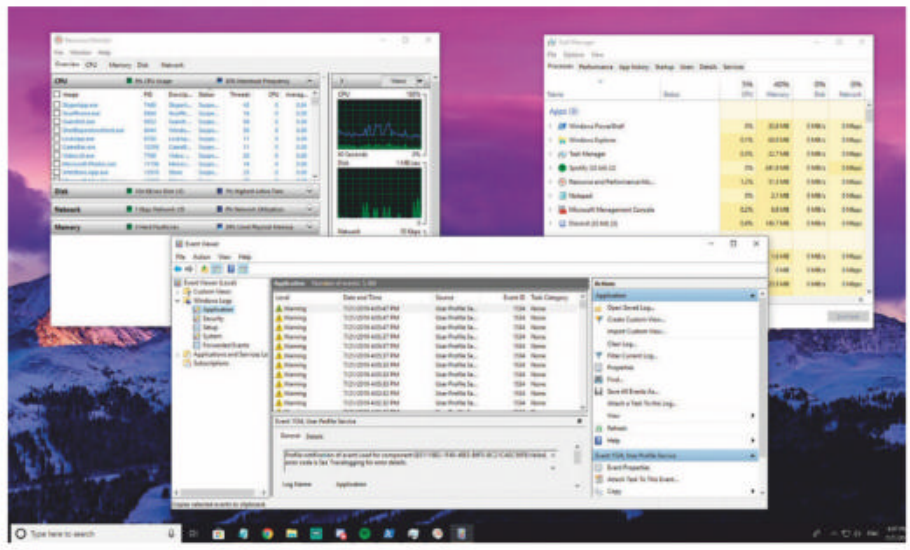
PRESS RESET

A better option might be to take advantage of Windows 10's 'reset' feature, which strips out all of your installed applications and drivers while giving you the option of leaving personal files unmolested. This doesn't mean you can get away with not using proper backup procedures, but if there's a particular software component causing you problems, this will very likely get rid of it. Put simply, it rolls your machine back to the state in which it came to you: preinstalled software, drivers, and all. You might remember that earlier editions included two

> "Windows 10's 'reset' feature strips out all installed applications and drivers while leaving personal files intact."



Choosing the Reset option enables you to immediately select whether to keep your files or not. Your apps are toast either way.



The holy trinity of system spying: Task Manager, Resource Monitor, and Event Log. You can add to these with thirdparty applications too.

options, the confusingly different 'reset' and 'refresh' – they're squashed together into this new, less baffling procedure. It does, technically, create a fresh installation of Windows, rather than uninstalling anything, as while it's running through, it uses the Windows Recovery Environment and sections off your personal files, putting them back where they were if you choose to keep them.

If you're insistent on reinstalling, perhaps you'd like to consider an upgrade? Not a version upgrade as such, but an in-place upgrade install – running through the Windows 10 install process, throwing fresh copies of all critical system files on to your PC, but leaving everything else, including software, as is.

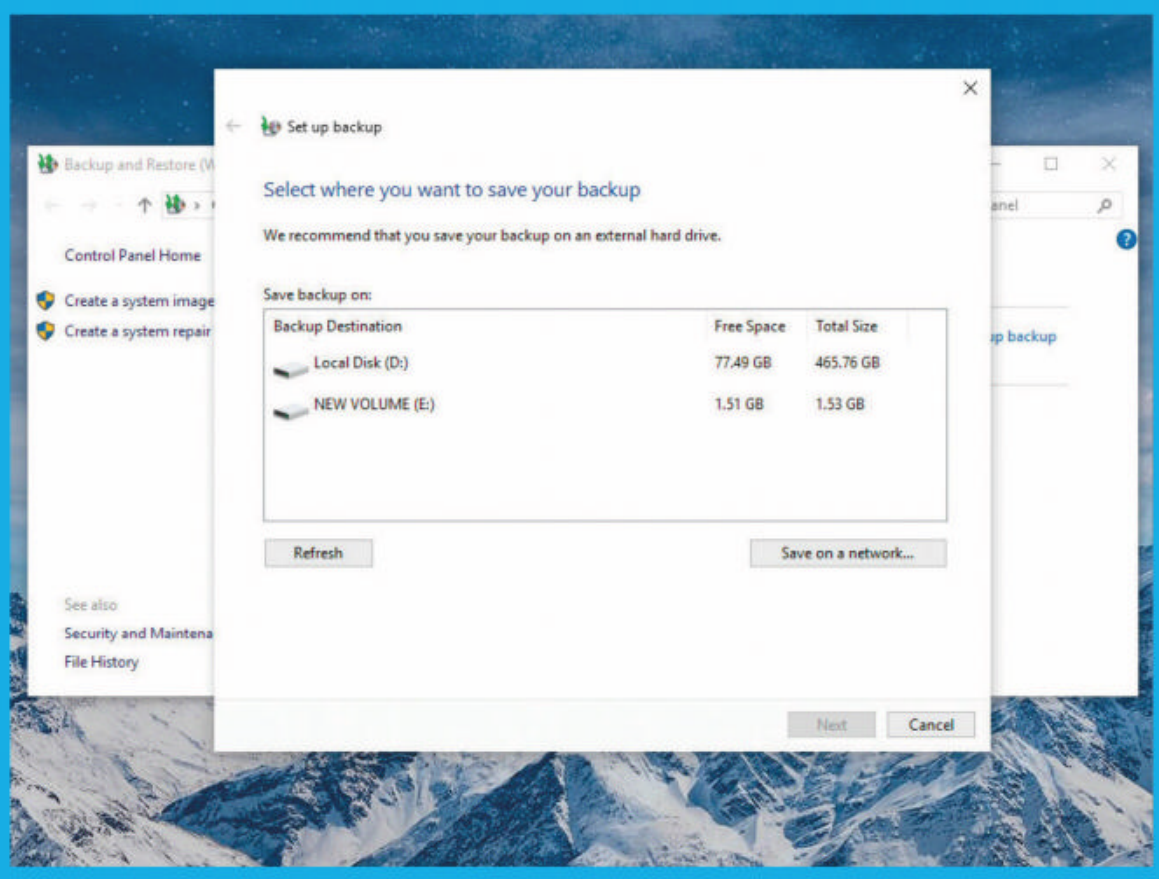
Opting to do this can (in theory) fix certain issues with your machine, and it's particularly effective against those problems that standard Windows prodding techniques don't solve. To perform an in-place upgrade, you need to be logged into an administrative account, have a good chunk of disk space free, and have secure boot switched off (at least temporarily) in your UEFI settings.

Use the Windows 10 Media Creation tool (see above) to create a USB stick, but don't boot from it: Open the drive from within Explorer, right-click the setup.exe file, and opt to run it with administrator privileges. Run through the install process, ensuring you check the box to keep all your files and apps. When done, you're left with your new, fresh Windows folder and a separate Windows.old folder on your main drive, the latter of which contains your previous install. It's possible to roll back, if everything has fallen apart, but don't take this as an excuse not to have a proper backup. When happy (you have 10 days to decide), you can dump the Windows.old folder and reclaim that precious space.

Building better backups

Reinstalling is, or should be, a last resort – and if you ever come to the point where you absolutely have to reinstall Windows and don't have copies of your files, it might be too late. A hardware failure, a cryptographic malware attack, whatever the case may be, you don't want to be left stranded. We've talked about using Windows' File History tools elsewhere, which is a good way to keep regular copies of your personal files, but Windows also includes a more thorough backup procedure in the form of Backup and Restore (Windows 7). Now, we can't be entirely sure how long this is going to last, given its archaic name, but for now, it works, and we'd wager that Microsoft will supply a tool to restore its backups even if the facility gets removed from future versions of the operating system. If you have a backup on an external drive, you can reinstall Windows from scratch and restore it using the same tool – aim to make one every week or so, so you don't lose too much time. EaseUS Todo Backup 11 Free (**www.easeus.com**) is a decent option for automating backups; make sure, if you do this, that you don't leave your backup drive permanently connected to your machine, because a hardware failure passed down the line is a double whammy of disappointment.

Do not discount the power of system restore points, either. While they're not kind to storage – we'd put them on your mechanical long-term storage drive, rather than an SSD, if you have the choice – making a system restore point regularly is good practice. Taking the overkill position of making one before installing anything even slightly questionable is an even better thing to do, although we don't really expect you to do that. Make sure you clean up when you're sure your machine is running fine, because a huge hoard of system restore points does nobody any good.



It's an older tool, sir, but it checks out. Backup and Restore has been with us for a long time, but does things File History doesn't.

The power of elbow grease

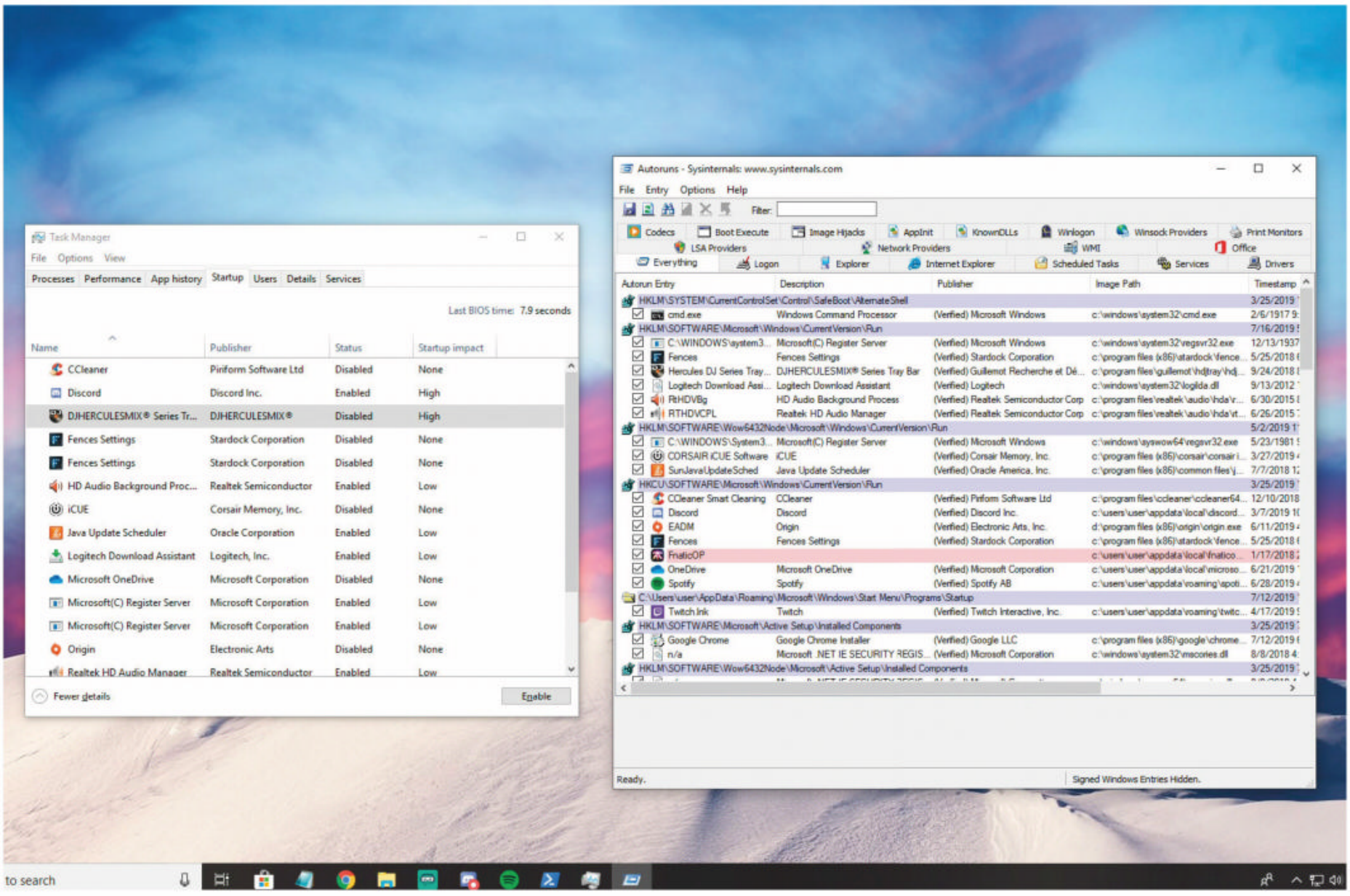
Why fixing problems as you go, and monitoring what your PC is doing, can be better than a full operating system reinstall.

Many people look at a Windows reinstallation as a way to fix any and all ills. However, we consider it as being more of a last resort. It's a little like dealing with unruly children. Before taking drastic action and shipping your PC off to military school, you should really do everything you possibly can to fix the problems you've got, and find out the cause of its misbehaviour, because you might just find that a simple solution works better. Heavy-handed metaphor aside, keeping a keen eye on your PC's actions isn't particularly difficult, because Windows 10 includes all the tools you might need at your disposal: There's the Task Manager (which you can pull up at any time with a quick Ctrl-Shift-Esc); there's Resource Monitor (type "resmon" into the search bar) for a more detailed report on what's doing what; and there's even the difficult-to-grok but absolutely useful Event Viewer, which can throw up some worrying but utterly benign messages, but also reveal the true cause of system crashes or slowdowns.

CLEAN LIVING

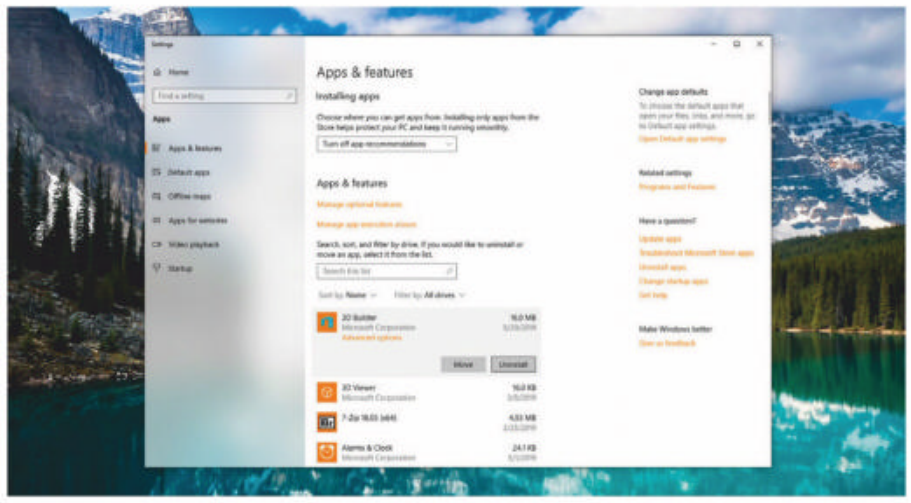
It is worth keeping your system clean, not in terms of hard drive space (unless you're critically full, in which case, you should definitely start scrubbing), but in terms of the number of things that are installed on your system, how up to date they are, and how many of them you allow to just run whenever they like and eat up your system resources in the process. In terms of the latter, the Task Manager startup tab can give you some clues, not just about those auto-running apps, but also about the impact they tend to have on your startup process, and you can also use it to disable their automatic execution. If you want to get more involved with

> "Keeping an eye on your PC's actions isn't particularly difficult, Windows 10 includes all the tools you might need."

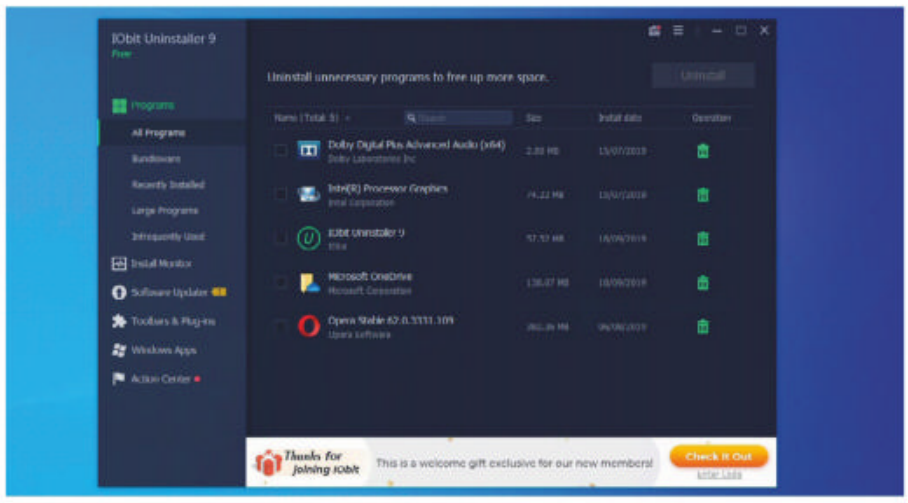


Task Manager can help squash auto-running programs, but Autoruns can do a whole lot more.

IMAGES © Microsoft



Head to Settings > Apps and Features to check what's installed on your PC, and when you last used it.



Uninstaller apps such as Iobit Uninstaller (above) or CCleaner can remove the dregs left behind by apps, and even remove built-in space-hoggers too.

what happens at startup, Autoruns (**https://download.sysinternals.com/files/Autoruns.zip**) gives you much more granular and deep control, although you should treat it with kid gloves, because heavy-handed tinkering could potentially cause more problems than it solves.

So, what's the best way to deal with old, unwanted apps? To completely expunge them from your system, of course. There's nothing wrong with Windows' built-in uninstallation procedures. You can flit through your Start menu, right-clicking things that shouldn't be there, and using the Uninstall option to get rid of them. Or you could use the Apps & Features tool, accessible from Windows' settings panel, which (sometimes) offers up a bit more detailed information about when a program was installed, and when you last deemed it important enough to run.

That usually works just fine. But if you'd like some more reassurance that a troublesome app is really gone, and with it any trace of its existence (we're well aware that revenge is usually a big contributor to any uninstallation process), something like the free version of IoBit Uninstaller 8 (**www.iobit.com**) can work wonders. It makes software removal quick and straightforward, and it hunts for absolutely every file associated with the app that's on death row.

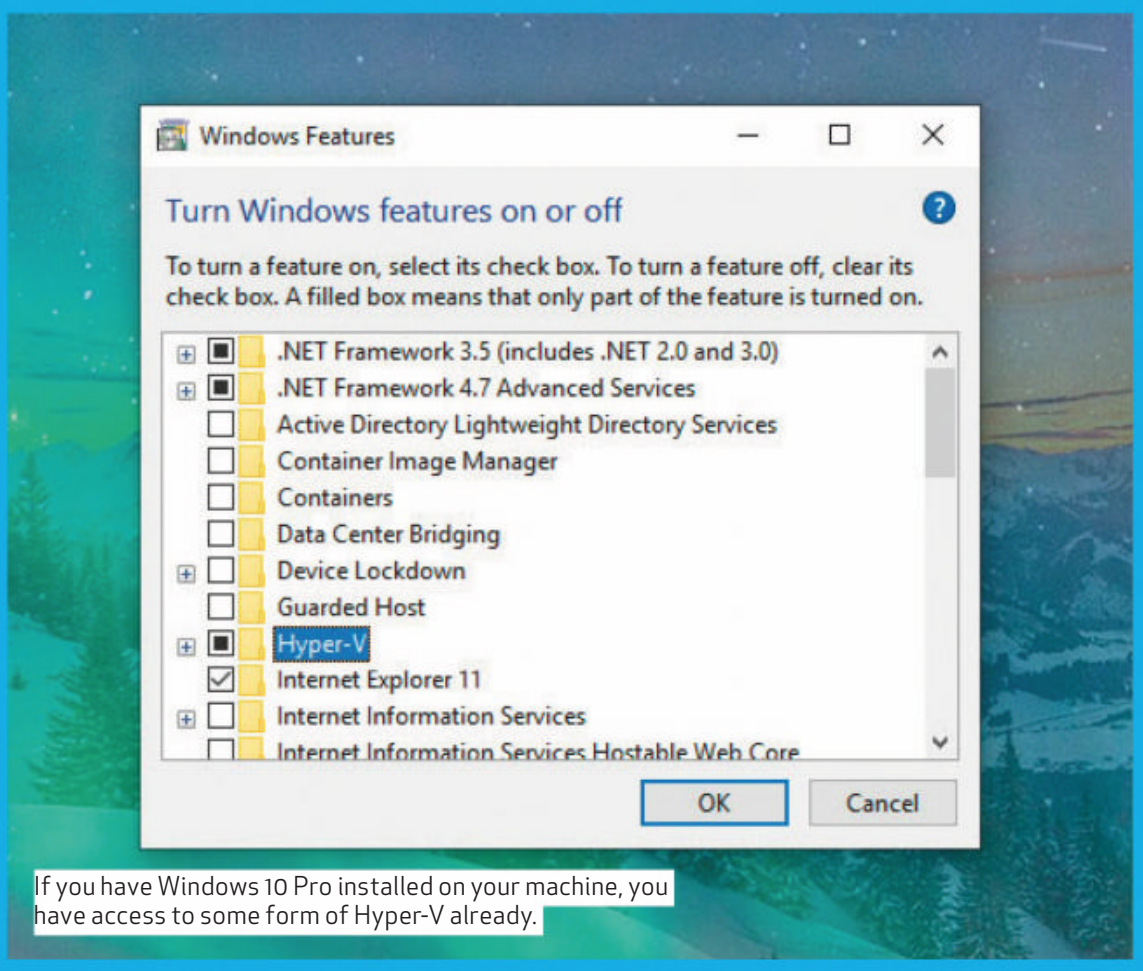
We wouldn't opt for the paid-for Pro version, even though it adds extra tools for stripping away manufacturer bloatware, because apps such as PC Decrapifier (**www.pcdecrapifier.com**) do the job just fine without any outlay. It might be tempting to try out CCleaner (**www.ccleaner.com**), too, given that it can even get rid of Microsoft's default apps, and we're not going to stop you – but it's worth pointing out that CCleaner can be very annoying in terms of notifications. If we do use it, it's generally immediately removed once the task is complete.

Go virtual instead

We're at the point in the PC's evolution where the overheads of virtualisation are proportionately so small, and the technology enabling it so plentiful, that running an everyday OS in a virtual machine is entirely reasonable. You obviously won't get 100 percent of bare metal performance from a virtualised instance of Windows 10, but it has a host of advantages. When you've got a system running just as you like it, you can take a snapshot, then quickly return to it at any point in the future. You can whip up a fresh copy of Windows in minutes, without any risk to your existing install. You can fire up other operating systems, and run them simultaneously on the same machine. If you're the kind of person who loves to settle down to a good Windows reinstall in the evening, then you're probably the right candidate for running a virtualised system.

We could fill an entire issue of this magazine with ways to do it, but if you're willing to experiment, here's a broad framework that's a good place to start. Use Fedora Workstation as your host OS (**https://getfedora.org/en/workstation**) and use the included Boxes app (a front end for KVM/QEMU) to get your VMs up and running. Install VirtIO to ensure that all of the IO functions work properly, and SPICE to deal with 3D acceleration. And make sure you've accessed your BIOS/UEFI settings and enabled all the good stuff that makes VMs work well – specifically Intel-VT or AMD-V, depending on your platform.

If you fancy a challenge, both VMWare ESXi and Microsoft Hyper-V Server are pro-grade bare-metal hypervisors, which put a minimal layer between your guest OS and the hardware they're working with, but they do require some pro-grade understanding to get the most out of them, so are beyond the scope of this feature.



If you have Windows 10 Pro installed on your machine, you have access to some form of Hyper-V already.

System News

Mark Williams looks at the CPU market and marvels at how much it has changed over the course of 2019.

If there's a technology award for 2019, it must go to AMD. The company was already competitively strong with the Ryzen 2000 series at the beginning of the year, but since launching its Ryzen 3000 series CPU line-up in July, AMD has barnstormed the market. According to German retailer Mindfactory, its CPU sales figures show that AMD now represents over 80% of all CPU sales! It's rather insane.

When you look at what Intel has done in the past year on desktop, you can see why. All it's released that's of interest to power users is the i7-9900KS, which is just a better binned and factory overclocked i7-9900K – which itself is now over a year old. Intel has stagnated on the desktop.

Intel did just release the 10th Gen X-series refresh for its HEDT X299 platform, spearheaded by what would normally be an outstanding 18-core i9-10980XE. Unfortunately for Intel, AMD launched its Threadripper 3000 series on the same day, which consists currently of a 24-core and 32-core part. Both of which dominate the poor i9-10980XE and its smaller brethren. And that's all before AMD launches its much anticipated 64-core Threadripper 3990X behemoth early in 2020.

Intel has got to be shaking at the knees right now.

Then there's the "mainstream" 16-core Ryzen 9 3950X, which many have dubbed baby-Threadripper due to it being able to hold its own against Intel's best HEDT parts for far lower prices.

AMD has been throwing as many cores into its products as possible since Ryzen launched and it's starting to blur the lines between what defines mainstream, what's HEDT, and even what a server CPU is.

There's still some clear delineation between each segment, with HEDT typically supporting quad-channel memory configurations and higher counts of PCIe lanes, not to mention the higher core-counts over mainstream. Server chips will get you into eight-channel memory territory and support for multi-socket configurations. But just looking at core count alone, with sixteen cores now available on AMD's mainstream product, in many ways that's HEDT territory already just from the pure compute standpoint. And when 64-core Threadripper drops, that some serious server-grade compute that'll be available for anyone to buy if they've deep enough pockets.

Intel isn't going to crumble or lose much revenue as it's still top dog in the mobile and server spaces, which are arguably more profitable, but for now and well into next year Intel is seriously on the back foot in the desktop and workstation space. However, once it manages to ramp its much criticised and troubled 10nm node or skip it all together and go straight to 7nm for a truly new generation of desktop parts, AMD will have a big fight on its hands once again.

It's also hard to see Intel continuing its monolithic chip design while offering similar core counts to AMD. The good news is that Intel is developing its EMIB (Embedded Multi-die Interconnect Bridge) which is much like AMD's Infinity Fabric, meaning Intel could soon start exploring MCM (Multi Chip Module) style CPUs (like AMD's Ryzen CPUs use). Combine that with its industry leading "Foverous" chip stacking technology, Intel will surely be able to come up with some interesting products in the future.

Until then, AMD appears to have a clear shot at dominating 2020 as well, so long as TSMC continues its march towards smaller processing nodes in 7nm+ and 5nm and AMD continues to execute on architectural improvements, soon to happen yet again with Zen 3.

2020 is shaping up to be another great year for CPU customers.

> "Intel isn't going to crumble or lose much revenue as it's still top dog in the mobile and server spaces."

SHOP TALK

Do you see the lines between mainstream and HEDT becoming increasingly blurred?

Richard, Aftershock PC:
"Aftershock PC currently delivers around 60% of our PCs as HEDT. Of those, approximately half are AMD and half are Intel. We have already had orders for 3950X and 3rd-gen Threadripper builds with two 3950X builds already completed.

We find that the lines between mainstream and HEDT have become very blurred in recent times with high end chips coming in at much cheaper prices which has led to regular consumers up-speccing their machines into the HEDT range."

Market Snapshot

A sampling of PC systems available this month.

PLE Computers Creative Cube

$1,008 – TINYURL.COM/APC476PLE

Coming in at just over a grand, this is about as basic a configuration as one can ask for if gaming is the goal. Suitable for 1080p gameplay, this'll do a reasonable job in eSports titles and other less demanding games, but will struggle with AAA titles. The motherboard is the weakest link in this build; being an A320 chipset you'll have no overclocking ability and limited upgrade options. We recommend spending $20-$30 at checkout and selecting a B450 motherboard instead, not only for better drop-in upgrade support, but better IO connectivity too.

If budget permits, choose a GTX 1650 Super at checkout for an extra $40. It'll boost gaming performance by 30%. Very worthwhile. Overall, a reasonable system for those on a budget.

KEY SPECS: CPU: AMD Ryzen 3 3200G, **COOLER:** OEM, **MOTHERBOARD:** Asrock A320M-HDV R4.0, **GRAPHICS:** Gigabyte GeForce GTX1650 OC 4GB GDDR5, **MEMORY:** GeIL 8GB DDR4 Pristine C19 2666MHz, **STORAGE:** WD Green 240GB M.2 SATA SSD, WD Blue WD10EZEX, **POWER SUPPLY:** eVGA GD Series 450W, **CASE:** TT Core V21 Micro.

JW Computers Lenovo Legion C530 Cube

$1,698 – TINYURL.COM/APC476JWC

Keeping with the cube theme, this system bumps up the specs relative to the PLE system, and the price. Coming in almost 70% dearer than the PLE system, do you get 70% more computer?

On the CPU front, despite a thread count deficit the two extra real cores do help the 9400F maintain a general 30%-50% speed bump in games.

The graphics card also cranks up the muscle, to the point where you can almost play any game at 1080p with decent graphical settings enabled and – depending on the title –smooth 1440p gameplay is also achievable.

An NVMe SSD, dual channel 16GB memory and a high-quality portable case make for a system that is worth the cash.

KEY SPECS: CPU: Intel i5-9400F, **COOLER:** OEM, **MOTHERBOARD:** Intel B360 based, **GRAPHICS:** Nvidia GeForce GTX 1660 Ti 6GB GDDR6, **MEMORY:** 16GB DDR4 2666MHz, **STORAGE:** 512GB NVMe M.2 SSD, **POWER SUPPLY:** 500W, **CASE:** Lenovo Legion Cube.

Aftershock PC Ultracore

$3,045 – TINYURL.COM/APC476APC

This is getting close to a perfect system build for those wanting great gaming performance, but not at any cost. Sure, the price is high, but you do get a lot of kit. The 3700X games well, and will give longevity to the system if you dabble in productivity work. The motherboard is overkill as a B450 board would achieve the same task here and be quite a lot cheaper; X570 does afford PCIe 4.0 compatibility for future upgrades, so there is that. A well-specced memory kit is always a nice pairing for Ryzen, and with a 360mm AIO cooling it, temperatures will be kept in check. Note: The picture of this system is with the custom water loop White Edition option chosen, which adds a further $1,299 to the price, but also an infinite amount of awe inducing hard-line tubing to this showy system improving GPU temps and lowering noise levels immensely.

KEY SPECS: CPU: AMD Ryzen 7 3700X, **COOLER:** Aftershock Spectra Glacier 360, **MOTHERBOARD:** Asrock X570 Phantom Gaming 4, **GRAPHICS:** Asus Dual GeForce RTX 2080 Super 8GB GDDR6, **MEMORY:** 16GB Adata Spectrix D41 DDR4 3600MHz, **STORAGE:** 512GB M.2 NVME SSD, 2TB 7200RPM HDD, **POWER SUPPLY:** FSP / EVGA 650W, **CASE:** Lian Li O11 Dynamic.

PC Case Gear Shift 2080 Super

$2,999 – TINYURL.COM/APC476PCC

This thin and slender system is an ITX build that packs in all you need for a great gaming experience. The CPU isn't high end by today's standards, but it covers the important things for games, with a high core frequency (4.7GHz) and eight cores. Perfect. Being an "F" variant means no overclocking to be had here. That kind of makes the water cooler a waste of money really, especially as a stock HSF comes with the processor. The spiffy motherboard and the second-best graphics card money can buy will soon make you forget that lost savings opportunity, especially when you see all the SSD storage included. A superb build for those wanting a small gaming rig without compromising much on ultimate gaming performance.

KEY SPECS: CPU: Intel Core i7 9700F, **COOLER:** Corsair Hydro Series H60 V2 120mm, **MOTHERBOARD:** MSI MPG Z390I Gaming Edge AC, **GRAPHICS:** MSI GeForce RTX 2080 Super Ventus XS OC 8GB, **MEMORY:** Team T-Force Delta RGB 16GB 3200MHz CL16 DDR4, **STORAGE:** Adata XPG SX8200 Pro M.2 NVMe SSD 256GB, Samsung 860 QVO SATA SSD 1TB, **POWER SUPPLY:** Corsair SF600 Gold 600W SFX, **CASE:** Phanteks Enthoo Evolv Shift Air iTX.

PC blueprints

The *APC* team's picks for a part-by-part perfect PC build to suit your budget.

