

May 31, 2018

CLOUD AND COMMUNICATIONS

# Blockchain Can Enable the Next Generation of Compute: FOG

## SUMMARY

We believe that Blockchain technology will be as important as the internet was to economic/social change in the past 25 years. This should drive the fourth wave of computing, which will be more decentralized/intelligent edge-based, what we call FOG. Blockchain combines cryptography, consensus algorithms, network and computer technologies that were already in place to create a network of participants that essentially record and agree on a shared distributed accounting ledger and changes to that ledger. This is an application on cloud infrastructure that will increase decentralization and demand for cloud infrastructure (MSFT, AWS, EQIX, ZAYO, AKAM) to support enterprise deployments. Smart contracts on Blockchain will drive unimaginable use cases that will forever change the tech landscape. This type of change has historically driven new leadership and disrupted incumbents (FANGs?)

## KEY POINTS

- **We Believe Microsoft leads In Providing Blockchain As A Service (BaaS), but AWS Is investing As Are All System Integrators:** MSFT was the first to automate the deployment/setup of private blockchains while integrating with popular Azure services. MSFT is platform-agnostic (Ethereum, Hyperledger, Corda), offers the most tools, and is the most open provider. AWS recently announced it's powering Kaleido's SaaS blockchain offering, which will drive demand.
- **Public Application-based Blockchains Will Drive Disruptive Use Cases:** Ethereum, NEO, and other platforms are using programmable smart contracts that can support web-like applications. The goal is to disrupt existing technology companies and business processes. There is an inherent trade-off between scale, decentralization and security, and different blockchains are best suited for specific applications (private vs. public), as are Tokens (utility vs. security).
- **Adoption Set To Ramp As Deployment Hurdles Fall:** The cloud companies are easing deployment hurdles by making it easier for non-developers to launch networks through automated solutions and easy-to-use frameworks. This along with lower cost cloud storage/processing costs will make automation easier. Protocols are also rapidly improving, and decentralized applications have tens of billions to spend on R&D.
- **Pilots Set To Transition To Deployments This Year:** Deloitte's survey of 1,053 executives at major companies found that ~40% are planning blockchain investments of \$5M or more in the next calendar year; or \$2B in total. Gartner estimates in 2030 the global productivity enabled by blockchain will be in the \$1.5 trillion range. We believe these estimates are likely conservative.
- **Early Use Cases Drive Enterprise Efficiency:** Supply chain (tracking, IoT, digitalization), finance (trading, settlement, insurance) and healthcare (digital locker) are enterprise use cases. Decentralized consumer applications aim to disintermediate middlemen, which will disrupt websites and services, but this will take time. The use of security tokens will have a profound impact on the way we own/transfer assets, but we see existing utility tokens as highly risky investments.

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**For analyst certification and important disclosures, see the Disclosure Appendix.**

# Blockchain: Hype Drove Speculation, Enterprises Driving Adoption and Consumers the Evolution

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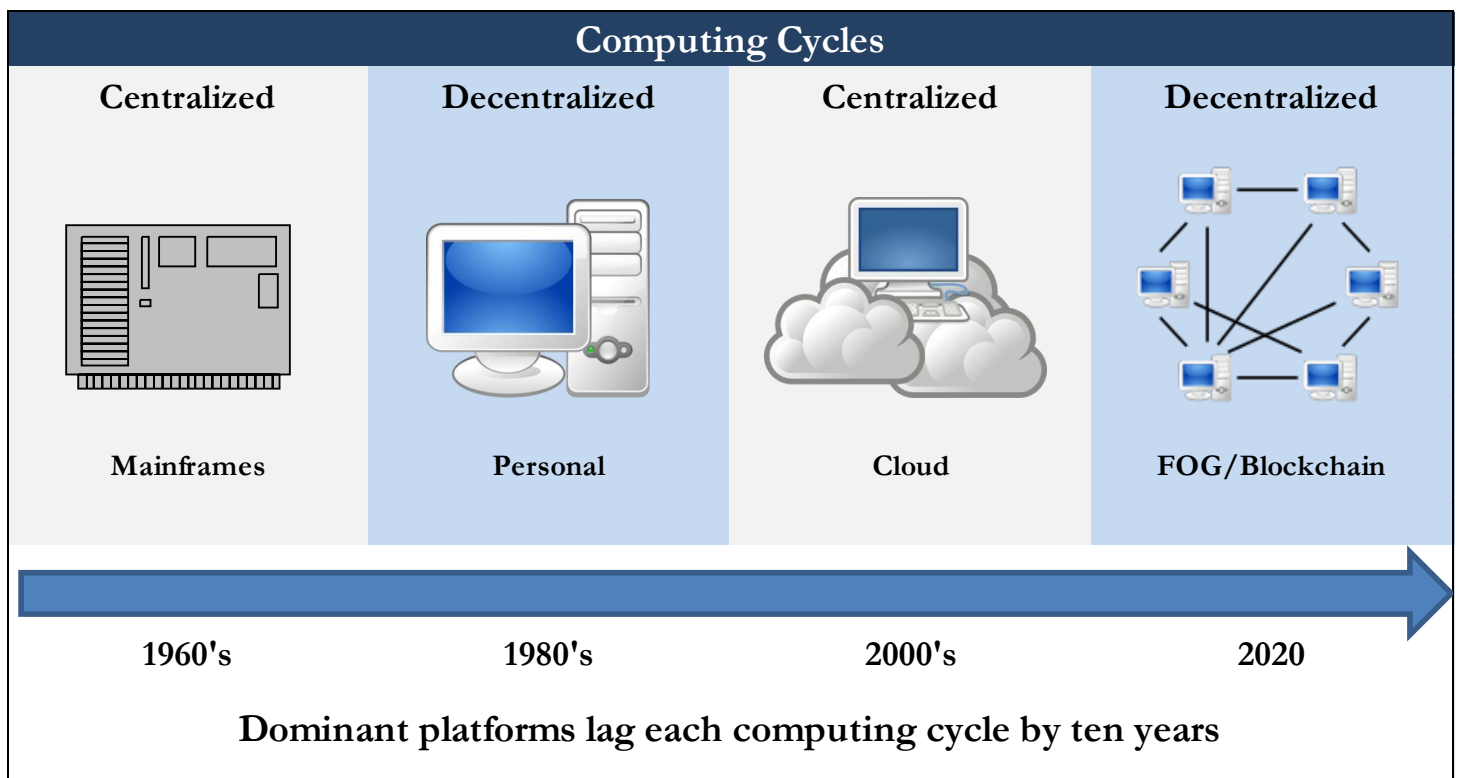
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**Note:** *In no way in this report are we recommending investors buy any cryptocurrencies, ICOs, utility tokens or security tokens.*

## Executive Summary: Blockchain Is Set to Drive More FOG/Decentralized Compute

We believe that Blockchain technology will be as important as the internet was to economic/social change in the past 25 years. Blockchain is a distributed electronic ledger that does nothing more than record a list of transactions (a database stored in multiple locations). It is a simple concept (and those are the only ones that can scale globally, as witnessed by the TCP/IP simplified protocols) that was created in 2009 with the launch of Bitcoin. It combines cryptography, consensus algorithms and P2P network and computer technologies that were already in place. It enables a network of participants that record and agree on a shared distributed accounting ledger and agree to changes to that ledger. This is a new application on existing internet and cloud infrastructure, but gives more user control and enables more distributed compute. This structure is ideal for situations where untrusted actors can still come to a trusted decision, and end users can have control over their own data/applications.

Exhibit 1: Compute Cycles

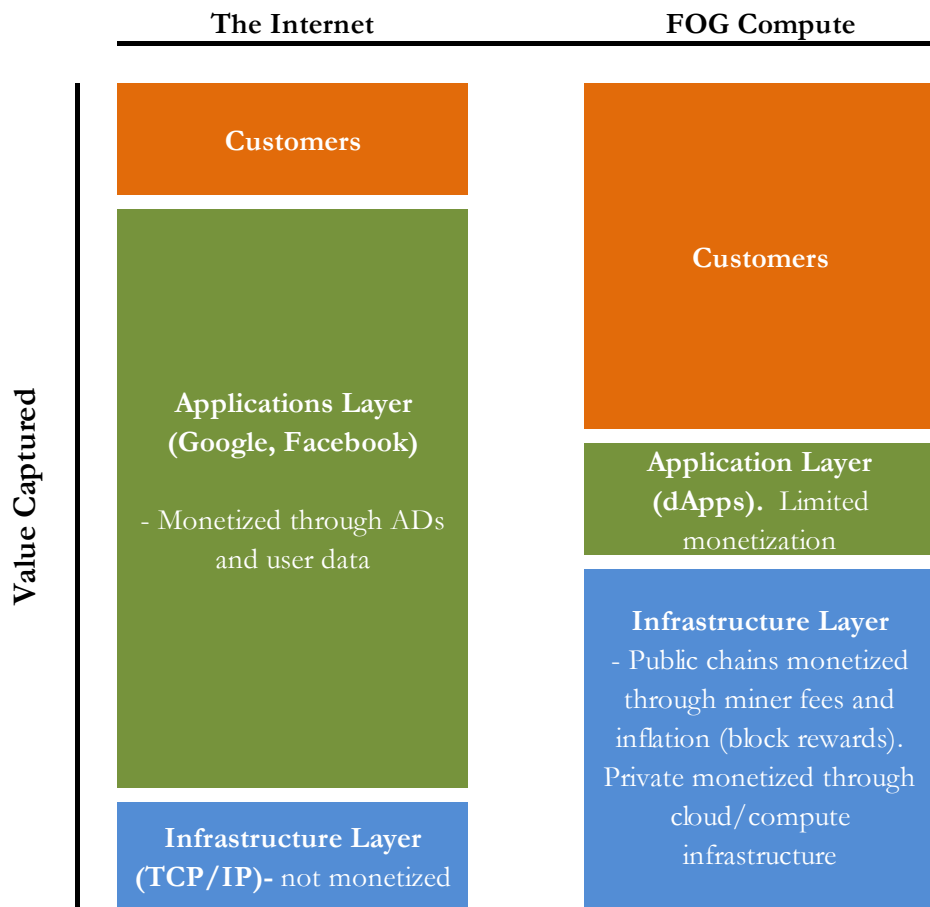


Source: OPCO

Blockchain will drive computer power and application development/control back to the masses again. Everything in life is cyclical, including compute and application dominance, with the latter lagging compute hardware technology by about a decade. Compute has been in a 50-year oscillation between centrally controlled organizations and end users; we have likely peaked in compute concentration/control in this cycle. The last two cycle peaks were probably in the 1978 and 1998 time frames, both at the peak of DOJ antitrust litigation, the FANGs (Facebook, Amazon, Netflix and Google) fairly clearly have stronger market dominance. When companies become too dominant in compute, innovation is stifled, but this is almost always corrected by technology/competition, not regulation. Even though the internet started as a highly decentralized compute platform, it has become dominated by the FANGs, which represent 70% of network traffic and have captured virtually all the value creation. Blockchain has the potential to correct this imbalance, as it

is structured for more P2P interaction and entrepreneurs are launching hundreds of innovative business models where collaboration is rewarded. Microsoft missed most of the value creation of the last compute cycle, but has made an impressive turnaround and we believe it is looking to use blockchain to be a leader in the next compute cycle, which it calls the intelligent edge. We expect more of the value creation to be captured by end-users and infrastructure in this next 20-year compute cycle.

