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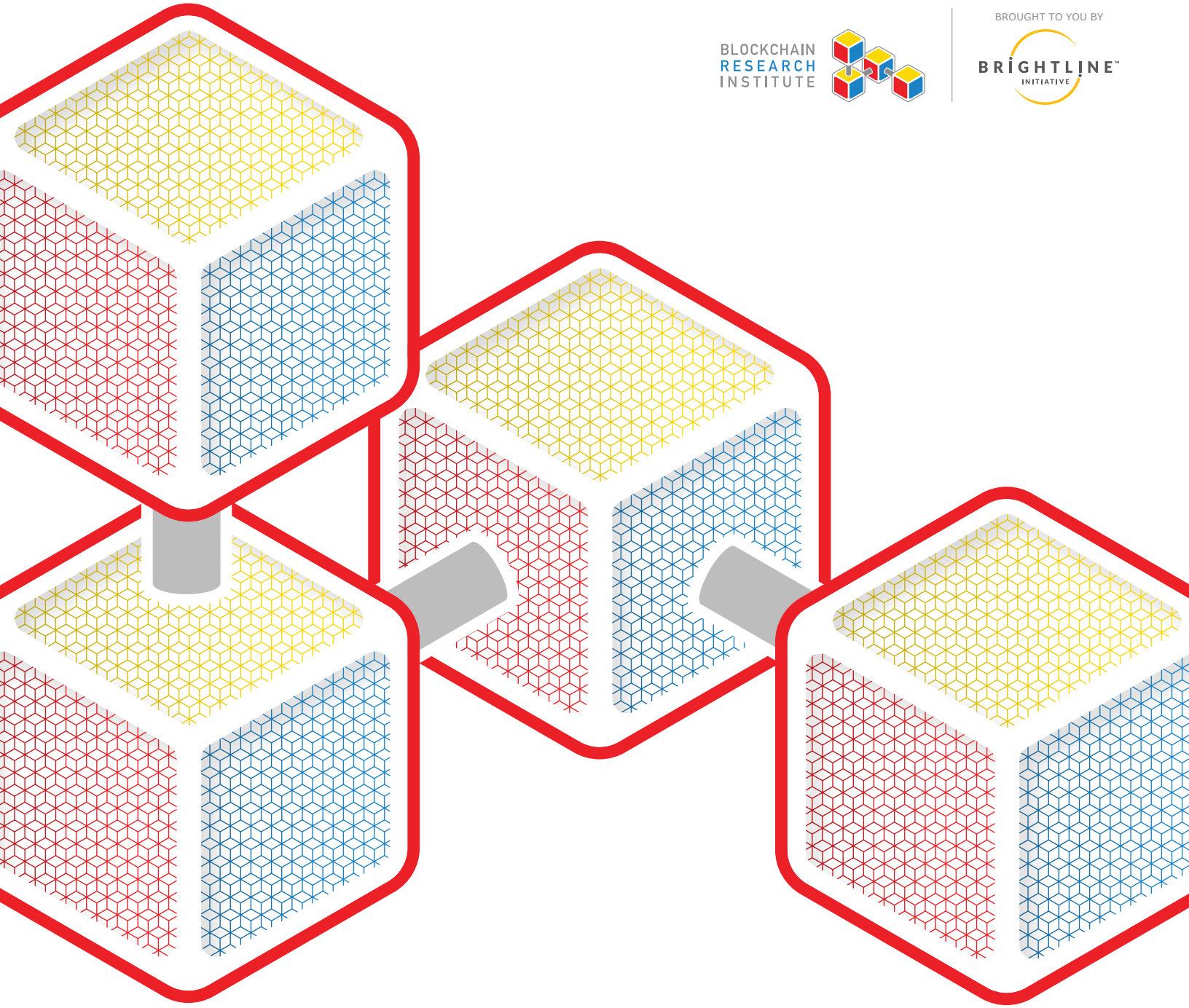

DISTRIBUTED CONNECTIVITY

The Blockchain-enabled Future of Telecommunications

Christian Keil
Blockchain at Berkeley

December 2017

A BLOCKCHAIN RESEARCH INSTITUTE BIG IDEA WHITEPAPER

Realizing the new promise of the digital economy

In 1994, Don Tapscott coined the phrase, "the digital economy," with his book of that title. It discussed how the Web and the Internet of information would bring important changes in business and society. Today the Internet of value creates profound new possibilities.

In 2017, Don and Alex Tapscott launched the Blockchain Research Institute to help realize the new promise of the digital economy. We research the strategic implications of blockchain technology and produce practical insights to contribute global blockchain knowledge and help our members navigate this revolution.

Our findings, conclusions, and recommendations are initially proprietary to our members and ultimately released to the public in support of our mission. To find out more, please visit www.blockchainresearchinstitute.org.

Blockchain Research Institute, 2018

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Message from the Executive Director

We are excited to share this research on blockchain technology as a result of an exclusive partnership between the Brightline Initiative and the Blockchain Research Institute, the leading knowledge network on the study of the strategic implications of blockchain in organizations, industries, and our society.

The Brightline Initiative is a coalition led by the Project Management Institute, together with leading global organizations dedicated to helping executives bridge the expensive and unproductive gap between strategy design and delivery.

In this research project, Christian Keil explores the breadth of blockchain's impact on the telecommunications industry. He presents a framework for evaluating use cases, actionable ideas for blockchain implementation, the risks and limitations of blockchain technology, and a path forward for telecom managers.

Mr. Keil details seven types of use cases: Ubirch's and British Telecom's initiatives in distributed network management; Huawei, BitMesh, and Sprint with TBCASoft, in intercarrier coordination; Bitwala, mPesa, and Orange (with VISA, Nasdaq, Citi Ventures, and Capital One), in transaction services; earn.com in micropayments; smart contracts instead of international data clearinghouses for international roaming; the efforts of SecureKey Technologies, IBM, and the Canadian government in consolidating digital identities; and such partnerships as IBM and Samsung, Tencent and Intel, and Thales with Chain and Gem, to secure machine-to-machine transactions.

We continue our mission to develop and share thought leadership and best practices on different topics related to strategy implementation. We hope this research can help senior leaders to increase their knowledge and understanding of blockchain technology, and how they can use it to overcome challenges and improve their success in implementing strategy.

RICARDO VIANA VARGAS
Executive Director
Brightline Initiative

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Foreword

During my research for *Grown Up Digital*, I noticed how many members of the Net Generation were using their mobile phones as their primary computing device. In fact, *telephone* seems like an archaic term for such as powerful computing device that uses a tiny percentage of its power for voice communication (and that likely goes to dutifully calling parents). Since then, I have carefully followed innovation within telecom and I believe that the industry has an opportunity to provide leadership within blockchain.

I believe that telecommunications technology will remain the backbone for human communication, even though the nature of communication will continue to transform. Consumers will want faster, more reliable, and cheaper data streams. It could also become the backbone for machine-to-machine communication, as the Internet of Things will generate massive amounts of information.

This research project evaluates how the telecom sector will evolve to support billions of new customers (including the most impoverished billion people who have traditionally been underserved) and potentially billions of new devices in a complicated, device-agnostic marketplace.

Christian Keil was our first choice for this project. He brings to the Blockchain Research Institute a compelling combination of skills and experiences. He is an academic, an entrepreneur, and a political activist. Keil was a key contributor to Deloitte's innovative white paper, "Ecosystems Come of Age." This diverse set of expertise and experience is readily evident in this fascinating and comprehensive project.

DON TAPSCOTT
Co-Founder and Executive Chairman
Blockchain Research Institute

Idea in brief

- Both technology and market power in the telecommunications industry appear to be *distributing*. Networks are transitioning from large towers to small nodes, as fifth-generation wireless technology demands network densification.
- The Internet of Things (IoT) has redefined the word, *device*, and atomized the connectivity needs of an average consumer or corporation; and network function virtualization and software-defined networking promise to make networks adaptive and decentralized.
- Simultaneously, the competitive dynamics of the telecom industry—particularly, but not only, in the United States—have radically shifted with the rise of mobile virtual network operators, voice over internet protocol (VoIP), and disruptive, emerging players.
- Telecom executives need to prepare for a future in which connectivity is distributed, democratized, and decentralized. In that future, blockchain—a protocol built to manage decentralized systems of value—may play a leading role.
- This research seeks to approximate the breadth of blockchain's impact on the telecommunications industry by developing a framework for evaluating use cases, exploring actionable ideas for blockchain implementation, examining the risks and limitations of blockchain technology, and proposing a path forward for those telecom managers convinced of blockchain's promise.