PARTS LIST

PART		PRICE
CASE	BITFENIX NOVA TG	$75
PSU	CORSAIR CX450 80+ WHITE 450W	$75
M/BOARD	ASROCK B450M R4.0 AM4	$99
CPU	AMD RYZEN 5 2600	$199
GPU	MSI GEFORCE GTX 1660 SUPER VENTUS OC 6GB **NEW**	$389
RAM	8GB (2X 4GB) PATRIOT VIPER 4 @ 3,000MHZ	$73
SSD	120GB CRUCIAL BX500 2.5-INCH	$30
HDD	1TB WD BLUE 3.5-INCH HDD	$59
OS	UBUNTU DESKTOP LINUX 18.04 LTS 64-BIT	$0
APPROXIMATE PRICE:		$999

Every month, we look through the ingredients for our budget build and find certain elements that simply don't need changing. Asrock's B450M R4.0 motherboard remains one of the best-value AM4-socket motherboards on the market, and the classic 120GB Crucial BX500 is still extremely cheap. With the release of the GTX 1660 Super, it's an obvious upgrade choice; just $10 more than our previous standard GTX 1660, while bringing 10–15 percent better performance. With a few other small savings, we've been able to significantly improve the graphical performance of this machine while only raising the price by $10.

PARTS LIST

PART		PRICE
CASE	FRACTAL DESIGN MESHIFY C	$149
PSU	500W SILVERSTONE ET500 BRONZE **NEW**	$69
M/BOARD	GIGABYTE X570 UD **NEW**	$229
CPU	AMD RYZEN 5 3600X	$375
COOLER	AMD WRAITH SPIRE	N/A
GPU	GIGABYTE RADEON RX 5700 8GB **NEW**	$579
RAM	16GB (2X 8GB) TEAM T-FORCE DELTA RGB @ 3,200MHZ **NEW**	$125
SSD	500GB SAMSUNG 970 EVO PLUS M.2 PCIE SSD **NEW**	$169
HDD	1TB WD BLUE 3.5-INCH HDD	$59
OS	WINDOWS 10 HOME 64-BIT OEM	$140
APPROXIMATE PRICE:		$1,894

We had a few changes to make to our mid-range build this month, although most of them were quite minor. The Sapphire RX 5700 rose a little while Gigabyte's offering dropped a little in price, so we've switched. With the cash we saved across this build, we opted to improve things somewhat by swapping out the 250GB SSD for a larger 500GB model of the Samsung 970 Evo Plus. This cost just $10 more. Double the M.2 storage on our primary drive will make this build even better for gaming, with more space to store your games for improved load times via the speedy connection of PCIe 3.0. Our previous EVGA PSU is now hard to find, so we've switched to a far more common and just as cheap Silverstone 500W unit.

UPGRADE OF THE MONTH

MSi GeForce GTX 1660 Super ventus oc 6GB

$389, WWW.MSI.COM

With performance that comfortably outstrips the vanilla GTX 1660, the new Super variant is a great card at a great price, ideal for new 1080p gaming builds. In fact, it sort of makes the previously appealing 1660 Ti practically pointless, with performance that falls less than 5 percent short of its big brother despite costing less. In practice, the real-world difference is almost impossible to discern in 1080p gaming, making the 1660 Super an awesome prospect. It's the best card in a crowded market right now, and while it misses out on proper ray-tracing support, it can comfortably run just about any game at above 60fps at 1080p ultra.

"Like an ailing furniture store being beaten into submission by online sales, Asrock's sale price for this motherboard seems to get a bit lower every time the sale is supposed to end."

The X399 Phantom Gaming 6 is on sale again! Like an ailing furniture store being beaten into submission by online sales, Asrock's sale price for this motherboard seems to get a bit lower every time the sale is supposed to end. A quick switch in cooler from 240mm to a 360mm model – more specifically, the MasterLiquid ML360 from Cooler Master – gives us improved cooling for our Threadripper 2950X CPU, and costs only $10 more. We've also swapped out the PSU for the Corsair RM850, keeping our wattage the same.

With those savings in place, we turned our aim to a significant upgrade elsewhere. We're making a big change, then: upgrading our GPU to the RTX 2080 Super Ventus OC from MSI. This will take our price up a fair bit, but we can live with that. The change will bring this machine from a high-end 1440p system to a PC capable of proper 4K ultra gaming. It also makes ray tracing a much more viable prospect in triple-A titles, if flashy unsettlingly realistic graphics are what you're after. If that's not your bag, but this system still appeals, the RTX 2070 Super is still an awesome GPU, don't get us wrong – we just felt it was time for a change.

PARTS LIST

PART		PRICE
CASE	NZXT H700I	$229
PSU	850W CORSAIR RM850 80+ GOLD **NEW**	$189
MOBO	ASROCK X399 PHANTOM GAMING 6	$230
CPU	AMD THREADRIPPER 2950X	$1,179
COOLER	COOLER MASTER MASTERLIQUID ML360 RGB 360MM AIO **NEW**	$179
GPU	MSI GEFORCE RTX 2080 SUPER VENTUS OC 8GB **NEW**	$1,199
RAM	32GB (2X 16GB) G.SKILL SNIPER X @ 3,600MHZ	$249
SSD	1TB SAMSUNG 970 EVO M.2 NVME **NEW**	$309
HDD	2X 3TB SEAGATE BARRACUDA COMPUTE	$360
OS	WINDOWS 10 HOME 64-BIT OEM	$140
APPROXIMATE PRICE:		$4,263

howto

» QUICK TIPS

Experts solve your computing problems

APC and its readers can be one giant helpdesk. If you have a technical problem, chances are one of us can solve it.

SECURITY

IS THIS RANSOMWARE?

A few days ago, I spotted a couple of strange-looking folders on my data drive: Tprogram136 and Oapplication5. An internet search revealed nothing, so I tried deleting one of the files only for Cybereason RansomFree to pop up and claim it had blocked an attempt to lock my computer. I selected the option to remove the ransomware, but then another file popped up in its place: Tfiles37. Inside these are seemingly random files with various formats. Where are they coming from?

John Buchanan

After some extensive research and further scans using John's other tools – Avast FREE, EEK and Malwarebytes – we suddenly had our eureka moment! The folders in question – hidden by default – are created by Cybereason RansomFree as bait.

It monitors these folders and, if it notices attempts to delete or modify the files, it leaps into action.

This so-called 'heuristic' detection means the application works solely by looking for certain types of suspicious behaviour associated with ransomware rather than relying on definition updates to spot potential infections. It can be effective, but is rather blunt. Cybereason has discontinued the tool now, but as John knows what it's doing, he can leave it in place if he wishes. Alternatively, he could try a free alternative such as Acronis Ransomware Protection (**www.acronis.com/en-gb/personal/free-data-protection/**), which works in a similar way but also offers 5GB of free online space where you can store particularly sensitive files out of any ransomware infection's reach, even if breaches Acronis's defences.

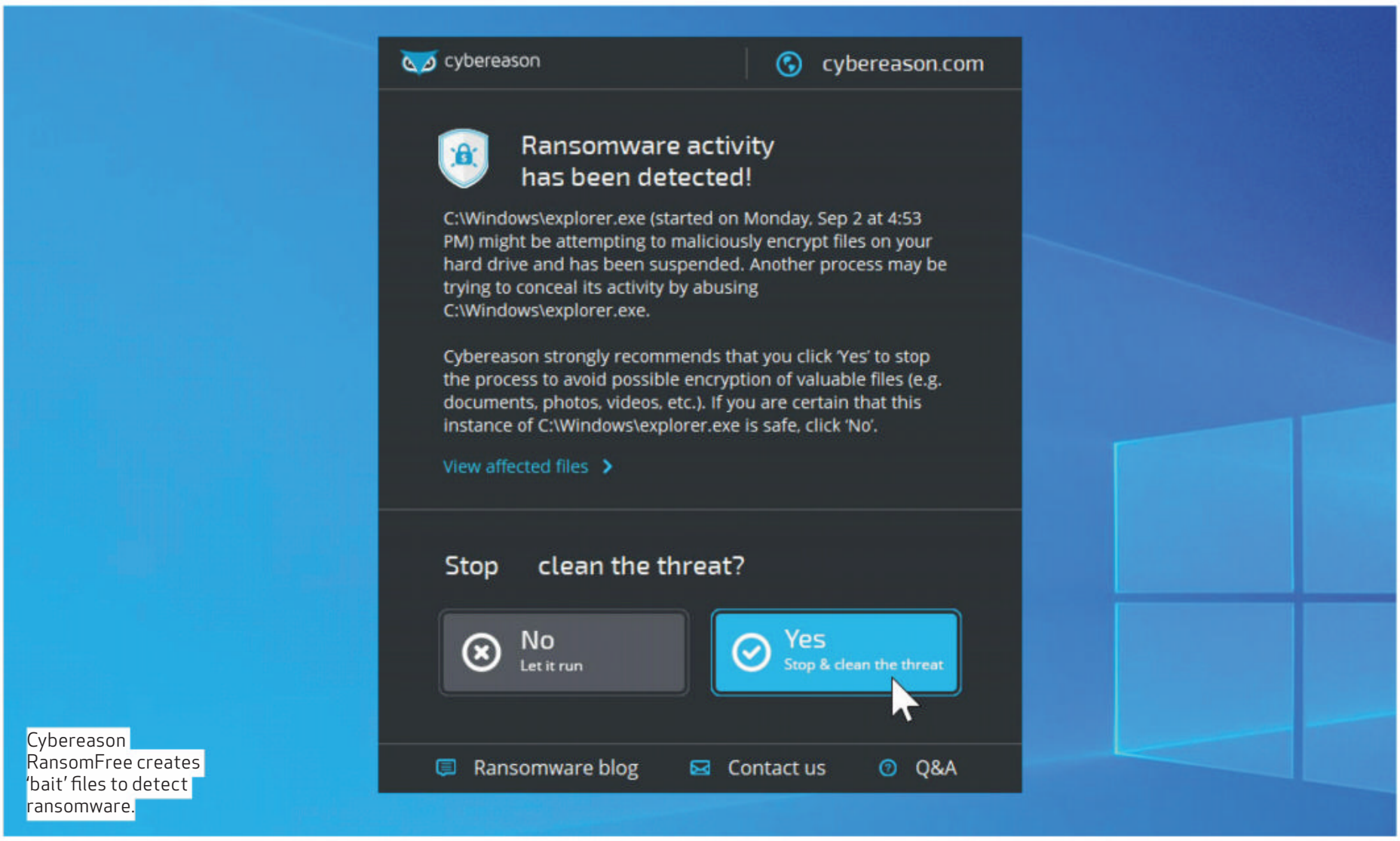
Nick Peers

WINDOWS

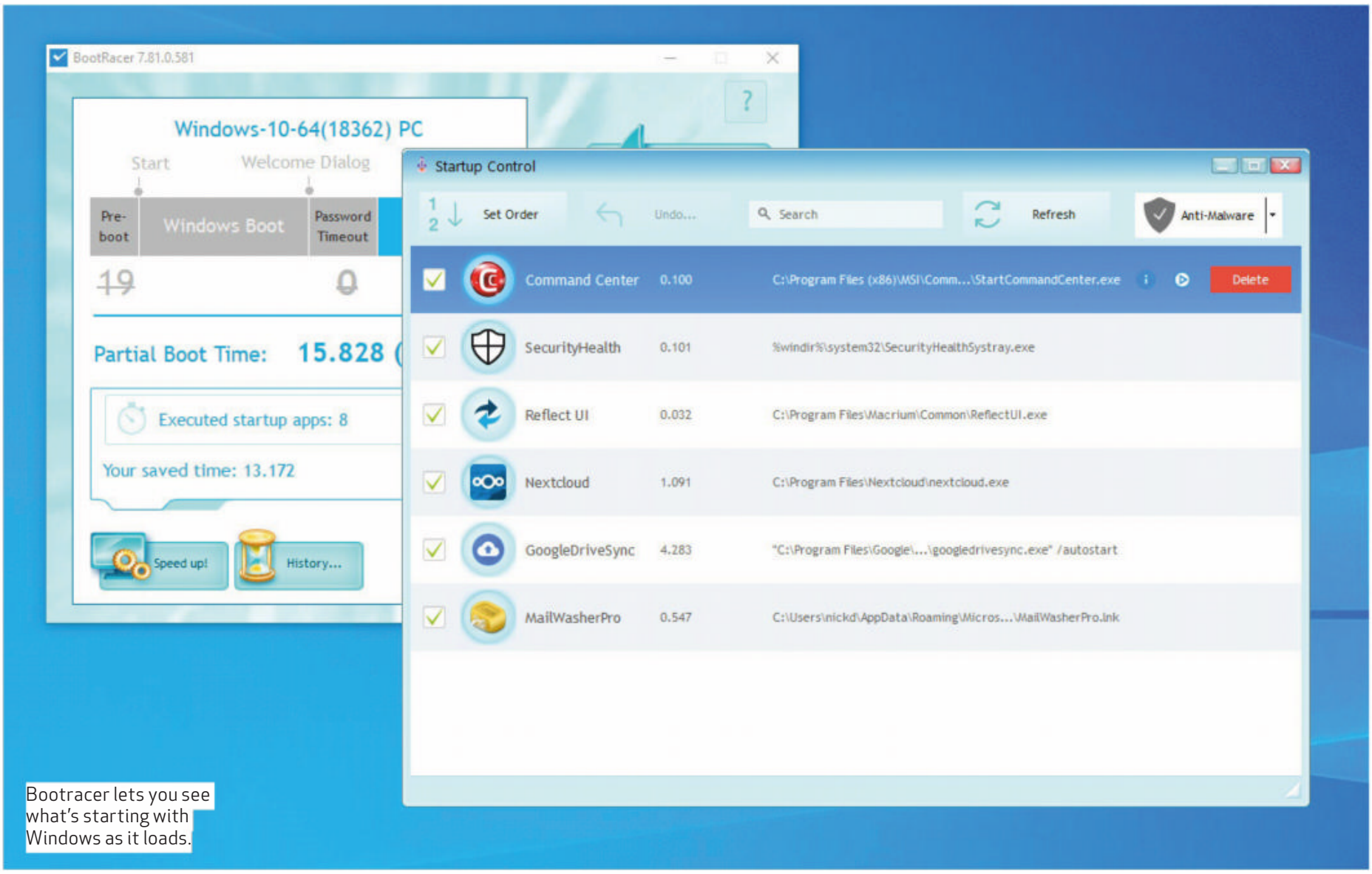
BLANK WINDOWS ON STARTUP

Can you help me please? On my Acer laptop I get six or so blank windows appear at startup, vanishing as soon as they start. I

> "The application works solely by looking for certain types of suspicious behaviour associated with ransomware rather than relying on definition updates to spot potential infections."



Cybereason RansomFree creates 'bait' files to detect ransomware.



Bootracer lets you see what's starting with Windows as it loads.

think it's something to do with Office trying to start.
Raymond Whithall

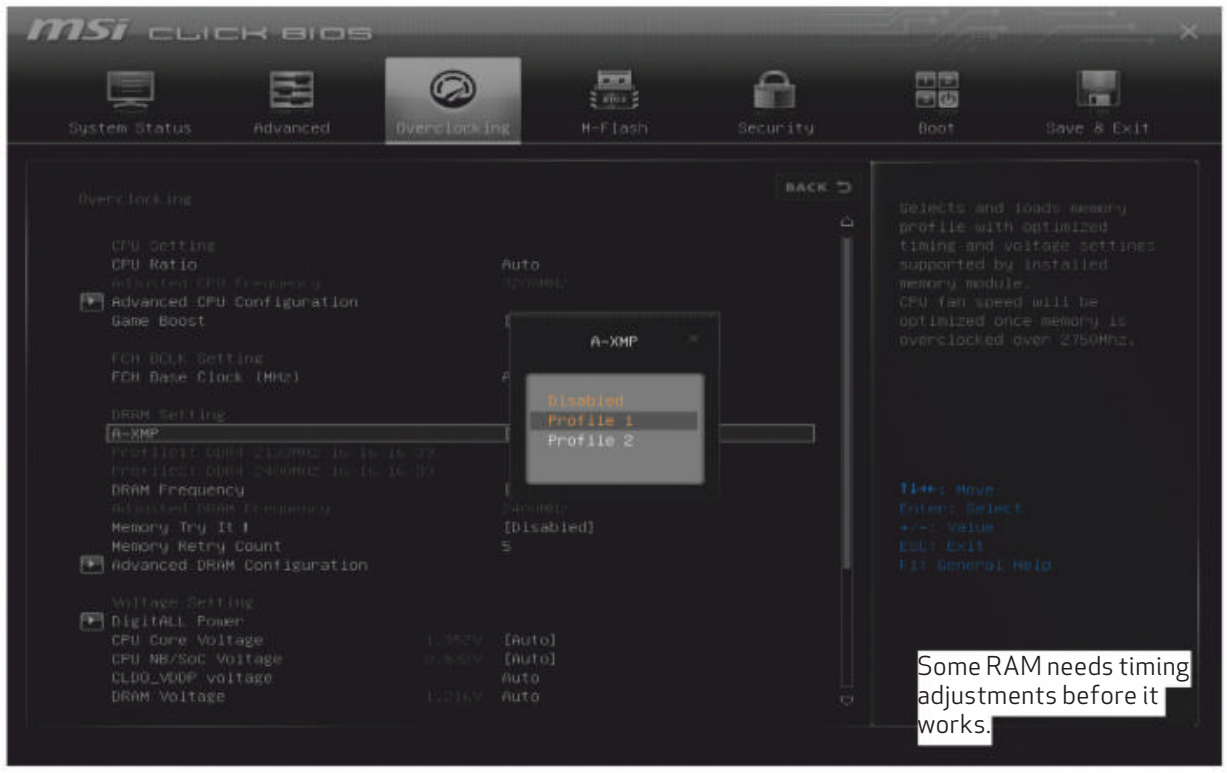
Raymond eventually traced his specific problem to a driver update – once installed, the blank windows vanished. If you're plagued by something similar, use a tool like Autoruns (**https://bit.ly/autoruns**) to see what's set to load with Windows – run the tool as an administrator and investigate the Logon tab.

Disable any suspicious looking entries and then reboot to see if the blank windows disappear – if they do, investigate the disabled entries further (right-click it and choose 'Virus Total' to see if the file is known malware, then right-click and choose 'Search Online' to investigate the filename further using Google.

BootRacer (**https://greatis.com/bootracer**) can monitor the start-up process to see which background program is starting when the windows flash up, then use that as the basis for further research.
Ian Sleightholm

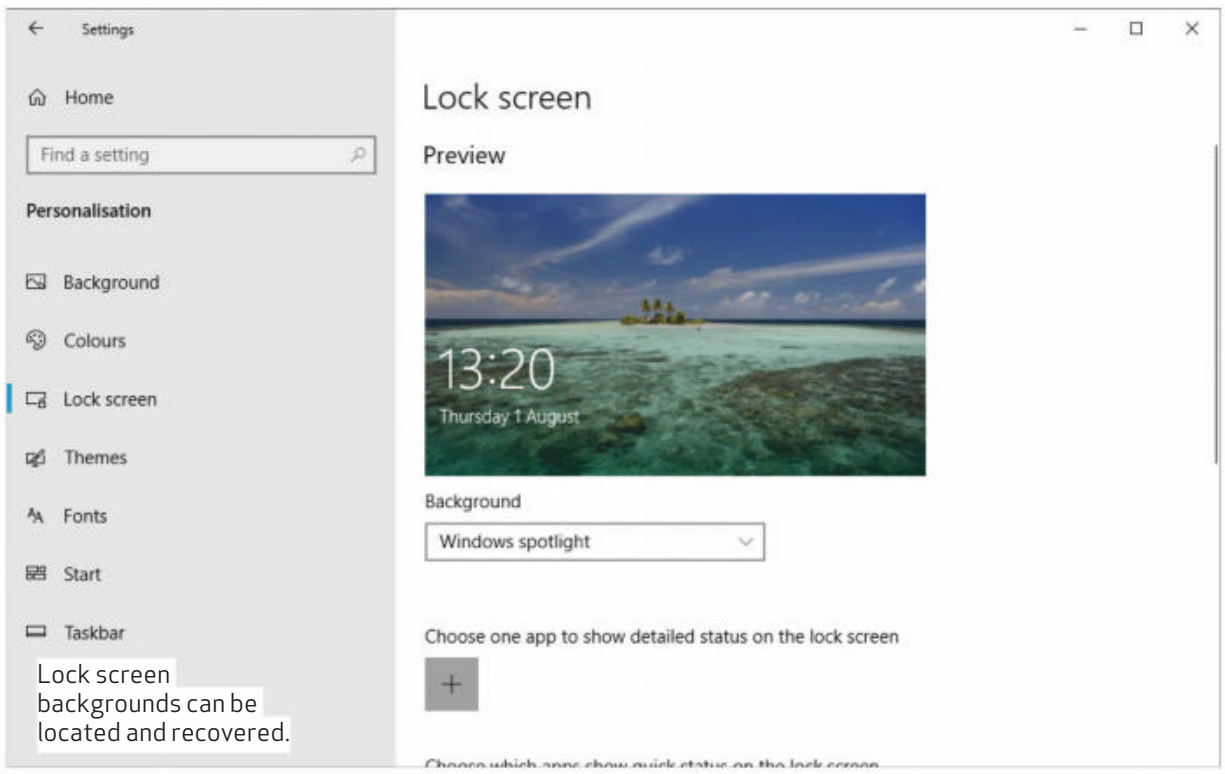
HARDWARE
CAN'T UPGRADE LAPTOP RAM

I bought a second-hand Toshiba Satellite c660 laptop for $150. It came with 3GB and I've tried upgrading it to 8GB RAM using Crucial's website to guide me to a purchase on eBay. But on installing it I get a blue screen "Kernel security check failure" error. A local shop also tried installing RAM and updating the BIOS but got the same error. I'm now at a loss as to what I can do – any suggestions?
Peter Blachford

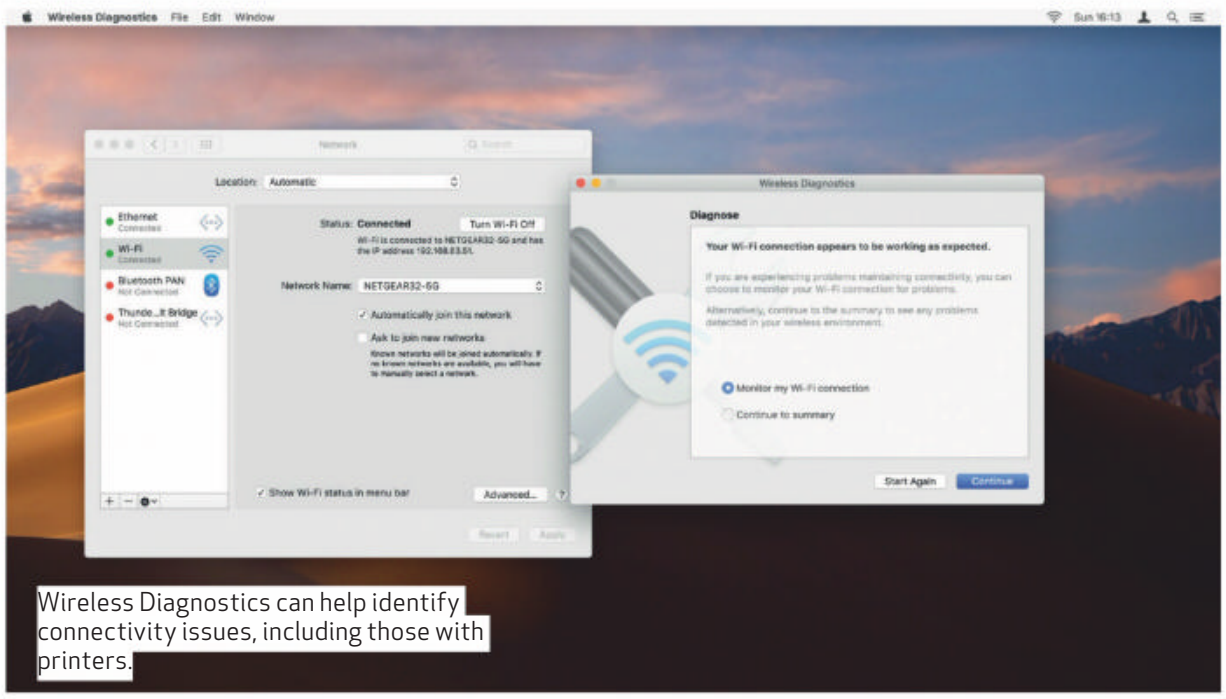


Some RAM needs timing adjustments before it works.

We first advised Peter on upgrading to an SSD drive to improve performance, which would also give him the opportunity to see if installing a fresh copy of Windows with the 8GB fitted would work, but sadly the same error message came up before anything was written to the drive. Older Toshiba Satellite laptops have a bad reputation for being sticklers about RAM – many users have reported success with adding a single stick of 4GB to the current 2GB stick, so Peter might like to try this to see if he can bump things up to 6GB. Otherwise it may be a case of entering the BIOS to see if he can find and write down the memory timing settings for the original 3GB sticks, then fit the new RAM (which is recognised correctly in the BIOS) and compare its memory timings – if necessary, alter these to match the original RAM. If Peter can get at least 6GB RAM working, then clone his Windows installation to his new SSD drive, he should see a significant improvement in performance.
Alex Cox



Lock screen backgrounds can be located and recovered.



Wireless Diagnostics can help identify connectivity issues, including those with printers.

"The problem was that Andrew had just purchased an impressively spec'd PC."

HARDWARE

MOUSE AND KEYBOARD PROBLEMS

My new PC is giving me problems – or rather my keyboard and mouse. Keystrokes are periodically delayed by a few seconds, while mouse movements can also appear jerky. The problems are intermittent, but if I reboot will occasionally go away for a while.

Andrew Inglis

This sounded like a classic issue of system resource issues – some rogue process or heavy duty program (Andrew was using Photoshop in conjunction with a scanner to sort through over 50 years of accumulated photos) consuming so much processor time and RAM that the system grinds to a halt.

The problem was that Andrew had just purchased an impressively spec'd PC: Intel Core i7 processor, 16GB RAM, GeForce GTX 1660 graphics card with 2GB onboard VRAM and an NVMe M.2 SSD drive. We directed Andrew to **https://helpx.adobe.com/au/photoshop/kb/photoshop-slow-lags.html.html** for an extensive list of remedial steps to try in case it helped, but after much to-ing and fro-ing he was advised to create a new user account. Logging into the new account seems to have cured the problem, suggesting a corrupt file or profile setting was to blame.

Carrie Marshall

WINDOWS

EXTRACT WINDOWS SPOTLIGHT IMAGES

I'm loving the images that pop up on my Windows 10 lock screen at startup – where does Windows store these, and can I extract them for use as, say, the wallpaper on my desktop?

Angie Johnson

It's fiddly, but certainly possible to find them. Press Windows-r and type **%LOCALAPPDATA%\Packages** and hit Enter to open this hidden folder. Now browse further to **Microsoft.Windows.ContentDeliveryManager_cw5n1h2txyewy\LocalState\Assets** where you'll find a load of files with apparent gibberish for names. Copy these into another folder, then browse to that folder in File Explorer, click inside the Address bar at the top, type cmd and press Enter to open a command prompt window. Type the following command and hit Enter: ren *.* ???-pic.jpg You'll immediately see the file icons update to show a thumbnail of each image, making it easy to identify the backgrounds from other photos in the same folder.

Ian Sleightholm

HARDWARE

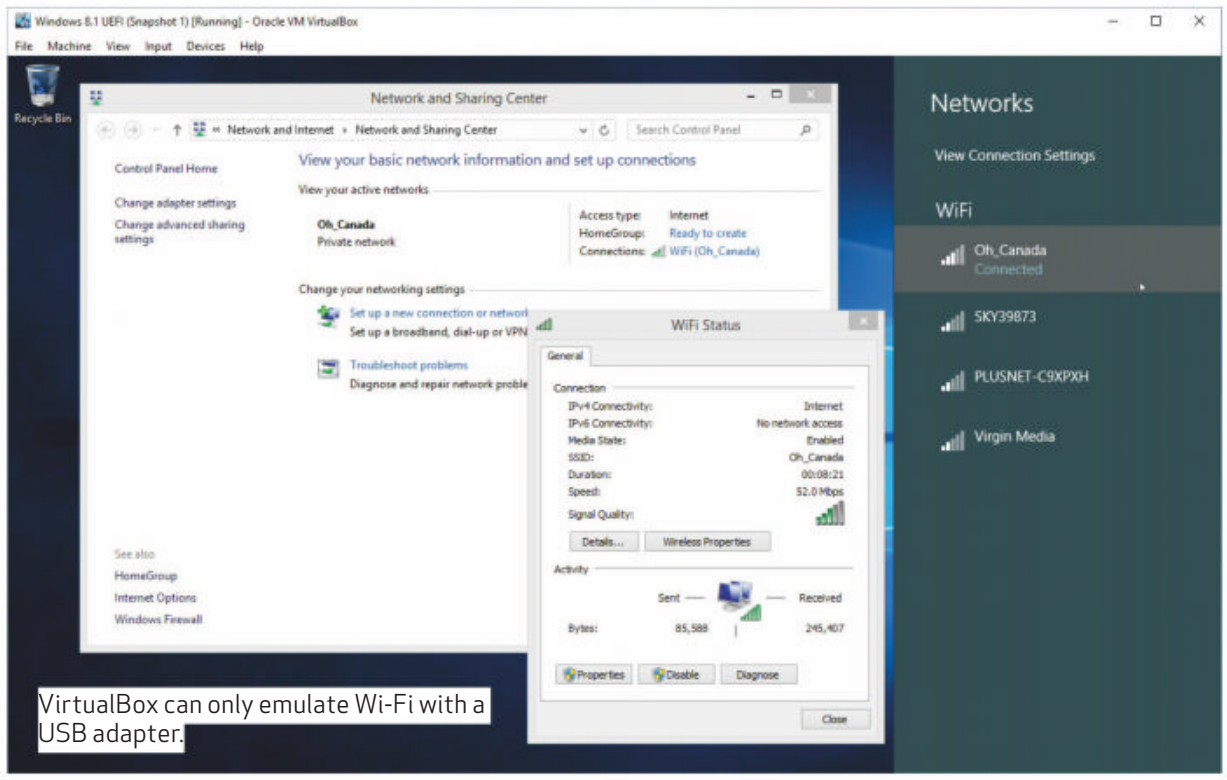
PRINTERS HAVE GONE MISSING

My Canon and Epson printers, which connect through my Apple Time Capsule, have stopped working wirelessly out of the blue. How can I work out what's gone wrong?

Harvey Beaudette

First, using AirPort Utility, check your Time Capsule's Wi-Fi setup and ensure that its firmware is fully up to date. Apple details this at **bit.ly/mf344airpfw**. If everything there seems fine, make a note of its IP address on your local network, and compare that with the address set on your Mac. For devices to connect, they need to be on the same subnet, with the same numbers in the first three groups, such as 192.168.1.3 and 192.168.1.12. Next, quit all open apps and run Wireless Diagnostics on your Mac. The easiest way to do that is by clicking the Wi-Fi item at the right of the menu bar with the option key held down: select the Open Wireless Diagnostics… command, and look for signs of problems there. This is largely self-explanatory and detailed at **bit.ly/mf344macwifi**. When you're happy that your Wi-Fi network is healthy and the printers, Mac and Time Capsule should all able to connect properly, remove the printers from the System Preferences > Printers & Scanners pane on your Mac, close System Preferences, then open it again and add both printers back. If the Wi-Fi in your Time Capsule isn't working properly and can't be fixed using AirPort Utility, contact Apple Support to see whether it can be repaired or needs replacement. If it's old, you could connect both printers to your Mac via USB and share them through a Wi-Fi router instead.

Howard Oakley



VirtualBox can only emulate Wi-Fi with a USB adapter.

"US$22 isn't a huge amount to pay for a program, however infrequently you use it."

APPLICATION

PRINT MUSIC FOLDER LIST WITH METADATA

I've ripped songs to separate folders per CD. I wish to make a printed list where first the folder is displayed and then all the songs inside that folder, displaying title, contributing artist and album. I tried the free version of Directory List & Print Pro but greys out the detail I'm looking for as I've not purchased a licence. Can you suggest a workaround or freeware alternative?
Gerald Gibson

US$22 isn't a huge amount to pay for a program, however infrequently you use it. We hunted high and low for a free directory printing tool with metadata support and came up short. In the course of our search we discovered Directory List & Print Pro (**www.infonautics-software.ch/directorylistprint/**) is the simplest tool for the job, another big tick in favour of paying the modest one-off fee for the features you need. A portable version exists too, which means you can run it without cluttering up your system.
Catherine Ellis

NETWORKING

EMULATE A WI-FI ADAPTER

I have a VirtualBox machine running Windows 8.1, and I'd like to be able to emulate a Wi-Fi adapter in it.
John Dexter

You'll need a compatible external Wi-Fi adapter. Open your virtual machine and click Settings › USB to add a filter selecting your USB device. Now start your VM – leave any existing network settings enabled for now to allow you to download and install any required drivers. Assuming the device is detected correctly, clicking the Network button in the Taskbar notification area should bring up the Networks list, with Wi-Fi options indicating you're now able to surf wirelessly with your VM.