**Exhibit 2: Value Capture of the Internet vs Blockchain**



Source: USV.com "Fat Protocols", OPCO edited.

The disruptive component of blockchain is that it enables “trust” to be automated and verified for the first time ever, and with preprogrammed if/then smart contracts imbedded. We believe that blockchain is at the same stage of development as the internet was in the early 1990s, but that its impact will likely be felt much sooner. As was the case in the internet in 1994 it is difficult to make direct investments in blockchain, but unlike 1994-2000, the infrastructure food chain is largely in place (broadband and cloud), and its development is relatively easy and requires regulation/governance/software (security tokens)/business models. The software part is fairly easy, which is why industries that already have a governance/regulatory structure in place such as logistics/manufacturing are seeing strong uptakes. IDC expects global spending on blockchain solutions to grow from \$945M in FY17 to \$9.2B in FY21; we think half of this could be spent on infrastructure. This is still a relatively small part of all global cloud spend, but growth should remain strong and Gartner estimates the global productivity enabled by blockchain will be in the \$1.5 trillion range. We think these estimates will turn out to be way too low, as blockchain will have unimaginable use cases. Global extensible platforms like blockchain and the internet will continue to disrupt legacy power structures. Bitcoin is just

one of the first applications; the smart contracts that Ethereum enables will dwarf Bitcoin in importance in the long term, though, in our opinion.

With blockchain, the community of users owns and pays for the servers instead of having a centralized organization like the FANGs, driving better innovation. The millions of developers/users will be much better at creating new products than any company can ever hope to be, which is exactly what we saw in both the original internet and the PC. They will all be using the same infrastructure so any advantages will come from their wits, and costs are lower from scale. To support the infrastructure, each transaction generally has a small payment associated with it, which is different from the internet that the FANGs run on, and should result in higher returns for infrastructure. Ethereum will thus become a giant global self-reinforcing network of new applications driving more payments to the platform/infrastructure for both R&D and CAPX, etc. The icing on the cake is that developers and customer can be granted tokens in the utility or security and can benefit monetarily from its improvement.

**Exhibit 3: Types of Tokens**

Three Main Token Types		
Type	Examples	Description
Cryptocurrencies	Bitcoin, Litecoin, Dash, Bitcoin Cash	Payments / Store of Value
Utility Tokens	Ethereum, NEO Gas, EOS	Needed to use a given network or dApp
Security Tokens	Real Estate, Commodity, Security Tokens	Ownership rights

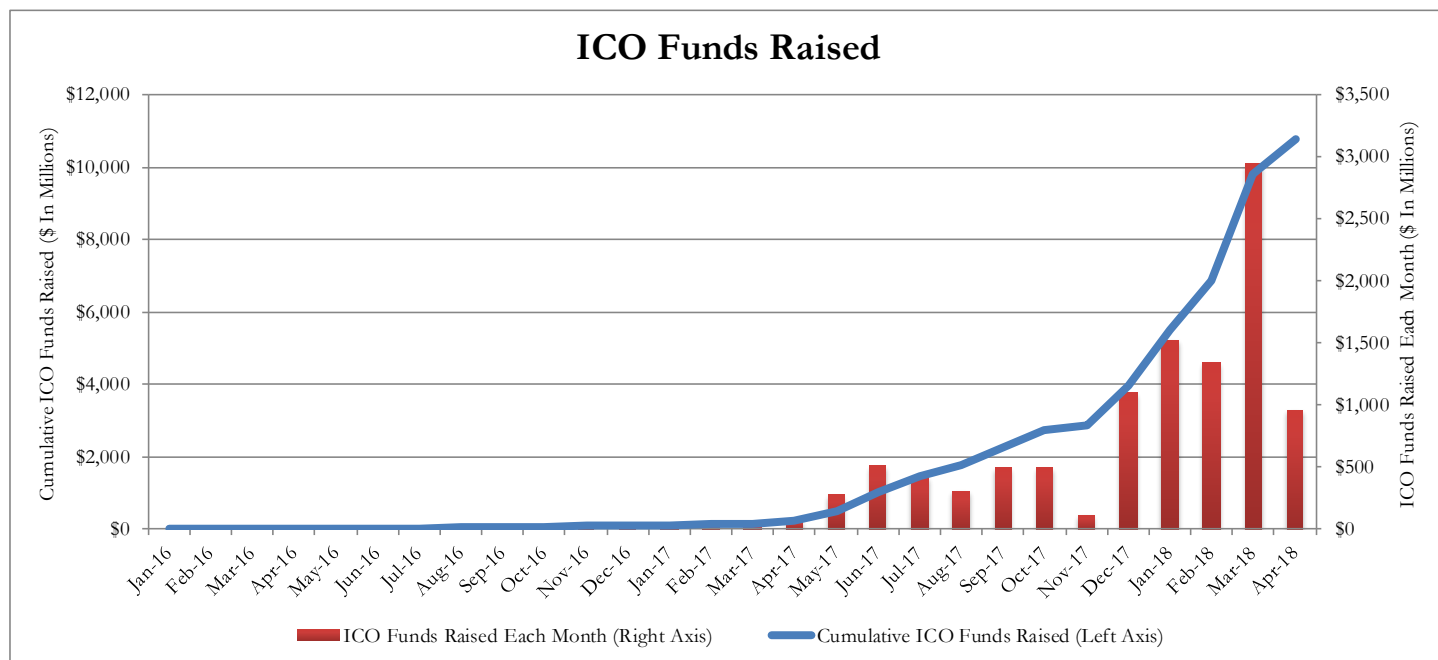
Source: OPCO

Blockchain is radically different from any other technology platform ever developed. While the internet enabled the financing and physical connections of thousands of global data networks, and more recently shared cloud compute capacity, blockchain will enable orders of magnitude more exchanges of physical goods (commodities, real estate, art, financial assets, etc.), technology services and “social” infrastructure. We will see global networks of collaboration amongst software developers that for the first time ever can create decentralized applications that are at this point unpredictable. There are three popular blockchain types currently; security tokens are the newest, but are likely to be the largest in five years.

Blockchain is set to transform the way every industry stores and processes data, contracts, and transactions. Shared blockchain databases will protect data from deletion or alteration, for the first time in history. The opportunity for distributed ledger technology and distributed computing to record immutable data and logically execute smart contracts applies to every industry. This is double-entry bookkeeping that will evolve into essentially triple entry. This will make the “securitization” of virtually every asset of value possible (a hundred people could own a share in a car or a private company or a piece of art work) through security tokens. While nascent, we view blockchain as revolutionary as TCP/IP was in providing the framework for the modern internet, but we are still in the early stages. There are, though, over 600K transactions a day on the Ethereum smart contracts platform.

The internet operates at the middle of the OSI network stacks of layer 3 and 4 with a simple global common network language (an open and extensible software protocol, which is exactly what blockchains are) that enables networks to interconnect traffic. This in turn allowed the global sharing of knowledge and information, which initially was highly democratized. Companies whose business models were information-focused and middle men got disrupted as a result. In many ways the internet is a giant “copying” machine now and the world has become aware of the problems with the internet--trusted data, theft, privacy, security, monopoly control, etc. Blockchain can solve these problems and create new services along the way, radically transforming government, stock exchanges, banking, accounting, ecommerce, social networks, medical data, search, music and film rights, and dozens of other services.

**Exhibit 4: ICO Funds Raised**



Source: Icodata.io

Blockchain, like the internet, is a relatively simple platform, but rides on top of the internet network stack, and one that requires a unique algorithmic construct for each application that is set up with the initial blockchain. These applications can drive transactions that represent almost anything--money, instructions, smart contracts, a piece of a physical asset, tracking provenance, logistics, etc. The key to blockchain is that it is decentralized. No single entity controls the data; any computer on the network can make a change to the ledger, but only if it follows preset “rules” that all the other computers agree to. This produces “immutable” records that cannot be tampered with as they are based on mathematical algorithms which are in turn encrypted and distributed. The “rules” of any given blockchain are dictated in the “consensus protocol” initial algorithm.

Transactions are conducted in bundles called blocks, which is where the name comes from, with the chain of blocks permanently stored. There are dozens of variations of blockchain; the three primary ways to delineate are:

1. Smart contract (Ethereum) versus no contract (bitcoin);
2. Cryptocurrency, Utility or Security token; and
3. Public (permissionless like blockchain) or private (permissioned like logistics management).

Mathematics provide the governance and math cannot lie, which is what guarantees the integrity of these distributed ledgers. Once these software protocols morph into a common global platform, innovation will explode.

Like all new technologies the capital and operating expense for blockchain can be much cheaper than using legacy technology and people for many services, and we expect costs to plummet. The rule of thumb on switching over to new technology historically is that it had to be 1/10th the cost of legacy. Offsetting this is that these services will be more secure and we will see better products and new services that are at this point unimaginable. The infrastructure required will be immense, and we are likely to witness a few booms and busts along the way, as we did with other new technological networks—the internet, electricity, railroads, canals, etc.—and major deflationary forces on many legacy industries.

Cloud is fundamentally disrupting many industries and Blockchain will help accelerate this. Cloud native computing is a key enabler as new applications are all going serverless which makes it easier to write new blockchain applications. Microservices then connect with serverless compute through APIs, which in turn are running on top of containers. All these containers/microservices are interchangeable. Kubernetes manages these new applications which are totally over the top and separate from the network and theoretically the cloud platform. This is a whole new way of building an application. Blockchain will help accelerate the migration of apps to be mostly cloud native.

**Ethereum Is The Leading Public Blockchain Platform.** Ethereum is a decentralized platform that runs smart contracts, or code, that run exactly as programmed without any potential interference or any third-party intermediaries. Ethereum's smart contracts run on its open source decentralized blockchain, operating on a decentralized compute/storage power in the form of nodes. Ethereum is the most well-known, and established public blockchain with a large developer community, a standards setting body with hundreds of member companies (Ethereum Enterprise Alliance), the most dApps (1,300+) and the most ICOs (initial coin offerings, \$4B+ raised in FY17). We do believe that most utility tokens that have been issued are highly risky and will likely fail. Ethereum also supports digital tokens such as ICOs. Ethereum's unit of currency, Ether, is used as "gas" which users pay to miners for usage.

