EVEN IF THE CRAZE FOR BITCOIN AND ETHEREUM ABATES, THE POWER OF THE "BLOCKCHAIN" TECH BEHIND THOSE CURRENCIES IS VERY REAL. HERE'S HOW BUSINESSES ARE TRYING TO HARNESS IT—AND WHY THEY CAN'T AFFORD TO IGNORE IT.

BY ROBERT HACKETT

BLOCK MANIA

ONE SUMMER MORNING in a coffee shop on Atlantic Avenue in Brooklyn, I sit behind my MacBook Pro as tens of thousands of machines around the globe prepare to indelibly inscribe a record of my tinkering into their collective consciousness. I am in the midst of creating my own digital tokens—essentially online currency—on a sprawling, decentralized network known as Ethereum.

Mike Goldin, a software developer at ConsenSys, an Ethereum development studio based in Bushwick, walks me through the coding process. Goldin is my Sherpa today, graciously attending, with utmost patience, to my every query. (The 10-plus hours I spent downloading software the day prior was unnecessary, he tells me; we're going to employ some work-arounds that will achieve my goal in a matter of minutes.)

After considering a variety of names for my token—"fortunecoin," "hackettoken," "neither"—I settle on a cheeky one that evokes a spectacular flameout of the great '90s Internet bubble: "Petsdotcoin." I click "create."

Transaction hash **0xc14d13893bd0f0ff997a8a701c-0c8844661a6ddb921a42f2f61c-8c7adb0d158c**

(Pending)... (Pending)... (Pending)...

Twenty-seven seconds and one block confirmation later, I am the proud owner of 500 newly minted "petsdotcoin" tokens. Their creation cost me $1.57 in Ether, the cryptocurrency that fuels the Ethereum network. Despite that expense, my tokens are valued at 0 Ether, or $0.00, as the program reminds me. They are worthless. But if I had tied those bits to some worthwhile business idea, petsdotcoin might have offered investors a radical new way to fund me, track their stake, and participate in a miniature, virtualized, in-app economy. In that respect, my funny-money vanity project is a tiny part of a movement of profound economic significance.

In case you haven't been keeping track, digital tokens are a new asset class, powered by cryptocurrency networks like Bitcoin and Ethereum. The sector has attracted maniacal investor interest this year, giving these

e-coins absurdly inflated valuations that have inspired endless comparisons to the "dotcom" era. (Hence, petsdotcoin.) At press time, the total market value of all virtual currencies had rocketed past $135 billion, up from just under $20 billion at the beginning of the year.

Hundreds of projects have collectively raised more than a billion dollars through "initial coin offerings" (ICOs). There are now tokens funding every conceivable endeavor: Decentralized cloud storage (FileCoin, Storj). Digital advertising (Basic Attention Token, adToken). A gentlemen's club in Las Vegas (Legends Room). Marijuana (Potcoin). Satire (PonzICO). There's even one for dentists (DentaCoin). In a photo recently posted to Instagram, Floyd Mayweather, the boxer, sits on a private jet surrounded by stacks of dollar bills, touting the sale of tokens for a prediction market called Stox—a moment some saw as proof that ICO hype had reached peak zaniness.

The smart money is also playing in this pool. Established venture capital firms like Sequoia, Andreessen Horowitz, and Union Square Ventures are pouring millions of dollars into cryptocurrency hedge funds. The topic is all the rage on Wall Street. But notably, the long-betting investors in this space see today's numismatic delirium as a distraction. "Right now it's much easier to get more focused on the short-term ICO money stuff," says Chris Dixon, a general partner at Andreessen Horowitz. "I think this unfortunately overshadows the more important technology story."

That story goes like this: Underneath the crypto-hysteria is a grand innovation in the humble realm of accounting. The most bullish acolytes of this electronic book-balancing breakthrough, Dixon included, hold that token-based projects will anchor the web's next revolution, spawning crowdfunded businesses and services that deliver more value to their users while being less dependent on advertisers or rent-seeking middlemen.