Once you've confirmed this, shut down your VM and open Settings › Network to disable the virtual network adapter, then restart to access your network exclusively through the wireless USB adapter.
Nick Peers

STORAGE

MOVE PROGRAMS TO ANOTHER DRIVE

Is there some way to free up space on my Lenovo Miix 310's internal storage (a paltry 32GB)? I have no room left to update Windows 10.
Richard Croucher

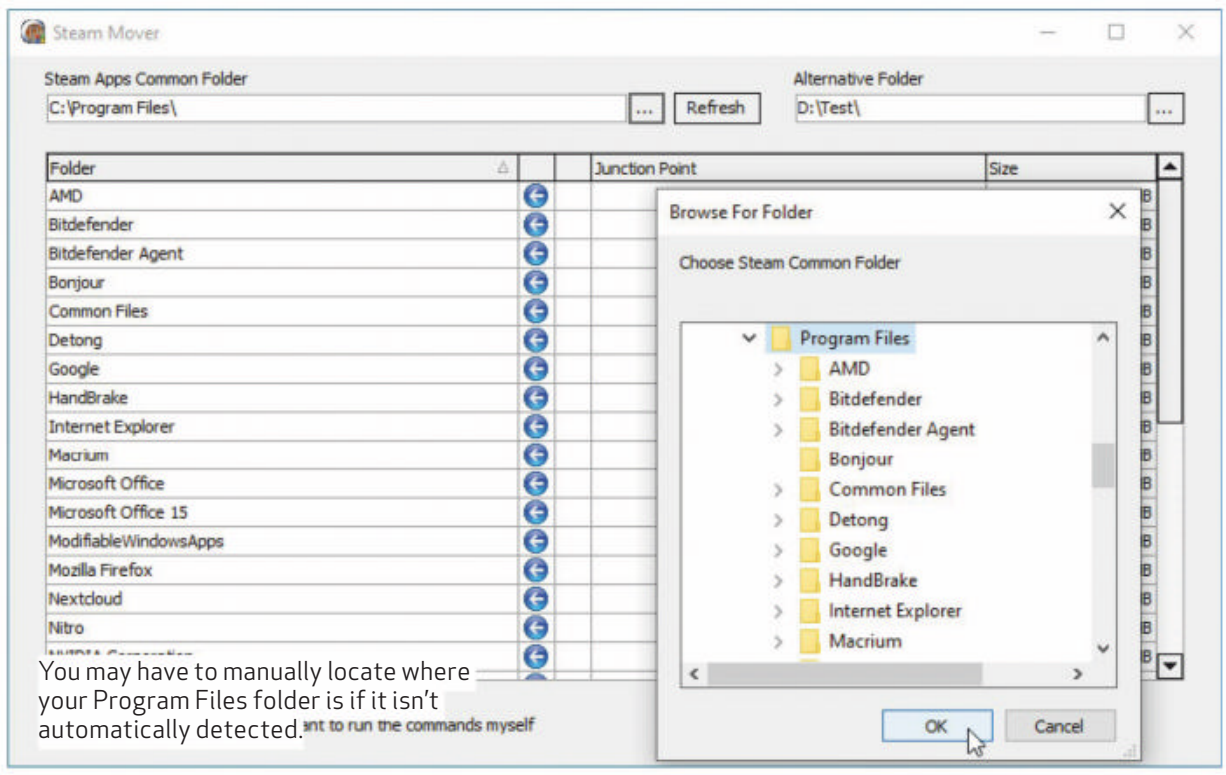
If you can get it to recognise a 64GB microSD card, then use that for additional storage – first move your documents and other user data across, then follow this guide to move apps over without having to reinstall them first.

Download Steam Mover from **www.traynier.com** – once done, right-click SteamMover_v0_1.zip and choose Extract All. Open the extracted folder, right-click SteamMover.exe and choose 'Run as administrator' to launch it.

If Steam Mover doesn't automatically select your Program Files folder, click … next to 'Steam Apps Common Folder' to choose C:\Program Files. Click … next to 'Alternative Folder' to select a suitable folder on your secondary drive.

A list of installed apps will appear in the list. Hold Ctrl and click on each app you wish to transfer to highlight it. Try to focus on larger apps and those you don't use that often. Once done, click › to move the files.

After the command prompt window closes, you should find the apps are now on your D drive, and space has been recovered. They should work as normal, but you can restore them by selecting them and clicking ‹ at any time.
Alex Cox



You may have to manually locate where your Program Files folder is if it isn't automatically detected.

Quickly fix a photo

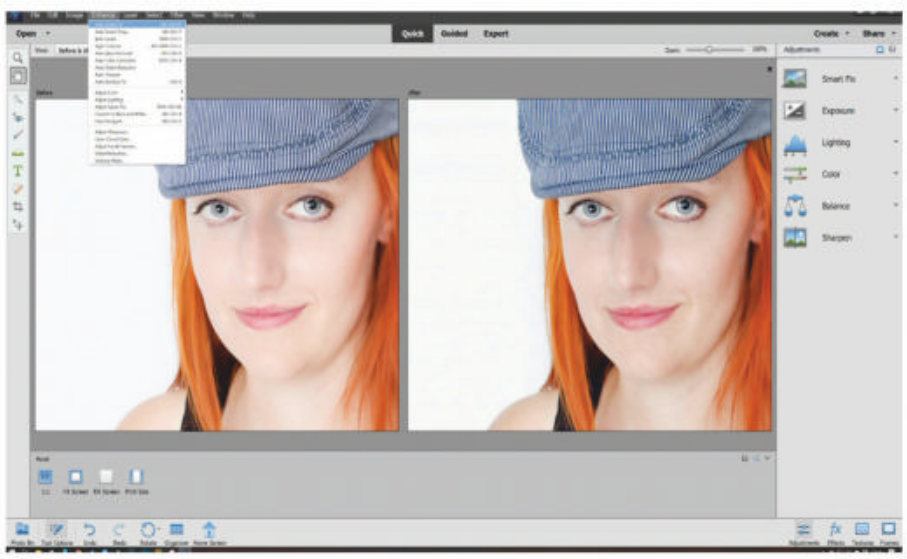
You don't have to spend hours editing an image in Photoshop Elements 2019 to get fantastic results, there are great time-saving tools built into the app. Ian Evenden explains.

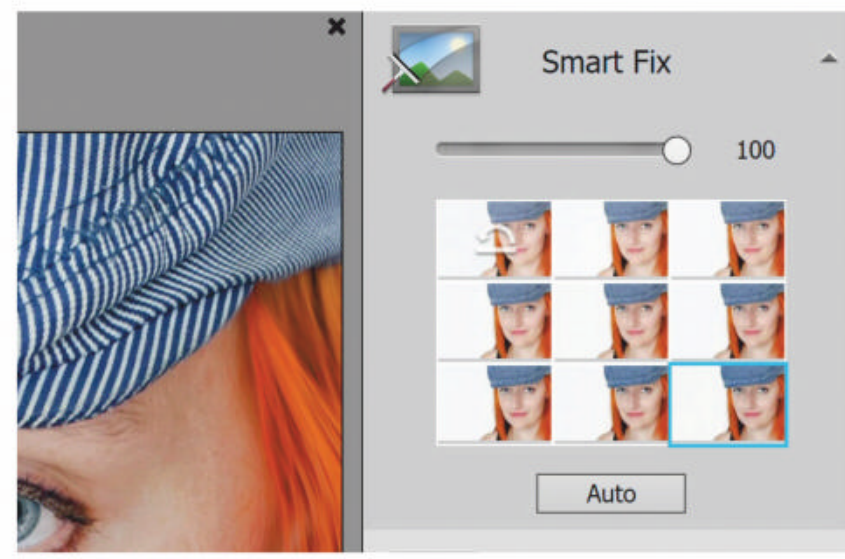
While Photoshop Elements is an extremely powerful image-editing app that can be used to create complex layered compositions, you can also use it to touch up your selfies.

There's more to the program than Expert mode, and by dropping down the Enhance menu, no matter which of the three modes you're in, you'll find a host of useful features that can transform an image. Dig a little deeper, though, and you'll find those fully-automated tools have close cousins that allow you more control over the results, so you end up with a natural-looking photo rather than an over-saturated, purple, excessively sharpened mess.

We're using the 2019 edition of the software here, but you can follow the steps in any recent version. Download a free trial from **http://bit.ly/PSE19trial**.

Edit with speed



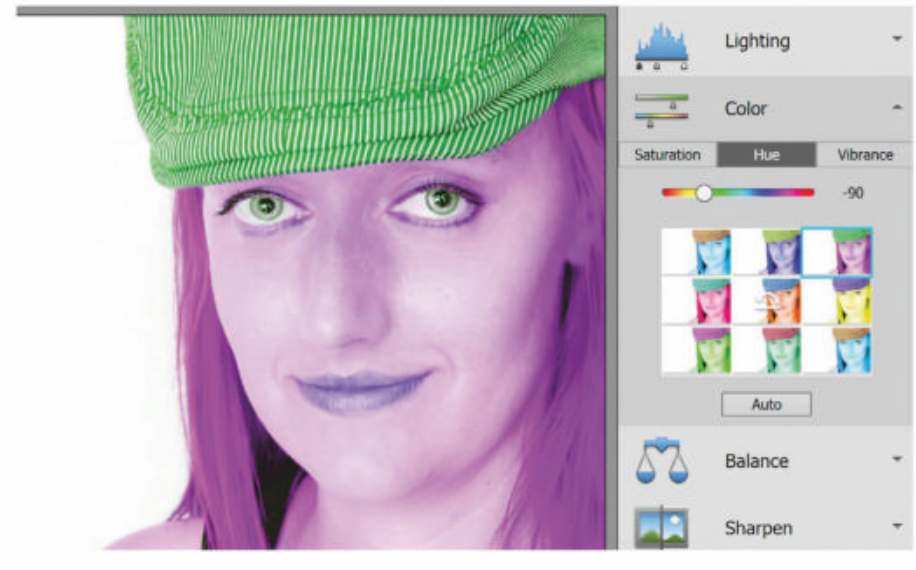


1 AUTO SMART FIX

This is a one-shot filter that aims to improve your image. Using the Before and After view can make it clearer what has happened. In the image above it has darkened the model's skin while retaining the brightness of her eyes and vibrancy of her hair. You have no control over Auto Smart Fix, but it's useful if you have a lot of images to process. Find it on the Enhance menu.

2 SMART FIX

For more control, open the Smart Fix section of the Adjustments panel on the right of the interface. This gives you a slider to alter the intensity of the effect, and a grid of thumbnails to choose from, although these effectively do the same thing as the slider. The Auto button does the same thing as Auto Smart Fix. There's a reset button at the top right of the palette.



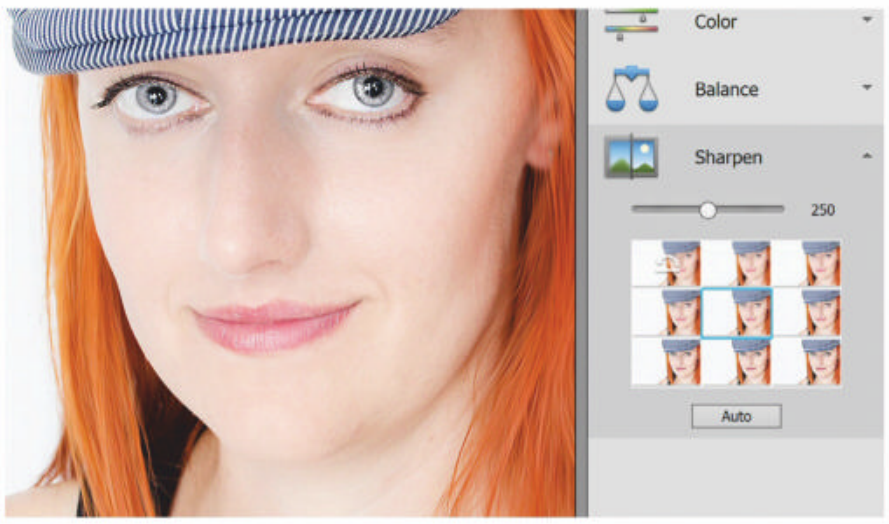
3 AUTO SMART TONE

Enhance > Auto Smart Tone is a good choice for portraits, where getting skin tone accurate is important. It projects a grid across your image, with a control point you can move. In the corners are extreme versions of the image. By moving the control point toward one of these images, you make your image more like it. Settle somewhere in the grid you're happy with, and hit OK.

4 LIGHTING AND COLOR

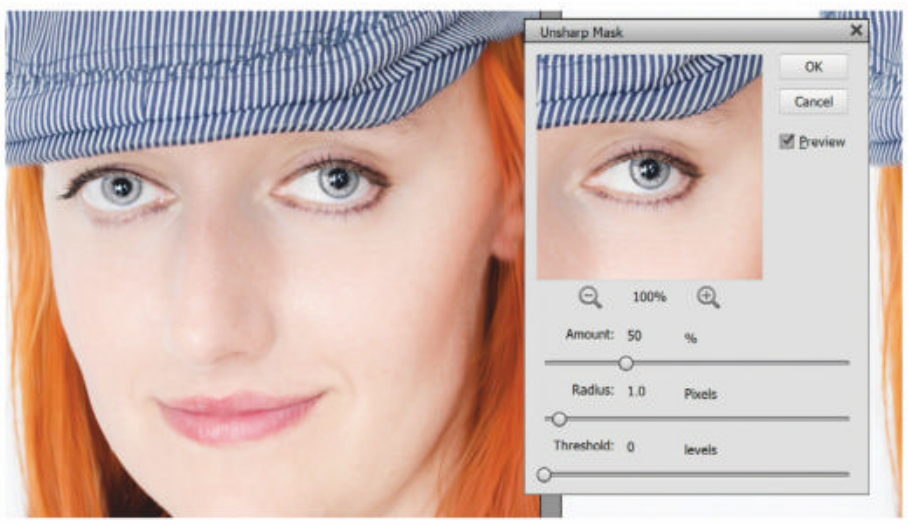
You can find Auto versions of both these adjustments in the Enhance menu, but the slightly more manual implementations in the Adjustments palette are far better. They work much like Smart Fix, with a slider and some thumbnails, across Shadows, Midtones and Highlights. There's a lot you can do under Lighting, and it gets more powerful once you open up the Color section as well.

THE
MOST FUN
YOU CAN
HAVE WITH
YOUR HANDS
WITHOUT
GOING
BLIND



5 SHARPENING

There's an Auto Sharpen option on the Enhance menu, and a Sharpen section on the Adjustments palette, but sharpening is such a complex beast that, even though this is meant to be about quick fixes, it's worth going straight to Unsharp Mask, which is also on the Enhance menu, but nearer the bottom. This gives you the chance to control the process and stop it going out of control.

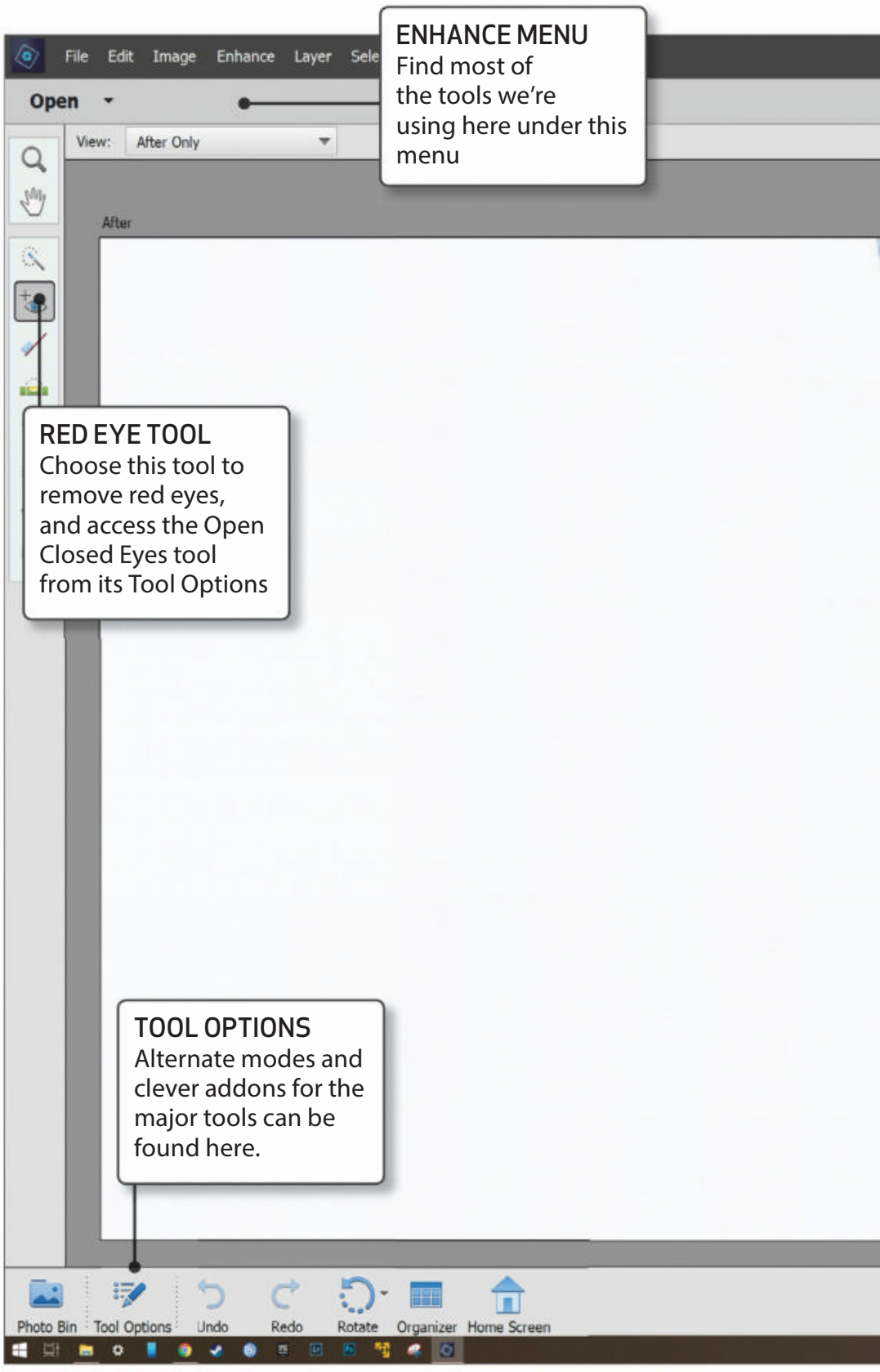


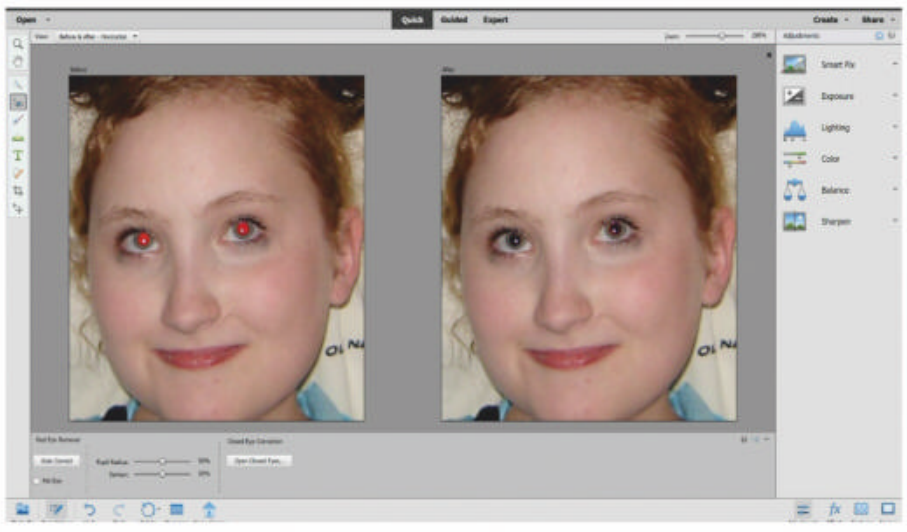
6 UNSHARP MASK

The Unsharp Mask window has three sliders. The Amount slider controls the strength of the effect. The Radius slider controls how far from edges the effect is applied – keeping this down restricts the sharpening to edges, areas of detected contrast, leaving areas such as soft skin alone. Threshold has a similar effect, determining how strongly the app detects these 'edges'.

7 ADJUST FACIAL FEATURES

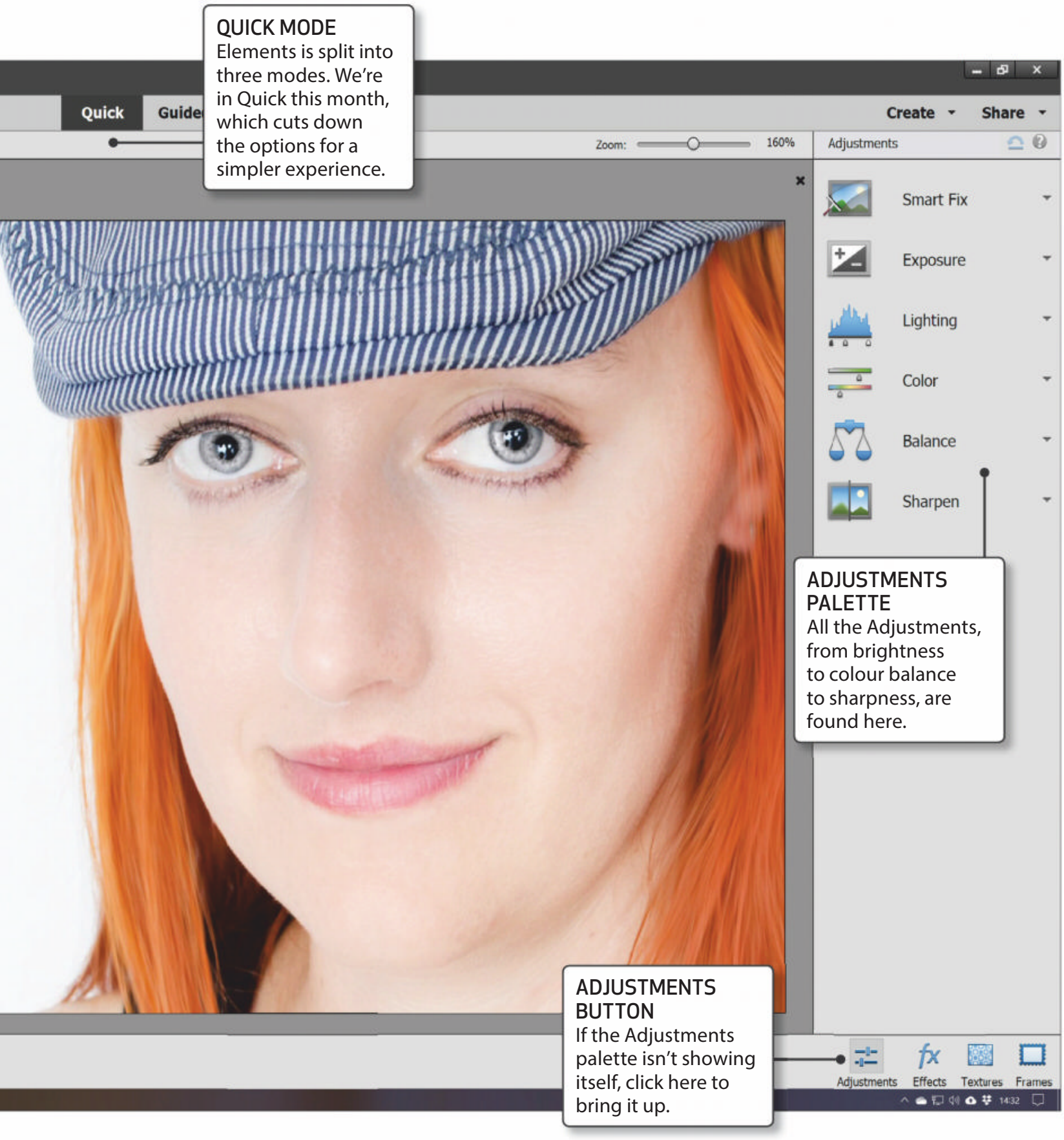
Another tool from the Enhance menu. This stretches and pinches the component parts of a detected face to change their size. So you can turn a face into a large-eyed, huge-nosed freak, or use it more subtly to enhance the beauty of a portrait sitter without them really noticing. It works extremely well as long as it can detect the face properly.





8 RED EYES

The red eye effect is caused by a flash that's too close to the lens axis bouncing back off the retina, but it's so well known and easy to mitigate you almost never see it any more. Elements has an automated red eye tool that works well, and can even be used on your pets. There's also a manual version, on the toolbar, which requires you to draw boxes around each eye.



IAN'S BEST TIP

Elements' before and after views are essential for keeping an eye on what you're doing.

JARGON BUSTER!

ORGANIZER

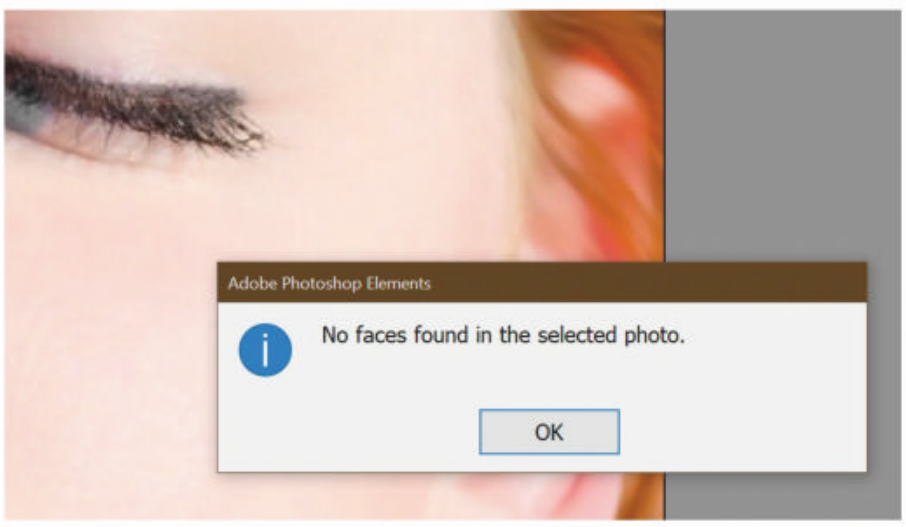
Elements' Organizer is an app that organises your photos for you.

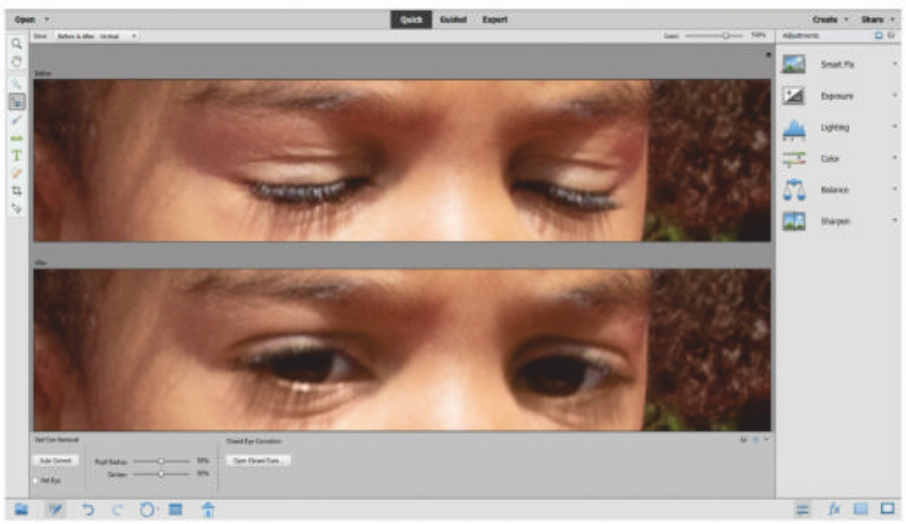
PHOTO BIN

Every open file lives in the Photo Bin at the bottom of the interface, where you can choose between them.

FACE DETECTION

Elements uses algorithms to determine whether an image contains a face, and can add these to the Organizer's database. It doesn't always work, however.





9 EYE OPENING

The ability to open closed eyes became part of Elements a few years ago, and works well as long as you meet a few criteria. You need a photo of the same subject with his or her eyes open as well as one with them closed. Pictures of other people, or even animals, can be substituted for hilarious results. Elements also has to be able to detect a face in the image – it can't always do it.

10 DON'T BLINK

Inadvertent blinks in photos can be fixed, however. Once the face is detected, click the Red Eye tool in the toolbar, and choose Closed Eye Correction in its Tool Options. You'll be prompted to choose the face you wish to edit, and where the open-eye image is, whether on your PC, in the Organizer, or already open in the Photo Bin. Then, it's a simple click. ■

Manage your Mac's storage

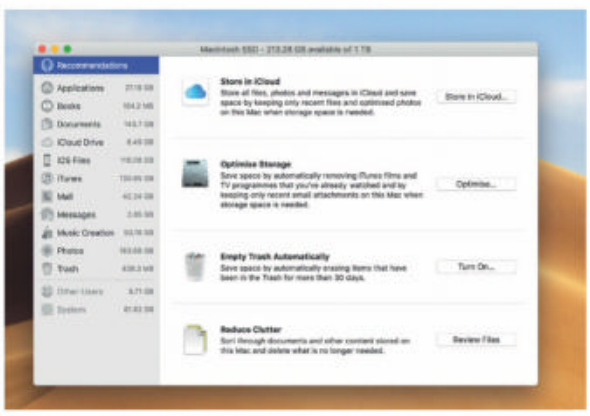
Craig Grannell shows how to use macOS and GrandPerspective to free up space on your Mac.

Modern Macs come with limited storage that typically cannot be upgraded. If you have a 128GB drive, you're likely stuck with it for the life of the machine. Run low on space and you may be able to work with external drives or the cloud, but those rely on extra hardware or internet access.

You may therefore periodically need to take a look at what you've got and refine what you store locally. The quickest free, safe and manual way to make more space on your Mac is to identify large files you no longer require, and then get rid of them.

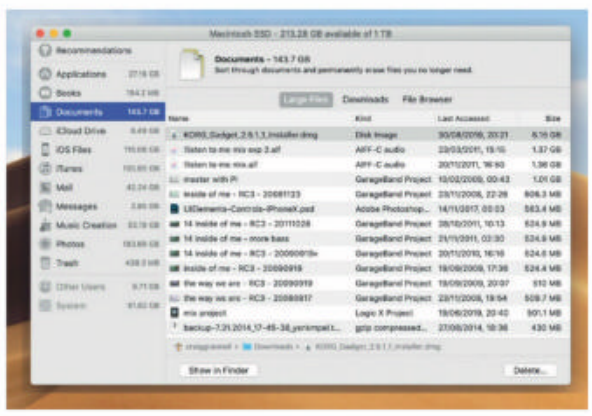
This tutorial shows how to use built-in macOS tools for this, and third-party app GrandPerspective. Free from grandperspectiv.sourceforge.net (or $1.99 from the Mac App Store), this app complements Apple's by offering an at-a-glance overview of any drive (rather than just a file list), and enables you to scan specific folders. Obviously, be mindful of deleting any file you don't have a backup of – once it's gone, it's gone!

HOW TO Find and remove unwanted large files



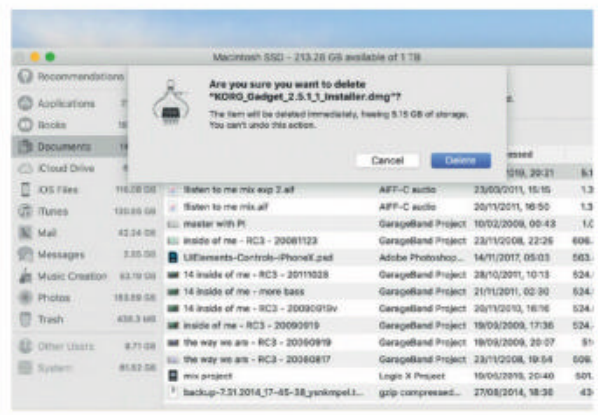
1 OPEN SYSTEM INFO

In the menu, select About This Mac. Click the Storage tab and then Manage. The System Information app will open, initially displaying recommendations regarding how to trim what's on your Mac's internal drive.