A new age is rapidly approaching

The telecommunications industry is entering a new age—and now, as in all unchartered territory, both excitement and uncertainty abound.

Fifth-generation wireless technology will transform the wireless industry.

New opportunities and blurring boundaries

Fifth-generation wireless technology looks to be truly transformative for the wireless industry. It will require large-scale changes to network architectures, but the speed and efficiency it promises may finally allow telecoms to meet the voracious consumer demand for data. Similarly, *network function virtualization* and *software-defined networking* (NFV/SDN) may make networks more reactive, efficient, and flexible. Many organizations have sensed the potential that these new technologies—alongside cloud computing, decentralized apps and functions, and instant service delivery—may be harbingers of a larger, tectonic shift in the provision of telecom services.

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From 40,000 feet, these trends and technologies appear to point toward the oncoming of *distributed connectivity*: an age in which both the technologies and economic power structures that enable communications services grow increasingly decentralized and democratized.

In conversations with telecom leaders around the world, one theme was constant: "The times, they are a-changin'," and the future may prove more dynamic and distributed than the past.

Mobile data traffic is expected to grow at a compound annual rate of 47 percent from 2016 to 2021.

From the perspective of Bell Canada, a Canadian telecom and partner of the Blockchain Research Institute, the industry is undergoing a "massive transformation." Petri Lyytikainen, Bell's VP of technology strategy, emphasized that Bell's focus today is on agility. He said,

> *Today Bell is focused on innovating new services faster and improving our operations to be more responsive to customer experience and preferences. The faster we can understand these changes, the better … together, they represent a fundamental change in how networks operate.*[1]

This new age of connectivity is creating a massive opportunity for growth. According to Cisco, mobile data traffic is expected to grow at a compound annual rate of 47 percent from 2016 to 2021, driven by staggering levels of mobile penetration and media engagement.[2] Nielsen estimates that Millennials spend more than 10 hours *per day* consuming media, up from 9.5 hours last year and 7.5 hours in 2014.[3]

Existing telecom power players, however, aren't capturing the value generated by these trends. Mobile virtual network operators, for example, *are* experiencing double-digit growth, and this position may only strengthen as higher frequency spectrum, the ubiquity of Wi-Fi, and related trends like VoIP further the rise of decentralization.[4] What will it mean for the telecom industry if more carrier combination plays like GoogleFi, or even upstarts like blockchain-powered Source, gain significant market traction?[5]

The lines around the telecom industry are blurring as connectivity becomes omnipresent and technologies adjacent to core telecom evolve.

To take an even broader view, the lines around the telecom industry are beginning to blur as connectivity becomes omnipresent and technologies adjacent to core telecom evolve. Major advances have been made around the IoT, automation, cloud, robotics, and augmented and virtual reality, all of which operate near or even directly interact with connectivity services—even our fridges and picture frames can now be connected to the online world. As Paul Saffo, technology forecaster and Stanford professor, said in a Deloitte report on the rise of ecosystems thinking, "The world has become more permeable, with much of the most interesting innovation coming from economic 'edges' rather than from the historic centers."[6]

In transformative times, both opportunity and risk are heightened. Executives understand that new, distributed networks may be the future—but they're unsure about where to play, particularly given their existing competencies (and, often, incredible organizational inertia).

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The challenge that they face is this: how can telecoms establish defensible, market-leading competencies in the technologies likely to drive the future while still paying heed to today's market realities?

Tower, Communications, Repeater, Sky by Manolo Franco (manolofranco), 2015, used under CC0 1.0.

The rise of blockchain technology

According to its evangelists, blockchain is a transformative, protocol-level disruption that is ready to change the world. Omer Ayfer, technologist and cybersecurity professor, said,

> *It's not often that you find a technology that claims to be faster, better, and cheaper simultaneously. Blockchain promises to automate out busywork, making systems cheaper and faster, while maintaining an extremely high standard and trust level for all transactions regardless of their size.*[7]

Of all people, Paris Hilton—reality TV star and perfume entrepreneur—recently tweeted her support for a blockchain token. "That," said Ethereum creator Vitalik Buterin, "is peak hype."

Recent months have seen a flurry of activity in the blockchain space, from blockchain companies raising millions of dollars in mere hours, to regular companies appending "blockchain" to their names and seeing their stock prices surge, to influential (and at times, nontechnical) individuals throwing their support behind this new technology.[8]

Of all people, Paris Hilton—reality TV star and perfume entrepreneur—recently tweeted her support for a blockchain token: "Looking forward to participating in the new @LydianCoinLtd Token! #ThisIsNotAnAd #CryptoCurrency #BitCoin #ETH #BlockChain."[9] "That," said Ethereum creator Vitalik Buterin of the tweet, "is peak hype."[10]

For better or for worse, investors aren't all talk: investment has been commensurate with the noise. Firms are investing billions of dollars in blockchain R&D and hiring blockchain developers.[11] They're also

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increasingly participating in consortia—the Enterprise Ethereum Alliance totaled just fifty organizations in February 2017 and now, less than a year later, hosts more than 100.

This isn't a fringe movement, either. Big players are making big bets on blockchain. Daimler issued a €100 million blockchain bond; Walmart is partnering with IBM to use Hyperledger blockchain tech to benefit food safety; Toyota is teaming with MIT Media Lab to use blockchain in developing autonomous vehicles; JP Morgan has an in-house blockchain team; Microsoft's Azure product now offers blockchain as a service.[12]

Big players are making big blockchain bets. Walmart is partnering with IBM to use Hyperledger blockchain tech to benefit food safety.

Even with all the hype and subsequent investment, however, one factor preventing wider adoption of blockchain in big business is perception. In the words of Matt Zarracina, director of innovation at Thales xPlor, "The best blockchain solutions are invisible to the user."[13] For example, few know that Nasdaq has blockchain live in production.[14] Users, frankly, don't care—they just want to check the $TSLA stock price. But this lack of credible awareness—meaning analogs from industry peers, not tweets from Paris Hilton—has made it difficult for organizations to justify investment in blockchain.

Within the telecom industry, for example, no at-scale blockchain implementations yet exist. How, then, can telecoms know where their investment dollars will be best spent? Is investment in blockchain technology even a good idea at this nascent stage?

Blockchain and telecom, intertwined

This research weaves together these two threads—telecom challenges and blockchain solutions—by detailing use cases within which blockchain technology can help telecoms develop the distributed networks of the future. First, we return to first principles: why do customers buy telecom services at all?

This may seem like a step back, and it is—but we need to ground analysis about the future in a firm understanding of the present. In reports like this, writing in abstractions and generalizations is easy, but analysis at that level often loses touch with market realities. Any insights we happen upon may not necessarily solve real problems that telecom executives face today.

Getting back to the basics, then, is (perhaps counterintuitively) the best way to prepare for analyzing the rapidly approaching age of distributed connectivity. Too often, speculative technologists use innovations like hammers searching for nails. To avoid the biases that rally around such thinking, we will focus first on the consumer and allow our work to flow from there.

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What do consumers need?

Consumers don't need products; they need what those products can provide.

Uber's strategic disruption of medallion-holding cab companies in the taxi industry is much lauded but poorly understood. Its insight wasn't only that medallions were expensive and hailing taxis by hand was annoying. Uber also recognized a *fundamental human need* and met it directly. That need was mobility; Uber's understanding of its customers as people with needs allowed it to succeed.

In some ways, Uber's innovation feels predictable—at least with 20/20 hindsight—because it mirrored Henry Ford's famous, if apocryphal, realization that founded the automotive industry: people don't want cars, they just want faster horses (i.e., greater mobility). Similarly, Uber knew that people didn't want *to own* more efficient two-ton steel boxes that sat in their driveways, they just wanted *to be* mobile.