Facebook, meet Tokenbook.

Look beyond the ICO frenzy, and you can glimpse another paradigmatic shift inspired by that same accounting innovation. Incumbent businesses in countless industries, from finance to energy to health care to food, are peeling back the layers on this budding technology, seeing the potential to trim costs, share and secure information more efficiently, and unleash new products at unprecedented speed. And they're doing so knowing that one day their survival may be at stake: Having witnessed what the advent of digital, cloud, and mobile did to laggard companies, no one wants to be the sucker left behind.

The technology in question: that choreographic marvel called a blockchain.

NO TERM AT PRESENT is more hyped, and more poorly understood. During a discussion at *Fortune*'s Brainstorm Tech conference this summer, Peter Smith, CEO of Blockchain, a London-based cryptocurrency wallet provider, half-jokingly defined "blockchain" as a marketing term exploited by salespeople to ink deals.

A less cynical definition might go as follows: A blockchain is a kind of ledger, a table that businesses use to track credits and debits. But it's not just any run-of-the-mill financial database. One of a blockchain's distinguishing features is that it concatenates (or "chains") cryptographically verified transactions into sequences of lists (or "blocks"). The system uses complex mathematical functions to arrive at a definitive record of who owns what, when. Properly applied, a blockchain can help assure data integrity, maintain auditable records, and even, in its latest iterations, render financial contracts into programmable software. It's a ledger, but on the bleeding edge.

Blockchain boosters say its development is one that rivals, in significance, the invention of double-entry bookkeeping. That's the revolutionary method of tabulating assets and liabilities that emerged in Renaissance Italy and that, according to some historians, put wind in the sails of capitalism, allowing investors and

entrepreneurs to team up in corporations and launch merchant ships beyond the horizon in search of commercial success. Blockchains, in this analogy, are triple-entry bookkeeping, where the third entry is a verifiable cryptographic receipt of any transaction.

Perhaps most spectacularly, a blockchain can get rivals to cooperate in creating a common record that is accessible to everyone and controlled by no one. This was the genius of Satoshi Nakamoto, the alias for the as-yet-unidentified creator (or creators) of the first blockchain, Bitcoin, which debuted in 2009. (Since then, the value of a single Bitcoin has reach a high of more than $4,300.) Part of Bitcoin's secret sauce is its consensus mechanism, which allows people to agree on a canonical order of transactions, thereby preventing double-spending and fraud, through a combination of cryptography and economic incentives based on game theory—all without needing a third party or middleman, like a bank. Even if participants don't trust one another, they can rely on the shared ledger they create through the transactional dance of their software. You don't need honor among thieves—you just need a blockchain.

If Bitcoin proved what was possible, Ethereum, a rival system, took its ingenuity to a logical extreme. Vitalik Buterin, a twentysomething Russia-born programmer (No. 10 on *Fortune*'s 40 Under 40 list this year; see page 62), created a blockchain that aims to be anything to anyone: His Ethereum can create representations of any asset, which has made it the primary fuel of the digital-token boom.

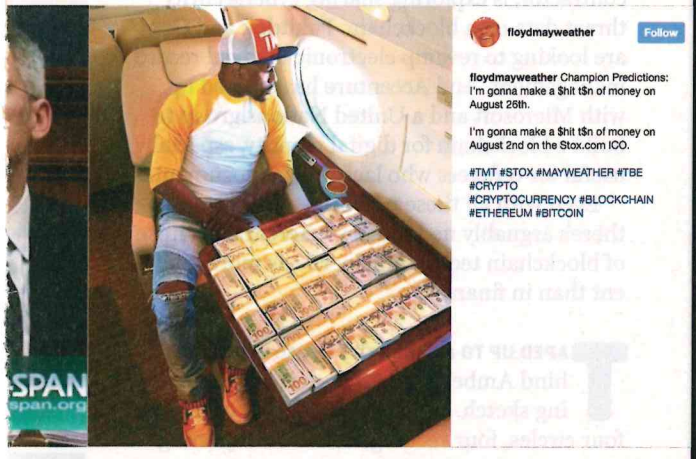
But by showcasing blockchain's fundamental flexibility, Ethereum's rise has also accelerated a deluge of research and development in corporate America. Scores of companies are adapting and advancing the core technology to suit their needs. While some are exploring digital currency and the open-source, free-for-all ecosystem of public blockchains (of which Bitcoin and Ethereum are prime examples), far more are concentrating on how the technology underpinning those systems can add value to their businesses—by helping them with everything from corralling medical records to tracking the provenance of a pork loin. Many are concocting "permissioned" or "private" blockchains, designed for a more centralized architecture where only authorized operators can join.