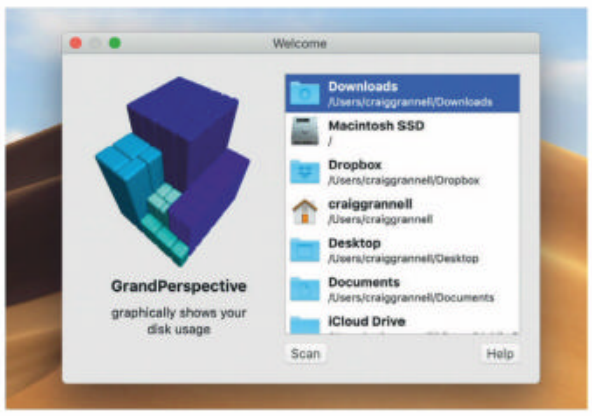
2 FIND LARGE FILES

We're primarily interested in deleting unwanted files here, so click Review Files next to Reduce Clutter – or you can select Documents from the sidebar. Next, click Large Files and then the Size column heading to see your largest files.



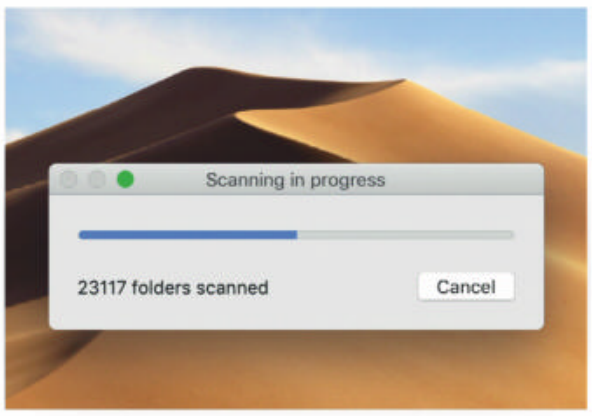
3 DELETE A FILE

Select an item and click Show in Finder to view it and check it's something you do want to remove. Or if immediately convinced, click Delete. But beware: this action has no undo – you cannot retrieve your item from the trash.



4 CHOOSE A FOLDER

Launch GrandPerspective. Select a listed folder, or scroll to the bottom of the list, double-click Select Other Folder, and choose an alternative. Or skip the window and kick things off with File > Scan Folder (command-n).



5 SCAN YOUR SELECTION

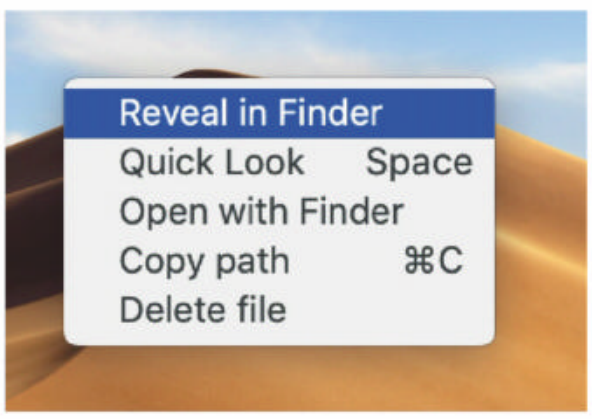
It may take a long time to scan your entire drive, or a large folder with many documents. It's therefore sometimes worth scanning smaller folders like ~/Downloads, to quickly weed out large documents you weren't aware of.

6 VIEW YOUR SCAN

When the scan is complete, your selected folder will be represented as a grid of coloured squares. Each of these squares is a document – and the larger the square, the larger the document. Hone in on the biggest ones.

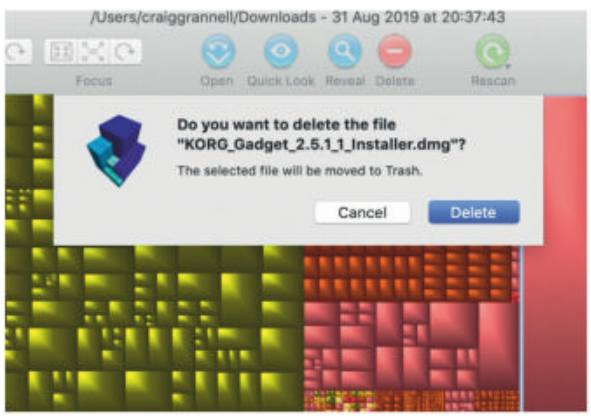
7 BROWSE ITEMS

Hover over or click any square. It will be highlighted, as will any containing folders. In the status bar at the foot of the window, you'll see the path to the document, its file name, and – most importantly – its size.



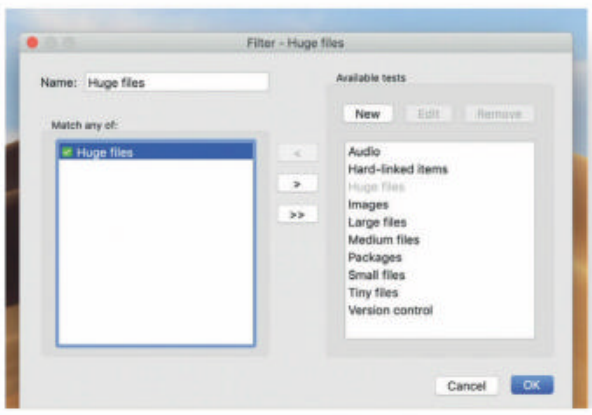
8 DOUBLE-CHECK DELETIONS

For the current selection, use toolbar buttons or the contextual menu (control-click) to view it using Quick View, or reveal it in Finder. It's best to check (and possibly back-up) anything you're planning to delete!



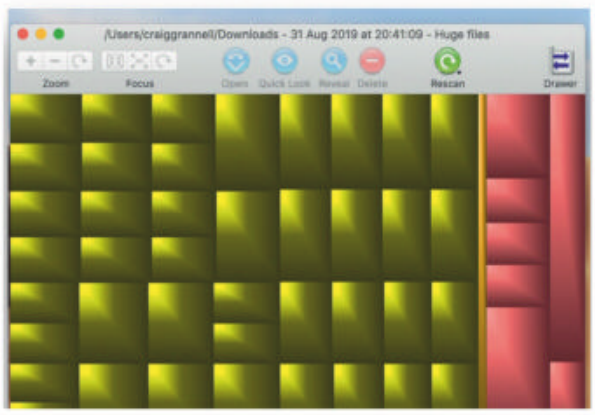
9 REMOVE A FILE

On selecting Delete, you'll be asked to confirm. Your file is not immediately removed – it's sent to the macOS trash, from where it can be retrieved. In GrandPerspective, the space it once took will be coloured grey.



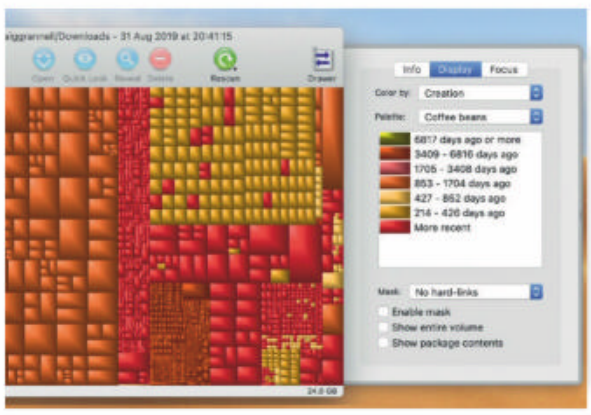
10 FILTER YOUR SCANS

Should you want to reduce noise, create a filter for your scans. Go to Window > Filter, click New and call your filter 'Huge files'. Select Huge files from the Available tests area, and click < to add it to the match area.



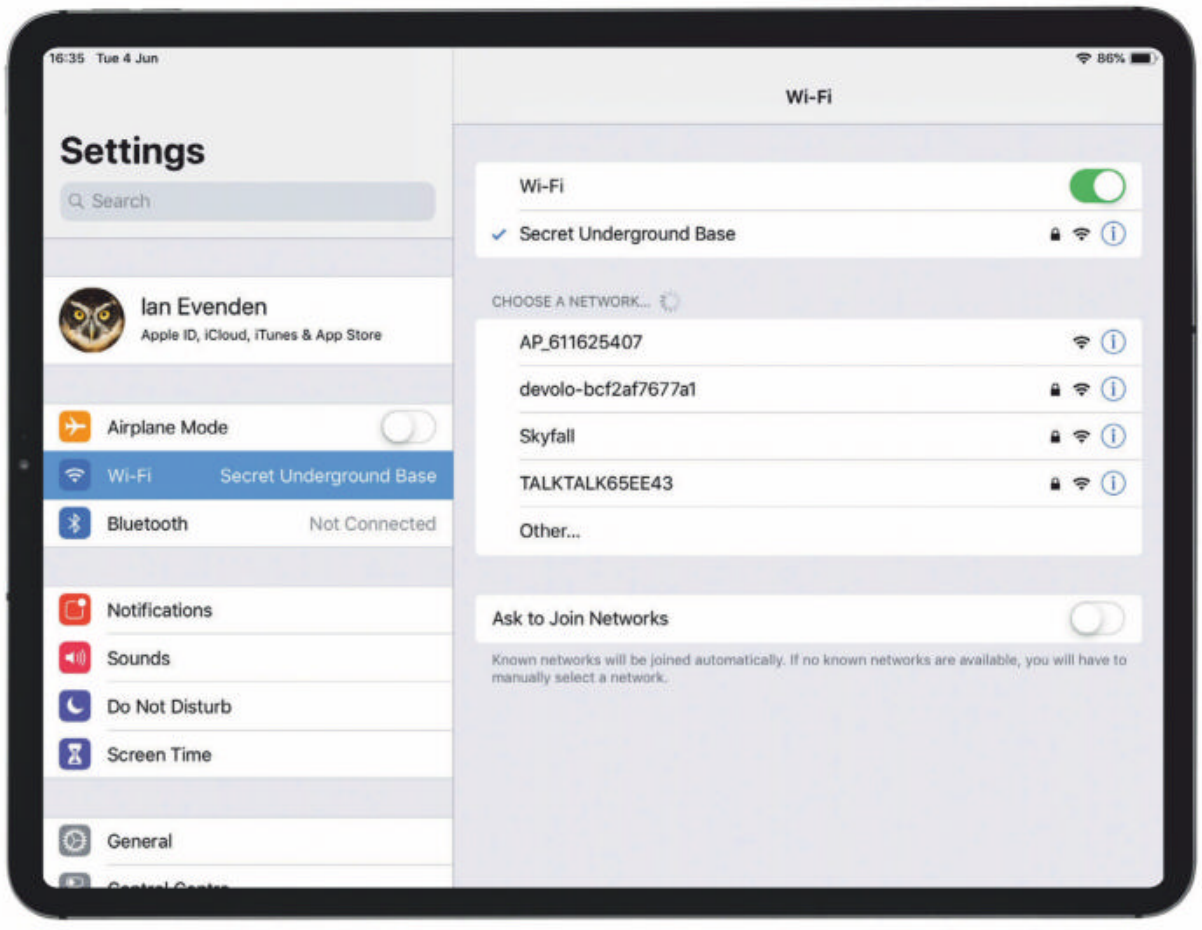
11 CHOOSE CRITERIA

Click OK to save your filter. Run a scan – or select an existing one on-screen. Go to Window > Filter, select your filter from the pop-up menu and click OK. The scan will now only display files larger than 100MB.



12 ADJUST YOUR DISPLAY

Click Drawer. Display > Color by lets squares' colours represent file type or age rather than folder. Also, use 'Show entire volume' to compare the current scan to your entire drive, and avoid pruning tiny files!



Manage Wi-Fi and Bluetooth

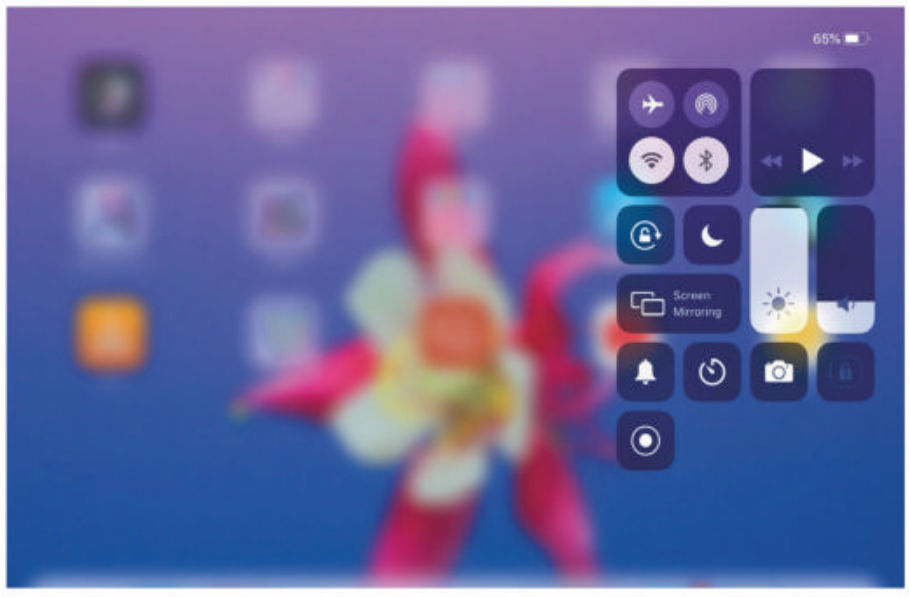
Ian Evenden cuts through the wireless confusion caused by iOS changes.

The release of iOS 11 in 2017 made some changes to the way Wi-Fi and Bluetooth worked on iOS devices, and it led to some confusion. When is off really off? How does it affect AirDrop and AirPlay? Why did they switch back on when I went for a walk?

A simple rule of thumb is that using Control Centre to turn Wi-Fi and Bluetooth off is enough to drop any existing connections for the rest of the day, but the system remains available. If you want to turn them off more permanently, you'll need to use Settings, or put the device in Airplane Mode – which isn't ideal if you still want to receive calls.

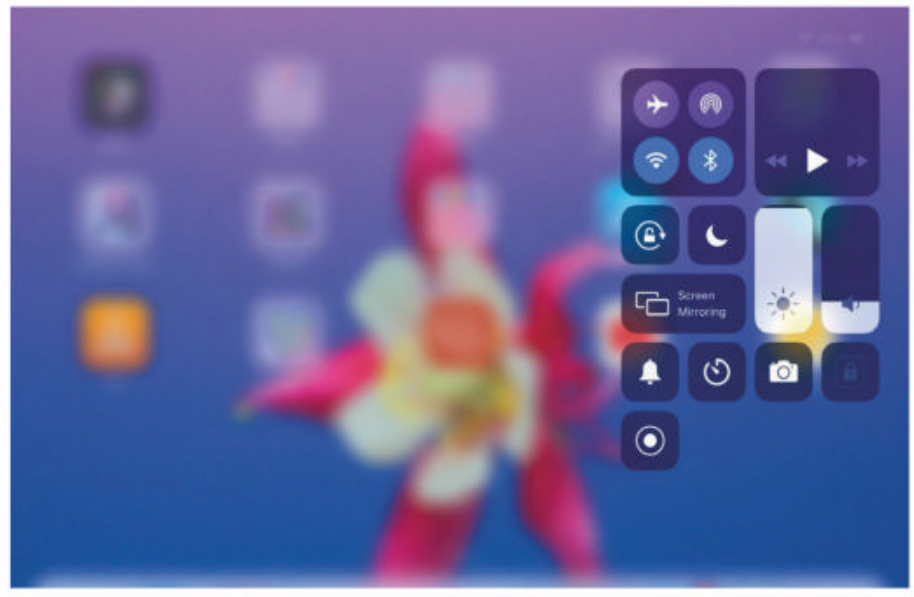
Apple recommends that you keep Wi-Fi and Bluetooth turned on to get "the best experience", but there are valid reasons for turning them off, such as saving battery power (though this is marginal), not being tracked in particular areas, or preventing your device from connecting to Bluetooth headphones when you're trying to pair them with something else.

HOW TO Control your connections



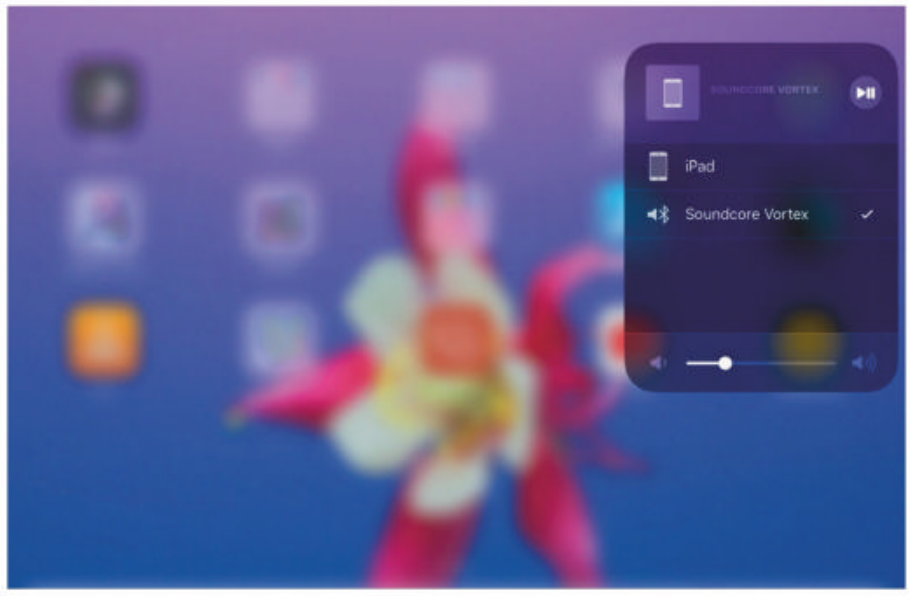
1 CONTROL CENTRE

The simplest way to turn off both Wi-Fi and Bluetooth in iOS is to open Control Centre. Press the symbols for Wi-Fi and Bluetooth (the stylised fan and runic B) and they'll turn from blue (on) to grey. Active connections will drop.



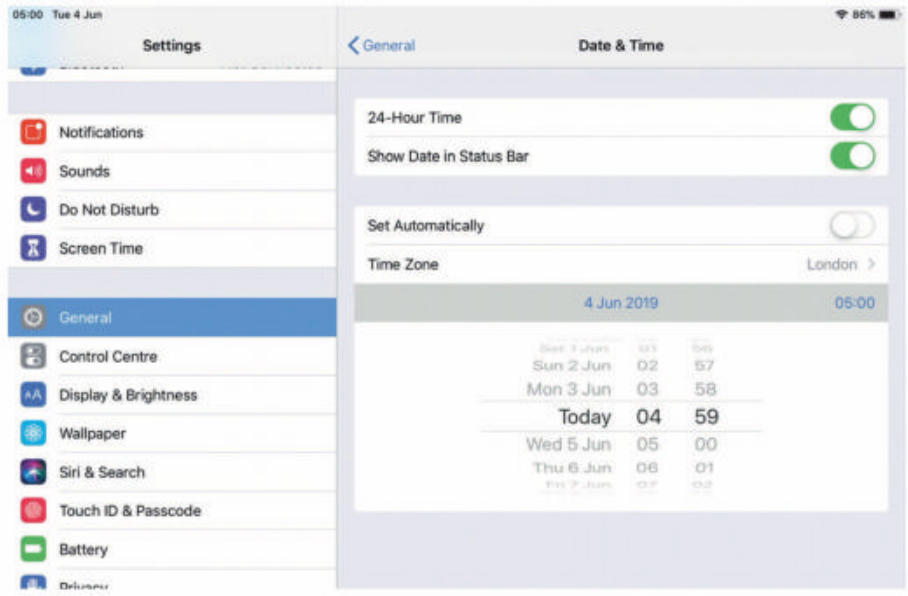
2 BRING THEM BACK

To turn them back on, just do the same thing, and the icons will turn blue again. This means you can still use AirDrop, Handoff, AirPlay and your Apple Pencil – none of these will work without Wi-Fi or Bluetooth.



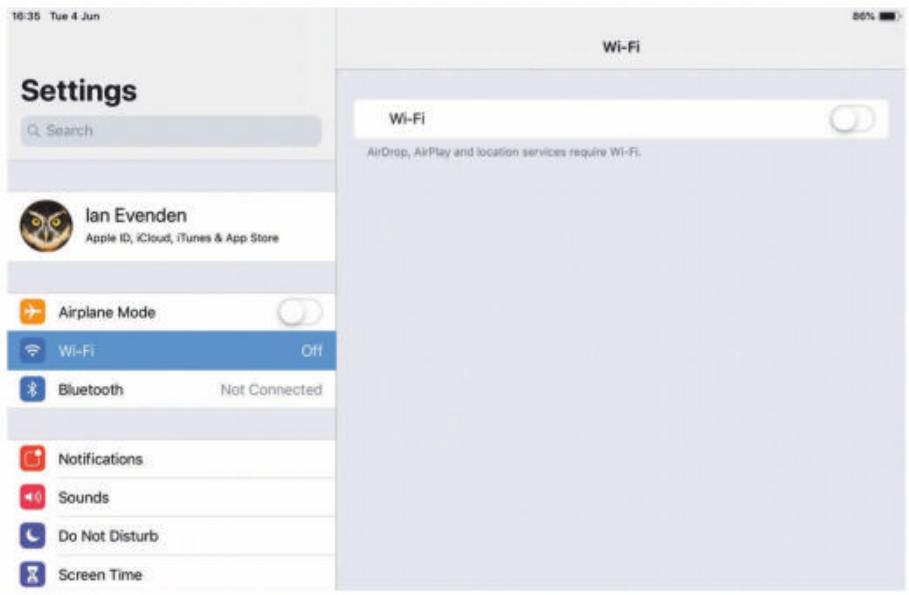
3 SWITCH AUDIO OUTPUT

While you're in Control Centre, press and hold on the audio controls to open them up. Now tap the triangle-with-circles button in the top right to switch between internal speakers and others, including Bluetooth devices.



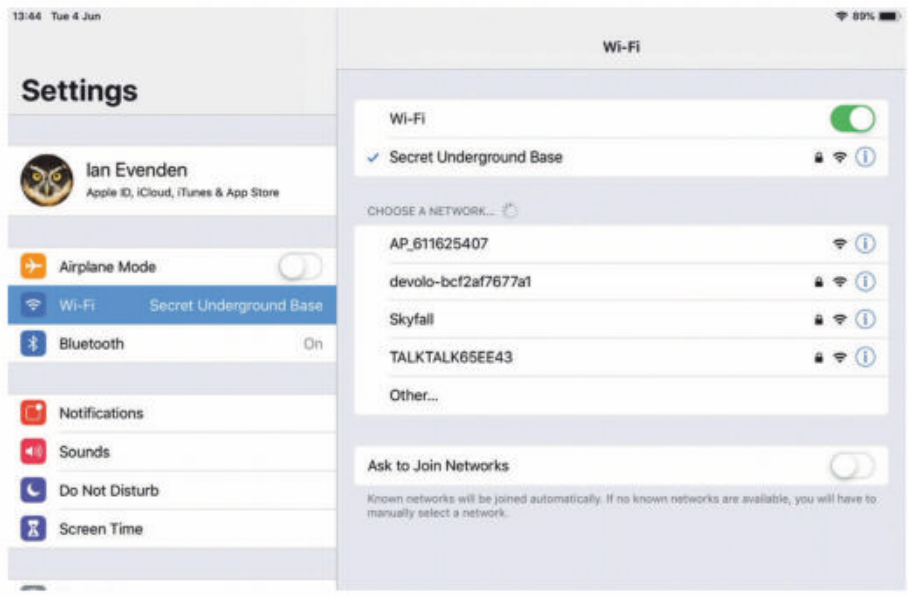
4 REACTIVATION TRIGGERS

The Wi-Fi and Bluetooth will come on again automatically if certain conditions are met, such as restarting your device, moving to a new location, and the time ticking past 5am. To prevent this, you will need to go to Settings.



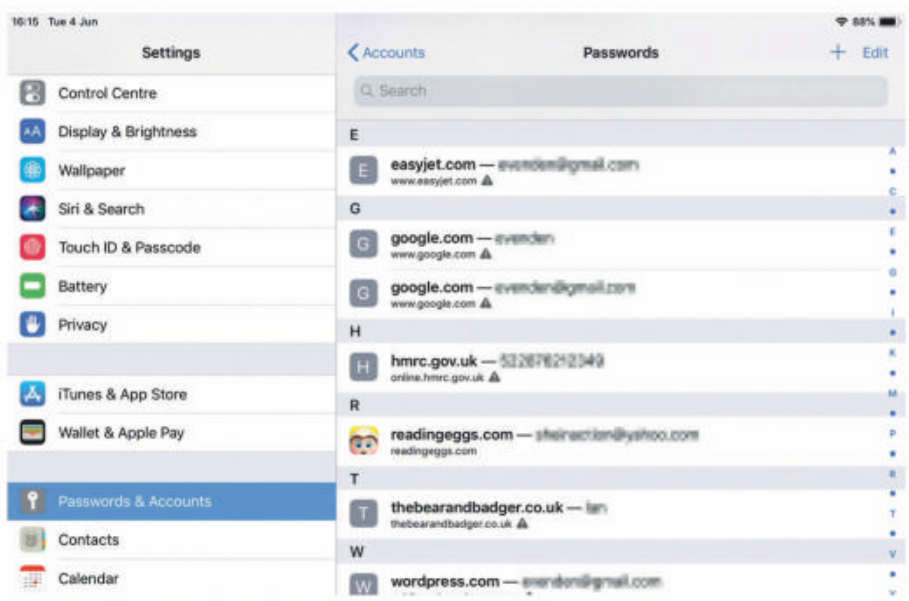
5 SETTINGS

Open up Settings and tap the Wi-Fi and Bluetooth entries. In each, you'll find a switch to turn them off. When they're in this state, many systems such as Instant Hotspot and Bluetooth music streaming become inoperable.



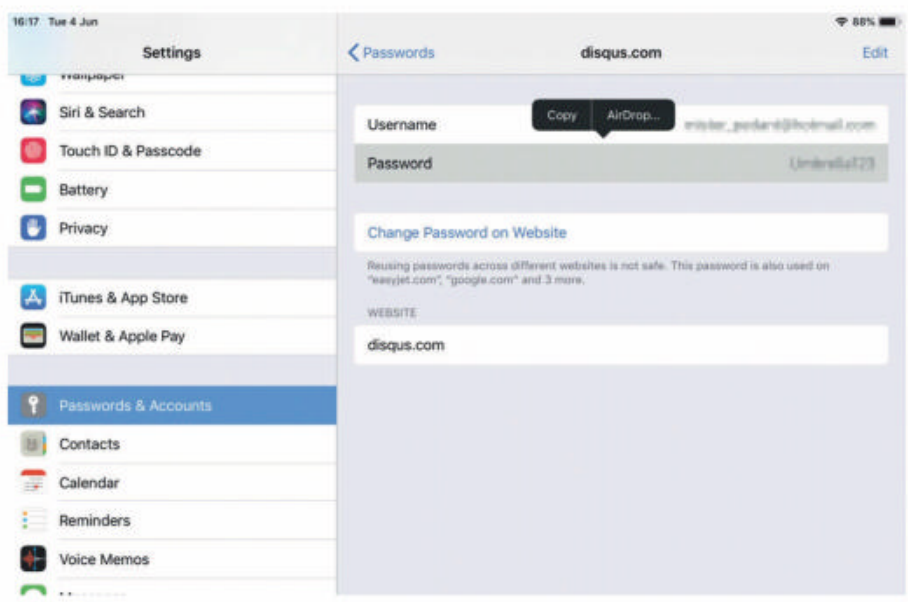
6 BRING THEM BACK

When you want to use Wi-Fi or Bluetooth, tap the switches again. If you're looking for something to connect to, you can refresh the listings of Bluetooth devices and Wi-Fi hotspots by pulling down on them and releasing.



7 AIRDROP PASSWORDS

While in Settings, you can use AirDrop to share passwords for websites and apps. Make sure Wi-Fi, Bluetooth and AirDrop are on, go to Passwords and Accounts, then tap Website & App Passwords. You'll need to authenticate.



8 LIST PASSWORDS

You'll be presented with a list of all the passwords saved to your Apple account. To share one, tap on it, then on the next screen tap on the password itself – an AirDrop option will appear. Tap a name to share with someone.

Running the Linux desktop on Android

Aaron Peters takes the Linux-on-Android concept a step further by cramming a full desktop onto an Android Phone.

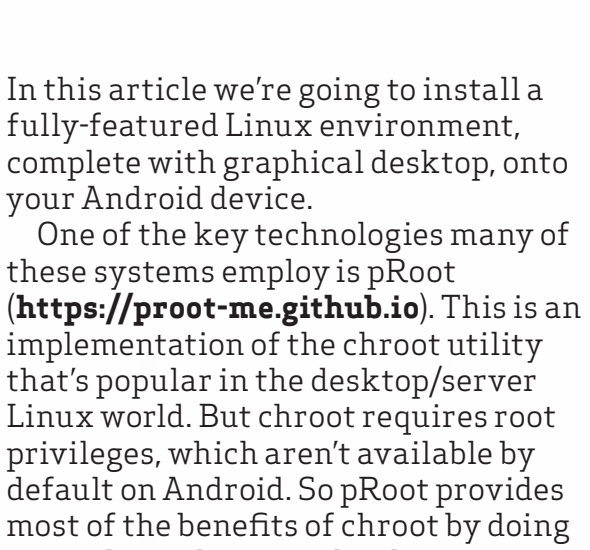
In this article we're going to install a fully-featured Linux environment, complete with graphical desktop, onto your Android device.

One of the key technologies many of these systems employ is pRoot (**https://proot-me.github.io**). This is an implementation of the chroot utility that's popular in the desktop/server Linux world. But chroot requires root privileges, which aren't available by default on Android. So pRoot provides most of the benefits of chroot by doing some clever directory binding.

CHECK THE BELOW

Unlike Termux, however, not all of these Linux-on-Android systems use BusyBox (**https://busybox.net**). The reason is because the whole purpose of these systems is to provide a 'full' installation, whereas BusyBox is designed to wrap up a number of common utilities into a single binary. Instead, these systems install a typical Linux bootstrap containing the full-strength versions of programs like ls, cp and mkdir.

There is one bit of additional technology for these systems that wasn't required for Termux, however. We'll be installing a full-strength Linux distro, which brings with it the expectation of a GUI desktop. We will get one of these, but in order to do so we'll need to make an important decision regarding the graphics system.



Set up either an App or Distro in UserLAnd with a username and password, plus one for VNC.

LINUX-ON-ANDROID

As we've said a few times, the packages we'll be looking at, as well as some others, run in userspace. This means they only have the permissions of the current user, which in the case of Android is always a normal user –that is, not root. However, in order to enable our Linux desktop, we'll need to be able to install a display server such as X or Wayland. If we did that in our Linux environment, it would run with the normal user's permissions, which don't include access to Android's graphics layer. So we'll need to look at options that install one of these servers in the 'standard' Android way in order to access the hardware, and will also provide a supported graphical environment.

The clever folks in the development community have come up with two solutions. One is to use the native Linux versions (typically X rather than the newer Wayland). This will start up and run in the background, and you'll then access this background process over VNC. If you already have a VNC viewer on your Android device for remoting into other machines, you'll basically just use that to remote into the local host. It's a straightforward solution that's easy to set up, although some users report issues with performance and lag with this setup.

However, a second option is to install a display server designed for Android. There are several of these available in the Play Store, both paid-for and free. The most important thing to check is whether it's supported, or at least has been known to work, with whichever Linux-on-Android package you choose. We favour the X-Server approach, and we've used the XServer XSDL package (**http://bit.ly/lxf256xserver**) in the past with no issues. We'll describe that here, although the process may be slightly different if you settle on another app, or use VNC instead.

SELECTING A SYSTEM

As with X-Servers, there are multiple options in the Play Store that provide the Linux system we're seeking. Here too, as with Termux, we'll be focusing on solutions that don't require you to 'root' your device. This carries a degree of effort and risk that's kind of hard to justify. These non-root solutions provide all the functionality most users will need, without the chance of ruining your warranty. Here are a few of examples of these apps in the Play Store:

- UserLAnd (**http://bit.ly/lxf256userland**): This popular option installs a number of common distros, including Debian, Ubuntu, Arch and Kali. Interestingly, while it doesn't include any RPM-based options, it does include Alpine Linux for devices with less space.
- AnLinux (**http://bit.ly/lxf256anlinux**): This app assists in installing one (or more!) of a sizeable list of Linux distributions, which includes Ubuntu/Debian, Fedora/CentOS, openSUSE and even Kali. You can also select from a couple of low-resource desktop options including Xfce4, MATE, LXQt and LXDE. It does require Termux to be installed. It also requires a device running Android 5.0 or higher.
- Andronix (**http://bit.ly/lxf256andronix**): Very similar to AnLinux. It has arguably a nicer design, but supports a smaller set of distros.
- GNURoot WheezyX (**http://bit.ly/lxf256gnuroot**): The GNURoot project started as a Linux-on-Android option focusing on open source software. As the name suggests, it's focused on the Debian distribution, while the 'X' at the end signifies this app is targeting a graphical desktop. While its developers have gone on to create UserLAnd, it's still available in the Play Store if it fits your needs.