This is why we now talk about banking, not banks; it's why Airbnb owns no property; it's why traditionally centralized industries are struggling to cope with empowered consumers. The rising sentiment is that the consumer ought to own the tools that allow her to meet her needs, as expressed so iconically by the J.G. Wentworth commercials of yesteryear: "It's my money, and I need it now!"

Ability, not ownership, is a more predictive long-term driver of purchasing decisions for consumer goods.

The lesson is that consumers don't need products, they need what those products can provide. Ability, not ownership, is a more predictive long-term driver of purchasing decisions for consumer goods.

When thinking about what telecom consumers want—the first step to understanding how we might create markets to meet those needs—

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we should think more deeply than is otherwise comfortable. We can easily get caught up in the day-to-day world of iPhones and the IoT, spectrum frequencies, and megabytes per second, but consumers don't need telecom products. They just need connectivity.

Ubiquitous connectivity is the fundamental human need that telecoms uniquely address.

People want to connect with other people—anytime, anywhere, seamlessly, and securely. They don't want to change their provider when they move; they don't want to lose service when they're out on the water with their friends; they are device-agnostic and don't care how they watch the football game as long as it can stream to their cabin in the woods; they surely don't care about which particular logo is running their service. They just want ubiquitous connectivity. That's the fundamental human need that telecoms uniquely address.

As a new era of connectivity approaches, products will change. The next iPhone may be a wearable, or an implant, or part of the IoT—or it may not. There will be another iPhone. But there won't be another connectivity. Products evolve alongside technology and consumer tastes—but fundamental human needs are less ephemeral and remain even as industries undergo fundamental shifts.

In the sections that follow, we will consider blockchain use cases that address the fundamental need for fast, affordable, secure connectivity.

Blockchain-enabled connectivity in the Horn of Africa

Today, Liya doesn't have a cellphone. She's in the majority for Ethiopia, where (some would say) Ethio Telecom dominates prices, stifles innovation, and limits the services that Liya and her fellow citizens in the rural town of Chencha can attain. She doesn't have the money to buy even the most basic service; she's unbanked and survives on about two dollars a day (roughly average in the Horn of Africa).

Liya could benefit from connectivity. Perhaps a reliable, affordable, attainable cell phone connection—even if only fast enough for a voice call—could help her connect with her cousin who lives in the United States, or attain private tutoring from a teacher in Addis Ababa. Liya wants, and could make good use of, a connection to the rest of the world.

Could blockchain technology enable the connectivity she needs?

Imagine a future in which being unbanked is the *norm* not only for the ultra-poor, but for nearly everyone—one in which value exchange doesn't depend on third-party institutions like banks. Imagine a future in which weather balloons and satellites from a wide variety of companies provide cheap, reliable, and ubiquitous connectivity to Liya and the rest of the "next billion" consumers in Africa—and in which any phone can connect to whichever carrier happens to have the best coverage for Liya's hometown at a given time.

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In that world, Liya can be connected—no matter what her government, its permitted monopolies, and the orthodoxy of telecom economics would suggest is likely, or even possible, today.

21 billion connected "things" will be online by 2020.

Speed: 5G and the network of the future

Fifth-generation wireless technology (5G) is coming and looks to be revolutionary, but it won't be easy to build and manage the network of the future.

A 2015 iGR study estimated that 5G would require up to ten years and an investment of more than $100 billion to roll out.[15] The technical challenges are immense: from acquiring and standardizing higher frequencies of wireless spectrum (e.g., mmWave), to deploying a vast network of smaller access points (e.g., micro- and picocells), to supporting the 21 billion connected "things" that will be online by 2020.[16]

With this generational change incoming, telecoms are wisely looking to innovate. How best to manage a more distributed network, one in which both the number of devices and number of cell sites are orders of magnitude greater than in the 4G/LTE world? How is a network to secure so many "things," all while maintaining reliability and guaranteeing the faster connectivity so widely expected by the public?

The challenges of building these new networks are many, but two may be particularly germane to our discussion of distributed connectivity: *distributed network management* and *inter-carrier collaboration.*

Two challenges are particularly germane to distributed connectivity: distributed network management and inter-carrier collaboration.

The former is a concern primarily felt by traditional, larger telecom players—today's market leaders whose networks differentiate through sheer geographic coverage. These carriers have the necessary capital to deploy 5G networks nationwide and will drive the adoption and standardization of 5G technologies. These carriers have already realized, however, that this transition is quite unlike those of the past. No longer can networks be upgraded simply by attaching new antennas to old towers; the new, distributed 5G networks will require a stepwise improvement in network management. This area has been primed for innovation, and carriers have already begun to explore creative options like NFV/SDN.

The latter concern is one felt by smaller players—those of a scale (or, in the case of nontraditional players like Google, of a scope) in which massive network deployment is infeasible or otherwise ill-advised. These players will need to master inter-carrier coordination to an extent not yet seen, to compete effectively.

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Use case 1: Distributed network management

In 2015, Verizon cut a wide swath through the yet-unexplored world of telecom blockchain technology with its investment in Filament, a blockchain start-up nominally focused on enabling the IoT at the industrial scale.[17]

The news release alongside the $5 million investment (which Verizon led through its venture arm) highlighted the lofty vision of the start-up and its investors:

> *Imagine a world where the cloud is no longer the centralized place connecting our fitness trackers or smart thermostats to a distributed network of computers. Instead, these connected objects are able to communicate directly with each other because they are built on blockchain. … In addition to eliminating the cost of storing data in the cloud, blockchain's network evolution can also enable the smart cities we anticipate in the near future. Exactly how will blockchain's capabilities help cities operate more intelligently without deploying massive costs? This is where Filament comes in.*[18]

That message draws a direct line from smart thermostats to smart cities, and embeds a casual disruption of cloud technology within. It was a grand, ambitious vision given the state of blockchain (and IoT) technology in 2015, but Verizon's investment seems to have gone according to plan: in March 2017, Verizon Ventures led a follow-on round for Filament, securing an additional $15 million in funding.[19]

Blockchain's network evolution can not only eliminate the cost of storing data in the cloud but also help cities operate more intelligently without deploying massive costs.

In early interviews, Filament claimed customers ranging from the Fortune 50 to smaller companies across manufacturing, oil and gas, agriculture, and mining—but Filament has largely operated in stealth mode to date.[20] The only clues to its future plans lie in the ambitious

Cyberspace 2784907 by Michael Jarmoluk (jarmoluk), 2017, used under CC0 1.0.

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"applications" section of its website, but Verizon's confidence in the company gives credibility to our first intuitively plausible use case for blockchain technology in telecom: management of a highly distributed network.

In a world where network technology is distributing—with 5G exponentially increasing the number of entry points to the average wireless network and NFV/SDN making each piece of that network flexible and dynamic—such solutions may prove to be a necessity.

Consumers don't care if they're browsing the web via smartphone, smart TV, smart car, or smart fridge—they just want ubiquitous access to content on the go.

Similar tests in this space include Ubirch's proof of concept of blockchain-powered IoT sensors and analytics aboard the *Serenity*, and British Telecom's patent for blockchain-enabled access control.[21] The latter suggests that some telecom players are moving beyond the IoT to core network management in their applications of blockchain, a solution that may gain more popularity as networks continue to decentralize.

Use case 2: Inter-carrier coordination

In a world of distributed connectivity, the business model currently pursued by *mobile virtual network operators* (MVNOs) may find increased popularity as consumer preferences shift and technology improves.

Consumers are quickly becoming device-agnostic—they don't care if they're browsing the web via smartphone, smart TV, smart car, or smart fridge, they just want ubiquitous access to content on-the-go. As noted, future consumers may not even care which provider supplies their service.

Concurrently, high barriers to entry and low asset utilization in the telecom industry are making the MVNO business model look ever more attractive. 5G will be expensive, and for those players who can't afford billion-dollar buildouts, microtransactions and smart contracts enabled via blockchain may prove invaluable tools for next-generation asset management and leasing.

Microtransactions and smart contracts enabled via blockchain may prove invaluable tools for next-generation asset management and leasing.