To some stalwarts, this corporate appropriation runs counter to the original, idealized blockchain as introduced by Nakamoto. "The word was hijacked to sell enterprise software, basically," says Olaf Carlson-Wee, founder of Polychain Capital, perhaps the most high-profile of the cryptocurrency hedge funds. Some entrepreneurs, like Chain CEO Adam Ludwin, argue that new ledger technology isn't really a blockchain if the items it tracks aren't financial. R3 CEV, a New York–based consortium of financial firms that began as a blockchain startup, now avoids the word, calling itself a "distributed ledger technology" company.

But this schism over terminology isn't hampering the science. Ultimately, anyone working on next-generation data structures with cryptographic signatures and joint-stakeholder elements might now be said to fall under the "blockchain" umbrella. "It's entered the vernacular like Kleenex," says Matt Higginson, partner in McKinsey's global banking practice. And whatever you want to call it, more and more businesses are gathering there.

ONE DAY LAST DECEMBER, Frank Yiannas went to a Walmart store near company headquarters in Fayetteville, Ark., and picked up a package of sliced mangoes. Yiannas is Walmart's vice president of food safety, and the fruit was part of a crucial experiment. He brought the mangoes back to his office, placed the container on a conference table, and gave his team a mission. "Find out where those mangoes came from," he ordered, setting a timer.

It took six days, 18 hours, and 26 minutes to get an answer. That's better than the weeks it can sometimes take companies, Yiannas says.



BELIEVE THE HYPE A Bitcoin fan photobombs Federal Reserve Chair Janet Yellen at a congressional hearing; boxer Floyd Mayweather shows his enthusiasm for the Stox cryptocurrency.

Still, a near-week is a long time. In the event of an outbreak of foodborne illness—one in which a suspected pathogen is tied to mangoes somewhere—a lag that long could be painfully costly. By that point, Walmart might have had to pull every package of every mango product off its shelves, as a precaution; farmers, distributors, and Walmart itself would take the hit.

Yiannas has for years searched without success for what he calls the "Holy Grail of food traceability," a technology that could track and catalog a product's status across his supply chain. He admits he was "very skeptical" that a blockchain could fill the gap, but he gave it a try. Walmart partnered with IBM for a trial run on Hyperledger Fabric, a blockchain built under the purview of the Linux Foundation's Hyperledger group, where companies collaborate on blockchain R&D.

In the Walmart test, food shipments were tracked and digitally recorded via a blockchain. (Yiannas's team's manual search was the "control.") From the start of their journey at the farm, pallets of mangoes were tagged with numeric identifiers. Every time they crossed another checkpoint—from farm to broker to distributor to store—their status was signed and logged.

A few months after the fact, Yiannas repeats a version of the IBM demo for me. He enters a six-digit "lot" number on a web portal. In an instant, the mangoes' identifying details appear on-screen: Mango spears, 10 ounces, "Tommy" variety (a cultivar optimized for transport). The fruit was harvested April 24 from orchards in Oaxaca, in southern Mexico. A day later, the fruit underwent hot-water treatment to exterminate the eggs of potentially invasive insects. On April 27, an importer received the shipment; after a few more days, it passed through Customs and Border Protection, entering a U.S. processing plant where they were sliced on May 1. From there, the mangoes moved to a cold storage facility in Los Angeles (you can pull up a safety inspection certificate with a click of a mouse). Finally, the lot arrived at a Walmart store.