We'll be using UserLAnd for this tutorial, for a couple of reasons. Firstly, it's open source (although so is AnLinux). It offers a good selection of distributions, and although these don't include Fedora or CentOS, they do install a couple of options to produce a very minimal system that won't take up a lot of precious storage. But mostly, UserLAnd has support for installing apps instead of entire distributions. We'll explore exactly what this means in a later section. But for now, let's get UserLAnd onto your device.

INTO THE USERLAND

The first step to getting this system spun up on your Android device is to install the app from Google Play or F-Droid (**https://f-droid.org/en/packages/tech.ula**). This installs just like any other app – you're not doing anything special just yet. Once the installation is done, you can launch it from the app drawer just like anything else.

The first thing you'll see is a list of distributions, and we'll get to those. But if you scroll down a bit, you'll come to a couple of desktop options: LXDE and Xfce4. Bringing up the rear are a list of apps, including Firefox, a couple of games, some utilities for development such as Git and science (GNUPlot), and some nice office apps: GIMP, Inkscape and LibreOffice. You may notice at this point that you're on a tab called Apps. You can think of this as holding the stuff you can install.

Once you've installed something, you'll see an entry for it on the next tab, which is Sessions. From here you can start or stop it, as well as see what's already running. Filesystems, the last tab, shows the installations you've already done. These two work together to allow you to control the 'processes' within UserLAnd as well as the installations. It's worth noting that when you delete something from Filesystems, its corresponding session will disappear, but the opposite isn't true. You're able to create a new Session based on an existing Filesystem, for example to be able to access it via VNC in one Session, and with XSDL in another.

Understanding this relationship is easiest when you see it in action, so we'll begin by installing just a single app in the UserLAnd environment.

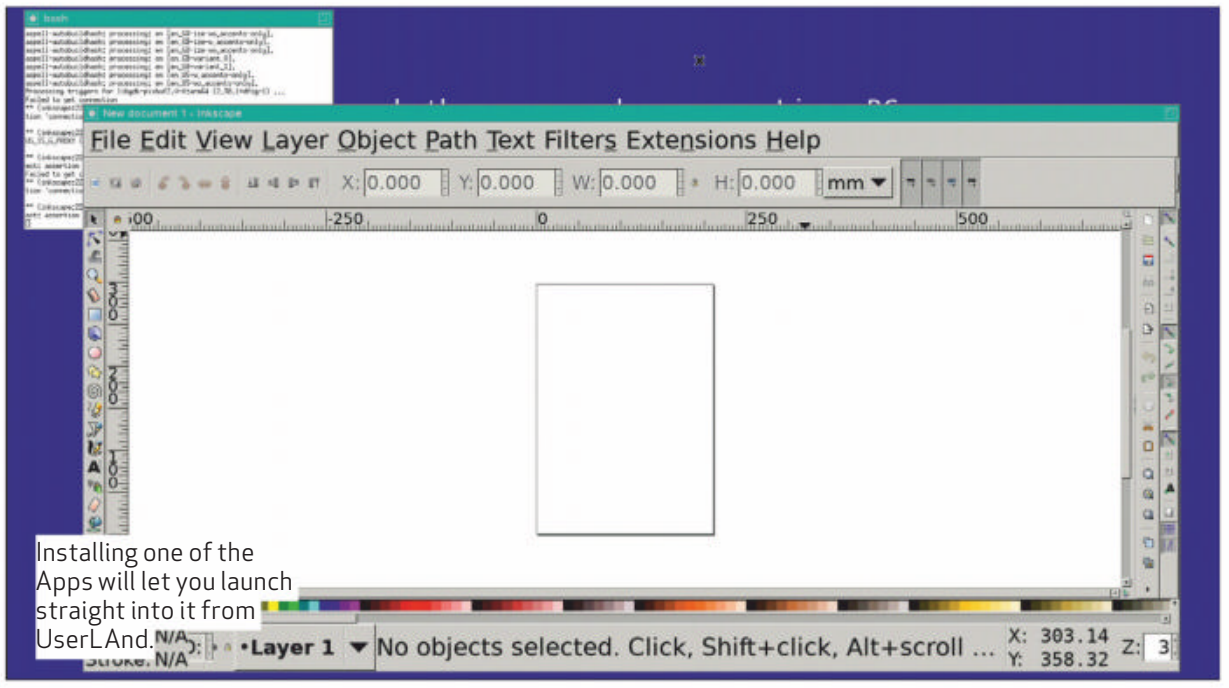
APPS IN USERLAND

If you scroll to one of the applications such as Inkscape in the list on the Apps tab and tap it, you'll begin the installation process.

1 When you select an app, a dialogue appears asking you to select what method you'll use to access it. With a GUI app like Inkscape, you can select either VNC or XSDL. As mentioned previously, we're using the latter for this exercise, although they'll both work.

2 Next, the app requires access to your internal storage, and will ask you for that permission. This is because UserLAnd will be downloading your selection and needs temporary storage before moving it to the protected part of the phone.

3 If you selected XSDL as the access method and haven't installed it yet, you'll be forwarded to the Play Store where you can pick it up.



Installing one of the Apps will let you launch straight into it from UserLAnd.

4 Once XSDL is installed it will launch, and after a few moments you'll be in an X-Windows environment that will be familiar to old-school users (rocking the TWM window manager, for those who are cool). No background image, no fancy desktop menus or docks, just an xterm window.

5 You'll see commands start to scroll through this window, though if you're on a phone they may be so small that they're hard to read. But this is the installation of your app, using standard Linux package tools. App-only installations use a Debian base, so here apt is duly installing the program you selected along with its dependencies.

6 Finally, once it's complete the program's window will appear. Tap to finalise its placement and the window will render, along with the menus and buttons you'd see on the desktop version.

There are a couple of things to keep in mind once the app launches. First, there's only a simple window manager controlling the placement of the window in relation to other windows. There's no nice, consistent treatment of things like fonts and images that you'd get with a full desktop environment. As you can see in the screenshot of Inkscape, the font in the menu bar is larger than the proportional treatment of the buttons. In addition, some dialogues or other elements will be developed with bigger screens in mind. So they'll appear very large, maybe too large to even be of use. In Inkscape on the our phone, for example, the 'Open file' dialogue is so large that most of the controls aren't accessible at first. You can fix this with keyboard-based commands to control windows, but it may present a bit of a challenge until you get the hang of it.

As a quick way to make a tweak to some file this may be sufficient, but let's see if we can get a better experience by installing a full desktop.

pRoot and Linux Distributions

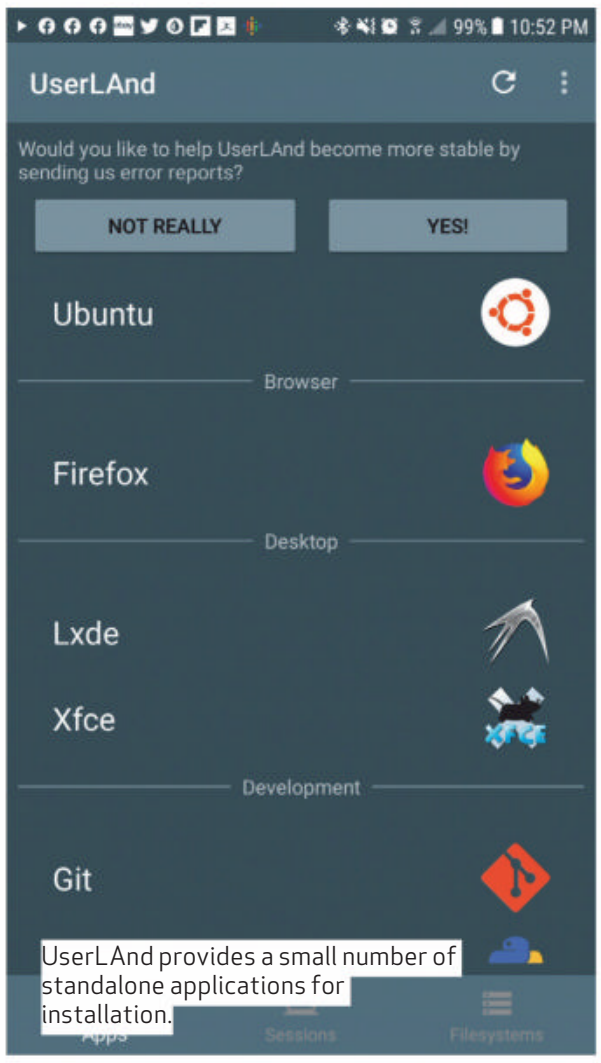
You'll notice that the solutions in this article, as well as Termux, rely on pRoot to host the Linux distributions that run on Android.

It may make it seem like pRoot itself is an Android utility, but it isn't. It's a general userspace implementation of chroot.

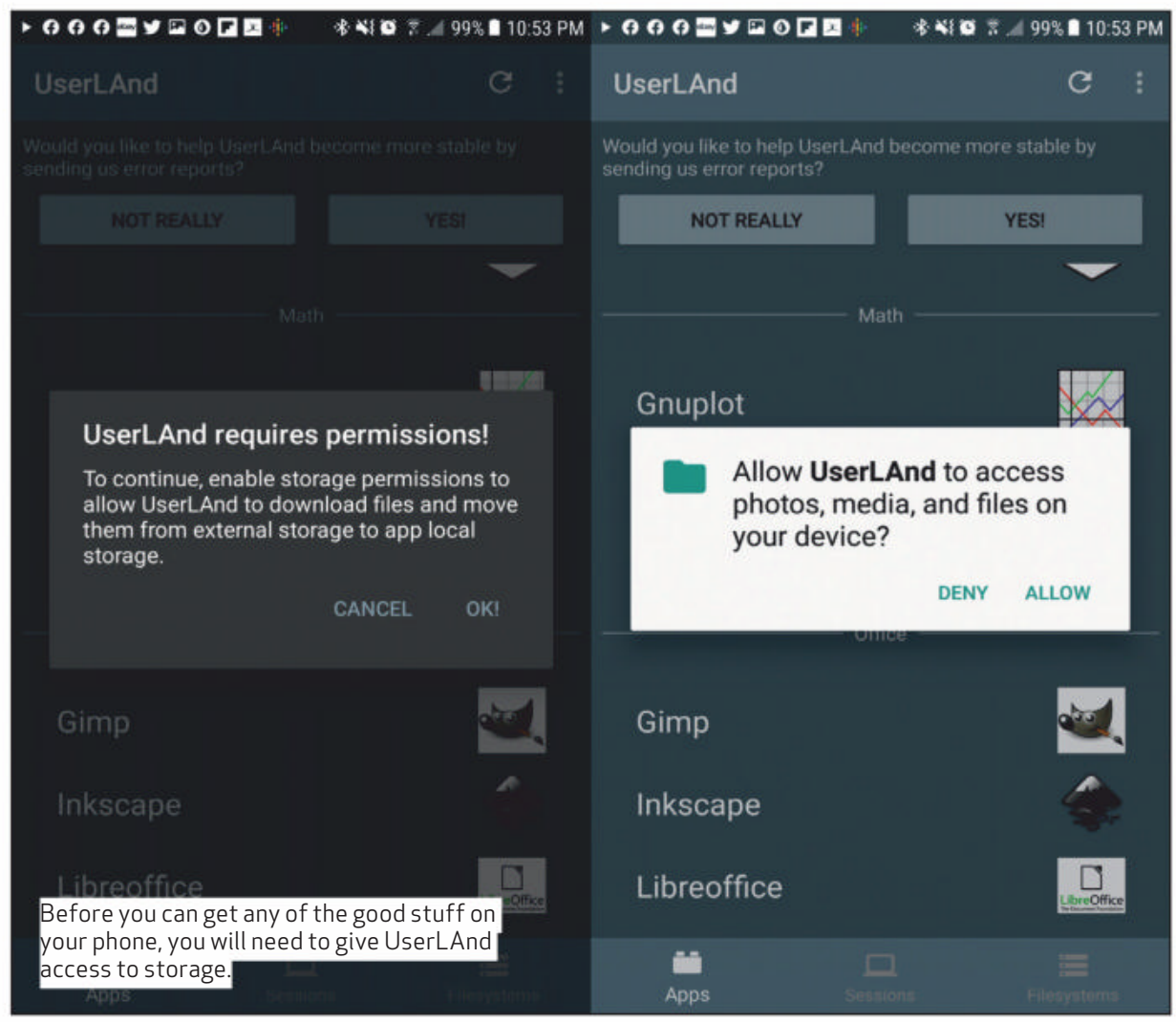
What this means is that you can use pRoot to install 'jailed' Linux distributions on any compatible host OS. You can most likely install it from your distro's repositories (sudo apt install proot will work on Ubuntu), or download it from the project's website **https://proot-me.github.io**. Once it's installed, you'll need to find a compatible root filesystem for the pRoot. The Downloads section of the site has some places where you can download these, while the Examples section shows some common command options.

This would allow normal (non-root) users to try out some alternative distributions within their own home directory. Another neat trick is to use it to test out applications for other CPU architectures. Finally, while most 'jailed' or 'containerised' apps operate only within their own space, pRoot offers bind support.

This would allow you to grant access to files outside the 'jail' to the pRoot's OS.



UserLAnd provides a small number of standalone applications for installation.



Before you can get any of the good stuff on your phone, you will need to give UserLAnd access to storage.

DISTROS IN USERLAND

From the Apps screen, select one of the distributions to install on your device. We'll use Ubuntu as our example here. Tapping it brings up the same dialogue as before, asking for a username, password and VNC password. You'll then select the method with which you want to access it, including the two prior options as well as SSH. The download will begin, this time fetching a base image for the distro you picked and unpacking it into UserLAnd's directory.

When it finishes, you should return to the XSDL 'desktop', and presented with an xterm window. You can issue a standard command to check what your Linux version is:

```
uname -a
```

The next step along to a desktop is to install it, again using standard Ubuntu commands:

```
sudo apt install lxde
```

You can also use `xfce4` if that's more your speed. Cue more downloading and installing… when you get to the prompt again, just use the following to start up your swanky new desktop:

```
startlxde
```

The last step is to make sure that your new desktop environment is the one that starts on launch. To do this, you'll need to edit your .xinitrc file; it currently has a single line of `/usr/bin/twm`. You just need to change this to `/usr/bin/startlxde`. Now exit out of the XSDL session (make sure you hit the STOP button in the notification area), long-press on the Ubuntu listing in the Sessions tab and hit Stop Sessions, then restart everything. You should see the LXDE desktop come up after a few seconds. Subject to some of the caveats we've discussed previously, you can do just about anything in this environment you could do on a desktop. It just might be a little smaller, a little slower, and take longer to tap into your device than it would be with a keyboard and mouse. Let's take some time to explore exactly what you can accomplish using a device.

ROUGH GUIDE TO USERLAND

If you take some time to click around the desktop, you'll find it's a faithful recreation of the desktop version. If you're using UserLAnd on a device with a keyboard and mouse (Bluetooth or otherwise), you'll find it easy to get around. Aside from a little lag as the X-Windows cursor tracks your Android device's cursor, everything works easily.

In this case, your screen is the trackpad: rather than tapping directly on what you want, slide instead to move the on-screen cursor, then tap the screen to click (two-finger tap for a right-click). If you need to input some text, press the Back button on your device. This will bring up (Android's) virtual keyboard. Hit the Back button again to close it; the screen will 'bump

Samsung's Linux on DeX

If you hapapen to own a Samsung phone, you're in luck.

In addition to the above options, you have an additional one that's not only compatible with your device and not just supported, but developed by the manufacturer themselves.

That's precisely what Samsung's (**www.linuxondex.com**) Linux on DeX is. Still in beta at the time of writing, this application enables you to install Linux to be used in 'DeX mode'.

What is this, you might ask? Well, Samsung offers this feature on newer phone models that enable users to plug them into a monitor – and, by extension, a keyboard and mouse. When it's connected this way, the phone's UI switches over to something that more closely resembles a traditional desktop. There's a taskbar, movable windows and so on – but all the applications are still the Android versions we know and love. Disconnect your phone and it exits DeX mode, going back to the standard Android UI.

Linux for DeX takes this one step further by launching a Linux distro when switching to DeX mode. By installing the Linux on DeX app from Samsung's Galaxy Store, you have the option for Linux to take over when connecting your phone to a display. Even better, if you're using a tablet you can launch it directly.

up' out of the way, then return once you're done.

The first thing you may want to do is to adjust the default system font, as the desktop size is still pretty big on phone screens (no worries if you're on a tablet). Head to the main menu, then go to Preferences > Customize Look and Feel > Widget. Here you can set the default font size to something more manageable: 6 pt makes things look pretty nice on a Note 5.

Obviously, the next thing you'll want to do is start installing some of your favourite programs into your new Linux environment. As shown above, the standard commands will do the trick here, so feel free to get the one truly indispensable tool installed in your UserLAnd environment ASAP:

```
sudo apt install emacs
```

Another thing you may want to consider is setting up alternative connection methods for your distro. Just because you initially installed it for an XSDL connection doesn't means it needs to remain that way. You can create another entry in the Session tab and select a different connection method. Just make sure you point it at the same Filesystem. UserLAnd tries to direct you to the correct application to handle the method you've chosen: either XSDL, ConnectBot for SSH, or bVNC.

Unfortunately, it's rather insistent that you at least try these, as it will shuffle you off to the Play Store automatically to install them. However, you can back out of this, and connect using the app of your choice. For SSH, we rely on trusty old VX ConnectBot. Just log into port 2022 on localhost with your username and password. For VNC, the proprietary but thoroughly excellent Jump Desktop works like a charm by pointing the VNC connection at 127.0.0.1:5951. Just hope you remembered the VNC password you set up when you created the Filesystem…

Note that you can also access your running UserLAnd session using similar tools on another machine on your network. For example, you could SSH into a running session (with the SSH connection type, naturally) using a Linux terminal like Konsole, or connect to a VNC session using KRDC. Just substitute the localhost addresses above with your Android's IP address. Paired with a couple of portable apps, this setup gives you a handy little portable Linux system you can jump into using whatever machine happens to be available at the time.

And that's really all there is to it – so load up and get hacking on your mobile device!

Installing BusyBox on Desktop

If you check your desktop distro's package manager, you may find that BusyBox is available for install.

On Ubuntu, it's as easy as:

```
sudo apt install busybox
```

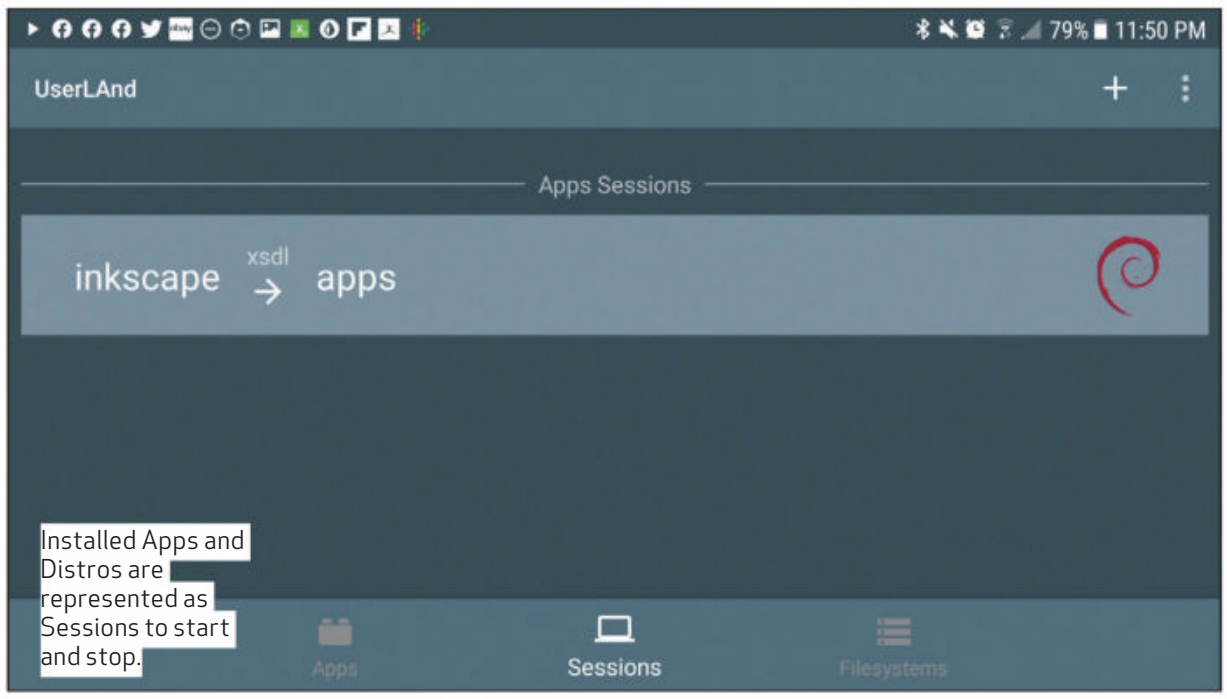
But wait, doesn't BusyBox replace lots of common Linux utilities? Won't this overwrite them? Fortunately, it won't. In fact, there's a good chance it's installed on your machine already. It's there in the event a normal boot-up doesn't work; many 'safe mode' environments use BusyBox instead of a full set of Linux utilities.

But under normal circumstances, bear in mind that while BusyBox is used as a replacement for these utilities, it doesn't need to overwrite them. It normally requires a number of symlinks to work properly, and on Ubuntu the package's description notes that it won't create any of the necessary symlinks that would allow BusyBox to handle those commands.

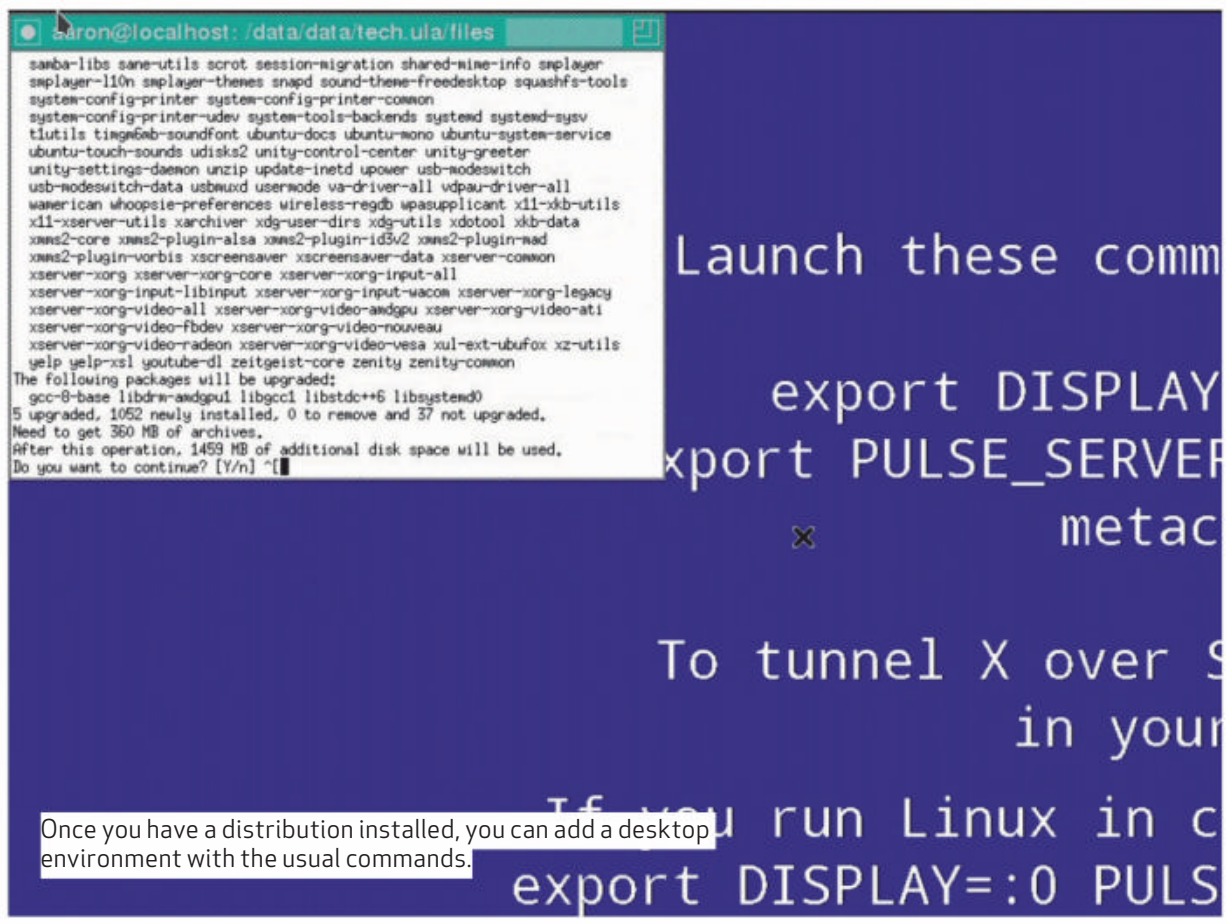
Instead, you can install it and issue actual BusyBox commands such as:

```
busybox ls
```

Overall though, there's not a lot of reason to install it yourself. Given that you already have standalone utilities that don't require you to prepend them with busybox , the value you'd get from installing it on a regular Linux system is negligible.



Installed Apps and Distros are represented as Sessions to start and stop.



Once you have a distribution installed, you can add a desktop environment with the usual commands.

Run Debian Linux on Android 9

Get a genuine Linux LXDE desktop on your Android 9 phone using free software. Darren Yates explains how – and why you'd want it. Best of all, you don't need root access.


Samsung's Galaxy A30 makes a passable mini Linux portable.

Android is a great operating system, no question. But, there are times when you need to run a more feature-rich desktop app on a more traditional desktop operating system. That's okay – you just pull out your Android phone (and a handy Bluetooth keyboard and mouse). Android is built on the goodness of Linux, but you can now get a real taste of Linux running as an app – and with good speed – on your Android phone. What's more, your Android OS is never more than a swipe away. So, this month, we'll show you how to get your Linux on with an Android 9-powered Samsung Galaxy A30 phone.

WAS BROKEN, NOW FIXED

We've previously looked at the excellent combination of XServer XSDL and UserLAnd, both available free from Google Play. XServer XSDL is a neat X Window server backend that delivers the Linux frames to your device screen, while UserLAnd is the front-end installer that builds and runs your Linux operating system. It does this inside a clever 'chroot'-alternative or 'proot' environment – think of it as like a virtual machine, but not.

However, the arrival of Android 9 effectively broke XServer XSDL for new Android devices, which was a huge disappointment. But it's back, bigger and better and now works a treat on Android 9 devices. The instructions have changed since our last take, so we thought we'd update and see what we can get it to do on a lower mid-range phone like the Galaxy A30.

WHAT YOU NEED

In general, you'll need an Android phone or tablet with at least Android 5.0, although in practice, we'd suggest a screen resolution of at least 1280x720-pixels, plus a reasonably hefty CPU on-board to give it some horsepower. A four-core ARM Cortex A53 CPU, 1.5GB of RAM and 16GB of storage would be our bare minimum.

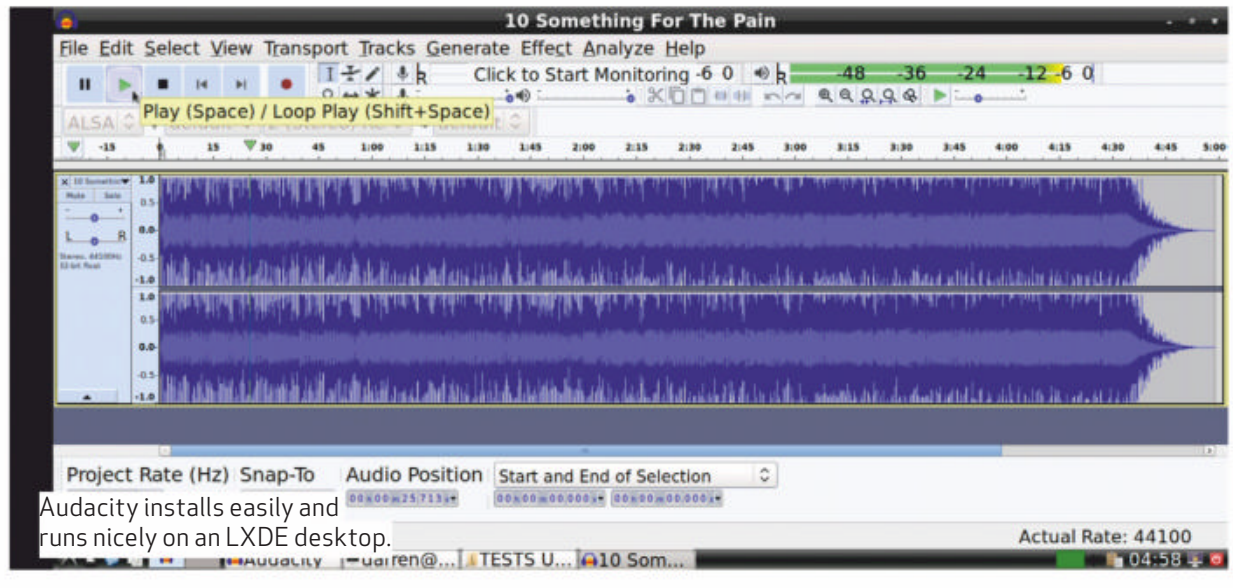
It's also highly recommended you have a Bluetooth keyboard and mouse, as bashing away on the on-screen keyboard is neither practical nor fun. That said, it doesn't need to be anything fancy – I bought a cheap $7 Bluetooth mouse and $10 Bluetooth keyboard, both from Ebay and they worked (the mouse, better than the keyboard).

Once that's sorted, it's just software from here-on. As we mentioned, you need XServer XSDL (**play.google.com/store/apps/details?id=x.org.server**) and UserLAnd (**play.google.com/store/apps/details?id=tech.ula**). Install XServer XSDL first and launch it. Once you get to the big blue screen, you need to write down the entire last command line that should start with 'export DISPLAY=…'. Once you've done that, head off and install UserLAnd, then launch that.

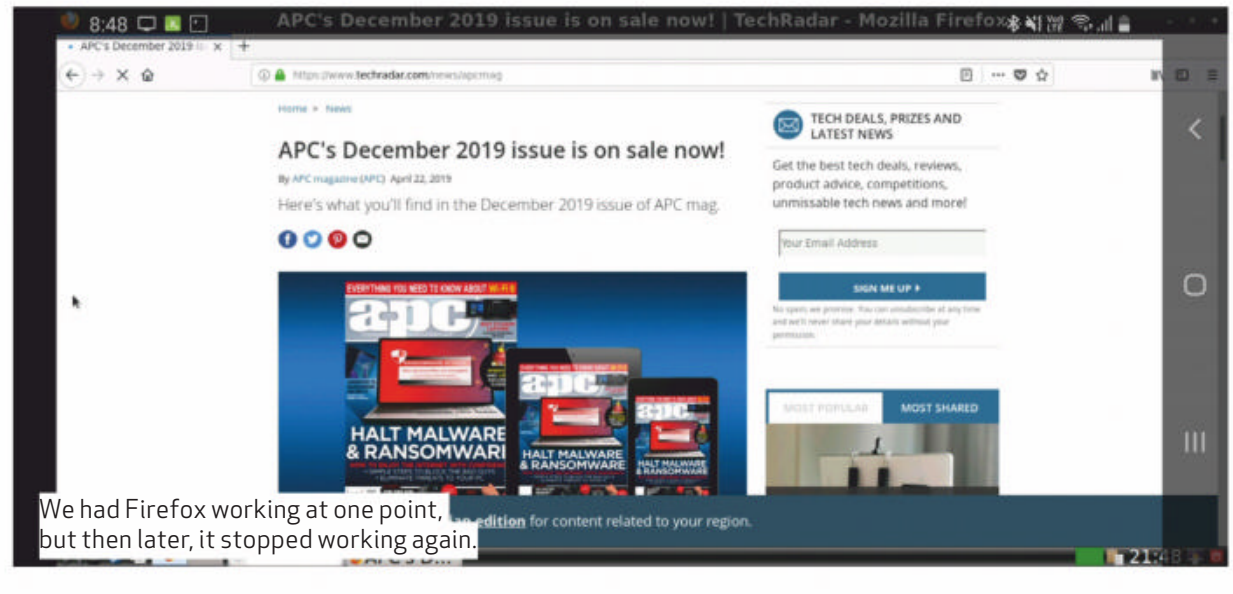
Be aware that if you're running an Android 9 device and have an XServer XSDL version installed prior to November 6, 2019, it will likely snag itself in a boot-loop, due to a prior incompatibility. Make sure you grab the latest version of XServer XSDL.