In an unabashedly futuristic report, Huawei wrote of that possibility:

> *[A] blockchain framework will assist a new generation of distributed wireless networks by allowing seamless provisioning between heterogeneous access nodes and devices. With blockchains, provisions and agreements between access nodes, networks, and subscribers are negotiated on the fly as digital smart contracts. Any device can negotiate the best service, and the carrier can dynamically adjust the code in the smart contract in any network node. This permits seamless services and new charging and business models among networks, providers, and 5G access nodes. Blockchain-enabled mobile services can be adapted to location and subscriber needs, and adjusted to supply and demand.*[22]

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That vision may seem implausible, but players both traditional and unconventional within the telecom industry are taking small steps to inch it closer to reality.

Sprint, for instance, announced the launch of a "consortium" with blockchain player TBCASoft in September 2017, and successfully demonstrated "cross-carrier top-ups, mobile wallet roaming, international remittances and IoT payment on a cross-carrier payment platform system using TBCASoft's blockchain technology that can be integrated with telecom carriers' existing systems."[23]

Nontraditional players in the Wi-Fi marketplace are looking to monetize idle bandwidth just as Uber monetizes idle cars.

BitMesh, a nontraditional player, also announced a collaboration-first product—a Wi-Fi marketplace that hopes to monetize idle bandwidth just as Uber monetized idle cars.[24] Such statements, again, feel more hopeful than practical, but they make future collaborative efforts seem feasible. What if future players used blockchain-based smart contracts to lease high-frequency spectrum from larger players, or even the government, in real time on an at-need basis?

Such blockchain-based innovations could be the key to providing ubiquitous 5G connectivity and thereby ensuring that the speedy networks of the future reach everyone—from the customers of the big players who want to manage distributed networks, to those of the smaller players who can seamlessly tap into next-generation networks, thanks to invisible but powerful innovations in inter-carrier collaboration.

Affordability: Profitability and payments innovation

The elephant in most telecom boardrooms today is that margin pressures have intensified significantly.

One reason for this pressure is the result of new, lower-margin communications technology: as the market underwent a series of transitions—from home phone, to long distance, to wireless, to DSL, to high-speed, to TV—lower-margin products have replaced higher-margin products. Most obviously, home phone was traditionally the segment with the highest margin, yet it is all but nonexistent today.

The elephant in most telecom boardrooms today is that margin pressures have intensified significantly.

Concurrently, markets in North America and abroad have faced pressure from disruptive players, like T-Mobile (a disruption-loving "un-carrier" that drastically altered telecom pricing strategy in the United States[25]) or Reliance Jio (a carrier that offers unlimited calling/roaming and data at one-tenth of the market rate in India).[26] The power in the telecom industry may be more distributed today than it was in ages past, and industry dynamics are rapidly changing as a consequence.

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The net result of these shifts and many more like them is that telecoms are looking for innovative ways to generate additional revenue and ease margin pressures—and many are turning to payments innovation as an area for exploration. Where payments go, so goes blockchain.

Many telecoms are turning to payments innovation as a means of generating new revenues and easing margin pressures. Where payments go, so goes blockchain.

Many people still consider Bitcoin and blockchain to be synonymous, through little fault of their own. A recent McKinsey article defined blockchain as "a digital system for executing and recording financial transactions," which isn't untrue but is roughly equivalent to describing an autonomous electric vehicle as "a machine that can pull itself out of your garage."[27] The true impact of blockchain is often found far from the particular use case of digital currency, and telecom executives would be wise to look beyond the financial world to uncover the true value of blockchain technology.

That said, because financial companies were the first to understand blockchain fully, a number of use cases for blockchain tech in payments innovation have been developed, some of which are particularly useful to financially pressed telecom companies, like transaction services and micropayments.

Use case 3: Transaction services

The boundary between communications services and banking is quickly blurring in developing telecom markets. Take mPesa, a Kenyan mobile payments service.

In 2007, Vodafone's Safaricom released a system for sending small payments from person to person using only text messaging on mobile phones. In the ten years since, that service—mPesa—has

Aerial 1880864 by Alberto Adán (Albertoadan), 2016, used under CC0 1.0.

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been credited with pulling hundreds of thousands of households out of extreme poverty and processing more than six billion transactions in 2016 alone. Vodafone has since launched similar services in nine more countries across Europe, the Middle East, Africa, and Asia.[28]

The boundary between communications services and banking is quickly blurring in developing telecom markets.

In the United States, a similar blurring of boundaries between traditionally distinct industries has taken place. Of all customer banking transactions, 85 percent are now completed via digital channels; peer-to-peer payment enablers like Venmo and PayPal are skyrocketing, growing the volume of P2P payments nearly 50 percent year over year to hit $147 billion in 2016; and AT&T even filed a patent for in-car cryptocurrency payments in April 2017.[29]

Could telecom companies help bring about the next revolution in banking? Telecom operator Orange is betting on it. In 2015, Orange joined Visa, Nasdaq, Citi Ventures, and Capital One in a $30 million Series C investment in Chain, a company that enables financial services using blockchain technology. Adam Ludwin, Chain CEO, said after the investment:

> *We are pleased to partner with Orange to explore the use cases of blockchain in the telecommunication market. We believe that these new networks will simplify data transfer between carriers and activate new services that will make it possible to improve the end-user experience.*[30]

The world of mobile money is quickly changing, and blockchain is at the fore. In fact, mPesa itself may be on the verge of disruption by blockchain technology—for many of the weaknesses of mPesa, such as high "gatekeeper fees" and centralized, slow innovation, are addressed directly by the benefits of blockchain-based cryptocurrencies. Bitwala, a blockchain-based payment services provider, now allows its users to send Bitcoin to any mPesa customer free of charge.[31]

The true impact of this deal, announced in March 2017, is still yet to be seen—but with blockchain's early traction within legacy financial services, this use case may prove a reliable bet for telecoms looking to explore the technology and ease margin pressures with new value-added services.

Peer-to-peer payment enablers like Venmo and PayPal are skyrocketing, growing the volume of P2P payments nearly 50 percent year over year.

Use case 4: Micropayments

Connections within the distributed network of the future are likely to be many, varied, and micro. The IoT may cause a proliferation of devices, but each will need only fractional bandwidth to operate effectively. In that future, use cases that require micropayments—or network interactions worth only cents or fractions of cents—abound.

As mentioned, AT&T recently filed a blockchain patent for in-car payments—a first stake in the ground of what could be a massive market (particularly after autonomous vehicles hit the mainstream).

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For fun, let's imagine a road trip in 2035. We order a vehicle for a nominal fee; we're charged for every volt of electricity the car consumes on the trip; we pay a small toll for every mile traveled on the highway, and micro-amounts to each car we're allowed to pass (because we're in a hurry); we stream an in-trip movie through a peer-to-peer network, offering fractions of cents to every car from which we borrow bandwidth; the data from each mile we travel are recorded and sold to car companies to improve their autonomous vehicle algorithms, which helps offset the marginal cents that get charged to our insurance bill for every minute we spend on the road. Get the picture?

In a distributed future of microconnections, micropayments become a necessity. Today, the marginal economics just don't work: current-state transaction processing fees make micropayments prohibitively expensive. We may find the future state of such transaction processing, then, in a blockchain solution.

In a distributed future of microconnections, micropayments become a necessity. Today, transaction fees make micropayments prohibitively expensive. Blockchain may change the economics of such transaction processing.

For an example of micropayments in action, take earn.com, a platform for requesting e-mail responses from high-profile individuals (e.g., famous venture capitalists, start-up founders, CEOs) in exchange for fractional amounts of bitcoin. They process these payments through a mixture of "on-chain" transactions (i.e., fully processed through Bitcoin), "off-chain transactions with BitTransfers" (i.e., subsets of payments written into a buffer technically outside of Bitcoin to avoid the inefficiencies of on-chain processing), and "micropayment channels," a non-rate-limited transaction type that waits for users to "flush" (withdraw) their currency before processing transactions through Bitcoin.

The path from what earn.com has already implemented to micropayments for telecom services is linear and doesn't extend over too far a technical horizon. Smaller transaction fees through scaling mechanisms such as Lightning Network or Raiden could make on-chain micropayments economically viable in the not-too-distant future. If they do, blockchains could be the key to unlocking those use cases that micropayments enable: increasing asset utilization and finding creative avenues for next-generation monetization of mobile services.