The time it took to compile and present all this information: about two seconds. (It clocked a similar time when Yiannas demonstrated it at Walmart's annual shareholder meeting this summer.) In the event of an *E. coli* or salmonella outbreak, the difference between two seconds and six-plus days can be decisive, even lifesaving. But in the context of a supply chain, a blockchain is far more than an emergency measure: The granular, secure records in the system could help prevent fraud, and provide an easy-to-use interface for executives to keep tabs on the flow of goods, as well as for regulators to peek under the hood when necessary.

"This was not about chasing the shiny coin," Yiannas says. "There were business challenges we were trying to solve."

Other companies are now exploring blockchains' potential for their logistics. Maersk, the Danish shipping giant, has started testing a blockchain to track its shipments and coordinate with customs officials. Airbus, the French aircraft maker, is looking to use blockchains to monitor the many complex parts that come together to make a jet plane. Daimler, the German automaker, is investigating similar possibilities for its vehicles.

The potential doesn't stop with tangible goods like windshield wipers or watermelons: Many companies and governments think blockchains could help them assemble tamper-resistant systems for storing virtually any kind of data. BAE Systems, the British defense contractor, is exploring sharing cybersecurity threat data on a blockchain. Pokitdok and Gem are looking to revamp electronic medical record management. And Accenture has teamed up with Microsoft and a United Nations group to build a blockchain for digital identity, especially useful for refugees who lack official documents.

Even with all these potential applications, there's arguably no industry where the promise of blockchain tech—or its peril—is more apparent than in finance.

FRUITFUL RESEARCH Frank Yiannas, vice president of food safety at Walmart, worked with IBM on a pilot project to track mangoes through the company's supply chain using a blockchain.

© COURTESY OF WALMART

TAPED UP TO A GLASS dry-erase board behind Amber Baldet's desk is an unassuming sketch. It displays the black outline of four circles, four rectangles, a few conjoining

lines, and a few acronyms of academic institutions such as SRI, UTAH, and UCLA.

The image is an early depiction of Arpanet, the forerunner of today's Internet. Baldet, who heads up the blockchain group at JPMorgan (and is No. 31 on our 40 Under 40 list), views her work as very much in a similar phase of development. For enterprises, she says, it's 1969, and they're tinkering with a technology that could, in time, be as important as the Internet.

Finance is the most obvious extension of blockchain tech, given the monetary roots of Bitcoin. Trade finance, security clearance and settlements, cross-border payments, and insurance are all areas that could be overhauled and made more seamless. Microsoft is collaborating with Bank of America on a blockchain to digitize and automate the money flow around

BLOCKCHAIN IN REAL LIFE

Amid the hype surrounding Bitcoin and Ethereum, it's easy to overlook how blockchains—the technology *behind* those currencies—are already transforming major industries. For businesses, the opportunities to secure supply chains, eliminate middlemen, and cut costs are increasingly compelling. Here are five examples of blockchains in action.—*Jeff John Roberts*

SHIPPING

Maersk, the world's largest shipping company, completed an inaugural test this spring of using a blockchain to track its cargo. The test involved not just Maersk but a series of third parties—the shipper, Dutch customs, and the U.S. Department of Homeland Security—with all of them tracking containers remotely. The tech's reliance on cryptographic signatures makes it harder for anyone to mislay goods or tamper with labels while cargo is on the move, and can reduce the time goods spend in transit.

BANKING

Despite its sophistication, the banking industry is still bedeviled by sluggish systems that can take hours or days to confirm basic transactions such as stock sales or money transfers. But the ongoing adoption of blockchains by the likes of Barclays, which conducted a groundbreaking transaction (it involved butter exports) using the technology in 2016, means this is changing. In the near future, look for rapid increases in the speed of banking services as well as the disruption of intermediaries like brokers and clearinghouses. Big banks are even planning to use blockchains to remake the SWIFT system, which is used for global interbank transfers.