SETTING UP LXDE

UserLAnd has evolved from the original GNURoot Debian app that offered a similar but slightly less-polished solution. However, it's now



Audacity installs easily and runs nicely on an LXDE desktop.



We had Firefox working at one point, but then later, it stopped working again.

expanded to offer a number of pre-set selections that makes the whole process much easier.

We're setting up a Debian installation (Debian is the mothership for Ubuntu) with the lightweight but still very useable LXDE desktop environment. If you have a Galaxy S10 or Pixel 4 XL, you could try running an Xfce4 desktop, however, the Galaxy A30 was just a little sluggish in its operation with Xfce. Obviously, a phone doesn't have the CPU performance of a PC or laptop, so there are some compromises to be made, but choose LXDE and the responsiveness is fine. Be aware, too, that running a full Linux distro will also require at least 1.5-3GB of storage space, which your phone will need to provide.

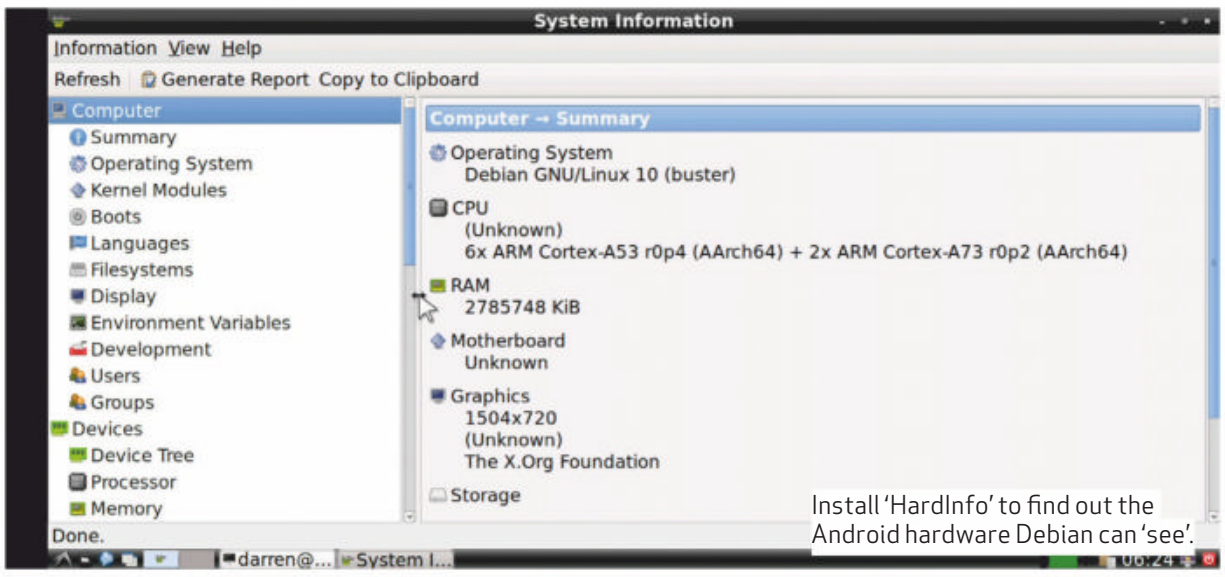
With UserLAnd installed and running, scroll down until your see the 'Lxde' entry in the 'Desktop' sub-menu and tap on it. After that, you'll need to give UserLAnd permission to access storage, then you create yourself a username, password and VNC password.

The next step is to select a remote connection type on the pop-up panel. If the XSDL option is blanked out, you must not select anything else – just tap 'continue'.

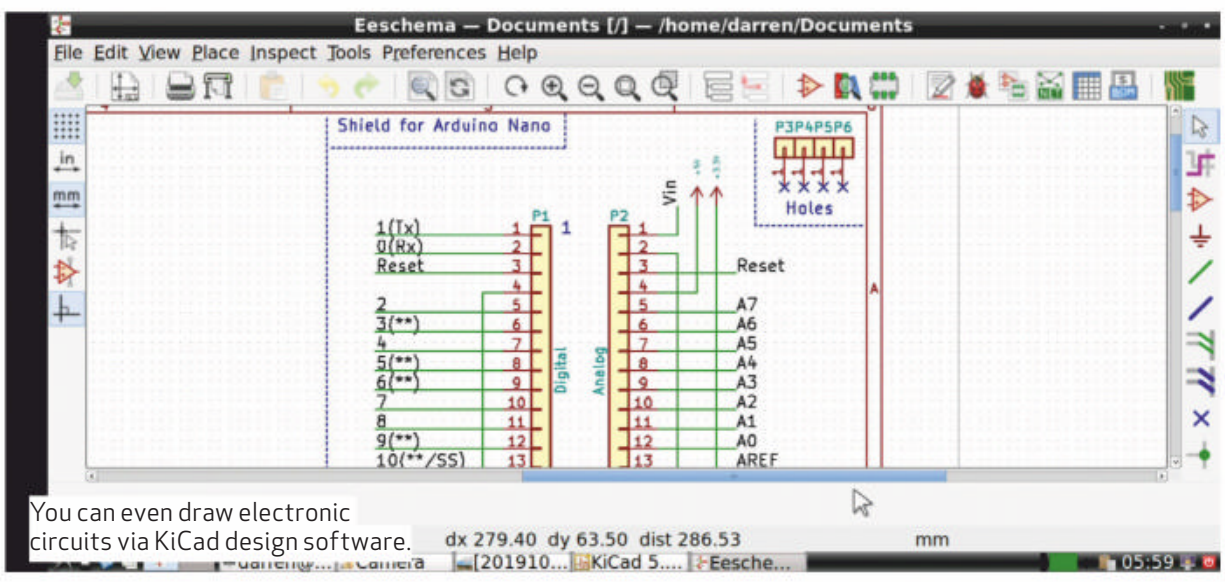
Now comes the waiting – UserLAnd begins downloading and installing a basic Debian distro. This could take between five and 30 minutes, depending on your connection. Once this first part of the install is complete, you'll be forwarded to UserLAnd's console terminal and be asked to type in your password. A tip here – have your Bluetooth keyboard and mouse ready to go (meaning, paired with your phone and working), so you can enter your password. The installation script will take over and begin downloading and installing the 40MB or so files that make up the LXDE desktop.

Once this is done, you'll drop back to the UserLAnd session terminal again.

This $10 Bluetooth keyboard is all over Ebay, not great but mostly works.



Install 'HardInfo' to find out the Android hardware Debian can 'see'.



You can even draw electronic circuits via KiCad design software.

LAUNCHING LXDE

Now you're ready to get UserLAnd and XServer XSDL talking to each other. At the terminal prompt, type the following and press 'enter':

```
export DISPLAY=127.0.0.1:0 PULSE_
SERVER=tcp:127.0.0.1:<port>
```

Replace <port> with the final four digits from the command you wrote down before from the XServer XSDL blue-screen. For us, that was '4713'. This not only sets up the display server, but also the audio server, so your Linux distro can play sounds via your Android audio engine.

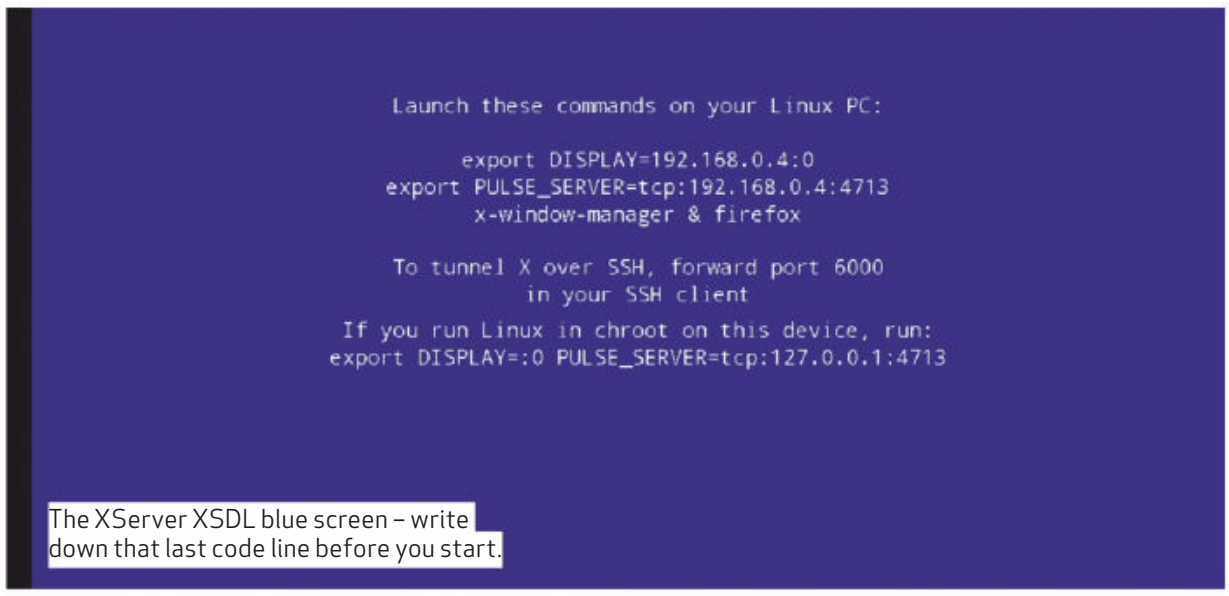
Now we're ready to launch LXDE, so type the following and press 'enter':

```
startlxde
```

Go back, open up XServer XSDL and within a second or two, the screen should change and the LXDE desktop appear. If so, congrats – you now have a Linux desktop running on your Android phone.

GETTING THE SCREEN FONT SIZE RIGHT

Depending on your device's screen size and resolution, the preset desktop font size might not be right for your screen, particularly if you're running a device like the Galaxy A30 with its 2340x1080-pixel panel. Adjusting it will be a bit of trial and error, but here's what you do. Drag down the Android notification panel and you should see an entry for XServer XSDL with a 'stop' button to the right. Tap it. Now go back and relaunch XServer XSDL, but this time, wait for the XSDL logo to disappear and tap the screen as soon as you see the white-on-black text screen. This allows you to set the virtual screen resolution and the font



The XServer XSDL blue screen – write down that last code line before you start.

"It's also fun watching heads turn when they realise you've got Linux running on your phone."

scale size.

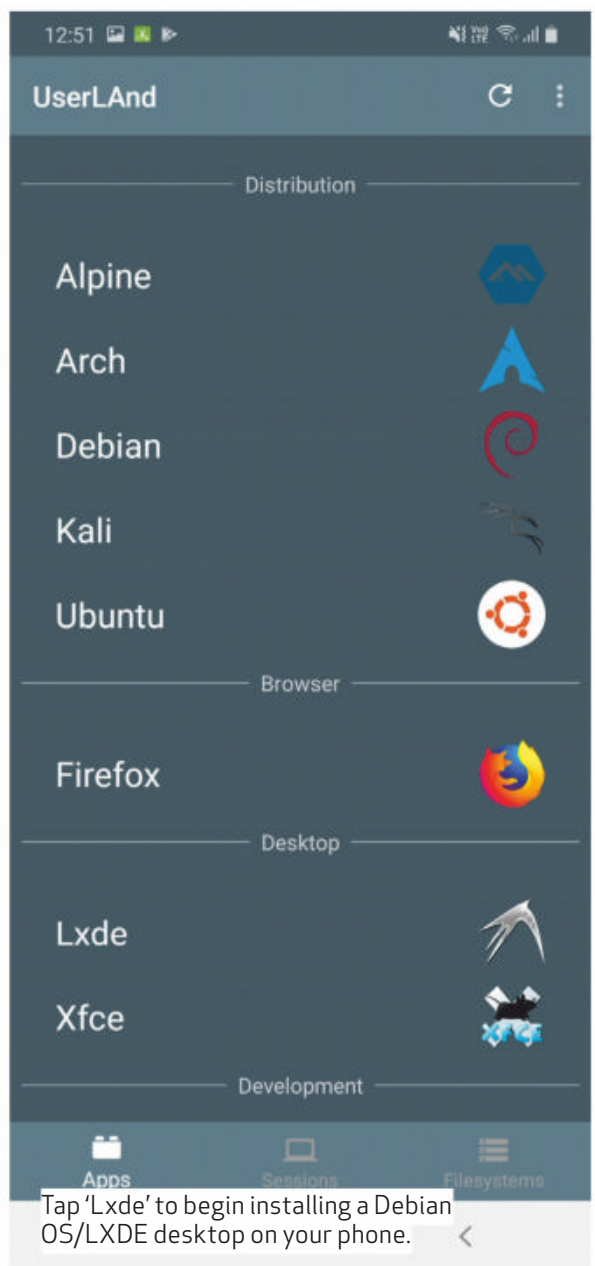
If you have a high-pixel-density screen, you may want to reduce the virtual screen resolution from 'native' to something around 70% of 'native'. For example, we've dropped the 2340x1080-pixel native resolution down to 1504x720-pixels and that works well for us. Once you've made your choice, the next option is setting the font scale size. Default is 0.7x, but if the LXDE button text was too big, go for something smaller – either 0.6x or possibly 0.5x, but no smaller than that. Once you make your selection here, XServer XSDL will go into 'blue screen' mode and wait.

What you do now is head back to UserLAnd, tap on the 'Lxde' entry, which should quickly take you back to the console terminal. Type in those two code lines above as before, go back to XServer XSDL and the LXDE desktop should appear. Ideally, you want the LXDE panel button text to be in proportion to your screen's resolution. Again, if you're not happy, you can experiment by stopping and restarting the XServer XSDL server and going through the process again, but choosing different options.

INSTALLING APPS

Just like Android, distros based on Debian should have an app repository. They're not usually as well stocked as Google Play, but there's normally more than enough to keep you busy. However, first things first, tap the LXDE 'Start' button at bottom-left, then choose 'System', 'LXTerminal'. When it appears, update the online repository server list, by typing the following and pressing 'enter':

```
sudo apt-get update
```



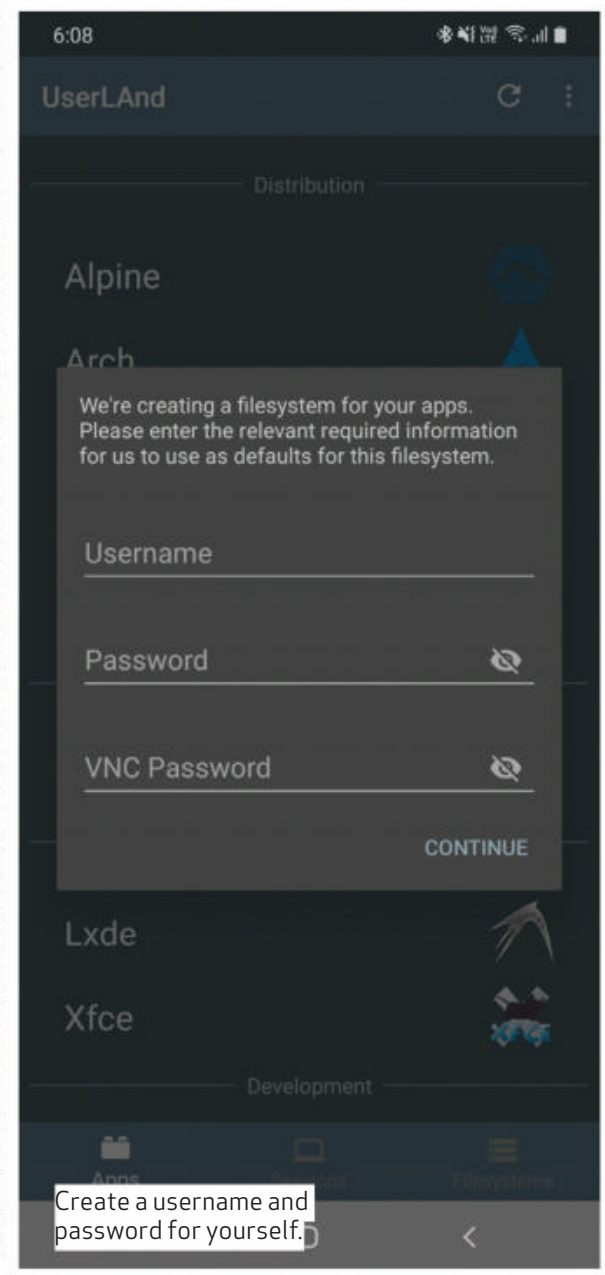
Tap 'Lxde' to begin installing a Debian OS/LXDE desktop on your phone.

Once that's done, you can start installing apps. If you're thinking gaming, you've probably missed the point a bit – you won't get GPU-acceleration here, so any gaming is going to be fairly ordinary, compared with native Android apps. However, it doesn't mean you're limited to text-based apps:

- **Productivity** – If you don't need a full office suite, all the better. Libre Office is fine, but a bit unwieldy for a phone. We'd suggest the classics here – 'Abiword' for word-processing and 'Gnumeric' for spreadsheet. Need an image editor? GIMP works nicely too. To find out the available hardware specs, 'hardinfo' is a lightweight CPU-Z alternative for Linux. Get 'em all with this:

```
sudo apt-get install abiword gnumeric gimp hardinfo
```

- **Multimedia** – it's important to make sure you entered the initial 'PULSE_SERVER' code correctly, otherwise you won't get any audio. If you want to create some of your own audio, Audacity is the go-to app in most Linux distros and it works well. VLC installs and runs, but gave us



Create a username and password for yourself.

weird decoding errors – your mileage may vary.

```
sudo apt-get install audacity vlc
```

- **Programming** – For me personally, this is where running a Linux desktop earns its keep. While you can run Python on Android already via the pretty decent Qpython3 app on Google Play, this is an opportunity to get the genuine article, installing Python 3.7 and the IDLE editor.

```
sudo apt-get install idle
```

Beyond that, you have pretty much the full Debian 'arm64' software repository to play with, but just be prepared for some apps not to work correctly. Wearing my 'machine learning' hat for a second, we tried installing the Weka data mining app, for example, and while it installed, it just produced a yellow window. We also installed the Arduino IDE, but unfortunately (as you'll see below), there's no USB support, so while it loads and compiles code, there's no wired way to get compiled code to your Arduino board.

If electrical engineering is more your thing, you can install KiCad, the open-source circuit and board layout suite. It works well, but a mouse here is an absolute must.

WHAT DOESN'T WORK

At time of writing, there were a few things not working, including:

- **no web browser** – the built-in Firefox web browser, which was working for us a few days earlier, stopped working again. The alternate Firefox install workaround also didn't work. If Firefox gives you a black-screen, use your Android browser, save your downloads and access them using PCManFM file manager within your Linux build (see 'accessing Android storage' below).
- **no USB** – there's no USB-OTG support, so even if your device has USB-OTG, it just doesn't work. If you need USB storage access, our work-around is to shuffle to and from internal storage via Android (see accessing Android storage' below).
- **no power monitor** – Debian can't see your phone's battery, so there's no obvious way to know the battery level. Not a deal-breaker, but not great, either.
- **no hardware video acceleration** – video playback sort-of works, but it depends on your phone's CPU to do the job, so the faster your phone, the better. It also means GPU-based games don't work either. Still, Android can cover these bases.

ACCESSING ANDROID STORAGE

It looks like plenty of changes are coming to Android Q, particularly for file manager apps that access your device storage. At the moment, UserLAnd allows you access to your Android internal storage from the PCManFM file manager – but there's a trick. The Android device storage path in Debian is /host-rootfs, but if you try to open this inside PCManFM, you'll get a 'permission denied' error.

The workaround is you specify the specific storage subfolder instead – for example, type '/host-rootfs/sdcard' (internal flash storage path on the A30) into the address bar, press Enter and you should sail over that permission error and get full access. You should also be able to create a bookmark to this subfolder in PCManFM. The 'sdcard' subfolder won't be visible in /host-rootfs, so you'll just have to try it via the address bar (it works perfectly on a Galaxy A30).

Having a desktop OS on your phone might also raise questions about wearing out your phone's flash storage if there's too much RAM-paging going on. We don't know if this is the case or not, but if we took a guess, we'd suspect it'd be a function of the amount of RAM your device has, how often you use the Linux OS and how much RAM-paging the Linux OS has to do. If this will keep you awake at night, simple – don't do it.

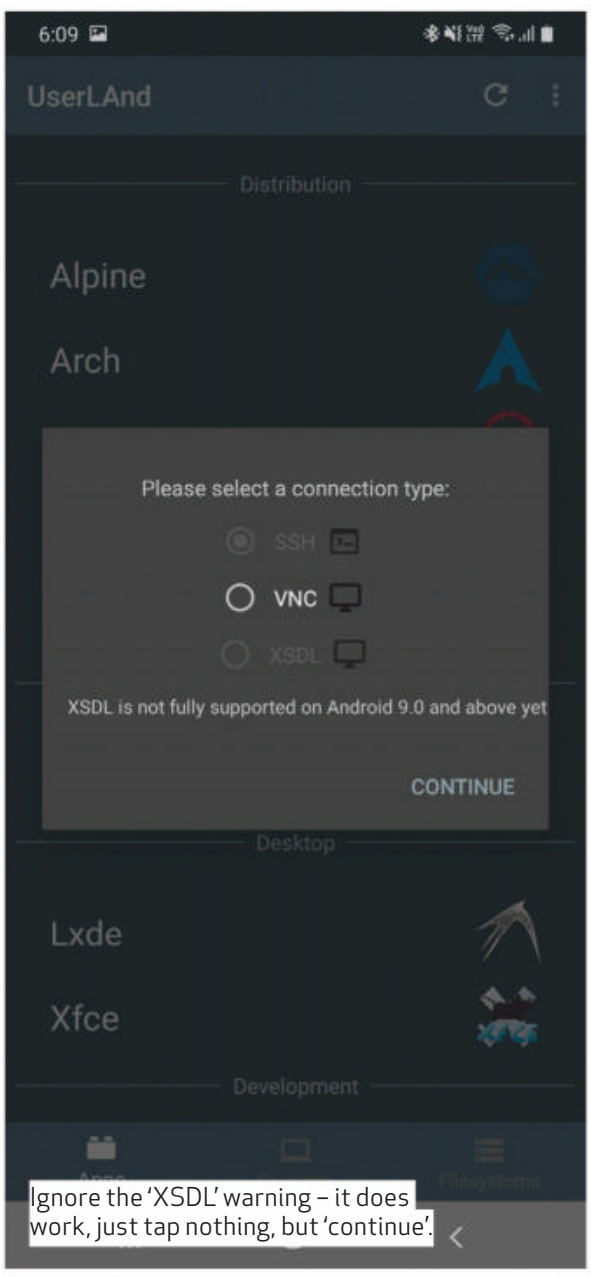
GETTING RID OF IT

If you've had enough of running Linux on your phone, just uninstall UserLAnd and XServer XSDL. The apps will go, along with the LXDE/ Debian filesystem (just backup anything you want to keep first). Your phone should return to its pre-install state.

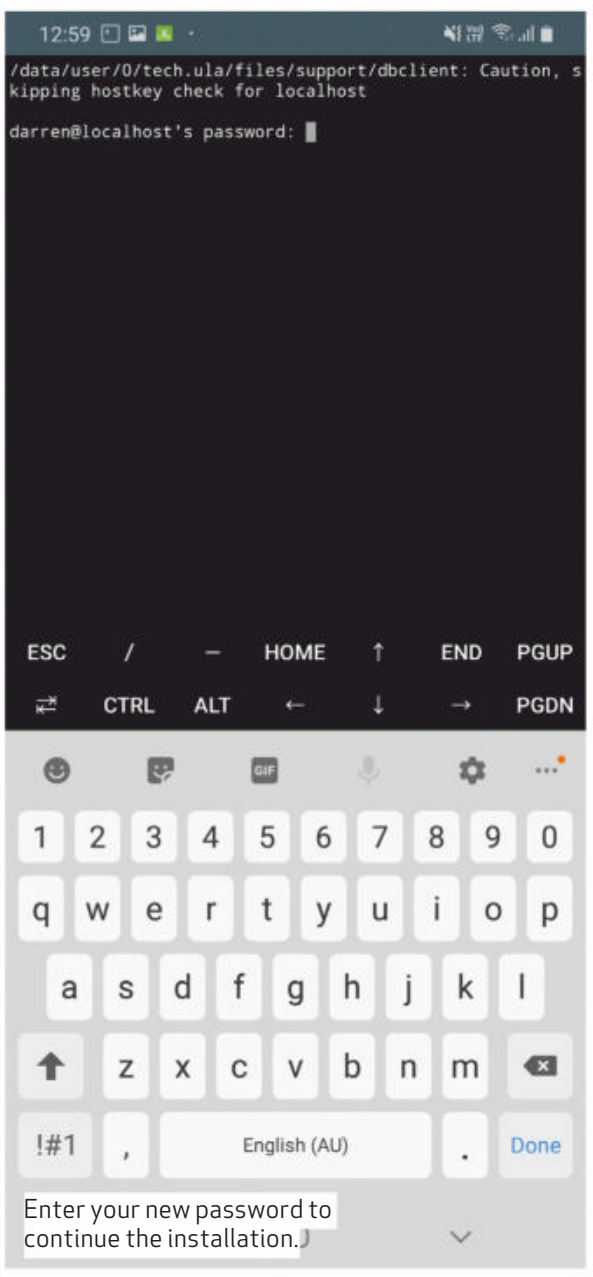
WHY DO I NEED THIS?

This is the great existential question, but there's an easy answer – Android is great, but it doesn't do everything. Having a Linux desktop on your phone might seem just short of barking-mad, but it gets you access to a second eco-system without carrying a second device. For example, I've already used this during a data-mining conference to operate a Microsoft Azure enterprise server just using my phone and X2Go remote desktop.

It's also fun watching heads turn when they realise you've got Linux on your phone. ■



Ignore the 'XSDL' warning – it does work, just tap nothing, but 'continue'.



Enter your new password to continue the installation.

Build a Pi-powered portable bodycam

Christian Cawley wants to record all the evidence that happens on his next family trip. The answer? A Raspberry Pi Zero bodycam.

Bodycams are chest-mounted cameras that have enough storage to record as much, oras little, footage as you like. Regularly used by police around the world, they're also a favourite of certain vloggers. Bodycam footage could be anything from extreme sports to recordings of the San Diego Comic-Con and everything in between.

Fancy a bodycam but unsure of whether you would use it? Thanks to the Raspberry Pi Zero, you can build your own. While the Model B boards are more suited to retro gaming and media centre tasks, the Pi Zero and its variants are perfect for camera projects like this.

By combining the Pi Zero with a Raspberry Pi Camera Module, rechargeable battery and 3D-printed case, you can set up your own bodycam and record the day's events for posterity. You might even livestream your activity to YouTube (see box on opposite page).

YOUR BODYCAM KIT

You'll get the best results from this project with the latest version of the Raspberry Pi Zero or Zero W. The only difference between the two is that wireless networking and Bluetooth are available only with the Pi Zero W. Both devices have a 1GHz single-core CPU and 512MB RAM, a microSD slot, and run the latest version of Raspbian.

In addition, you'll need:

- Raspberry Pi Camera Module (any model)
- Camera ribbon cable for Pi Zero
- Portable rechargeable battery
- 3D-printed case

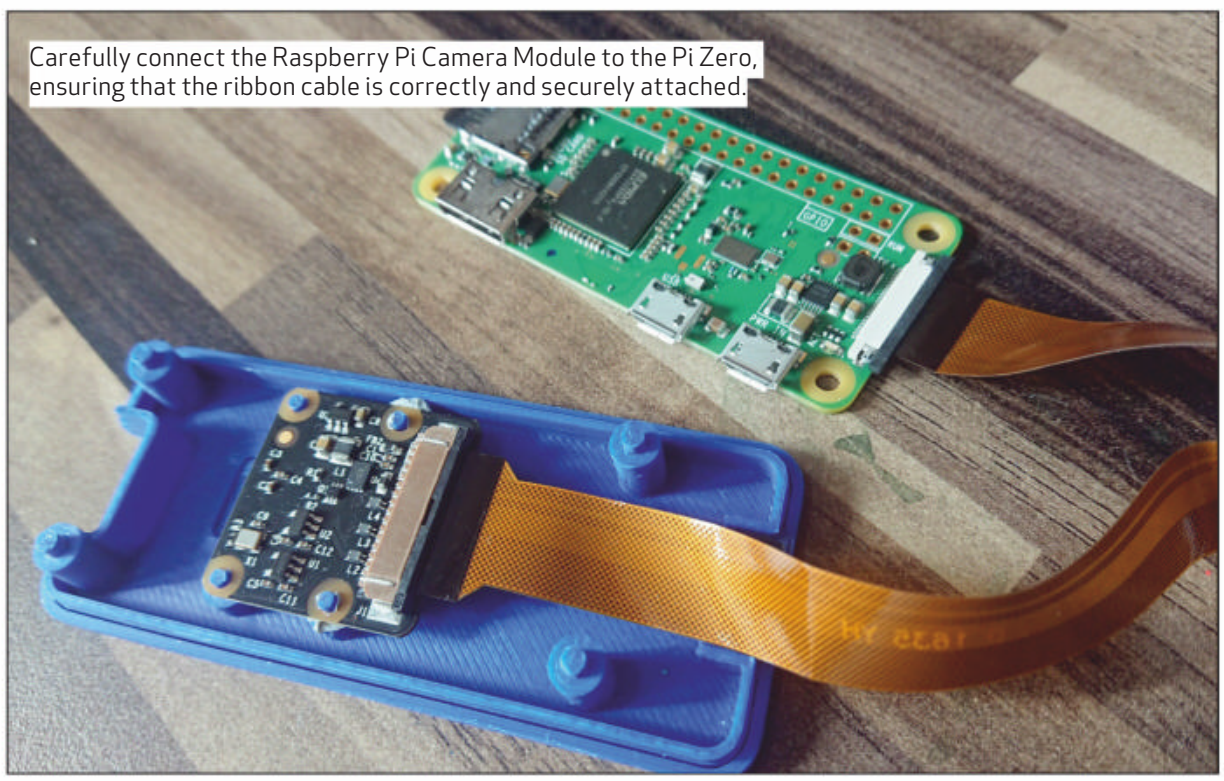
The Raspberry Pi Camera Module you choose will affect the footage. The original camera module was just 5 megapixels, compared with the later 8 megapixels camera. Both have infrared variants, which would result in quite striking 'washed-out' video. These may be more suited to evening bodycam use.

A camera ribbon cable for the Pi Zero is necessary, as the port on the Zero is smaller than that on the Pi Model A and B. Some versions of the camera module come with a suitable cable. If you don't have one, you should be able to order one online for under a fiver.

Your battery option may differ depending on your budget, your chosen case and what you already have handy. The easy solution is a portable smartphone charging battery. For onboard power, however, a 500mAh lithium-ion polymer battery and PowerBoost 500 Charger will do the job.

Keeping the bodycam tidy in a 3D-printed case is a smart choice. Two of the two best options are the One Piece Raspberry Pi Zero + Camera Case and the (**www.thingiverse.com/thing:1595429**) Raspberry Pi Zero Wearable Camera Case by Adafruit (**www.thingiverse.com/thing:1649799**). The Adafruit option comes with a built-in clip and a hole for attaching a cord and wearing as a lanyard. Don't own a 3D printer? Look online for a local or

> "By combining the Pi Zero with a Raspberry Pi Camera Module, rechargeable battery and 3D-printed case, you can set up your own bodycam."



Carefully connect the Raspberry Pi Camera Module to the Pi Zero, ensuring that the ribbon cable is correctly and securely attached.

This 3D-printed bodycam case features a stylish clip for attaching to your clothes.

mail order 3D-printing business.

Whichever case you decide upon, and it may be something completely different, it's wise to assemble the project before installing the boards in a case. Don't do this until you're certain everything is working right.