Micropayments could be economically viable in the not-too-distant future.

Security: Maintaining control of a distributed network

In December 2016, Yahoo—still in crisis mode after its September announcement that 500 million user accounts had been hacked—disclosed yet another security breach, one even larger than its first. The attack, it estimated, compromised more than one *billion* accounts. The public's response was one of justifiable fury. The full extent of the attack was communicated just months after similar data breaches by Target and Sony PlayStation (and months before

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those of Home Depot and Equifax). Massive losses of personal identification information were, and still are, quickly becoming a trend. Why can't corporations protect their customers?

Nick Szabo, a blockchain pioneer and the inventor of smart contracts, offered one theory in the wake of the second Yahoo breach. His refrain was simple, but powerful: "Trusted third parties are security holes, and data is ludicrously easy to copy."[32]

"Trusted third parties are security holes, and data is ludicrously easy to copy."

NICK SZABO

Since that date, Nick has tweeted variants of that quote no fewer than six additional times, each in response to a new breach—including Verizon's loss of data on more than 14 million customers, data exposed on an unprotected Amazon Web Services server.[33] These attacks—and the vehement public responses to them—have left companies wondering if it is time to step up their cybersecurity and cryptography.

This problem is particularly pronounced in the telecom industry because of the sheer amount of data that flows through a modern network. These networks often depend on third parties, like international roaming clearinghouses, and—as we have learned—those third parties are potential security threats.[34] In all, telecom operators are losing an estimated $38 billion yearly to roaming, identity fraud, and related prevention measures, even before accounting for reputational damage and increased churn by security-conscious customers.

Telecoms need solutions to these problems, and blockchain tech for disintermediated international roaming, consolidated digital identity, and securing the "things" may fit the bill.

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Use case 5: Disintermediated international roaming

Let's pretend that we're AT&T customers traveling abroad to a nation that is covered only by Telefónica. We want to place a call. Thanks to the roaming agreements between those carriers, we can do so.

Telecom operators are losing an estimated $38 billion yearly to roaming and identity fraud.

Today, that process works something like this: our phones ask a Telefónica tower if they can place a call; the Telefónica tower asks a central database if we're allowed to receive those services, and we are; the Telefónica tower then provisions us the services we request and sends a *call detail record* (CDR) through an international *data clearinghouse* (DCH) to AT&T, so that it can bill us, and back to Telefónica, so that it knows how much to charge AT&T.

It's a simple process but, as Nick Szabo would instantly realize, it relies heavily on third-party validation by the DCH, which is a security hole.

The following is an excerpt from a 2015 interview with Guy Feiffer, a vice president of Starhome Mach, one of the two largest roaming clearinghouses in the world:

> *[T]he biggest issue with the legacy method is the disconnect between the clearing of billing records and the settlement. The clearance process is complicated enough since several hundred operators are usually being billed off one platform.*
>
> *However if billing and settlement are not fully integrated, you end up with big data integrity problems. And this creates a kind avalanche situation [sic] where thousands of error-filled invoices are created, and it takes great effort and time to get them resolved.*
>
> *Legacy systems also create a large queue of outstanding payments that can cause severe cash flow problems. So the whole process is archaic and very manual driven. …*
>
> *[B]elieve it or not, much of the industry still relies on paper invoices, so if your document scanning technology is weak, it's hard to do the conversions properly, so you end up having to input invoices manually.*[35]

The representative continues to explain that Starhome Mach has introduced solutions to modernize those "legacy methods," but these kinds of problems with roaming fraud still exist today. The GSMA (Groupe Speciale Mobile Association), a telecom standards and advocacy body, introduced "Near Real Time Record Data Exchange" guidelines that are now the industry standard—but companies that offer those services suggest that "near real time" means anything from 15 minutes to four hours.[36]

If based on blockchain technology, conversely, CDRs could be exchanged *instantaneously* as an automated result of the provisioning request—and, as blockchain protocols are wont to do,

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DCHs would be disintermediated out of the process altogether. A smart contract for international roaming could be a simpler, more secure mechanism for exchanging billing information and authorizing network access, and could prevent roaming fraud by eliminating a third-party security hole and improving the efficiency of inter-carrier communication.

A smart contract for international roaming could be a simpler, more secure mechanism for exchanging billing information and authorizing network access, and could prevent roaming fraud.

Use case 6: Consolidated digital identity

Managing digital identity is a problem for consumers. A 2016 Intel Security survey found that the average individual has 27 independent online identities, and keeping a hold on those accounts is a significant pain point.[37] Identity management is also a significant problem for telecoms; stolen identity and illegitimately acquired *subscriber identification module* (SIM) cards are another major source of telecom fraud.[38]

Blockchain is uniquely suited to enable digital identity management; advances in this space have been driven in large part by partnerships between governments and private companies: the Republic of Georgia recently announced a land titling project through a partnership with Bitcoin mining company BitFury.[39] Estonia has released a campaign, deftly branded as "e-estonia," through which its "*keyless signature infrastructure* (KSI) blockchain" product offers identity verification through ID cards.[40] The state of Illinois unveiled a "Blockchain Initiative" in late 2016 to explore digital currencies and applications for digital ledger technologies within government.[41]

Most notable among these solutions is a partnership among SecureKey Technologies, IBM, and the Canadian government geared toward creating a digital identity network.[42] The project is ambitious, hoping to unite Canada's leading banks behind a unified system, but the team looks to have the technical expertise to make it work—

The average person has 27 independent online identities. Blockchain is uniquely suited to enable digital identity management.

Telecom 339828 by Luis Wilker Perelo WilkerNet (wilkernet), 2014, used under CC0 1.0.

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the solution will use IBM's Blockchain and Linux's open source Hyperledger Fabric.

eSIM technology: A potential solution?
Some analysts suggest that blockchain-based eSIM technology is a potential solution—blockchains provide security, and an eSIM could be more easily activated/deactivated—but that solution misses the mark in two key ways.

First, eSIM technology doesn't need blockchain to operate effectively. In fact, the latest Apple Watch 3 *and* the Samsung Gear S2 3G have eSIM tech today.

More importantly, self-interested carriers should consider the competitive dynamics that surround the eSIM decision. Would carriers really want to allow device manufacturers to sidestep telecom operators and control customers end to end?

Could similar solutions and partnerships provide an answer to identity fraud for telecoms? The results of these early banking experiments could speak to the feasibility of these solutions, and the potential is undeniable. The future may be one in which digital identity is commonplace. In the words of IDC's Stewart Bond:

> *There will be one digital representation of an individual, shared across institutions, service providers, and retailers; giving that individual the ability to control what personal data will be shared and with whom, protection from identity theft, all with validated, correct and immutable data integrity—it's about time.*[43]

Use case 7: Securing the "things"

The Internet of Things is a beachhead, the first location at which the macro-trend of distributed connectivity has made contact with the mainstream market.

Analysts suggest that the transactions enabled by the IoT could total more than $3 trillion by 2020. That estimate is built on the assumption that in 2020, there will be more than 20 billion "things"—compared to just 6.3 billion today—which comes out to roughly five connected items per person worldwide.[44] To call that change a proliferation hardly does it justice. Just a few years ago, those numbers would be unfathomable to network architects and telecom executives.[45]

The world has changed. Today, executives (and their consultants) understand that the Internet of Many, Many Things is coming and networks need to be prepared to adapt. The final—and perhaps most promising—use case covered in this paper is a blockchain solution for securing a network with an exponentially growing number of entry points and potential attack vectors.

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To understand the need better, consider the challenges that a (anthropomorphized) fitness monitor would face in the future. The monitor actively collects data—very sensitive data, data regulated by the Health Insurance Portability and Accountability Act (HIPAA)—and needs to decide which of the many devices requesting that data it should trust. How can Ms. Personified Wearable make sure that she sends information only to the right things?

Today, the question is how to authorize connections securely between things. Blockchain may be the answer.