LIVESTOCK

You might not peg Walmart as a blockchain pioneer. But the retail giant began using the technology in 2016 to track how pigs from China moved through the supply chain to the American table. Smaller outfits are following suit. In August, an Arkansas farmers' collective used QR codes on chicken crates to trace transactions involving their poultry. All of this promises to help companies reduce food spoilage and prevent disease outbreaks.

LAW

All sorts of agreements—from home sales to business purchases to employee contracts—require lawyers and courts to enforce. Now, more firms are experimenting with "smart contracts" that execute themselves: A blockchain system can, for instance, release money from escrow once one party to a contract transfers a deed. Lawyers nervous about their jobs can rest easy for now, as smart contracts are still a novelty. But this could change soon, especially as states like Arizona pass laws that confirm smart contracts are valid.

DIAMONDS

The diamond business is a tight-knit industry whose members and customers share common concerns over stones' origins and authenticity. This helps explain the success of Everledger, a company that can record over 40 identifying features of a diamond, including color and clarity, and register them to a blockchain. Everledger has digitized more than a million diamonds and has plans to branch out to other industries—specifically fine wine—in need of better anticounterfeiting records.

trades. HSBC, ING, U.S. Bank, and eight other banks recently completed a prototype application for the same purpose on R3's Corda ledger. Northern Trust, the asset management firm, is using Hyperledger Fabric for private-equity deal record keeping. And Ripple built a system to rival the SWIFT interbank money-transferring service. In a hotly competitive sector where customers demand faster transactions and lower costs, the rewards of building the best blockchain mousetrap could be vast—the penalties for missing out, proportionately painful.

To help stake JPMorgan's claim, Baldet's team has created a so-called permissioned variant of the Ethereum blockchain. The bank open-sourced the code late last year, under a "general public license" that allows anyone to draw from or contribute to the design. This retooled blockchain, dubbed Quorum, is the first software ever released by JPMorgan this way. It's an unusual move by the bank, which certainly had the resources to work in-house and in secret. But JPMorgan sees a benefit to rallying all parties to work on a common platform that could reduce costs. "We spend a whole lot of money trying to transact with our counterparties and our clients," Baldet explained at a recent *MIT Technology Review* event in Cambridge, Mass. "The more free that sort of thing is, the better for us."

The JPMorgan team is already breaking ground—and, in the process, underscoring key differences between private and public blockchains. In March, Quorum began adding support for "zero knowledge proofs," advanced cryptography commercialized by the Zerocoin Electric Coin Co., makers of the Zcash cryptocurrency. That cryptography enables state-of-the-art privacy features—something the Ethereum Foundation, the Swiss nonprofit that maintains the public Ethereum blockchain, has yet to do, though it plans to. JPMorgan, after all, is designing Quorum to prioritize the needs of corporations, especially in data confidentiality

DIGITAL DOINGS IN DELAWARE

The state that's the de facto capital of U.S. business law has caught the blockchain bug.

As of Aug. 1, a new law permits companies in Delaware—where more than two-thirds of *Fortune* 500 companies are incorporated—to keep their list of shareholders on a blockchain.

The boosters of the blockchain law hope it will encourage companies to replace Excel spreadsheets and SQL databases as a way to keep track of shareholders. But the law is also just the start of what could be a revolution in corporate record keeping. That's because Delaware is also in the process of creating a system intended to let companies do everything from file incorporation documents to register shares via a blockchain.

According to CEO Mark Smith of Symbiont, a New York–based company supplying blockchain technology to the state, a network of law firms and registered agents is already building tools to help companies store their records on Delaware's blockchain. If successful, the tools will provide an efficient new way for companies to undertake anything from proxy votes to share splits. Firms will also be able to use the cryptographic features built into the blockchain to provide regulators or investors with secure temporary access to confidential documents on a case-by-case basis.

The venture capital arm of retailer Overstock.com has already pledged to move records to Delaware's blockchain service, and other firms are expected to follow suit before long. For these companies, the advantages could be huge: These could include saving millions of dollars a year in record keeping and transaction costs, as well as much quicker auditing and due diligence procedures.