While it's hard to envision which dApps will be successful, we believe Ethereum is the most popular public blockchain and the current go-to service for dApps and initial coin offerings. Decentralized applications could pave the way to users truly owning their data, which is a marked shift from the current social media model. BlockStack is an example of this new model where applications interact with user data, instead of the other way around, restoring users' data sovereignty. The ability to deploy smart contracts and dApps on Ethereum with no intermediary is a major change, and disruptive, for established platform business models and social media platforms that have a sole owner.

Scalability is critical for Ethereum, as the network is currently at 85% usage and is only able to handle 10-20 transactions per second. Ethereum's global and expansive developer community is working on numerous scalability initiatives, as detailed in this report.



Exhibit 5: Web 3.0 Transition



Source: Matteo Gianpietro Zago, Medium

For some applications blockchain can eliminate the need for a centralized intermediary (banks, social networks, medical records, etc.) and we can see cloud/SaaS providers provisioning these services directly to consumers. This is likely going to be the way that privacy/data control shifts from Facebook/Google/Amazon/HMOs etc. to consumers, creating new services along the way. These internet companies are in essence storing all of our transactions. While they offer many convenient services, they do control our digital data and in essence our humanity, to maximize profit. This data is being sold to organizations that use it to manipulate all sorts of behavior and to control and curate content, and this is before governments have figured out how to harness the power of this data. We believe that consumers and businesses will regain control of their digital lives using blockchain.

Legacy internet companies started out by giving consumers a lot of trust, and they were clearly the first movers in the space and benefited from network effects. Over time though the nature of successful companies is that they abuse that trust, and we are starting to see that today. On Google, we don't believe their search business will be affected by blockchain, but many of their other services could be over time. Overall, internet disrupted industries include music, travel agents, newspapers, magazines, yellow pages, communication networks, long distance, and taxis.

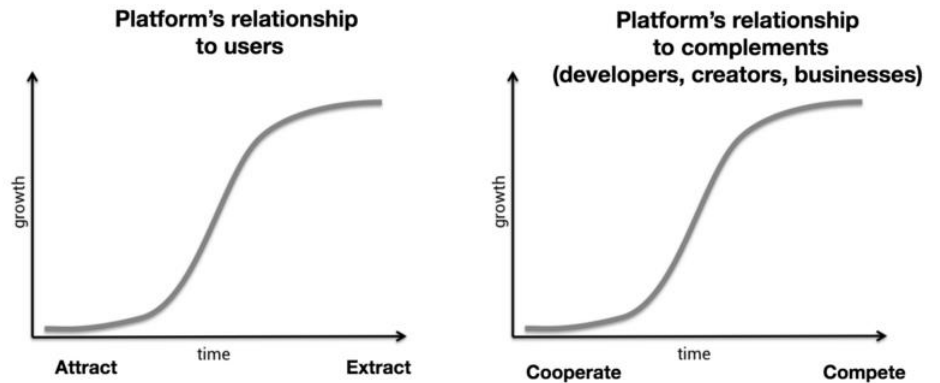
**Exhibit 6: Most Popular Social Media Sites**

Most Popular Social Media Sites	
Network	Monthly Active Users
Facebook	2.1B
Instagram	800M
Twitter	336M
Snapchat	300M

Source: Brandwatch.com, Statista , Omnicoreagency , ExpandedRamblings.com

Blockchain use cases are now being deployed privately by companies to lower operating and capital costs. These services include payments, supply chain monitoring/processing, royalty/copyright payments, Title transfers (real estate, mineral rights, autos), asset securitization, asset provenance (art work, photography), medical healthcare records, and trading. On the consumer front hundreds of utility tokens called initial coin offerings (ICOs) have been issued and are traded and we expect security tokens to begin trading shortly. Peepeth is a decentralized distributed social network that is censor proof and is paid for using a cryptocurrency, and is looking to replace Twitter. We believe consumers do like some curated content, and there will be companies built on top of new blockchain like services, such as Peepeth, that can provide this.

**Exhibit 7: Platform Relationships**



Source: Why Decentralization Matters, Chris Dixon

This type of ecosystem lends itself to accelerating innovation as Blockchain becomes the marketplace. We see partial ownership of assets like art, cars, companies, and real estate as an early use case. Each share in these assets will have a unique digital “token” which is verifiable in an “automatic” way. Unfortunately some of the first uses for partially securitizing assets have been through suspect ICOs where investors purchase utility tokens (some call them crypto currencies) that give them a right to purchase a service but usually not ownership of an asset, and appear highly risky. We think security tokens that are regulated and represent ownership of an asset will be a game changer.

The problem with centralized control of web applications as ended up happening in the last three compute cycles is that over time compute and other dominant platforms extract all the value as the linchpin between the developer and user community. However with blockchain, incentives can be given through tokens and other methods so that these developers/users keep large parts of the value that they are creating. We think this will make the underlying infrastructure more valuable. It looks like a great place to invest while it lasts, and one of the primary reasons we have remained so bullish on wireless towers and neutral datacenters for the past 20 years.

Platforms follow a life cycle where entities begin, in the case of compute, by recruiting third party software developers, and become the neutral meeting point benefitting from the network effects of multiple parties as companies, organizations and customers interconnect. As these platforms become dominant they always take advantage of their monopoly position and compete with developers/companies by bundling in services as part of the platform. Examples in this trend include Microsoft over Netscape/Quattro/WordPerfect and Google over Yelp, but there are dozens of other examples. Companies that build on top of these platforms are well aware of the history of this, but are themselves unable to switch as the network flywheel accelerates, while end users also give up their privacy and data. The same problem is likely to happen to developers supporting AWS.

Blockchains can remain neutral, eliminating the bait-and-switch issue of centralized platforms, if;

- 1) The contract between cryptonetworks and users is enforced through open source code
- 2) Participants can leave the network and sell their coins or fork the code.

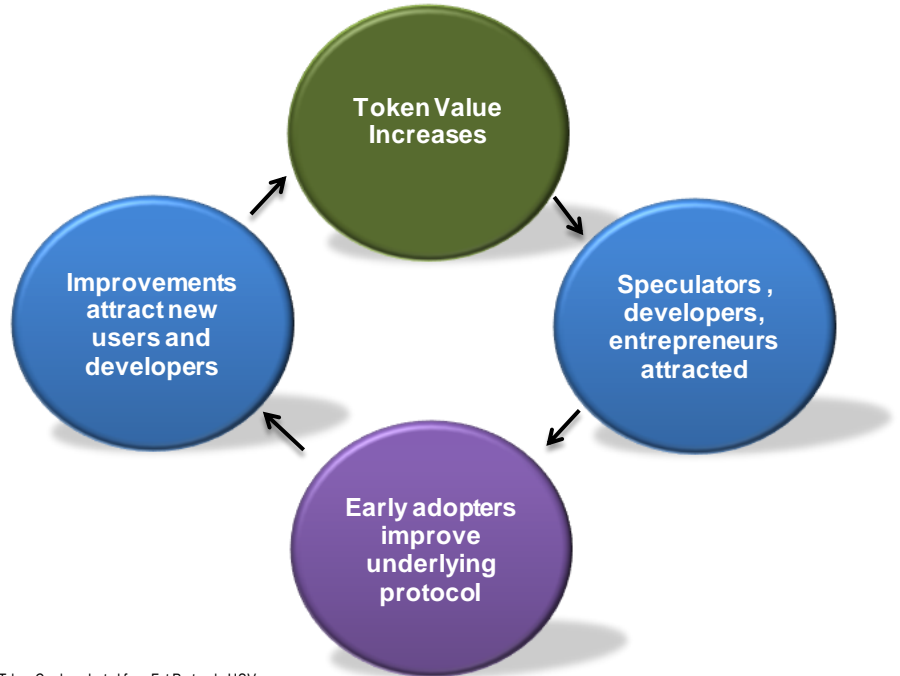
In this way both developers and users are incentivized, most likely through the ownership of tokens, which they are incentivized to see increase in value.

Open source cryptonetworks benefit over existing systems as developers are paid to enhance the foundational protocol and value added services. We note this is already in practice, as the NEO Council (a competitor to Ethereum) pays out NEO tokens to developers in its primary developer community called the City of Zion. Public blockchain/open source initiatives range from uncensored and decentralized social networks (Peepeth and Steem a decentralized version of Facebook) to decentralized prediction markets where users can bet on any outcome through Gnosis and even OpenBazaar's person-to-person selling platform, that removes legacy middlemen (AMZN, eBay, Uber, Airbnb?) fees. Through tokenization, as in these examples, developers are able to monetize open source software in a democratic manner for the first time. In this realm, the focus is on developing/using great applications/protocols, not on individual companies.

The below scenario applies more to the consumer use cases on public blockchains, but we can see consortiums set up for private block chains that improve operational efficiencies where the contributors are granted tokens for improvements. Digital cryptocurrencies and ICO tokens are the main public blockchain use cases now, but the aforementioned operational blockchains use dApps and Ethereum primarily. The benefits of building a dApp on a public blockchain are numerous but include not being locked into an underlying platform that can change the rules at any time (i.e., Facebook, Twitter), eliminating middlemen and allowing users to own their data and digital experiences.