IBM and Samsung are two key players in this subset of the IoT market. Their *autonomous decentralized peer-to-peer telemetry* (ADEPT) proof of concept showed their ability to deliver the three key features of an IoT network using blockchain: P2P messaging, distributed file sharing, and autonomous device coordination. With the natural cryptographic standards built into blockchain technology, then, the ADEPT team is bullish on the potential impact of its work:

> *Distributed systems like ADEPT can make businesses and consumers more efficient and open a huge range of economic opportunities. These technological changes could foretell the biggest revolution since the origin of general purpose computing and transaction processing systems. Future commercial systems may exist as hybrid centralized-decentralized systems depending on the value, longevity, and application of devices on the IoT. The feasibility of ADEPT paves the way for augmenting today's centralized IoT solutions with more decentralized capabilities.*[46]

Blockchain enables three key features of an IoT network: peer-to-peer messaging, distributed file sharing, and autonomous device coordination.

Other large players have also shown their interest in IoT security through blockchain technology. Most notably, Tencent, the Chinese Internet conglomerate that owns WeChat, announced a partnership with Intel to develop a new standard for blockchain IoT security called TUSI: the Tencent User Security Infrastructure. Together, Tencent and Intel hope to make strides toward additional hardware security within the IoT world—much like the partnerships struck between Thales, a world-leader in hardware security, and blockchain-native companies like Chain and Gem.[47]

The distributed world will pose both challenges and opportunities—and by pursuing the use cases above, some telecom players may find outsized rewards by making early bets in these burgeoning industry segments.

Risks, limitations, and mitigation strategies

The previous sections have built the case that blockchain technology has the potential to solve significant problems for telecom executives.

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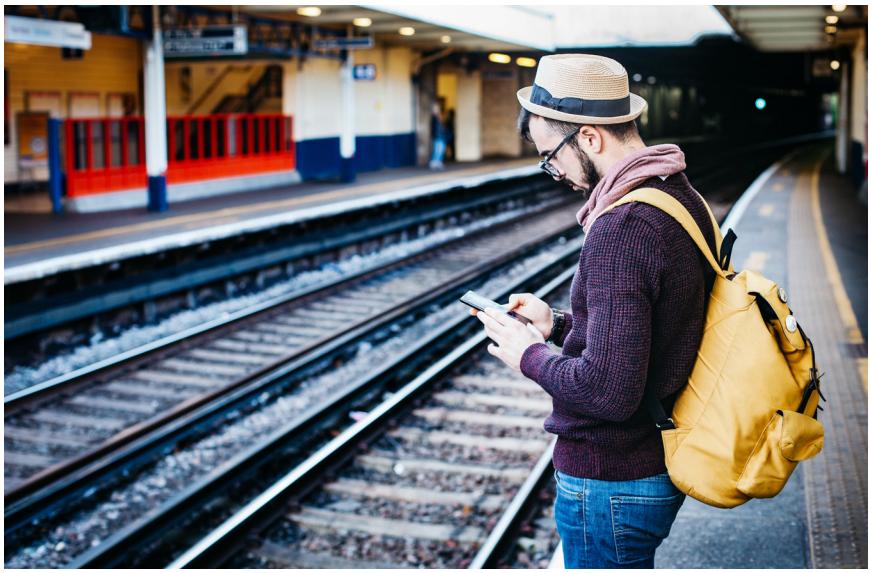
This report would be incomplete, however, without a sober reflection on the challenges that blockchain technology will face as a fledgling, unproven entrant in a complex regulatory, operational, and historic context.

These concerns are valid and deserve a thoughtful response, because technology solutions don't exist in a vacuum. This is often forgotten (or ignored) by evangelists who attempt to drive early adoption through blind optimism and hyperbole.

Technology solutions don't exist in a vacuum. Blockchain is a fledgling, unproven entrant in a complex regulatory, operational, and historic context.

In the end, the news is good for all—industry skeptics and technology evangelists alike—because the largest risks for telecom operators have already been explored by many smart developers, companies, and government agencies. Accordingly, strategies exist to mitigate even the most daunting risks, and telecoms that proactively spot and mitigate such risks will have a greater chance to succeed in the new age of distributed connectivity.



Clem Onojeghuo 141803 by Clem Onojeghuo, 2016, used under CC0 1.0.

Regulation

The sentiments most often attached to blockchain, at least from the point of view of the public, are "FUD"—fear, uncertainty, and doubt—undoubtedly driven by several high-profile crackdowns on blockchain-related technologies.

The first, and harshest, was the bust of Silk Road, a cryptographically secured marketplace for illicit trade. Run by "Dread Pirate Roberts" and operating on the dark web, Silk Road sold upward of $1 billion of illegal drugs in less than three years.[48] After the FBI captured DPR and took his site down, any number of news articles were published that linked cryptography with illegal activity—well-branded by some as the "sin economy." This association has proven hard to shake from public consciousness.

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More recently, China announced a flat-out ban of *initial coin offerings* (ICOs), a move that signaled doom and gloom to many bitcoin speculators and caused the price of Bitcoin to fall from $4,900 to $4,200 (-14%) in a single day.[49]

Nearly all global regulators have adopted a wait-and-see-and-learn approach to regulating blockchain.

These examples are spectacular, and therefore available (in the psychological sense of the word) to individuals who know something about blockchain but follow the news about it only infrequently. In large companies, regulation of blockchain is raised as a major risk. What happens if another bust or ban ensues, and a company's blockchain investments are either nullified or overshadowed by reputational losses?

These concerns are fair—but the regulatory outlook isn't nearly as grim as public perception may lead us to believe. Michèle Finck, senior research fellow at the Max Planck Institute for Innovation and college lecturer at the University of Oxford, painted a very different picture of blockchain regulation—one of uncertainty, surely, but one that replaces fear and doubt with optimism and positive intent:

> *First and most predominantly, regulators have been adopting a "wait-and-see" approach to regulating blockchain. They're fully aware of what's happening, and they're curious. Like many people, they're trying to learn more about blockchain, but they're not doing anything yet.*[50]

She continued to explain that nearly all global regulators have adopted this wait-and-see-and-learn approach.

When asked about the regulators who bucked that trend, Finck acknowledged the iconic China ban and Silk Road bust but called those activities "rare." Other regulators have largely adopted experimental approaches such as regulatory "sandboxes"—as the United Kingdom has attempted for fintech in general, and Canada has applied to ICOs in particular.

Overall, however, Finck believes that governments are more eager to support and harness blockchain innovation than to stifle it. As mentioned above, Georgia, Estonia, Canada, and the State of Illinois have all experimented with blockchain innovations in identity management—a clear attempt to use the technology to solve public sector problems.

Governments are more eager to support and harness blockchain innovation than to stifle it.

Similarly, many government bodies are making deliberate moves to enable and support blockchain innovation to become the Silicon Valley equivalent for blockchain. The best example is the aptly nicknamed "Crypto Valley" of Zug, Switzerland, a locale that offers low taxes, friendly regulations, and a supportive government to all prospective blockchain companies—a strategy that successfully brought the Ethereum Foundation headquarters to this previously pastoral town in the Swiss countryside.[51] Similar blockchain-enabling governments include those of Ukraine, Kazakhstan, Singapore, and Dubai in the United Arab Emirates.[52]

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In 2014, Tom Wheeler, then chair of the Federal Communications Commission, said in relation to innovative technology:

> *We cannot hope to keep up if we adopt a prescriptive regulatory approach. We must harness the dynamism and innovation of competitive markets to fulfill our policy and develop solutions. This new paradigm … needs to be more dynamic than rules, and—this is a key point—it needs to be more demonstrably effective than blindly trusting the market.*

Regulators understand—or are proactively learning—the potential benefits of blockchain technology. The role of the interested telecom executive, then, should be to participate actively in the shaping of new regulatory frameworks, rather than sitting on the sidelines and hoping future bans don't cascade down from on high. There are features of blockchain that should appeal to government—for example, immutable ledgers could prove instrumental to audits and compliance inspection—and if telecom leaders invest now in those relationships by taking a proactive approach, they have little to fear.

"I expect more convergence between law and technology in the future," Finck said. "Blockchain can actually help governments achieve what they want … so innovators may come to realize that it is in their benefit to have a friendly, proactive relationship with regulators."[53]

Scaling

In 2016, the world consumed more than three billion gigabytes of data over the Internet *per day*, which equates to 1.2 zettabytes per year. By 2021, experts predict the flow of traffic over IP will nearly triple.[54] Mobile networks will carry only a fraction of that traffic, but the challenge is still immense: mobile is expected to increase seven times from 2016 to 2020 and may ultimately handle 20 percent of all IP traffic.[55]

Long story short—lots of traffic flows through the Internet in general and wireless networks in particular, and blockchain technology will need to scale massively in order to enable a number of the more ambitious use cases outlined above.