More broadly, the Delaware project aspires to create a one-stop shop for corporate records that is tamperproof—one of the hallmarks of blockchain technology—and always accessible. Meanwhile, access to the records will be available via a website [all the new blockchain stuff will be tucked into the back end] so there will be little in the way of a learning curve for ordinary people.

While Delaware's ambitions are grand, the experience of other states offers a cautionary note. Vermont, for instance, announced to much fanfare in 2015 that it would put its property records on a blockchain—but bailed on the plan after a year upon finding it to be too costly.

Smith claims Delaware will be different since it is using his company, rather than its own bureaucracy, to create and implement its blockchain bet. Meanwhile, Andrea Tinianow, a state official whom some call "the blockchain czarina," says the sweeping changes to Delaware records are not years away, but will be in place by 2018. —*J.J.R.*

and scalability—areas where private blockchains excel and, for now, public blockchains struggle.

Still, many industry insiders believe that public and private will eventually intersect—just as internal networks came to coexist with and feed the public Internet decades ago. "I think we're going to see the distinction between public chain and private chain eradicated in the next two to three years," says Jeremy Millar, chief of staff at ConsenSys, and a founding board member of the Enterprise Ethereum Alliance, a group of financial and tech firms that includes JPMorgan and is pushing Ethereum-based blockchains for business. "We'll be talking about global chains vs. industry and company chains."

At a recent blockchain event hosted by Microsoft in Manhattan, I ask a group of executives whether they're similarly bullish. The responses span the gamut from "absolutely" to "I have no idea." Patrick Nielsen, lead engineer of Quorum, overhears my line of questioning. He can barely conceal his amusement beneath an impressively leonine beard. We've got some academic institutions and military research agencies, he says with a wry smile, referencing the topology of the Internet in its early days. "Just have to add a few more nodes to the network."

IF AND WHEN ALL those nodes are in place, it could presage a major shift in the way humans, companies, and their data organize. Of all the analogies that come up in discussing blockchains, perhaps the most frequently cited is the design, in the 1970s, of TCP/IP—the watershed networking protocol that enabled computers to talk to one another and swap data and info. This technology helped upend the point-to-point telephone lines that predominated during the Bell era, paving the way for a network of networks—the Internet.

If the Internet is a supranetwork, then a blockchain, in its purest form, is a way to turn these networks into decentralized marketplaces. Ronald Coase, a 20th-century economist, won a Nobel Prize for formulating an explanation for why corporations existed. Their raison d'être, he said, was to maximize efficiencies in business and market negotiations: Dealmaking is more productive when done collectively. Blockchains could take that principle and multiply it exponentially.

Granted, there are many technical and cultural challenges standing between that vision and reality. The cryptocurrency boom has drawn attention to some of the drawbacks and limitations of blockchains—including the paucity of present demand for cryptocurrency in actual business dealings and transactions outside of pure speculation (lots of people invest in it, few use it) and the potential for security lapses. (For more on the latter, see "The 21st-Century Bank Robbery" in this issue.)

Vint Cerf, one of the coauthors of TCP/IP and now vice president and "chief Internet evangelist" at Google, has reservations. "I think that the claims that blockchains will change the world are hyperbolic for the most part," he zapped in an email to *Fortune*. "It has become a kind of magic pixie dust for some proponents." Still, even Cerf sees potential in blockchains, where "the parties involved in the system are known and can be evaluated for reliability and trustworthiness."

If Cerf's cautious hunches pan out, businesses could be innovating and growing with the help of blockchains, even if the digital token craze proves to be a fad. Maybe petsdotcoin won't be the next big hit. But it's no exaggeration to believe that blockchains could, in the long term, revamp business, government, and even society itself, just as surely as the Internet did last century, and double-entry bookkeeping did centuries earlier. Someday, you may literally be able to count on it. F

OPEN SECRETS Amber Baldet's team at JPMorgan built an open-source blockchain platform: "The more free that sort of thing is, the better for us," she says.

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