**Exhibit 8: Virtuous Token Cycle**

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Source: Token Cycle, adapted from Fat Protocols USV

Exhibit 9: Blockchain, Private vs Public

Blockchain A Tale Of Two Cities (Private and Public)			
Specific Platforms	Hyperledger, Private Ethereum, Corda (Infrastructure run on MSFT's Azure, AWS and IBM Cloud)		
	Ethereum, NEO, EOS (Infrastructure run by 10-20,000 miners in a PoW world)		
Uptake	100-200 Deployments	500-1,000 Deployments	Thousands of Deployments
	1% of Consumers Interact with Public Chains	2-5% of Consumers Interact	5-25% of Consumers Interact
Scalability	Already Scalable to Thousands Of Transactions Per Second		
	10-15 TX/s (Ethereum)	100-1,000 TX/s (Ethereum)	5,000+ TX/s (Ethereum)
Use Cases	Reduce Operational Inefficiencies, Increase Transparency, Provide Immutable Records and Data (Supply chain management, financial trading and settlement, health records, inter and intra office data transmissions).		
	Digital Cash and Store of Value		
	ICOs for Utility Tokens with True Network Utility		
	Speculative ICOs		
			Security Tokens for Assets, Commodities, Real Estate
			Viral decentralized applications with no single owner where users own their data and interact using utility tokens
	2018	2019	2020
<b>Time</b> 			
Legend	Private and Consortium Blockchains (Enterprise Users)		Public Blockchains (Consumers)

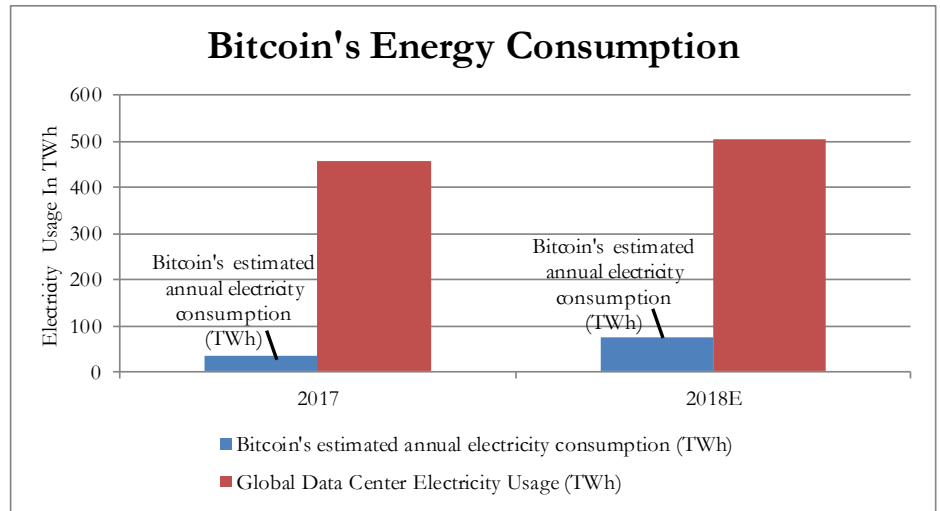
Source: OPCO

In summary, while actual blockchain deployments are in their infancy, we believe the technology will be just as impactful as the internet was over the long term. We believe blockchain is currently comparable in its development to the communications tool ARPANET which earlier scientists used over the internet, before the internet itself evolved to offer Facebook, Apple, Netflix and Google.

The process will be highly organic. We detail numerous exciting blockchain-based decentralized applications that are in development, and while we don't know what the future killer applications will be, we see value in closely following blockchain technology, as it has the potential to become disruptive across every industry.

**Critics of Blockchain:** There are many applications where a centralized service or even a simple ledger makes more sense to use than a public blockchain. The rule of thumb is to take any blockchain scenario and ask "is the distributed ledger really solving the problem here? Is there a more conventional solution?" In most cases the answer is, Sure you could use blockchain, but there are a whole lot of other ways to solve this using existing tools.

**Exhibit 10: Bitcoin's Energy Consumption**



Source: Data-economy.com, Digiconomist, Singularityhub.com, Peter Shin

Most of the use cases for block chains have been around cryptocurrency, and this unfortunately has soaked up huge amounts of energy. For comparison purposes, we estimate Bitcoin mining will use the ~15% of the global electricity used on Datacenters globally in FY18, doubling from last year.

**Exhibit 11: Bitcoin Network Statistics**

Bitcoin Network Statistics	
Description	Value
Bitcoin's current estimated annual electricity consumption* (TWh)	59.1
Annualized global mining revenues	\$5,751,362,524
Annualized estimated global mining costs	\$2,954,927,354
Country closest to Bitcoin in terms of electricity consumption	Colombia
Estimated electricity used over the previous day (KWh)	161,913,828
Implied Watts per GH/s	0.242
Total Network Hashrate in PH/s (1,000,000 GH/s)	27,801
Electricity consumed per transaction (KWh)	927
Number of U.S. households that could be powered by Bitcoin	5,472,088
Number of U.S. households powered for 1 day by the electricity consumed for a single transaction	31.33
Bitcoin's electricity consumption as a percentage of the world's electricity consumption	0.26%
Annual carbon footprint (kt of CO2)	28,958
Carbon footprint per transaction (kg of CO2)	454.29

Source: Digiticonomist

## Investment Potential—Own the Cloud and Infrastructure Suppliers

We see the whole cloud chain infrastructure benefitting from this new service including MSFT, AWS, EQIX, and ZAYO, as well as the component and equipment suppliers. To date specialized China-based semiconductor companies have created enormous value in a short period of time. Depending on the initial algorithm it can be expensive to deploy a public blockchain. The main bottleneck for public blockchains surrounds scalability or the ability to offer comparable levels of transactions per second over the private blockchain or cloud model. Blockchains require large amounts of datacenter capacity, compute and bandwidth. The reason to deploy all this capital is to automate processes for businesses and consumers. As storage costs and bandwidth productivity continue to improve by 25% to 30% per year more and more use cases for blockchain become apparent.

**Cloud Providers Have Built the Infrastructure to Support Block Chain Applications:** Both AWS and MSFT offer blockchain templates to ease the deployment of private blockchain networks. They have integrated the network/datacenters/compute platform and value added services with easy to use interfaces. AWS's partnership with ConsenSys's Kaleido allows businesses to deploy private blockchains through a SaaS model with AWS supporting the back end infrastructure. MSFT's recently announced Azure Workbench can automate the setup of blockchain networks while linking to existing Azure cloud services.

**Neutral Datacenters Will Benefit from Blockchains:** Neutral datacenters are well positioned to enable lower latency/cost blockchains. Most companies will be part of multiple blockchains; positioning various blockchain interconnectivity through one data center offers low latency, lower costs and more security. While in the early innings, Equinix and Interxion are leading the space and these companies expect private blockchains to take hold and multiply in 2018.

**Blockchain Investments Increasing:** Only 8% of enterprise CIOs surveyed by Gartner have deployed blockchain technologies. This is not too surprising because new technology is almost always adopted at a grassroots level. Positively, Deloitte's 1Q18 study of 1,053 executives at major companies with over \$500M in annual revenue found that 39% are planning blockchain investments of \$5M or more over the next calendar year.

**Blockchain's Low-hanging Fruit is Enterprise Cost Savings:** Microsoft has put together the platform for enterprises to easily adopt services and has deployed hundreds of applications over the past three years. Supply chain management has been early adopters; Walmart and IBM have used blockchain to cut down food tracking time from weeks to seconds and streamline dozens of parties and legacy paperwork to one digital ledger. The financial services industry is also adopting and according to Global Management Consulting firm Oliver Wyman, using blockchain for near real time settlement could reduce the cost of clearing and settling trades by \$80B annually.

**Security Tokens Will Likely Run on Public Cloud, Boosting Confidence:** The ability to tokenize any asset (real estate, commodities, equity, debt, derivatives) unlocks the value of previously illiquid assets to the masses, making them more valuable. Confidence in the technology and legal backing are keys to growth. Security token platforms (Polymath, Harbor, etc.) are focused on embedded KYC/AML provisions into their protocols to be positioned as more compliant for regulators over anonymous/deregulated ICOs. These security tokens will trade on exchange platforms like Tzero. Security tokens can significantly cut down on primary listing fees, secondary trading fees and allow non-technical businesses to create tokens in minutes using easy to use interfaces. Security token platforms aim to tokenize legacy assets (venture capital, real estate, commodities, equities, debt, derivatives) whose aggregate notional value is in the trillions and have had

limited liquidity. When the SEC/regulators finalize the structure that they want for these products we will see strong growth. *Polymath detailed later in this report.*

## Datacenters to Benefit from Private Blockchains

While in their infancy, datacenter companies are well positioned to benefit from the growth in private blockchain deployments. In its top IT predictions for 2018, Equinix stated private blockchains will take hold and multiply. Equinix is well positioned since it is able to bring enterprises together to work on private blockchain ecosystems and its global platform can support distributed and serve global blockchain networks. Further, since most companies will be part of multiple blockchains, positioning various blockchain nodes close together, such as in one data center, offers the ability for private blockchains to interact with one another in a secure manner. Equinix is trailblazing this idea in the datacenter space with an aim to attract both network/cloud providers and enterprises to create a synergistic blockchain ecosystem.

Equinix stated in a recent post that the growing number of blockchain nodes and emerging cryptocurrencies could be catalysts for the estimate increase in the banking and insurance industry's demand for interconnection. Underlying this demand is the growth in private blockchains in the financial services industry, as blockchain technologies are being used to reduce transaction settlements from days to minutes, handle money transfers and manage customer identities.

In Equinix's Global Interconnection Index, the company found banking and insurance companies are expected to have the largest demand for interconnection bandwidth capacity by 2020, a 61% annual increase from 2016 to more than 955 terabits. This interconnection bandwidth is a critical factor in securely interconnecting blockchain nodes and in delivering fast data between nodes; as such EQIX is uniquely positioned to target the growth in blockchain technologies.

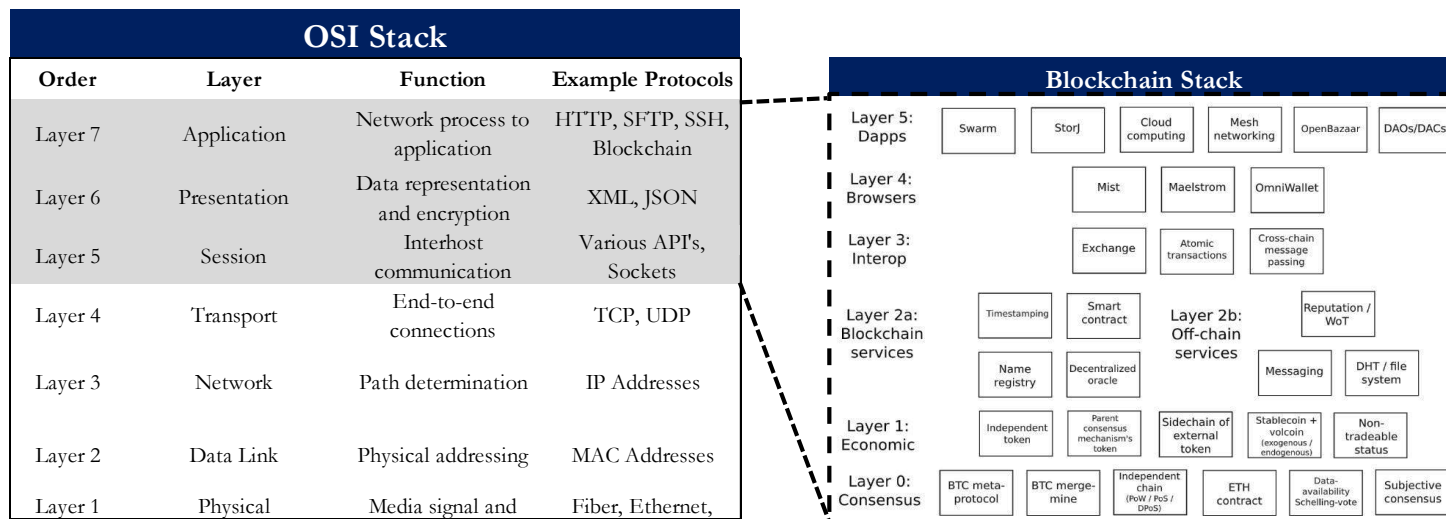
For public blockchains, there isn't a huge drive to convert these facilities for mining operations. The reasoning is that PoW does not require a redundant, 100% uptime facility with high security. Instead bitcoin miners look, for example, for cold regions with cheap electricity and don't need the thrills of a Tier 4 data center.