If you're planning to power the Pi Zero using the li-Ion polymer battery and PowerBoost, you'll need a soldering iron. Connect two wires around 5cm in length to the + and - pins on the PowerBoost, then to the 5V and GND pins on the Pi Zero (pins 4 and 6).

Should you go full Raspbian or Raspbian Lite for your operating system? A browse of the Raspbian downloads page at **www.raspberrypi.org/downloads/raspbian** reveals three options, rather than two. There's the Raspbian Buster download with a bunch of preinstalled applications, a stripped-down Raspbian Buster with Desktop (a version without the apps), and then Raspbian Lite, without a desktop.

For the purposes of demonstrating this project, we used Raspbian Lite. However, for the most flexible option, you might consider Raspbian Buster with Desktop. Given the amount of space you'll need on the SD card, it would be unwise to use the largest version of Raspbian. For quick results, copy Raspbian to the SD card using Etcher from **www.balena.io/etcher**, for Linux, Mac and Windows.

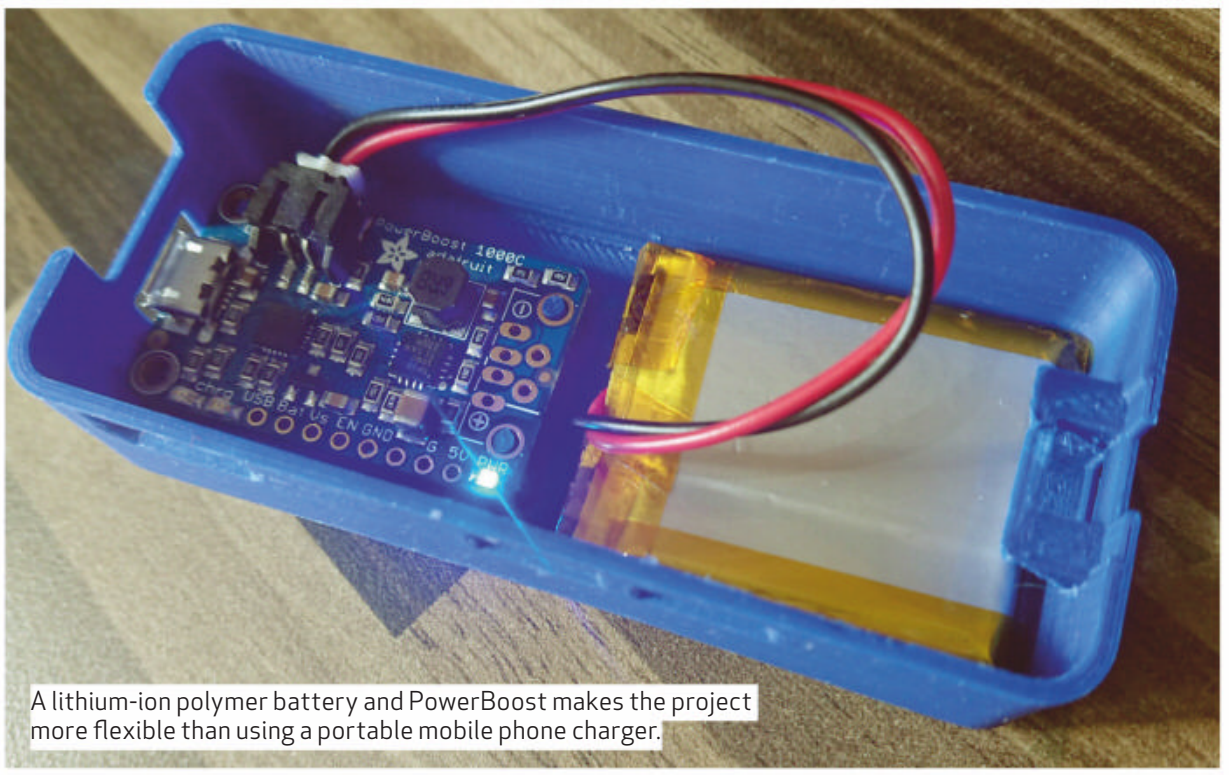
With Raspbian installed, connect a keyboard, mouse and monitor. Alternatively, insert the SD card into your computer and create an empty file called ssh in the /boot/ directory to enable SSH mode. For wireless use, you'll also need to create a wpa_supplicant.conf file. Add the following lines to it:

```
ctrl_interface=DIR=/var/run/wpa_supplicant GROUP=netdev
update_config=1
country=US
network={
ssid="SSID"
psk="PASSWORD"
key_mgmt=WPA-PSK
}
```

Take the time to input your own SSID and network passkey to ensure the device connects to your network. With SSH set up, the following steps should be easier.

Connecting the camera is straightforward. Start by attaching the cable to the Pi Zero, then to the camera. Ensure the securing clips on both the camera and the Pi are loosened before inserting the ribbon, silver side facing up. Snap the clips back into place, then power up your Raspberry Pi Zero.

On the command line, open the configuration tool:



A lithium-ion polymer battery and PowerBoost makes the project more flexible than using a portable mobile phone charger.

```
sudo raspi-config
```

Here, select '5 Interfacing Options > P1 Camera' then Yes to enable the camera. Once enabled, go to '7 Advanced Options > A1 Expand Filesystem'. Reboot the Pi when prompted.

The raspicam software is already installed with Raspbian, so to create a video, all you need is:

```
raspivid -o video.h264 -t 10000
```

This will record 10 seconds (10,000 milliseconds) of footage. You'll probably want more than this, however. As such, some experimentation will be needed. The best results, of course, will be enjoyed with a larger microSD card – the Pi Zero supports up to 256GB. If you're using the bodycam for sports, use the exposure setting:

```
raspivid -o video.h264 -ex sports
```

If you're concerned about the amount of storage being used, the stop-motion bodycam is a smart alternative. Start by checking for package updates and install the WiringPi library:

```
sudo apt update
sudo apt install -y wiringpi
```

Next, create a new file, timelapse.sh:

```
sudo nano /boot/timelapse.sh
```

Next, head to Adafruit at **http://bit.ly/LXF256-timelapse** and grab the timelapse script. This is designed to work with an LED. Copy the timelapse script into timelapse.sh, then exit nano with ctrl-x and confirm with y. So that the code launches on startup, edit the rc.local file:

```
sudo nano /etc/rc.local
```

Here, add a line before the exit 0.

```
sh /boot/timelapse.sh 2>/dev/null &
```

With the Pi Zero hooked up to the power supply and camera, a script for capturing video or time-lapse frames, and a case, your project is ready to go. ■

Stream footage to YouTube

With a Raspberry Pi Zero bodycam set up and running, you'll probably have an eye on the limits of storage. After all, standard high definition video is going to fill up most microSD cards within a few hours. While timelapse is an alternative, it can't be streamed – you'll have to upload the combined video file later.

A smart option, therefore, is to build the project with a Raspberry Pi Zero W (or the pre-soldered GPIO model, the Raspberry Pi Zero HW) and use your mobile device to stream footage directly to YouTube if you're heading out.

You'll need a YouTube account to set this up, along with a channel stream key. You can find this in the Go Live option on YouTube; add it to your avconv command. It should look something like this:

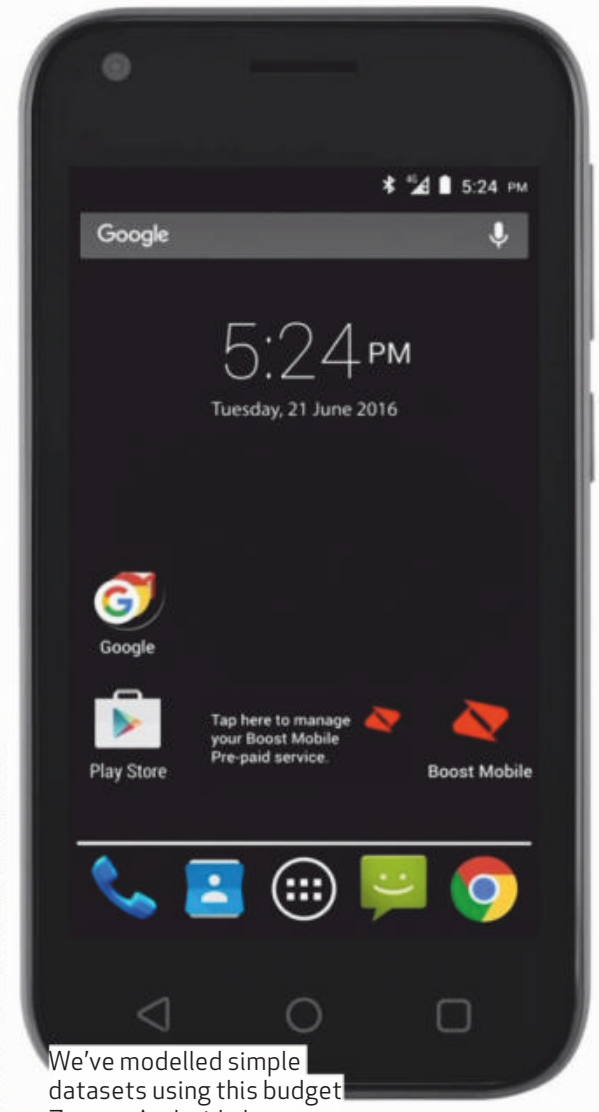
```
raspivid -o - -t 0 -vf -hf -fps 30 -b 6000000 | avconv -re -ar 44100 -ac 2 -acodec pcm_s16le -f s16le -ac 2 -i /dev/zero -f h264 -i - -vcodec copy -acodec aac -ab 128k -g 50 -strict experimental -f flv rtmp://a.rtmp.youtube.com/live2/[your-secret-key-here]
```

Note that not only is your mobile data plan at risk, but also variations in bitrate might result in the stream ending. As such, be sure to use this option only in places with reliable 4G or 5G.

Machine-learning on your Android phone?

Machine-learning happens in the cloud and on your PC/laptop, but your Android phone? Darren Yates shows how DataLearner, free on Google Play, does just that.

Back in November, the Australian government, in conjunction with Data61, the CSIRO's data mining off-shoot, released a report on establishing a national artificial intelligence (AI) framework to fire up the future economy. The report estimates AI's economic benefits to be worth $315billion to Australia's economy by 2028. You can download the report from the Data61 website at **data61.csiro.au/en/Our-Research/Our-Work/AI-Roadmap**. Machine-learning and data mining are practical out-workings of AI, appearing in applications from aeronautics to zoology. You can do it in the cloud and on your PC and laptop, but it's much less common to see user-executed data mining on your phone. However, there's a new app, free on Google Play, called 'DataLearner' that allows you to mine datasets, much like we've shown you recently, but on your Android phone or tablet instead – no external resources or root-access required.



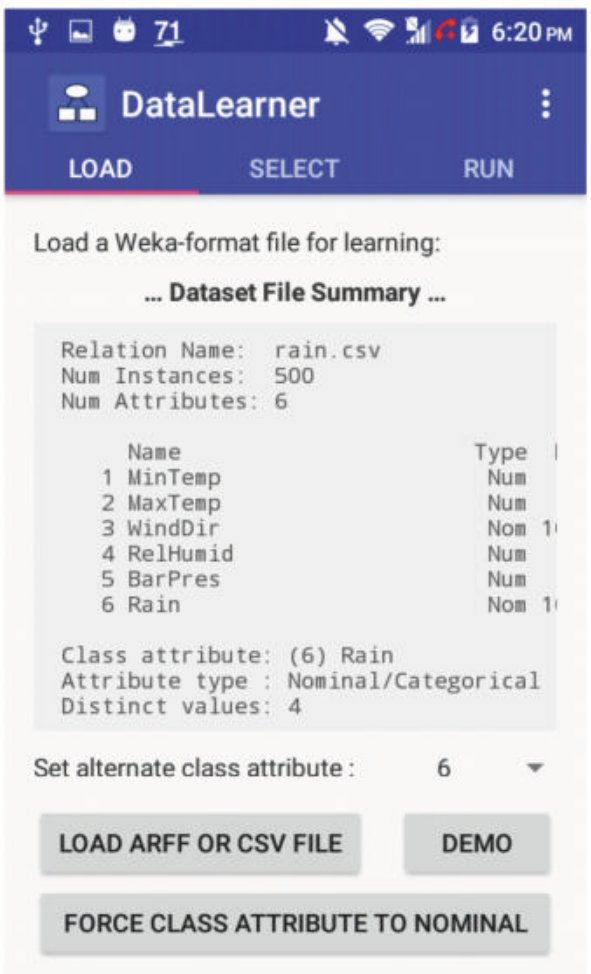
We've modelled simple datasets using this budget Zume 5 Android phone.

PHONES WITH MUSCLE

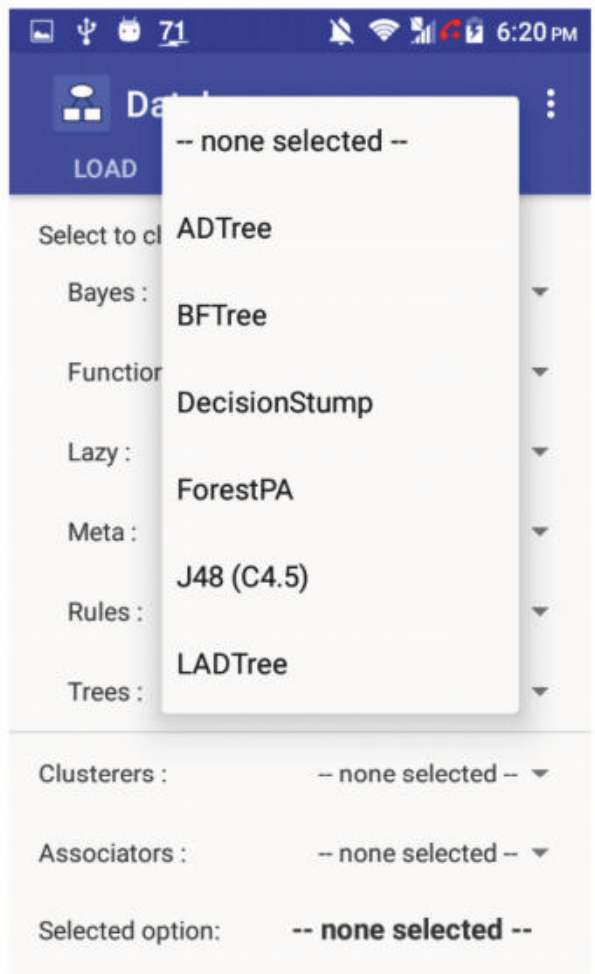
There's a bit of a misconception that you need masses of cloud computer resources, or at the very least, a high-octane PC, to do machine-learning and data mining.

But, the resources needed actually come down to the size of the data you want to analyse and the type of machine-learning you want to perform on that data.

While most of us concentrate on features like folding screens and multiple camera sensors, phone CPUs have also come along in leaps and bounds, to the extent that they can now handle concepts like augment reality (AR) and concurrent app execution. Phones are also loaded with RAM – even super-cheap sub-$50 pre-paid phones now come with 1GB of RAM minimum, while most sub-$400 phones now feature at least 3GB of RAM and aren't far behind laptops. Machine-learning comes in degrees of difficulty, so if you think of recent 'deep learning' techniques, such as convolutional neural networks (CNNs) as high-performance muscle cars, other techniques, such as decision trees and many 'forest' learning methods, are more like 'hot hatches' – they deliver excellent performance, but are still fast and nimble, even on limited CPU horsepower.



DataLearner's 'Load' screen lets you select CSV and ARFF datasets.



The 'Select' fragment provides over 40 algorithms to choose from.

THE 'DATALEARNER' APP

Google recently released TensorFlow Lite for smartphones and Internet of Things (IoT) to focus on the 'deep learning' side of things. However, DataLearner goes in the other direction, and allows you to perform traditional classification algorithms, such as Naïve Bayes and Random Forest, all on your smartphone, with no external help.

The app combines the core of the

> "Data mining is all about recognising patterns in data and how different attributes or features relate."

open-source Weka data-mining app we looked at a few issues ago, with new machine-learning algorithms developed by Australia's Charles Sturt University. DataLearner is self-contained, meaning it needs no cloud computing or internet connection to work. It doesn't need root-access, doesn't collect any data (other than what Google collects for any download from Google Play) and runs on any Android device with at least Android 4.4 OS. It's easy to drive, with a swipe-able user interface consisting of three main screens.

On launch, you arrive at the 'Load' screen, where you can load in a CSV (comma-separated variable) or ARFF (attribute-relation file format) dataset file, either stored locally or downloaded. The CSV format requires a header row. Once the file is loaded, you get a summary of the data, including types and number of attributes, plus the categorising or 'class' attribute.

CHOOSE YOUR ALGORITHM

Swiping left gets you to the 'Select' screen, where you choose one of over 40 algorithms to learn the patterns within your chosen dataset. Data mining is all about recognising patterns in data and how different attributes or features relate. No one algorithm is perfect, so DataLearner gives you a wide range to choose from. While most of these are supplied courtesy of the Weka data-mining core, a number of new algorithms recently developed at Charles Sturt University are also included, such as ForestPA, SysFor and SPAARC. Select your algorithm from the drop-down lists, then swipe-left again to the 'Run' screen.

RUN YOUR ALGORITHM

This is the fun bit. There's not much to do here, other that tap the 'Run' button and let DataLearner get to work. First, it models your data, meaning it learns how the attributes relate to each other. The key is how they relate to the categorising or 'class' attribute that determines the groupings each dataset record belongs to. For example, the built-in demo dataset looks at recent days of weather, with temperature, humidity and wind direction, plus the day's rain levels. You perform data mining to see if there's a pattern in how those weather readings compare to whether or not it rained that day.

The app then cross-checks the set of rules or 'model' created using a technique called '10-fold cross validation', which we've talked about before, to see how good its predictive capability is. The results come back giving you mathematical analysis, the primary result being the accuracy percentage at the top.

Tap the 'View details/matrix' button at the bottom and you get even more detailed information on the model itself and how it works. This allows you to discover knowledge about the pattern(s) within the data in a more visual form.

The thing to keep in mind is scale – your phone's CPU is powerful, but don't expect it to perform at the same speed as AWS or Google Cloud. Nor should you expect to try and load in, say, Facebook's daily traffic data for the last ten years and have a result before… forever. That said, there are still plenty of applications with more modest data sources where a smartphone can be the ideal solution.

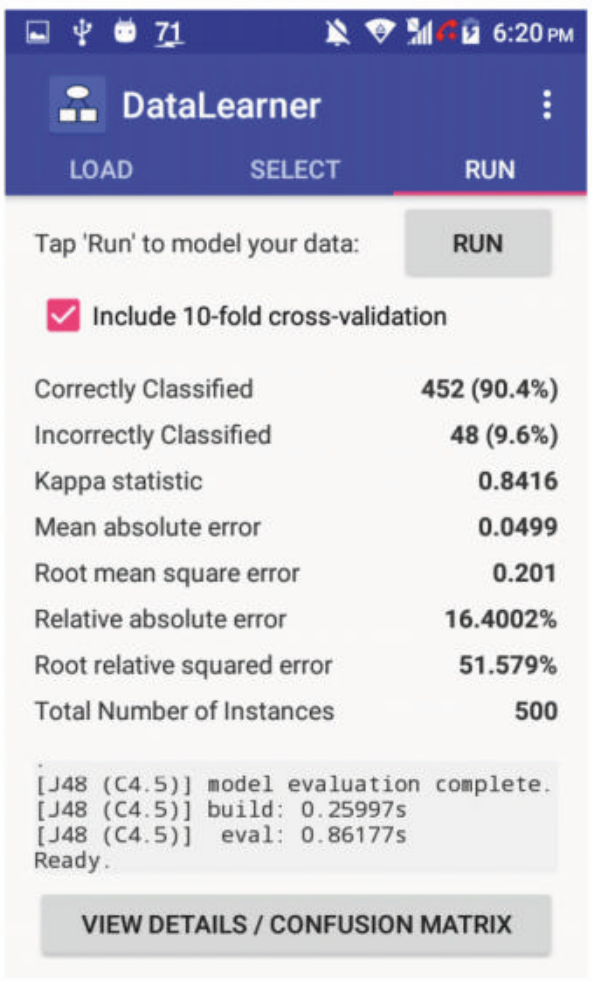
GIVE IT A GO

DataLearner isn't going to replace cloud-based machine-learning any time soon, but that's not its purpose. Instead, it gives you a fully-portable solution that fits in your pocket, so it's not tethered by a power cord or an internet cable. You'll find it free on Google Play (**play.google.com/store/apps/details?id=au.com.darrenyates.datalearner**), plus the GPL3-licensed open-source source code is also available on GitHub (**github.com/darrenyatesau/DataLearner**). At time of writing, DataLearner is the only app of its type on Google Play that we know of, so you won't find many others like it.

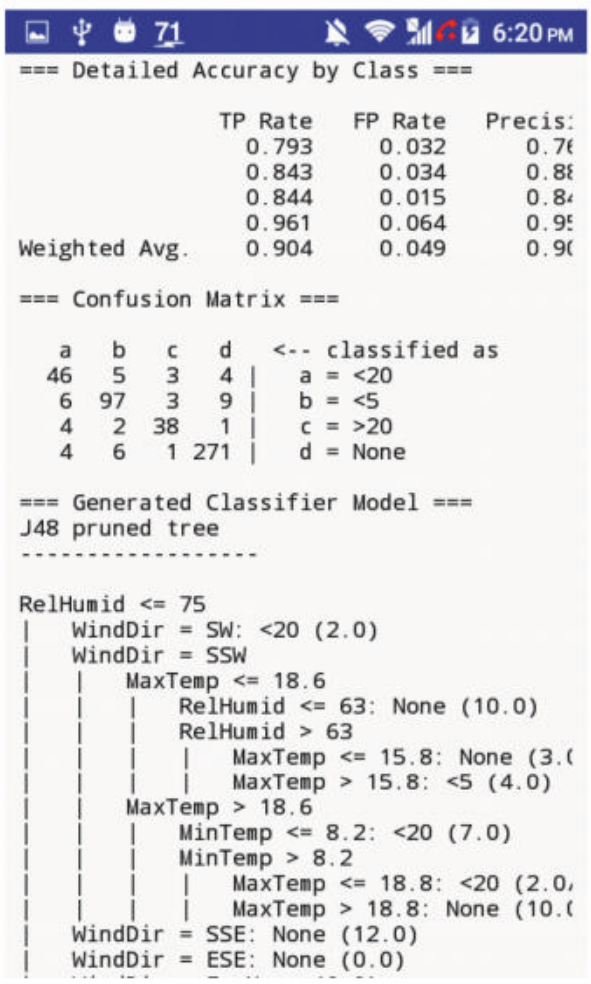
DISCLOSURE

I developed DataLearner as a proof-of-concept showing phones are capable of locally-executed data mining. It was selected for and presented at the recent international Advanced Data Mining and Applications (ADMA) conference in November 2019. Special thanks to Associate Professor Zahid Islam, director of the Data Science Research Unit at Charles Sturt University and Professor Junbin Gao of the University of Sydney.

If you're ready for a deeper dive into mobile data mining, read the pre-review research paper on ResearchGate (**researchgate.net/publication/333679260**), or the published conference paper online at **doi.org/10.1007/978-3-030-35231-8_61** (paywall). ■



Run the algorithm on your dataset to create and test your model.



DataLearner can also produce detailed analysis on the model you create.

downtime

WHAT'S HAPPENING IN THE WORLD OF FUN, WITH SHAUN PRESCOTT.

The Stanley Parable: Ultra Deluxe delay announcement is the funniest way to push back a game

The new edition was supposed to come out late 2019.

The Stanley Parable: Ultra Deluxe edition is delayed, but you almost can't be made about it. Developer Crows Crows Crows released a lengthy video featuring the game's narrator allegedly responding to letters and emails from the fans (they're definitely fake, though).

The "letters" from "fans" serve as an ingenious way to comment on video game production production and fan expectations, packaged neatly and tied with a sarcastic little bow. "To characterise the game's development as anything other than unhindered forward momentum, would be grossly inaccurate," the narrator insists. After a few letters state the impossibility of completing the game before the end of the year, the narrator hits us with the ol' reverse psychology, and promises to give the fans what they asked for: a 2020 release date. Hilarious presentation and accurate accents aside, *The Stanley Parable: Ultra Deluxe* is definitely not coming out in 2019, despite last year's The Game Awards announcement.

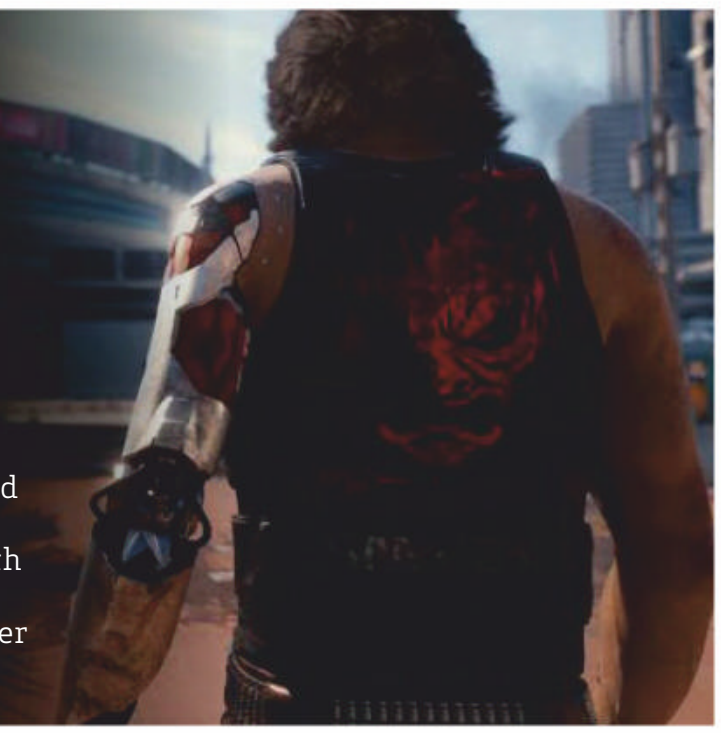
The Stanley Parable: Ultra Deluxe edition will be full of new content, with additional choices and endings that will help us torment Stanley in new, creative ways.

Cyberpunk 2077 will be shorter but more replayable than The Witcher 3

A Q&A WITH DEVS REVEALS WE'LL SPEND LESS TIME IN NIGHT CITY THAN WE DID WITH GERALT.

Cyberpunk 2077's main storyline and major side quests will be "a little shorter" than *The Witcher 3*, according to a Reddit user's account of a Q&A with the CD Projekt Red team. User u/shavod writes that the developers believe the main story will be a little shorter than *The Witcher 3*, but the game will have "much higher replayability" than the developer's last blockbuster title.

Despite this, the devs claim to have only added up the main storyline and major side quests, not "all the encounters and smaller quests", which are currently unaccounted for. So, as far as completionists go, the entire length of the game and how it compares to *The Witcher 3* is still unknown – it's still entirely possible that a 100% run *Cyberpunk 2077* ends up being longer than *The Witcher 3* (not including those two massive DLCs).



Youtube eases restrictions on game-related violence

Videos featuring 'scripted or simulated' violence may no longer be age-restricted.

Youtube's policies on violent or graphic content are clear: "Violent or gory content intended to shock or disgust viewers, or content encouraging others to commit violent acts are not allowed on Youtube." It goes on from there, but that lays out the basics pretty clearly. It also opens the door to confusion and conflicts. What happens, for instance, when the "gory content intended to shock" rule runs up against, well, this?

Youtube has therefore taken steps to get in front of that by updating its policies to differentiate between the real bloodletting it wants to keep off the platform, and the fun stuff in videogames that makes up a significant portion of its content.

Effective December 2, "scripted or simulated violent content found in video games will be treated the same as other types of scripted content," Youtube said in a policy enforcement update. The change means that future uploads featuring scripted or simulated violence may be approved rather than age-gated, and that gaming-related content will face fewer violence-related restrictions overall.

Firewatch studio, now with Valve, has abandoned its in-development game

CAMPO SANTO TEAM HAS NOW BEEN MOVED TO OTHER INTERNAL VALVE PROJECTS.

Valve acquired independent studio Campo Santo last year, presumably on the strength (and positive critical reception) of its debut game *Firewatch*. At the time of the acquisition, the studio was working on an ancient Egypt themed title called In the *Valley of Gods*, but that project has been put on ice in favour of a handful of other Valve projects.

"To fans looking forward to In the *Valley of Gods*, it's probably clear that the optimistic '2019' at the end of the announcement trailer isn't going to be accurate," Campo Santo co-founder Jake Rodkin told *Polygon*. "In the end, Valve Time makes fools of us all. But yes, developers from the former Campo Santo team have joined other projects at Valve, including *Half-Life: Alyx*."

Members of the original Campo Santo team are also reported to be working on *Dota Underlords* and Steam. There's a remote possibility that development on *Valley of Gods* will resume, but given Valve's famed "work on what you want to" structure, it'll take someone especially motivated.

Star Wars Jedi: Fallen Order breaks sales records

RESPAWN WANTS TO "KEEP TELLING" CAL'S STORY IN *STAR WARS JEDI: FALLEN ORDER*, AND EA'S LATEST SALES FIGURES ALMOST GUARANTEE A SEQUEL.

Star Wars Jedi: Fallen Order has become the fastest-selling digital Star Wars game in its first fortnight, and Electronic Arts' best selling Star Wars PC title at launch, the publisher announced, beating both *Star Wars Battlefront 2* and *Star Wars: The Old Republic* against their original sales figures in the same period.

The Vatican now has a *Minecraft* server

... BUT IT DIDN'T TAKE LONG FOR PEOPLE TO GRIEF IT.

The Vatican now has its own *Minecraft* server, thanks to the efforts of former tech blogger Father Robert Ballecer. Designed to be a place for gamers who want something a bit less "toxic" and a bit more community oriented, the server was almost immediately DDoS'ed by trolls upon its launch. At the time of writing, Father Ballecer is looking at ways to salvage the project.

The Steam Controller is dead

VALVE HAS DISCONTINUED ITS ZANY HANDHELD EXPERIMENT.

Released four years ago, Valve's Steam Controller was meant to provide a way to play mouse-and-keyboard PC games on a specially built gamepad. But the dream is over: Valve has discontinued the Steam Controller and it's now officially sold out, thanks to a Black Friday sale which saw the failed device sell for as little as five dollars.

Resident Evil 3 remake is reportedly coming next year

YOU GET REMAKE, AND YOU GET A REMAKE, AND...

Resident Evil 3 is reportedly in active development at Capcom and will be released sometime next year, according to Youtuber Spawn Wave and multiple sources that spoke with *Video Games Chronicle*. Following the remarkable success of the *Resident Evil 2* remake that dropped this January, it makes sense that Capcom would want to push out another remake as soon as possible, and they allegedly are.

$65 | PLANETZOOGAME.COM | PC

Planet Zoo

Beautiful creatures can be a real handful to manage.

The difference between a roller coaster and a ring-tailed lemur is that when one has a problem it's a mild irritation and when the other has a problem it's a cause of unbridled panic and guilt. There are stressful components to every management simulation game, but where *Planet Coaster*'s mechanical breakdowns make me worry briefly about profits, *Planet Zoo*'s biological breakdowns make me feel like a neglectful, abusive monster who should be dragged off to jail and never allowed near another living thing ever again.

Planet Zoo has several official modes: Career, Challenge, Sandbox, and Franchise, but its two actual modes are 'Things Seem Fine' and 'Oh God What Have I Done?!'. My elephants, giraffes, orangutans, panda bears, and dozens of other furry friends can starve to death or die of dehydration if I'm not careful. They can contract diseases or get injured by fighting one another. They can feel fear and stress and the effects of isolation. They can overheat or get too cold. They can kill each other if you put the wrong animals together in the same habitat. At one point I saw protestors carrying picket signs in my park. It was because my giant burrowing cockroach's glass box was slightly too humid for its liking. I couldn't even keep an ugly bug that eats dead leaves happy and I instantly felt terrible about it.

Planet Zoo isn't just a management sim, it's a survival game. In fact forget that I just compared it to *Planet Coaster*. At its most stressful *Planet Zoo* is more like *Frostpunk* or *Prison Architect*. None of the lives you're in charge of actually want to be there, and making a mistake puts those lives in danger.

With the exception of Sandbox mode where you have a bottomless wallet and the ability to turn off things like animal sickness, injury, and death, *Planet Zoo* is an extremely busy and occasionally exhausting sim. Everything needs constant attention all the time – not only keeping your animals healthy but your staff happy, managing your budget and zoo's reputation, and dealing with day-to-day concerns like preventing guests from vandalising park benches (by hiring a security guard and installing cameras) and making sure habitat walls don't get so dilapidated they crumble and allow a tiger to terrorise the park (the guests won't get mauled, but they do leave the zoo in a hurry).