Mobile traffic is expected to increase seven times from 2016 to 2020 and may ultimately handle 20 percent of all IP traffic.

At the moment, Ethereum, one of the leading blockchain protocols, can handle about 13 transactions per second.[56] For comparison, Visa can process more than 24,000 transactions per second, and Facebook is on the order of 175,000 data requests per second.[57] By any estimate, Ethereum is multiple orders of magnitude away from handling an enterprise-level application. Notably, a Tamagotchi-for-blockchain game called "CryptoKitties" recently caused major congestion in the Ethereum network, increasing the number of unprocessed Ethereum transactions almost six-fold.[58] Telecom executives may be thinking, "If blockchain can't handle *kittens*, it surely can't handle my network."

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That's the bad news. The good news is that everybody knows the bad news. Many consider scaling to be the primary limitation of blockchain technology, and so developers are working on many promising solutions.

Many consider scaling to be the primary limitation of blockchain technology, and so developers are working on many promising solutions. There's Raiden for Ethereum and Lightning Network for Bitcoin.

For Ethereum, there's Raiden, a solution that allows the processing behind transactions to occur "off-chain," meaning, not all processed through blockchain code. The transactions are still secure, but not all intermediate steps are recorded on and executed through the blockchain itself, which allows transfers via Raiden to occur instantaneously and for no charge.[59] (A similar solution called the Lightning Network is working toward the same goals for Bitcoin.[60])

Even outside those high-level efforts, however, individual companies have ways to relax blockchain features slightly to improve speed.

For example, there's "sharding," a solution named after database sharding in which smaller pieces of a large database are stored on different servers. In the blockchain iteration, the full history of all blockchain transactions is no longer required to exist at every node in the network—which may reduce the "trust-free" feature of blockchain but drastically improve speed.[61]

Even more simply, telecoms could choose to apply the 80/20 rule in deciding which customer segments to keep on-chain. In the roaming fraud use case, for example, telecoms may want to keep only high-volume business travelers and other frequent roamers on-chain. Doing so wouldn't require any special technology like Raiden, just an intentional choice to process some, but not all, traffic through the blockchain protocols before they can scale to support the full enterprise.

Cig Break by Igor Ovsyannykov, 2017, used under CC0 1.0.

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It's difficult to estimate how fast Ethereum and other blockchain applications will scale, but Fred Ehrsam, the co-founder of popular cryptocurrency exchange Coinbase, predicts that Ethereum may see a 100-fold improvement by the end of 2018.[62]

We are still in the early stages of bringing blockchain technology to the scale of modern business, so when considering the challenges of scalability, patience is perhaps the most effective strategy.

When billions of dollars are secured by code, that code had better be perfect.

"Code is law"

In May 2016, 14 percent of all the world's Ether—or $8 billion of cryptocurrency, based on 12 December 2017 prices—was put into a *decentralized autonomous organization*, a grand experiment in smart contract technology that resembled an entirely democratized investment fund. The DAO, as it became known, was the largest crowdfunding campaign in history.[63]

The logic behind such incredible investment was clear: fund operation would be based on cold, hard code, and therefore wasn't subject to the whims of any particular fund manager's blind intuition; power was distributed such that, while the wisdom of the crowd made investment decisions, nobody could run away with the money. Until someone did.

In June 2016, a hacker exploited a miswritten line of code that allowed the hacker to repeat automatically small withdrawals of ether from accounts while keeping the balances apparently unchanged. The hacker walked off with over $50 million in ether, shut down the DAO, and forced the community into a contentious debate about how and when to reclaim the stolen currency.

The specifics aren't important here, but the larger message is: when billions of dollars are secured by code, that code had better be perfect. Inevitably, however, human beings are still involved in the equation. Klint Finley, writing for *Wired*, concluded:

> *[D]espite the Ethereum team's best efforts, machines will always be subject to the messy politics of the human world. But that also might end up saving the project. The heist has divided people and exposed the inevitability of human weakness. But it's also bringing people together to fix things. Humanity is making that possible, not mathematics.*[64]

That "code is law," according to Professor Omer Ayfer, is the biggest challenge facing blockchain today. "After a mistake made by a traditional bank," he said, "there is a way to plead with a person and reverse the mistake. With immutable blockchains, that backup doesn't exist. You need the software to be perfect, but software is never perfect. There are always bugs."[65]

One of the things that scares long-term investors is the realization that so few people are actively working to develop these massive,

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global, billion-dollar cryptocurrencies. Bitcoin's market cap is now more than $290 billion, and the core development team is made of *14* people.[66] For comparison, PayPal has a $52 billion market cap and *18,000* employees.[67]

Bitcoin's market cap is now more than $290 billion and the core development team is made of 14 people.

Blockchains themselves may be nothing more than code, and therefore infallible executors of programmed functionality, but the developers who write that code are undeniably fallible, and the consequences can be great if they make even small mistakes.

Gray Asphalt Road Between Green Grass and Gray Electric Post during Daytime by anonymous, 2015, used under CC0 1.0.

Compounding this problem is the long time-horizon to which blockchains must look ahead. Consider a land registry, a classic "no-brainer" blockchain use case being implemented by forward-looking companies around the globe. To be useful, such registries must stay archived for decades—and if it's already difficult for us to guess how blockchains will scale next year, who could possibly predict with confidence what will happen over the next hundred years?

Should any company succeed in producing a chip with 50 qubits, we will pass the point of "quantum supremacy"—where quantum computers outperform traditional computers and undermine the digital signature scheme used in blockchain technology.

To explore a slightly (but not wholly) tongue-in-cheek example, consider quantum computing. Classical computing scales linearly—add another bit and you have another unit of computing power. But quantum computing scales exponentially, with each "qubit" doubling the computational power of the machine. These machines sound far-fetched, but the possibility that future computers will be quantum-based is gaining credibility: in October 2017, Intel announced that it produced a chip with 17 qubits.[68] That's equivalent to 131kb—still far smaller than a commercially viable chip, but we should remember how quickly exponentials scale. Should any company succeed in producing a chip with 50 qubits, we will pass the point of "quantum supremacy"—where quantum computers outperform traditional computers—and at 256 qubits, the cryptographic standards built into Bitcoin may be at risk of falling to a brute force attack from a super-quantum computer.[69]

Over the next hundred years, technology will change significantly, and so blockchain developers should think ahead, way ahead, when designing their products today. Perhaps they will need to sacrifice some of blockchain's darling features to make for a smoother

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transition—such as relaxing immutability standards as long-term systems are given time to initialize, or creating more robust testing grounds for new features (like the Bitcoin-SegWit experiments hosted live on Litecoin).

That solution is unlikely to appeal to blockchain hardliners, but may be necessary to prepare for a future where code is law and the wiggle room offered today by human influence is slowly but surely surrendered to (quantum-computed) blockchain-enabled systems.

Some telecom executives are beginning to think that this blockchain stuff is worth a second look.

Recommendations: Minimum viable blockchains

Some telecom executives are beginning to think that this blockchain stuff is worth a second look. Others are leading a network group and know that blockchain technology can transform their business but don't know where to begin investing time and resources. Still others manage a nontechnical business unit and are armchair blockchain enthusiasts who want their senior leadership to understand the transformative potential of this new technology.

All of them want to know the tangible steps that they can take to explore blockchain within their organization. Here are a few recommendations.

Education: Start learning

When asked the question, "Where to begin?" Matt Zarracina, director of innovation at Thales xPlor, hardly hesitated before answering: "Education. You have to get the decision-makers in your organization informed."[70]

Many other interviewees agreed—the biggest hurdles to blockchain adoption are misinformation and no information at all. An important first step toward prioritizing use cases and aligning of definitions and strategy is to get both the executive team *and* the business units that will execute on blockchain initiatives informed.

The biggest hurdles to blockchain adoption are misinformation and no information at all.