# Blockchain Explained

A blockchain is a digital, distributed ledger of transactions, stored across multiple participants (nodes) in a peer-to-peer network. Blockchains have no single central repository that stores the ledger or its information and the blockchain allows new transactions to be added to the chain using secure cryptographic signatures, once every node on the blockchain agrees that the transaction has meet preprogrammed criteria. Blockchain sits at the higher layers of the OSI stack, along with other protocols such as HTTP, leveraging the Internet/Cloud.

**Exhibit 12: The OSI Stack and Blockchain**



Source: Vitalik Buterin (On Silos), HPE, Wordfence.com, OPCO,

Blockchain was invented in January 2009 in a nine-page whitepaper published by Satoshi Nakamoto, who is currently unknown. The algorithm P2P decentralized network was preprogrammed to have no central authority, but to operate organically, issuing a finite block of coins every ten minutes, based on solving a mathematical problem, called mining. The difficulty of the mathematical problem is adjusted to make sure that the block of coins issued matches the original schedule. In 2015 Ethereum invented smart contracts. Smart contracts can make blockchain applications look identical to web applications but powered by decentralized shared infrastructure instead of company servers.

In bitcoin a transaction is a simple transfer of the cryptocurrency from one person to another. To conduct this transaction it must reference a past transaction on the blockchain (funds are in place) give a private key to the bitcoin and then the address of the person receiving the funds. This transaction is then sent out to the other computers on the network (also called nodes) that validate that this is a legitimate transaction if it has followed the appropriate rules and the entire global blockchain is updated to reflect the transaction on all the computers (nodes).

**Exhibit 13: Blockchain Characteristics**

Blockchain Characteristics	
Characteristic	Explanation
Distributed	This is a critical area that distinguishes blockchain from traditional databases. A connected and synchronized system of nodes allow transactions to be stored on the network, guaranteeing the validity of a recorded transaction. As the blockchain is distributed, it eliminates the risks that come with data being held or validated centrally as everyone has access to the ledger.
Decentralized consensus	Decentralization eliminates the role of a designated administrator to approve, clear, and settle transactions on the ledger. The ledger or blockchain's protocols process, validate, or authenticate what goes into the ledger, allowing the process to be automatic. This differs from the centralized database that most companies use today. Before a transaction is executed, agreement in the form of a digital signature must be made, preventing inaccurate or fraudulent transactions from being added to the network.
Transparency	Transparency comes with blockchain-based time-stamping of a date and location. As each transaction and asset has a distinguished provenance, improved trust among participants of the blockchain may result.
Incorruptible	Blockchain creates an immutable record of all transactions that have occurred on the distributed ledger. Once a transaction has been recorded, it can never be changed. Subsequent transactions can be recorded to change the asset, but the original record will remain on the blockchain.

Source: IDC's Customer Insights and Analysis Group, 2018

To create the bitcoin currency in the first place, a subset of computers called miners competes to solve a mathematical puzzle (randomly guessing at a number called a nonce with difficulty levels automatically changed). Nonces are then combined to create a hash; if a hash meets a certain mathematically stipulated condition it is awarded bitcoins. Mining is usually done in large pools so that compute resources can be combined. Ethereum works in a similar way except it has the added complexity that a blockchain could include a smart contract that is triggered if certain conditions are met.

**Exhibit 14: Public vs Private Blockchains**

Public vs. Private Blockchains		
	Public	Private
<b>Access</b>	Open read/write access to database	Permissioned read and/or write access to database
<b>Speed</b>	Slower	Faster
<b>Security</b>	Consensus Algorithms (Proof-of-Work, Proof-of-Stake, dBFT)	Pre-approved participants
<b>Identity</b>	Anonymous/pseudonymous	Known identities
<b>Privacy</b>	Data publicly available	Privacy policy similar to traditional databases
<b>Hosted</b>	Globally on Nodes	Primarily on the cloud Azure/AWS
<b>Number of Users</b>	Millions/Billions	Dozens to several hundred
<b>Cost To Use Network</b>	Networks' Cryptocurrency, I.e. Ethereum converts Ether to "Gas" for network utilization	Dollars (AWS/Azure) for cloud usage and in some instances a cryptocurrency (I.e. EXP on Ripple).
<b>Examples</b>	Bitcoin, Ethereum, Neo	Ripple, Blockchain-as-a-service implemented for entities on Azure

Source: Steemit.com, OPCO

There are two basic distributed ledger (blockchain) standards and infrastructure for applications —private (primarily using hyperledger) and public (Ethereum). The hyperledger fabric is different from other blockchains since it is a private and permissioned blockchain. The system does not require proof-of-work but instead relies on approved members that enroll through a centrally controlled Membership Service Provider (Azure). Privately run and owned blockchains are mostly self contained/centralized versus public which are decentralized and owned in a type of cooperative by the users. Both methods have their benefits. The private space is dominated by the larger technology companies (MSFT, AWS, and IBM that support Hyperledger) that create more of a complete applications platform with APIs. This sector is known as blockchain-as-a-service (BaaS). The private block chain infrastructure is a lot more like the existing public clouds, where public blockchains are closer to Grid or Fog computing, where users in a community contribute their own processing and storage for a fee, and there is no centralized manager of the databases. Public blockchains (Ethereum, NEO) are positioning to be the new infrastructure layer for a wave of decentralized applications (dApps) that remove centralized intermediaries and have been used for cryptocurrency primarily so far.

Due to the current cost inefficiencies of public blockchains for compute/storage, they are much less efficient at high transaction workloads. The costs of paying for items with crypto micropayments are currently high. There are some areas where public blockchains offer cost savings/unique services, such as through deploying escrows as smart contracts and having no central authority is a requirement for bitcoin for example. The main bottleneck for public chains to reduce costs/increase speed is in scalability improvements, which are slowly coming. To support blockchain applications on public cloud we need clouds to migrate to more serverless and container-focused architectures. These allow microservices to directly link through APIs to the compute capacity/storage required. It also makes it easier to integrate with other enterprise applications such as ERP and CRM.

### **Hybrid Blockchain, Where Private and Public Blockchains Meet**

We expect the cloud providers to provide interoperability with public blockchains, forming a new hybrid cloud architecture. In the case of applications that leverage both cloud/edge infrastructures, logical smart contracts could enact rules that drive data to the most efficient or best processing or storage infrastructure in the cloud or at the edge for a specific application. Microsoft's Blockchain-as-a-Service is interoperable with Ethereum. Microsoft is also a founding member of the Ethereum Enterprise Alliance (EEA), a non-profit organization with over 400 members, in an effort to advance Ethereum. Beyond Ethereum, numerous decentralized cloud storage providers and compelling new dApps are being developed.

## Cloud Players' Blockchain Strategies

We expect total global blockchain spending to reach ~\$58B in FY25, and the total amount spent on cloud infrastructure to remain constant at 30%, akin to total cloud spending, of which ~30% goes to IaaS per Gartner. Net, we believe total blockchain IaaS spending over total cloud IaaS spending will grow to the ~10% level by FY25E. We believe Microsoft can continue to capture ~20% share of spending on the space. This would drive 15-25% growth to Azure's revenue growth in later years.

The benefits of private, cloud hosted, blockchains is that public blockchains are slow by design as they seek consensus with everyone able to see the entire process. Enterprises require privacy and scalability which the cloud providers are targeting, while still offering interoperability with public chains. **IBM and Microsoft have been early to the market, and Amazon has just announced a SaaS blockchain service that runs on AWS.**

**Microsoft is currently the dominant blockchain as a service (BaaS) provider**, in our view. It is the most open platform with the most tools, offering easy deployment through workbench and it is easily integrated with other blockchain platforms (Ethereum, Hyperledger, Corda). The company monetizes the service by charging customers for the underlying compute, storage and network resources akin to any cloud service and by integrating it with its other higher level products and services such as Dynamics and Office. It has the added benefit of locking customers into their cloud ecosystem.

Unlike public blockchains, through the use of private blockchains Microsoft can offer more security, easier scalability, more value added services, improved governance and efficient internal network with less need for redundant storage/nodes. This speeds time to market for new applications, makes working in consortiums easier and drives lower costs, and enables higher transaction volume.

**Microsoft**

Microsoft has taken an open and aggressive blockchain adoption strategy and positioned Azure as one of the leading platforms to support a variety of private blockchains, run on Azure. MSFT launched its CoCo (Confidential Consortium) framework to support private blockchains in a trusted environment to enable scalability and governance, since the nodes are set up to be trusted.

**Exhibit 15: Blockchain and Cloud Spending Outlook**

<b>Blockchain/Cloud Spending Outlook (in Billions)</b>									
	2017	2018E	2019E	2020E	2021E	2022E	2023E	2024E	2025E
<b>Total Global Blockchain Spending</b>	\$0.9	\$1.8	\$3.3	\$6.0	\$10.5	\$17.3	\$27.6	\$41.4	\$58.0
% of Blockchain Spending on IaaS	30%	30%	30%	30%	30%	30%	30%	30%	30%
<b>Blockchain Spending on Infrastructure</b>	<b>\$0.3</b>	<b>\$0.5</b>	<b>\$1.0</b>	<b>\$1.8</b>	<b>\$3.1</b>	<b>\$5.2</b>	<b>\$8.3</b>	<b>\$12.4</b>	<b>\$17.4</b>
<b>Total Cloud Spending</b>	\$153.5	\$186.4	\$221.1	\$260.2	\$302.0	\$341.3	\$378.8	\$412.9	\$441.8
<i>Y/Y Growth</i>		21%	19%	18%	16%	13%	11%	9%	7%
<b>Total Cloud IaaS Spending</b>	\$24.9	\$33.6	\$43.7	\$55.5	\$69.5	\$84.8	\$101.7	\$122.1	\$146.5
<i>Y/Y Growth</i>		35%	30%	27%	25%	22%	20%	20%	20%
<b>Blockchain IaaS Spending/Cloud IaaS Spending</b>	1%	2%	2%	3%	5%	6%	8%	10%	12%

**Microsoft:**

<b>Azure Revenue</b>	\$5.0	\$9.7	\$17.5	\$28.0	\$39.2	\$51.0	\$61.2	\$67.3	\$74.0
<i>Y/Y Growth</i>		94%	80%	60%	40%	30%	20%	10%	10%
MSFT Share of Total Blockchain Spending %	20%	20%	20%	20%	20%	20%	20%	20%	20%
MSFT Share of Blockchain Spending Absolute	\$0.19	\$0.36	\$0.66	\$1.20	\$2.09	\$3.45	\$5.52	\$8.29	\$11.60
<b>MSFT Blockchain Spend/Azure</b>	4%	4%	4%	4%	5%	7%	9%	12%	16%

Source: IDC, Bloomberg, OPCO

MSFT released the Azure Blockchain Workbench on May 7, 2018 to quickly deploy blockchain networks that are pre-integrated with popular Azure cloud services (i.e. Azure Key Vault for passwords or Azure's IoT services to pull sensor data). Thousands of customers have experimented with MSFT's blockchain templates and Workbench.