The layers of micromanagement extend all the way down to elements like which colours of balloons you sell in a particular vendor stall and how much to charge for each individual colour, and *Planet Zoo* will even show you the profit margin for each.

A few more tutorials would have been nice to completely understand all of the features available – while the lengthy career mode walks you through managing, fixing and building several different parks in different parts of the world there's a lot of obscure functions and options it never even mentions, so be prepared to dig through the help menu to figure a few things out.

Chris Livingston

Verdict

Another strong, yet stressful, management sim from Frontier Developments.

★★★☆☆

$43 | UNITYOFCOMMAND.NET | PC

Unity of Command II

A wargame for both hardcore and new players.

One of my high bars for a strategy game's sequel is that I can unreservedly recommend the game over its predecessor. *Unity of Command II* is one of those games, though I was initially wary of all the new mechanics added to an otherwise delightfully simple wargame. *Unity of Command II* has the same baselines that made the first *UoC* a success. Every division on the battlefield is made up of sections called steps, each represented by a little dot below the unit's model. Sometimes divisions have 'specialist steps' of attached assets – like a detached tank company temporarily assigned to support an infantry division. Steps are either active, a full circle, or suppressed, an empty one. When a unit attacks or defends its active steps are multiplied by their combat value, totalled and compared to the other unit's total for the odds of various results. If that sounds complicated, it's not, because the game just… shows you the most likely results. Sure, there's a detailed combat resolution table buried in the manual,

but you can happily play this (quite complex) wargame without ever looking at it. That feels good.

The combat lets you really focus on what an operations-scale game does best. This is a game about orchestrating breakthroughs, exploiting gaps with armour and strategically blocking chokepoints. The terrain of the western front isn't about vast encirclements, it's about pushing over the mountains of central Italy or struggling through the bocage in Normandy. I found great pleasure in capturing railway depots and balancing supply dumps to keep up with my advancing forces. The strategy is very simple to manage but just complex enough that it feels like a challenge.

Customisable factors like cards and specialists and upgrades lend a lot of flexibility to scenarios and campaigns. There are even a few points of historical divergence, where doing better than the historical figures can allow you to take alt-history paths like pushing the Italian front to the alps by mid-1944

Jonathan Bolding

Verdict

***Unity of Command II* builds new things out of familiar parts.**

★★★★☆

Triggore

Clean up your own messes in this bloody browser horror.

FREE | BIT.LY/TRIGGORE BROWSER

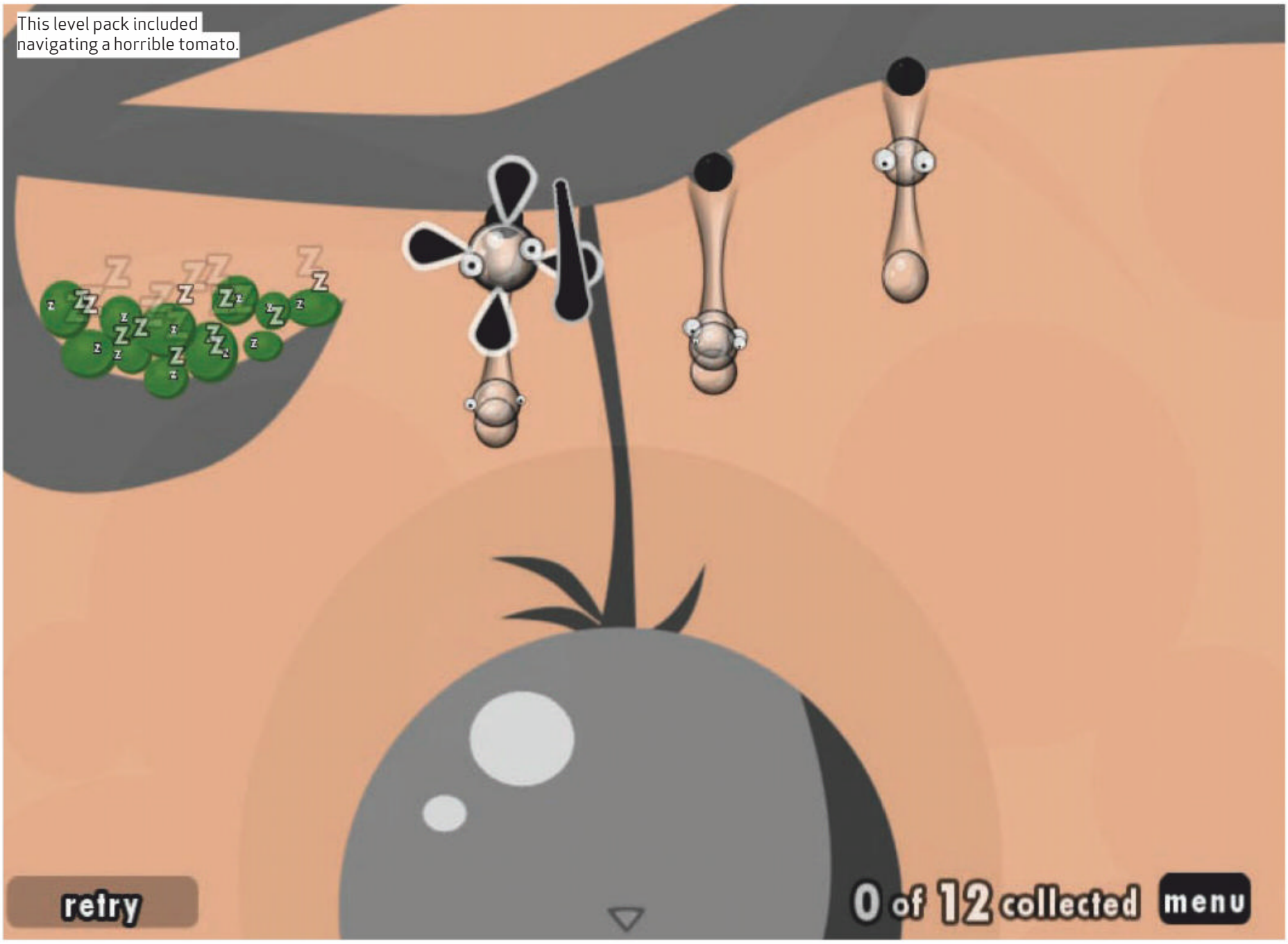
Here's a game that mixes horror with light-gun-style shooting. You're trying to survive for as long as possible here, in a dimly lit house stashed with supplies and, less welcome, with advancing monsters. The deadly zombies, bats, wormy things, and skittering spiderlings are at once cartoonish and genuinely horrible as they explode in a satisfying shower of blood and bits.

When you've killed enough monsters, you may find that dropped items, or candles, or containers have been covered in blood. So, how to clean them up so you can find them? One of the items is a mop. The other is a bucket. Putting two and two together, you can use both to clear up messes in the house.

Triggore is a small game that keeps on going. You've fully explored the house, you've killed waves and waves of monsters – and yet the horror keeps on going. Lights are snuffed out, containers refilled with helpful stuff. It's like you've been snuck back to the beginning of the game. **APC**

★★★☆☆

NEED TO KNOW
RELEASED October 13, 2008
DEVELOPER 2D Boy
PUBLISHER In-house
LINK www.2dboy.com



Game Changer: World of Goo

Dealing with a load of balls.

Having long since forgotten the plot of *World of Goo* but not its glorious, weird jelly Meccano physics, I think I was expecting this reinstall to be a mainly sensory experience. Something like Peggle – great music, appealing cartoonish aesthetic – but with a slippery puzzle element instead of pinball, and a streak of black humour involving some goo balls going through a mincer.

I had forgotten the observations about how companies use data and cookies (*World of Goo* operates in a GDPR-less world), about idiotic, wasteful product launches, about the value of physical beauty and so on. These observations are relatively broad-brush – corporations that put financial gain over consumer welfare, the ugly being trampled by the beautiful – but it's a tang of playful cynicism I haven't seen much in games recently.

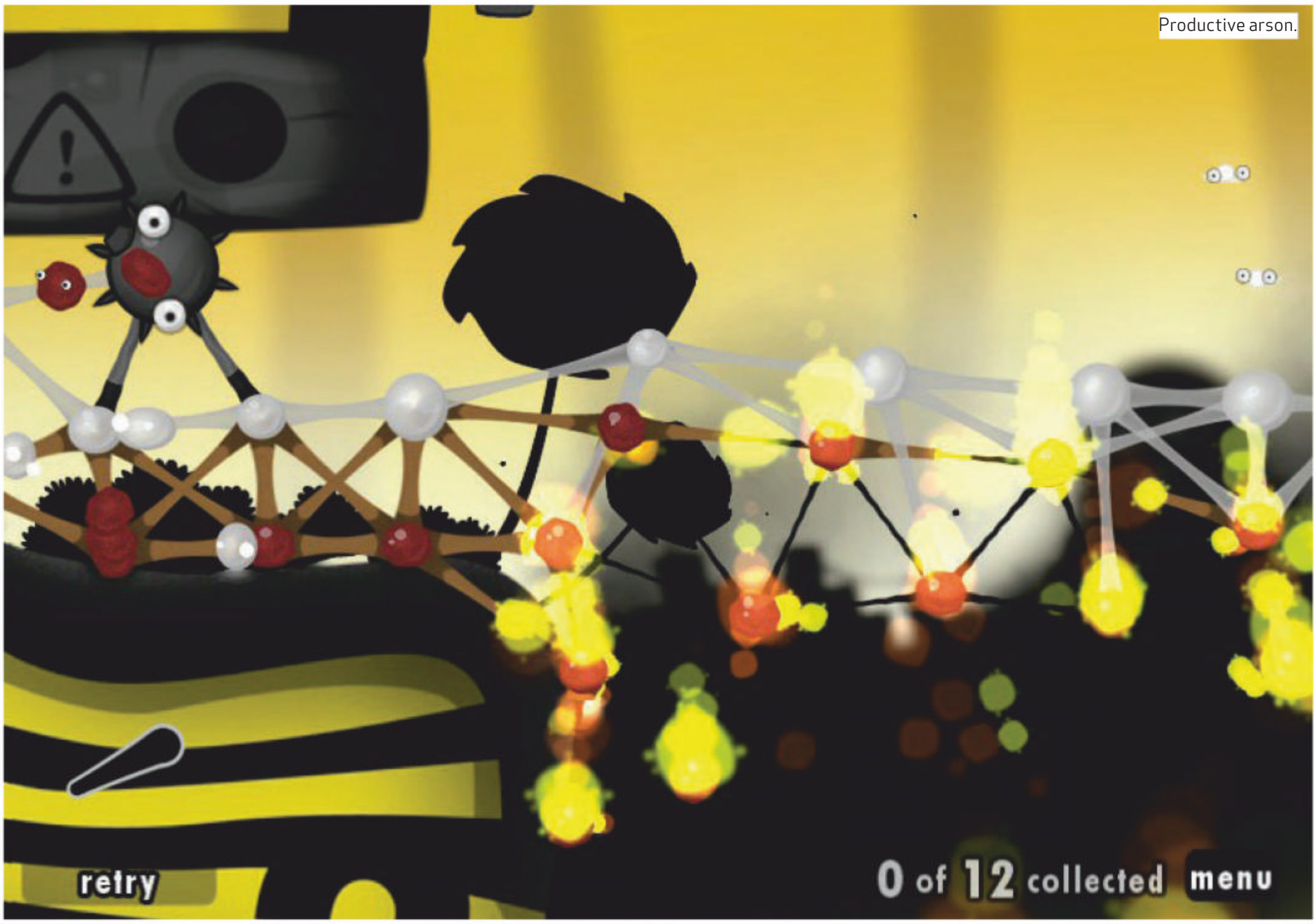
That's not to say we're less cynical now, but there's a specific flavour of breezy side-eye which feels very much rooted in the late-'00s and is interesting to encounter now. These were the heady days when we were only questioning some, not all, of our metastructures. The result is that its shots still hit their targets (we've only really doubled down on what the game calls out) but the mood it adopts is peppy and perky rather than exhausted. Certainly a curio to me right now, at any rate.

The jiggly, chirruping construction side is as excellent as I remember. Have you played *World of Goo*? If you haven't, the idea is that you have these sentient blobs which like to attach to one another by sending out tendrils to other blobs. You'll use this to create structures – 2D lattices of varying levels of messiness. Loose goo blobs swarm over the structure, their weight and movement contributing to the instability of the whole thing, sometimes sending it tumbling to one side.

The point of these structures is that you use them to bring the loose goo swarm to an exit pipe which will suck them up. But the pipe only activates when the goo structure is close enough, hence you can't just fire goo balls into the air and hope they get slurped up.

BUILD UP

At a bare minimum, the challenge is to build a structure and reach the pipe with enough loose goo balls to meet the level's target. Later on in the game it's about factoring in the different properties of the different types of goo, about navigating obstacles, and even moving larger non-goo objects around.



Productive arson.

The levels start off relatively simply. You have one type of goo and plenty of it, meaning it's easy to meet the level targets. The starter goo is wonderfully uncomplicated. It puts out two tendrils and you can't detach it once it's in place. It naturally lends itself, then, to building robust triangular shapes and thus is relatively stable.

These early levels remind me of the weird team-building exercises we had to do as part of a few corporate away days I've been on, or as part of school physics projects – build a bridge out of newspaper that's capable of bearing some kind of heavy weight, or a teammate or whatever. You'd always have someone who spent a whole day explaining the value of the triangle in construction.

"It's really hard to deform a triangle, you know?" Yes Dave. We know. "Consider the pyramids." I've considered the bloody pyramids, Dave. "It's because of trigonometry." Shut up and roll newspaper, Dave. "It's why you see so many triangles in bridges too." DAVE THAT IS WHY WE ARE USING TRIANGLES TO BUILD THIS BRIDGE. "Did I show you this picture of a bridge I took while I was away last month?" Yes, Dave. Please just roll some newspaper so we can bear the weight of that encyclopedia and get out of here. "Look! There's a picture of a bridge in this newspaper! I'm going to cut it out so we can stick it on the bridge as a mascot. It even has triangles." I swear to god, Dave. "You know what? My favourite triangle is the equilateral triangle."

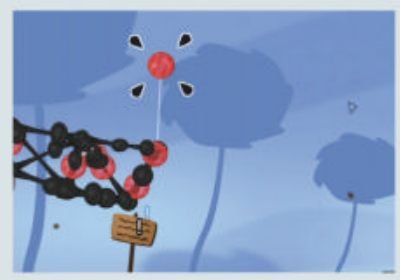
Unlike Dave, I have a soft spot for a scalene triangle. They're awkward and difficult and spiky, like me in a team-building session. Anyway, where was I?

GOO-REAT

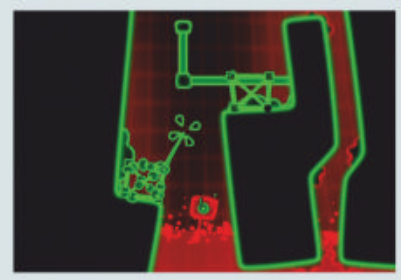
Ah yes. Goo. So there are different types of goo. There's that first kind I mentioned, but you'll soon encounter others – green goo, beauty goo, matchstick goo, balloon goo… My favourite is the green goo. It can put out up to three tendrils which is nice, but the best bit is that it can be detached and reused or just left loose. The reason I love it is because I

GETTING TO KNOW GOO The best balls

1 **GREEN GOO**
Ivy-green balls are the best – repositioning them lets you extend ropes, inch up crevasses and save extra goo.



2 **BALLOONS**
These floaty spheres can support bridges, carry goo through the air AND make the level feel like a party.



3 **DIGIAL GOO**
Digital balls can jump from one mesh to another as well as picking up useful viruses that turn them into ropelike formations.

spend a lot of time trying to rescue as much goo as possible from each level. If a level uses plain black goo, every blob you use to build is one you can't collect. If you're on the green stuff there's a chance you can detach it and collect it once you've activated the pipe.

Having blasted through the story chapters in a few hours I went back to the beginning to try OCD mode. I winced at the name – another reminder that the world has changed a little, I guess – although it technically stands for Obsessive Completion Distinction. This is the hard mode where you need to meet far more challenging targets. Every ball and every placement becomes incredibly important.

This is where I started to feel real annoyance with the interface. It boils down to the fact the game doesn't have a quick restart button or a replay option if you reach the end and find out you didn't meet the target. Having to sit through the end section of a level and start again from the level select screen is just a bunch of extra clicking which gets between me and the challenge. The alternative is to try and work out whether you've succeeded or failed before you activate the pipe, so you can use the in-level retry button, which isn't always possible.

"Every ball and every placement becomes incredibly important."

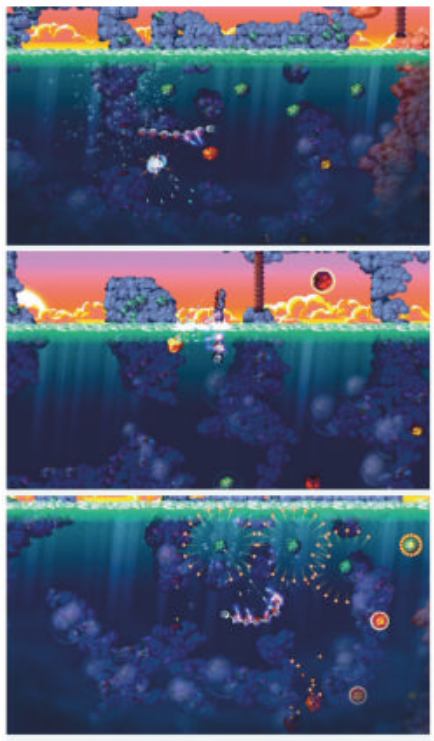
HEAVYWEIGHT

My other gripe is that goo becomes heavier when you attach it to a structure. I'm assuming this is because it is now considered to have the weight of the blob and the weight of the legs attaching it to other goo balls, but where did that extra weight come from? In a physics puzzler, this manifestation of substance from nothing, rather than the blob being spread thinner, feels like a tiny betrayal. "But what of the laws of physics?" Exactly, Dave. I'm with you on this one.

Trying to see if there was a way to quick restart using a mod or some other tinkering is how I ended up on **www.goofans.com**. This is where you can download GooTool; a utility for installing new levels and goo ball mods. It's a bit old at this point and requires a touch of Java tinkering, but I've found a number of level packs which offer some curious new challenges. You can't create new chapters for the game, so these levels just hover in the sky in the chapter 1 level select screen – a bit messy-looking, but useful for extending the life of the game that bit further.

I was also considering some of the goo ball colour mods, but the game does a good job of clearly communicating function via its colour coding, so adding a random colour variable felt like it wasn't likely to help me play (much as I would love to build a riotously bright tower that rivals my Christmas tree for coloured balls).

But all of this is just me distracting myself. I'm clearly going to end up tearing my hair out over how you get one last infernal ball into that infernal pipe on vanilla mode. It's 2008 all over again. ■ **Philippa Warr**



Sub Dragon

Pick a side.

FREE | DEEPNIGHT.NET
BROWSER

In this shoot-em-up/puzzler instead of piloting a ship, you're piloting a dragon. Though it's one that looks and handles more like a snake. Also, you're not in space, but in a samey aquatic environment home to urchiny, coral-esque enemies. Unlike our Earth coral, which sits around waiting for us to ruin it, the coral on this planet spews out streams of deadly bullets – one hit and you're back at the checkpoint. That's only when your red side is facing the bullets, however. Rotate the dragon so that its white half is pointed at the projectiles, and they'll plink harmlessly off its armoured carapace. So it's less a matter of switching forms and more of tactically slithering around the environment – while finding the time to expose your underbelly now and again to destroy enemies.

There's a jewel of an idea at the core of *Sub Dragon*'s ocean planet. There's just not enough progression in its level or enemy design to really make the most of it, which is a shame. ■ APC

$23 | AGEOFEMPIRES.COM | PC

Age of Empires II: Definitive Edition

A fitting remaster of the series' best entry.

Yes, the venerable classic is being wheeled out again – not quite new, but definitely improved. It wears its two decades well, but the years are still there hidden beneath polish and new art and myriad tweaks. *Age of Empires II: Definitive Edition* wavers between remaster and remake updating nearly everything from the art to the AI, but reverence for the original means that the changes, though broad and welcome, are somewhat restrained.

This remaster makes it easier to appreciate why the original had the impact it did. Finally, in 2019, *Age of Empires 2* lets you tell your villagers to automatically reseed farms! No more returning from a war to find the fields fallow and my villagers twiddling their thumbs. This might be the most exciting change for me, the most boring man in the world. Quality of life improvements might not sound like much of a headline attraction, but *Age of Empires 2* needed them just as much as the visual overhaul.

Unlike the first *Age of Empires*, armies are more manageable thanks to formations and improved pathfinding. They try to take the most efficient route and, while units can still get stuck when they're blocked by their mates, you can switch formations to give them more room to move.

Melee brawls are brisk and, even with the otherwise helpful zoom feature, it can still be hard to decipher what's going on in the scrum.

The three new campaigns, collectively known as the Last Khans, take a crack at spinning historical yarns through the deeds of historical figures. Mission intros and outros do all the exposition, but there are plenty of narrative moments and scripted sequences within the missions themselves.

While *Age of Empires 2: Definitive Edition* undoubtedly goes several steps further than previous remasters, it also makes me even more eager for a different take on the classic RTS. You won't find that here. This isn't for people looking for something new; it's for people who are already enamoured with the original game.

■ Fraser Brown

Verdict

A polished, wide-ranging update that brings the classic RTS into the modern age.

US$20 | MANIFOLD.GARDEN | PC, PS4, XBONE | LINUX, MAC

Manifold Garden

A serene gravity-switching puzzler.

There have been quite a few games that play with the fun of gravity. *Antichamber*'s mind-bending puzzles, *Dandara*'s explosive wall-jumping and the upcoming *Boundary*'s zero-G shooting – all grant the player the ability to defy physics. William Chyr's first-person physics-based puzzler, *Manifold Garden*, also lets you mess with the force of gravity, but in this game your playground is the never-ending, mind-bending realms of infinity.

Waltz up to any visible surface in *Manifold Garden*'s geometric world and you'll automatically flip gravity so that the wall becomes the floor. Using this ability, players are tasked with solving a number of gravity-manipulation puzzles and working out how to progress through *Manifold*'s many eternal spaces.You're forever being confronted with colossal towers, cathedral-like edifices, massive windows, never-ending flights of stairs – it's bonkers. There are giant cubic trees that grow square blocks that you can pluck from their branches like fruit.

Manifold Garden's puzzles have a straightforward core logic – mostly they just require you to move cubes onto buttons. Sounds simple enough, but the catch is each block can only be moved when they share the player's gravitational orientation, and the matching button usually lies past a series of baffling obstacles.

Manifold's world is cleverly shaped so that it wraps around itself in a never-ending loop, meaning that if you look out into the distance you can see the same structure that you're standing on mirrored all around you. Step off the edge on one of these structures and you'll fall directly into the one underneath you – actually the same one. It actually ends up being a useful way of getting around the maze of walkways.

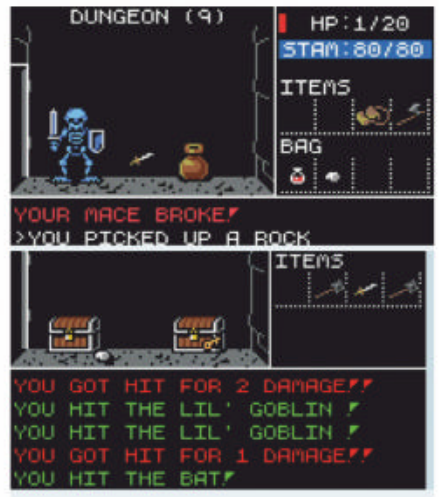
It's a joy to try and work out *Manifold Garden*'s impossible geometry and dizzying infinite world. It's an intricate and impressive spectacle – it took William Chyr seven years of development to make, and it shows. When I finish playing it the first time I immediately start again, just to revisit some of its fascinating spaces.

Rachel Watts

Verdict

A serene gravity-flipping puzzle game with impossible, infinite structures.

★★★★½



Dungscoot

Throwing daggers.

FREE | ROBINFIELD.ITCH.IO
PC

Old-fashioned dungeon crawlers might purport to be games about exploration or character-building, but really they're games about chucking stuff – chucking rocks onto pressure plates, flinging daggers at kobolds, throwing junk to make room for not-quite-junk. *Dungscoot* gets it. It's almost entirely about chucking stuff. About using projectiles to injure enemies in a dungeon. Like a compressed dungeon crawler, *Dungscoot* shunts you from one tiny room to another tiny room, each of which may contain monsters, or closets, or locked chests.

From its point-and-click combat to its constant inventory wrangling, *Dungscoot* looks and plays like an old 2D CRPG, such as *Dungeon Master* or *Lands of Lore* – minus, slightly disappointingly, the open maps and puzzles. There's also an element of randomness – some rooms will be packed with riches, while others will be empty save for a goblin or a useless bench.

It's a silly, slightly broken game that, through its exuberance and its keen nostalgia, becomes more than the sum of its parts.

APC

★★★

» JOEL BURGESS REPORTS ON THE UNUSUAL SIDE OF TECH NEWS.

The Mootrix

VR is responsible for an all new cowspiracy.

A farm just outside of Moscow is using custom-built VR headsets to show cows scenes of rolling summer fields in the hope that it will prompt them to produce more milk. Studies have shown that calmer cows produce more, better quality milk, so the experiment, which was announced by the Ministry of Agriculture and Food in the Moscow Region in a press release, makes perfect sense. We're not sure whether The Mootrix actually improves the mood of the herd enough to affect milk yields just yet, but the results of the 'Unique Summer Fields Program' study are expected to be announced at the 6th International Agro-Industrial Dairy Forum in Russia.

Massachusetts police test robot dog cops

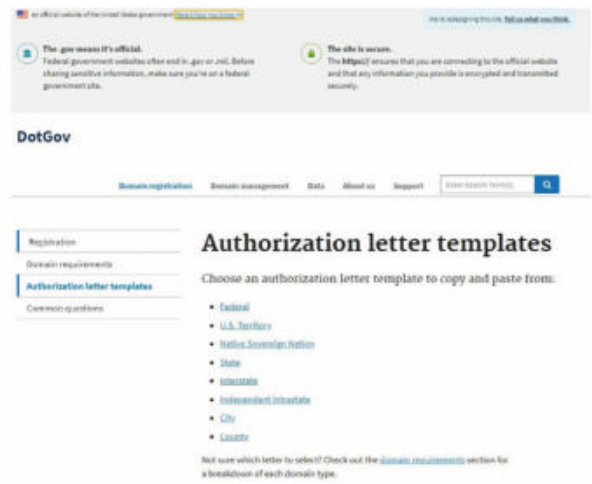
K9, MORE LIKE AI9.

Massachusetts State Police Bomb Squad has been quietly testing the use of Boston Dynamics' dog-like robots known as Spot, to see if they could be useful in the field. These robotic 'good boys' have been used as mobile remote observation devices to scout potentially dangerous situations before putting human officers in harm's way. While these robots are equipped with enough AI smarts to navigate on their own, they can also be controlled remotely using a camera live-feed and a controller (which might be enough to stop them from turning situations into a bad Deep Dream). While police have used armed robots to kill terrorists in the past Boston Dynamics prohibits weapon modifications to its robots.

Signed Macintosh 6.0 floppy disk goes for over $11,000

DOES STEVE JOBS' SIGNED FLOPPY EXCITE YOU?

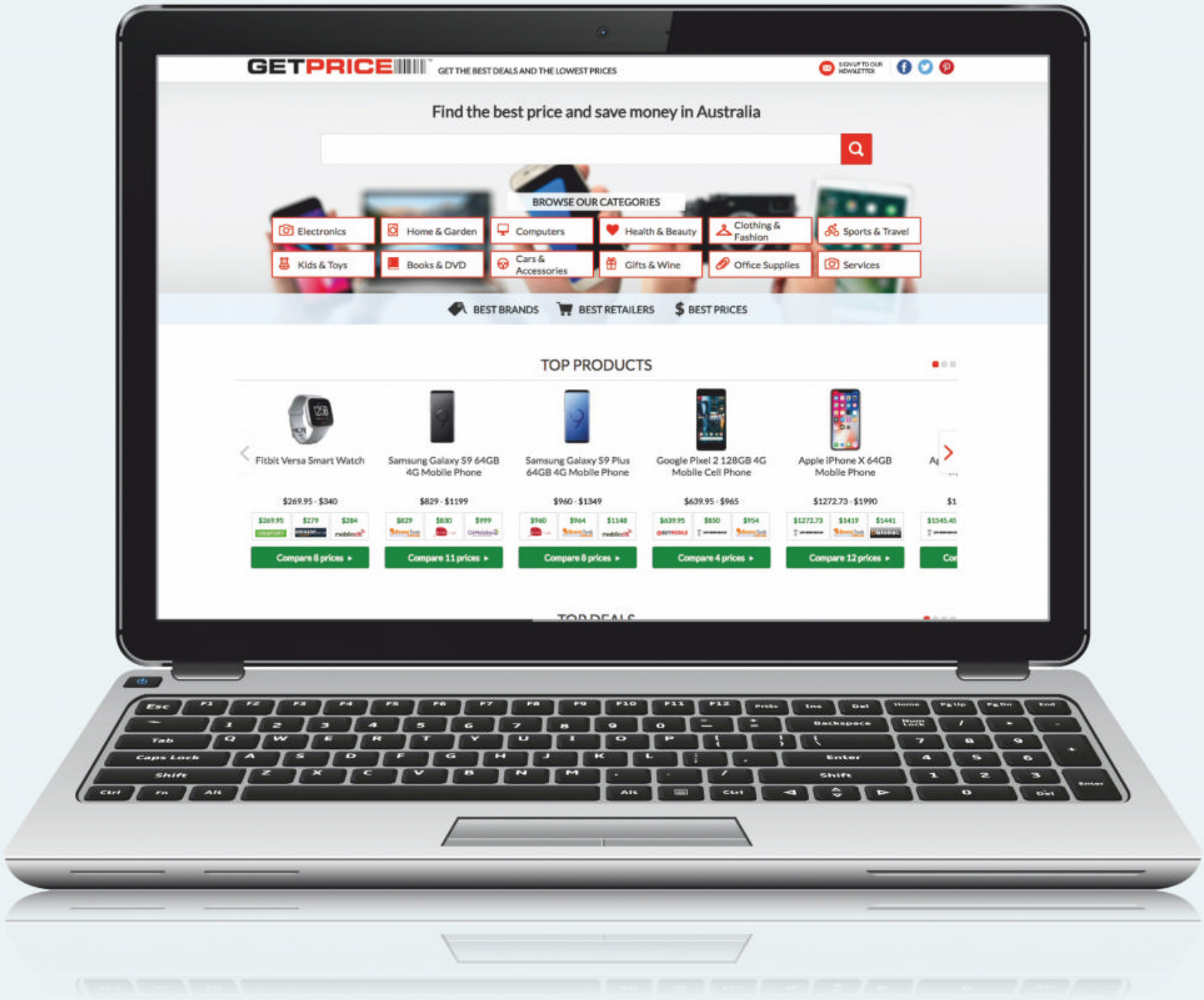
A 1MB floppy disk is about as useful as wired headphones these days, so it was a little surprising to see one up for auction with bids over US$11,000 in December of 2019. This unusually expensive technology relic features a working copy of Macintosh System Tools Version 6.0 and a squiggle from the tech messiah himself: Steve Jobs. We can just imagine the black skivvy army swooning over this 'surprisingly affordable' and rare instance of signed Apple memorabilia from the company's heyday… i.e. sometime before it ditched the headphone jack. So far, 15 people have put their money up to get a hold of Steve Jobs' floppy.



Security researcher tricks US into giving him a .gov website

.GOV WEBSITES MAY NOT BE QUITE AS SECURE AS YOU THINK.

A security researcher was able to trick the US government into giving him a .gov URL after he posed as the mayor of the small 6,500 person district of Exeter, Rhode Island. The only other details the issuing body required as proof of the position was a phone number and an email address, both of which the researcher generated without having to include any directly identifying information. After being issued the official domain the researcher reached out to well known security website Krebs on Security using the **exeterri.gov** domain he had just acquired to highlight the infiltration. The issuing body only rang the Exeter government office ten days after the domain was issued.



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