Some managers have found that the best use cases are identified only after explaining blockchain to technical teams—especially those in charge of technology implementation or management. For example, after a leading technology consulting firm explained blockchain to its SAP (Systems Applications and Products) implementation practice, the technical experts fully bought in, and brainstormed use cases that would never have occurred to their nontechnical evangelists.

Similarly, many leaders—like Zarracina—attempt to create a common baseline understanding within their own organization *and* between

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their company and their clients, by aligning all stakeholders around a common set of definitions for blockchain and helping them agree to a strategic direction for additional R&D.

If business unit leaders and executive managers still believe blockchain to be synonymous with bitcoin—or harbor other misconceptions, like those negative associations with the sin economy—then securing a meaningful investment in blockchain technology will be difficult.

Education comes first. All other steps conditionally follow.

This may sound like sacrilege within the über-competitive telecom industry, but in times of great technological change, innovations are not always zero-sum.

Partnerships: Collaborate with start-ups, labs, and even competitors

This may sound like sacrilege within the über-competitive telecom industry, but in times of great technological change, innovations are not always zero-sum. Consider, for example, how the financial industry has come together to expedite the advance of blockchain technology.

Born in September 2015, the R3 consortium has rallied more than 100 global financial institutions and regulators behind the development of Corda, a blockchain-based protocol for financial services. In May 2017, investors like Bank of America, HSBC, and Intel poured $107 million into the joint effort—a huge vote of confidence in the prospects of cooperative technology development.

"Innovation in digital technologies is reshaping the banking industry," said Andrew Challis, managing director of strategic investments at Barclays, "and this investment is reflective of our belief that distributed ledger technology and smart contracts have the potential to significantly enhance capital markets infrastructure. R3's collaborative approach is key to the progress of this technology."[71]

Other organizations might consider less kumbaya, but equally effective, partnerships outside their industry to drive blockchain research and adoption. For example, Toyota is working with the MIT Media Lab, Gem, and BigchainDB, a blockchain start-up that recently raised a $3.4 million Series A financing round, to explore blockchain use cases and expedite the development of autonomous vehicles.[72] Jaguar and Land Rover also invested in DOVU, a UK start-up whose DOV token will help fund a distributed marketplace for transport data and *application programming interfaces* (APIs).[73]

Cooperation can work, and telecoms need not go it alone in their exploration of blockchain technology.

Testing: Find an edge case and solve it

One truth which blockchain evangelists find hard to swallow is that the technology, despite its incredible promise and hacker appeal, is largely unproven. The only killer app for blockchain technology to

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date is bitcoin; it's reasonable for executives to demand additional proof points before betting the farm on a new protocol.

Innovation teams and business unit managers should adopt several initial *minimum viable blockchain* solutions to prove the effectiveness of blockchain technology to their organizations.

Innovation teams and business unit managers should adopt a number of initial "minimum viable blockchain" solutions to prove the effectiveness of blockchain technology to their organizations.

First, David ought to conquer Goliath: small bets should come before big ones. For example, the roaming fraud use case may not sound mission-critical to many telecoms, but that's precisely the point. Find an edge case, one that executives aren't losing sleep over, and apply blockchain technology to solve it.

Another example could be to convert some contracts—perhaps for a smaller business unit—into smart contracts housed on a blockchain. In fact, such noncore functions (like billing) may be the best locations in which to pilot initial tests—they are far from the leery eyes of organizational brass, and so won't arouse too many organizational anti-change antibodies.

In contrast, some of the best toe-dips into the blockchain deep end may be found by offering business-as-usual (BAU) services to existing blockchain companies. Thales, the leader in security solutions, found success by offering its hardware security modules to top blockchain innovators such as Chain. By so doing, it found a niche within the blockchain ecosystem, and built trust by proximity; recently, Thales has launched more ambitious blockchain-first research efforts that were likely bolstered by those initial BAU forays.

Second, firms can consider beginning with blockchain-lite solutions. Remember on-chain versus off-chain processing? Perhaps housing many transactions off- with a select few on-chain would be a palatable starting point. Telecom players could also consider beginning with a totally private, or "permissioned," blockchain—one closed to all players outside the organization. Those blockchains can be radically faster even if they aren't the most technically sound use case for blockchain tech, given our criteria itemized above. (As an example of an off-chain, organizationally palatable solution, take Coco—a framework released by Microsoft for enterprise-level interaction with the Ethereum protocol.[74])

A middle ground exists between traditional databases and full blockchains, and managers of large firms should seek to build trust in blockchain in the early stages.

A middle ground exists between traditional databases and full blockchains, and managers of large firms with significant organizational inertia should seek to build trust in blockchain in the early stages.

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Conclusions

A new age for communications technology is rapidly approaching. How can carriers stay profitable in this new world of decentralized connectivity? Shutting oneself off from the rest of the world is one option; learning to win by creating the enabling and driving technology of the future is another.

The best blockchain solutions in telecom have yet to be discovered, so the winnings are still there for the taking by motivated managers and organizations.

Both strategies—withdraw or embrace—have long track records through ages of technological advancement, and while the meek may inherit short-term wealth, the bold often own the future. As telecom operators launch into this new era, they should remember to stay motivated, diligent, and timely.

It may be easy to be discouraged by the lack of existing blockchain solutions. There hasn't yet been a killer telecom blockchain app, so many organizations may hesitate to invest fully before concrete proof is available. But that reality can be reframed in a positive light: The best blockchain solutions in telecom have yet to be discovered, so the winnings are still there for the taking by motivated managers and organizations.

Similarly, organizations should be careful not to be too widely confident in the potential for blockchain to solve every problem. Blockchain is at peak hype today, and whether the technology will live up to that immense excitement is still to be seen. To direct activity toward the most promising paths, telecoms should diligently consider the fit between the topology of the opportunity and the topology of the solution. If they match, good—but if not, make sure blockchain doesn't become the hammer searching for the nail. Blockchain isn't a panacea, even if it can smooth some rough edges in next-gen telecom technology.

Finally, organizations should move fast. Mergers and acquisitions (M&A) activity and talent are still relatively cheap and, as mentioned, killer apps are still there for the taking. But there's no way to know how long those statements will stand true. The new age of telecom is here, and its distributed nature is all but an explicit call for novel applications of blockchain technology.

In the end, if telecoms move quickly enough, they can navigate the challenges of today by investing in the technology of tomorrow.

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About the author

Christian Keil is an MBA Candidate at the University of California, Berkeley—Haas School of Business—where he leads LAUNCH, Cal's start-up accelerator, and serves as a Haas Venture Fellow, where he completes strategic projects for top venture capital firms in Silicon Valley.

Christian is also a co-founder of The Tuesday Company, a technology start-up that is reinventing political engagement for the digital age. Tuesday recently closed its seed round of funding through the Higher Ground Labs accelerator and is working to elect progressive candidates in Virginia, New York, and Michigan this fall.

Before attempting to save the American Republic, Christian spent four years as a management consultant at Deloitte, where he specialized in telecom strategy. He worked with a number of top telecoms in the United States, and his analytics and modeling work helped guide multi-billion-dollar spectrum-purchasing decisions in the spectrum incentive auction. Christian also worked with Deloitte's chief strategy officer to publish "Ecosystems Come of Age," Deloitte's flagship eminence report that generated more than 100 million media impressions in 2015.[75]

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About the Blockchain Research Institute

Co-founded in 2017 by Don and Alex Tapscott, the Blockchain Research Institute is a knowledge network organized to help realize the new promise of the digital economy. It builds on their yearlong investigation of distributed ledger technology, which culminated in the publication of their critically acclaimed book, *Blockchain Revolution* (Portfolio|Penguin).

Our syndicated research program, which is funded by major corporations and government agencies, aims to fill a large gap in the global understanding of blockchain technology and its strategic implications for business, government, and society.

Our global team of blockchain experts is dedicated to exploring, understanding, documenting, and informing leaders of the market opportunities and implementation challenges of this nascent technology.

Research areas include financial services, manufacturing, retail, energy and resources, technology, media, telecommunications, healthcare, and government as well as the management of organizations, the transformation of the corporation, and the regulation of innovation. We also explore blockchain's potential role in the Internet of Things, robotics and autonomous machines, artificial intelligence, and other emerging technologies.

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