**Exhibit 16: Early Azure Blockchain Workbench Adopters**

Early Azure Blockchain Workbench Adopters		
Company	Country	Using Workbench To:
Apttus	U.S.	To help banks and asset managers quickly build and deploy smart contracts to secure, track and adjust to change in the loans that are securitized and pooled for collateralized debt instruments.
Bank Hapoalim	Israel	Build a solution that simplifies the time consuming, manual processes required to issue bank guarantees for large purchase like real estate.
Nestle	Italy	Piloting an IoT-enabled solution that tracks the movement of famous Bacio Perugina chocolate throughout the supply chain

Source: Microsoft

MSFT's goal is to accelerate the deployment of blockchains on its platform. MSFT stated it can complete a proof-of-concept for a business' blockchain idea in two days vs. months for IBM through the use of proprietary programs designed to assess blockchains with business requirements. Further, MSFT is providing safety as although the blockchain is hosted on Azure, users hold the private keys, so trust is provided. MSFT allows customers to deploy a blockchain instantly using their choice of frameworks (private Ethereum, Hyperledger Fabric, Corda, Blockapps). Microsoft is agnostic in offering the leading blockchain architectures on its cloud infrastructure, unlike other players such as IBM, which is focused on Hyperledger.

**The CoCo Framework**

MSFT launched its CoCo Framework on August 10, 2017, as an open source blockchain platform to enable high-scale and confidential blockchain applications for enterprises. The framework explicitly defines where blockchain nodes are declared and controlled, offering enterprises the scale/security/immutability of a blockchain while also offering confidentiality and control. The CoCo framework uses a private/customized version of the Ethereum network that is able to support ~1,600 transactions per second with latency of ~125ms, a large improvement over the public Ethereum network's 11tx/s and ~40,000-60,000ms latency.

MSFT achieves these results by utilizing a trusted execution environment (TEE), or a physical (Intel's Software Guard Extensions) box where updates are trusted by design and no proof-of-work (mining) needs to take place. On governance, CoCo allows users, such as a bank consortium, to decide on rules and voting decisions on who is a part of the private network. Public blockchains do not allow the flexibility to choose which parties can be included or the rules of the overall network.

The CoCo framework is compatible with public blockchains, such as Ethereum, and other blockchains such as R3, Quorum, Hyperledger, Sawtooth and Corda are all committed to being integrated as well. The melding of public compute/storage (Ethereum and its dApps) with MSFT's centralized resources will enable a new era of low latency use cases, services and applications.

We believe MSFT will gain traction in the space as it is able to link in Azure services for blockchain use cases, which is a competitive advantage. For example, users can log in using MSFT's active directory instead of their public/private keys, or once a smart contract executes it can have an ERP/CRM system take action automatically.

**MSFT's Blockchain Use Cases.** There are a multitude of use cases for blockchains run on Azure, ranging from redesigning financial systems for near-instant settlement and clearing of trades to secure access to one's healthcare records across all providers.

**Exhibit 17: High Level Enterprise Blockchain Use Cases**

Selected Enterprise Blockchain Use Cases	
Industry	Potential Use Cases
Financial	Redesign legacy workflows, reduce infrastructure costs, increase transparency, reduce fraud and improve execution and settlement times.
Retail/Manufacturing	Better supply chain management, smart contract platforms, digital currencies and tighter cyber security
Healthcare	Remove 3rd party verifiers such as health information exchanges by directly linking patient records to clinical and financial stakeholders. Also provide safe and secure access to personal medical records across healthcare organizations and geographies
Government	Increase transparency and traceability of how money is spent. Track assets such as vehicles and reduce fraud.
All	Increase quality and control. IoT is an excellent use case for blockchain across all industries for tracking, monitoring quality and verification across all asset types.

Source: Microsoft

Our channel checks suggest Microsoft has seen strong interest from businesses in supply chain management, finance and manufacturing. This is because these businesses have existing multi-company workloads (i.e. a 20 vendor supply chain) that can be codified onto

a blockchain. This is much easier to do than to also have to handle the governance and rules for a new multi-business blockchain use case.

MSFT has also spent a lot of time and investment working with service integrators (Ernst & Young, Accenture, and Deloitte) to make the case for their customers who approach them with new blockchain use cases. These service integrators are seeing strong demand from those in finance, insurance and corporate banking.

**Amazon**

Amazon launched its AWS Blockchain Partners Portal in late December 2017 to support customers' integration of blockchain solutions with systems built on AWS. It already has numerous blockchain partners. More recently the company announced a partnership with ConsenSys' Kaleido subsidiary to offer blockchain as a SaaS model supported by AWS' infrastructure. This removes numerous developer hurdles and allows enterprises to deploy private blockchains within minutes. Kaleido also allows integrations with native AWS services including Amazon EMR for analytics, Amazon Athena for queries and Amazon CloudWatch for logs and monitoring. The service is interoperable with the public Ethereum blockchain to relay and anchor transactions.

On April 22, 2018, AWS introduced Blockchain Templates for Ethereum and Hyperledger, making it possible for AWS users to quickly and easily launch their own blockchain networks while paying for the underlying compute and storage. AWS' announcement comes ~2.5 years after MSFT released Ethereum BaaS on Azure, in November 2015.

**Exhibit 18: AWS Blockchain Partners**

AWS Blockchain Partners	
Partner	Focus
Sawtooth	An enterprise-grade solution for building, deploying, and running distributed ledgers.
Corda R3	Corda is a distributed ledger platform. As a financial grade ledger, Corda meets the highest standards of the banking industry, yet it is applicable to any commercial scenario.
PokitDok	PokitDok is changing the way healthcare systems and applications communicate by allowing customers access to technology that empowers better healthcare experiences for everyone.
Samsung Nexledger	Nexledger is a blockchain platform built for enterprise, empowering your organization to take control of distributed transactions securely and conveniently.
Quorum	Quorum is an Ethereum-based distributed ledger protocol that has been developed for the financial services industry to support transaction and contract privacy.
BlockApps	BlockApps provides the fastest development platform for building and deploying Ethereum blockchain applications. BlockApps' quick deployments and RESTful API enable developers to build, test, and deploy smart contracts faster than ever.

Source: <https://aws.amazon.com/partners/blockchain/>



While in the early stages, public blockchain entities have started to run nodes on AWS. On March 31, 2018, startup blockchain Zilliqa announced it released its testnet with 1,000 nodes running on AWS. Another blockchain entity Dragonchain, spun off from Disney, is running on AWS as well. These are both public blockchains that anyone can use/join (not permissioned like enterprise) but run on cloud infrastructure. Public blockchains sell their tokens to fund their cloud network usage.

Last, Luxoft holdings Inc., a global IT service provider, announced in late February 2018 that it is collaborating with AWS to help accelerate the deployment and integration of blockchain projects on AWS.

**IBM**

In December 2015, the Linux foundation launched the Hyperledger Project with IBM and dozens of other partners with the goal of developing a framework for enterprise blockchain deployment. In mid-2017, IBM began offering blockchain-as-a-service on top of hyperledger components in the IBM Cloud. Like MSFT, IBM’s goal is to overcome the privacy, scalability and governance limitations of public blockchains. IBM offers a tiered subscription planned based on various deployment models. For starter networks the company charges per CPU/hour and for enterprise deployments it charges per peer per month.

**Exhibit 19: Hyperledger’s Characteristics**

Hyperledger's Key Attributes	
Type of Blockchain	Private and Permissioned
Shared Ledger	Ledger system comprises the <b>world state</b> and the <b>transaction log</b> . The world state is the database of the ledger at a given point in time and the transaction log records all transactions that have led up to the current value of the world state.
Smart Contracts	Smart contracts are written in <b>chaincode</b> in Java/Go programming languages.
Privacy	Hyperledger supports privacy using channels, to allow groups of participants to create separate ledgers of transactions to choose which information is shared.
Consensus	Participants can choose their consensus method (PoW, Practical Byzantine Fault Tolerance) that is best for the network participants.

Source: [Hyperledger-fabric.readthedocs.io](https://hyperledger-fabric.readthedocs.io)

IBM has been active in the space, with over 500 blockchain customers and dozens of live pilots with large companies such as Walmart and Maersk. IBM has a focus on offering the implementation and support companies need to deploy their solutions, which has helped

to onboard enterprise customers. We believe IBM's consulting focus has helped to drive uptake but ultimately DIY/automated models such as Workbench/Kaleido will be easier to use.

**Oracle**

Oracle released its Blockchain Cloud Service division in late 2017 to explore different use cases for the technology. The company leads with its platform-as-a-service offering that uses Hyperledger, akin to IBM. Blockchain Cloud Service leverages the company's public cloud and is also offered as a managed service for applications that range from supply chain management to ERP systems.

**Akamai**

AKAM has a new, proprietary blockchain platform that is being coupled with its global acceleration platform to provide a service with exceptionally high transaction speeds. The company has stated it can process transactions on the order of millions per second and is able to finalize transactions in under 2 seconds. We believe AKAM is targeting areas and use cases that cannot be solved under existing blockchain systems. This platform is a new offering that is not solely focused on CDN, although AKAM is using its global CDN to accelerate its blockchain platform.

Recently, AKAM announced a plan with Mitsubishi UFJ Financial Group (MUFG) to offer payment network on its blockchain platform enabling next gen payment transactions at scale; handling 10M tx/s. The platform is expected to support payment processing, pay-per-use, micropayments and other developing IoT-enabled payment transactions. The network is expected to be available in 1H20.

**Real World Private Cloud Blockchain Examples**

Real world private blockchain examples are beginning to surface. Most notably, IBM and Maersk recently formed a JV to put the global shipping industry on IBM's Blockchain. Logistics and IoT are a perfect fit for blockchains since asset tracking information is easily visible, all parties can view data in real time, digital documents are immutable and quality control is tracked and broadcasted in real time

**Exhibit 20: Live Private Blockchain Examples**

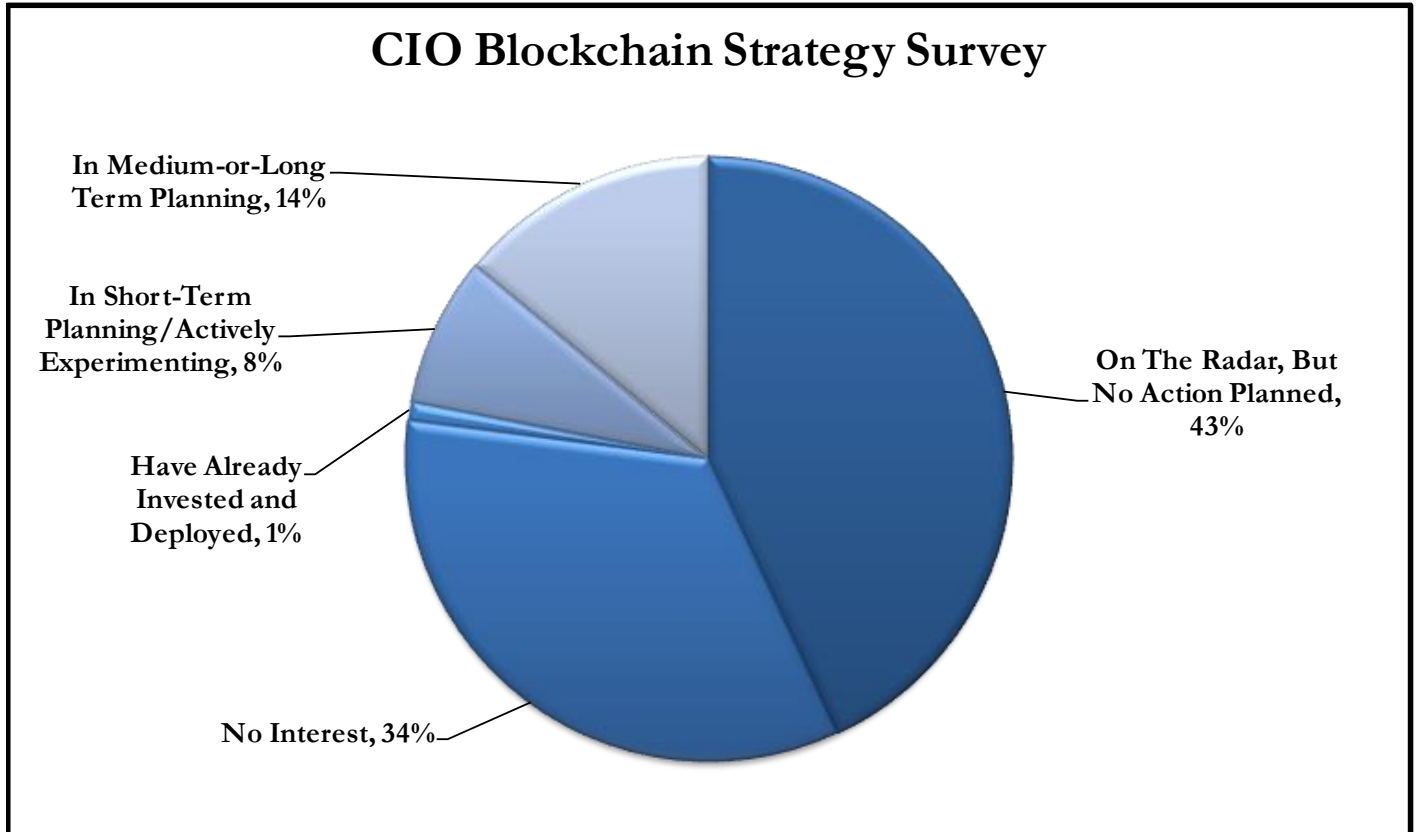
<b>Real World Private Blockchain Examples</b>	
<b>Company</b>	<b>Use Case</b>
Maersk	IBM with Maersk's recently formed a JV with the goal of creating an open and global trade digitalization platform. Run on the blockchain, the entire logistics process is hosted on a single source offering end to end supply chain information. All digital documents are verifiable and immutable, there is trust across organizational workflows, and there are far lower administrative expenses. The platform will be powered by IBM's blockchain technology (Hyperledger Fabric 1.0) and the IBM Cloud.
Webjet.com	Webjet's goal was to anchor travel bookings in the blockchain. With thousands of arrangements made everyday and this information has to flow through over 50 systems with dozens of interactions ranging from purchasing tickets to airline schedules, running its process on a single blockchain helped to markedly improve efficiency

Source: Microsoft: <https://www.youtube.com/watch?v=YJ7LaN0yGTg>

**State of Blockchain Deployments**

While interest in blockchain has been driven by the meteoric rise in the value of cryptocurrencies, we believe that actual real world deployments have been slower than expected but will ultimately be the dominant use case. The food chain needs to improve technology/governance/regulation and to have lower costs and companies need to understand the value propositions and train the skilled workers who can implement actual strategies. The results are skewed toward larger enterprises, as Gartner found that ~70% of enterprises with over \$1B in revenue have implemented or are planning a blockchain based strategy.

Exhibit 21: Gartner CIO Blockchain Strategy



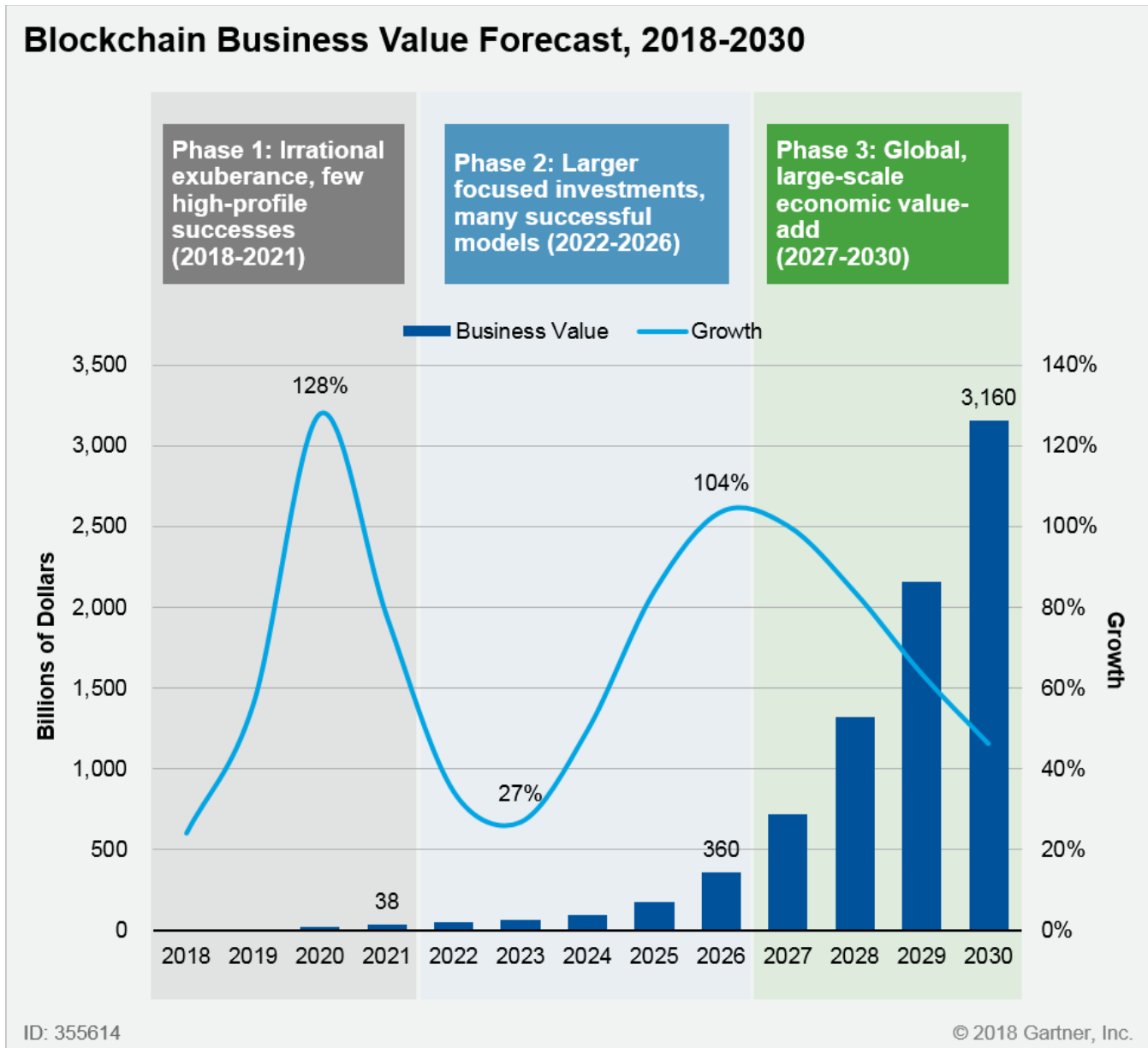
Source: Gartner, March 2018

Seen on the next page, Gartner places the blockchain market in the exuberance phase with few high-profile successes, but this is set to expand into larger investments in FY22 and beyond and eventually a global economic value creation stage between FY27-FY30. We think this time line is way too conservative.

## Enterprise Blockchain Case Studies

Blockchain technology is disruptive for virtually every industry (see Appendix 10 for a detailed list). Companies are leveraging blockchain technology to improve or revolutionize processes such as transaction records, auditing, trade processing, privacy, content ownership, compute/storage, compliance and a multitude of other use cases.

Exhibit 22: Enterprise Blockchain Timeline and Forecast

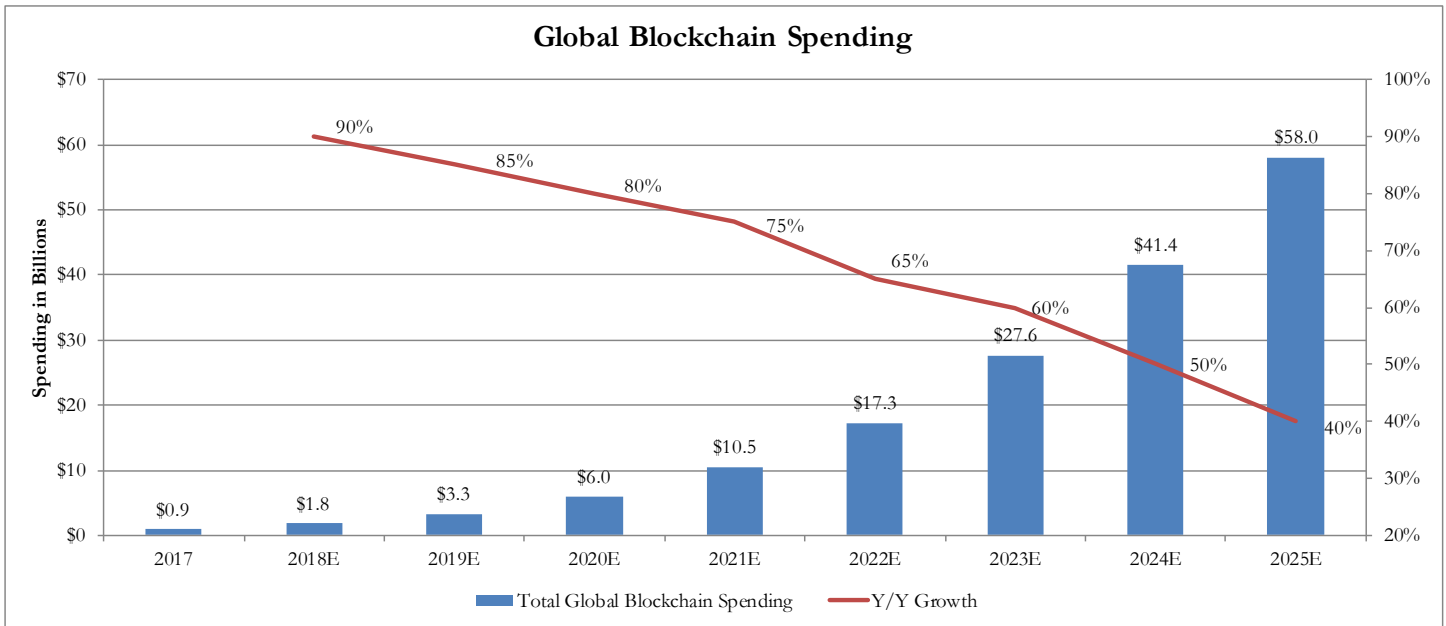


Blockchain will improve enterprise productivity through automation. Accenture's *Banking on Blockchain* analysis found that the eight largest banks could see annual savings of \$8-12B on an initial investment of \$30B through using blockchain. The breakdown of potential savings includes:

1. 70% savings on central finance reporting through more streamlined data reporting and transparency;
2. 30-50% potential savings on compliance due to improved transparency and auditability of transactions;

3. 50% savings on centralized operations such as KYC and client onboarding due to more robust digital identities and mutualization of client data among participants; and
4. 50% potential cost savings on business operations such as trade support, middle office clearance, settlement and investigations by eliminating the need for reconciliation, confirmation and trade break analysis.

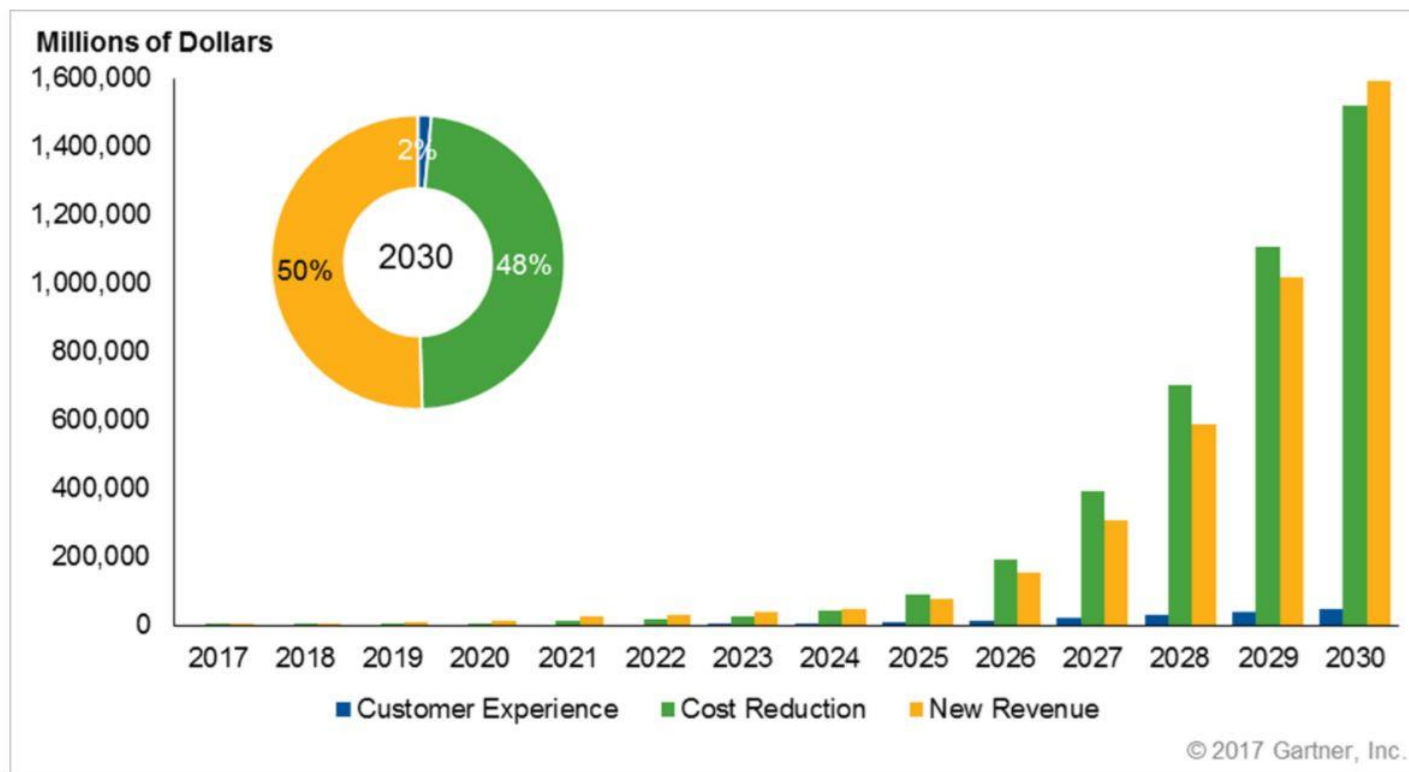
**Exhibit 23: Global Spending on Blockchain Solutions**



Source: IDC, OPCO

Cost savings will be specific to certain industries, for example Oliver Wyman found that the insurance industry could see \$60B in savings from fraudulent claims.

**Exhibit 24: Blockchain Cost Savings and Spending Forecast**



**Microsoft**

**Travel and Bookings - Webjet:** The hotel bookings site stated it is now using Ethereum on Azure to power Rezchain, its data reconciliation service for the travel industry. Through Rezchain, Webjet has seen a 90% reduction in losses associated with transaction disputes across its internal brands. The system uses smart contracts to create independent records which can alert any company participating in the chain as a transaction occurs. Webjet stated the travel booking industry is complex with dozens of systems and millions of transactions, thus leveraging a blockchain based reconciliation system keeps every party aware and updated on all transactions in real time.

**Settlement of Payments - Monetary Authority of Singapore:** Microsoft is collaborating with the Monetary Authority of Singapore and The Association of Banks in Singapore to explore the use cases of distributed ledger technology in the clearing and settlement of payments and securities. The entities chose to work with Microsoft due to its open, scalable and flexible platform that allows multiple distributed ledger and blockchain platforms to be deployed while offering the ability to customize the technical and security requirements for each deployment.

**Finance - Nivaura:** On March 21, 2018, MSFT announced that Nivaura created the world's first blockchain-based investment product using Azure. With help from Azure, Nivaura's platform registered, cleared and settled two principal protected notes, one on traditional clearing infrastructure and one using the public Ethereum blockchain. Nivaura's CEO stated this method can slash post-trade administration costs from £30,000 to just £50 over the life of the instrument.

**AWS**

**Finance – Union Bank of the Philippines:** In early May, 2018 Union Bank of the Philippines announced its intent to launch a clearing system that connects rural banks through blockchain technology, using Kaleido, called Project i2i. Union Bank stated that blockchain can enable connectivity among rural banks as small lenders do not have the capability to join clearing houses. This blockchain based clearing system will also enable streamlining of numerous bank processes such as inter-rural bank funds transfers, financial and accounting reports, remittance, its KYC process and branch locating. Ultimately project i2i is aiming to build a decentralized, cost-effective retail payment system for the currently 35M unbanked Filipinos.

**IBM:**

**Global Trade – Maersk:** In January 2018, IBM and Maersk announced a Joint Venture to provide more efficient and secure methods for conducting global trade using blockchain technology. The goal is to provide end-to-end supply chain visibility that enables all shipping participants to transact securely and seamless while digitalizing and automating all paperwork and filings Maersk's aim to offer costs savings of ~10% in the \$1.8T global trade with the platform being the single source of data across all organizations, eliminating physical paper across customs/duties etc.. Since its launch other parties including DuPont, Dow Chemical, Tetra Pak and The US Customs and Border Protection agency have piloted the platform.

**Supply Chain – Walmart:** Walmart's Vice President of Food Safety, Frank Yiannas, traced a package of sliced mangos back to their source which took six days, 18 hours and 26 minutes. Using software developed with IBM and blockchain technologies, Walmart was able to cut this time to 2.2 seconds, tracking the mangos from a farm in Mexico to US stores. Frank Yiannas stated that most parties in the food supply chain have their own method to track products and ingredients and most involve paper, not through digital means. Blockchain integrates safety systems to enable all parties and consumers to know if a product was sustainably grown, its specific shelf life, where it was grown, the state of its transportation and other details. The company worked with IBM to develop the service.

**Pharmaceutical Procurement – Sichuan Hejia Co:** IBM and Sichuan Hejia Co launched a blockchain-based supply chain financial services platform for pharmaceutical procurement to improve efficiency and transparency of supply chain finance. In China it is difficult for small pharmaceutical retailers to credit and it takes 60-90 days to recover payments after delivery. The new blockchain based platform tracks drugs through the supply chain which established authenticity of transactions which helps to lower the credit risk profiled by the financial institutions which should allow payment periods to be shortened down to one day. Banks are more informed of the pharma supply chain and are more willing to lend funds to smaller pharma dealers.

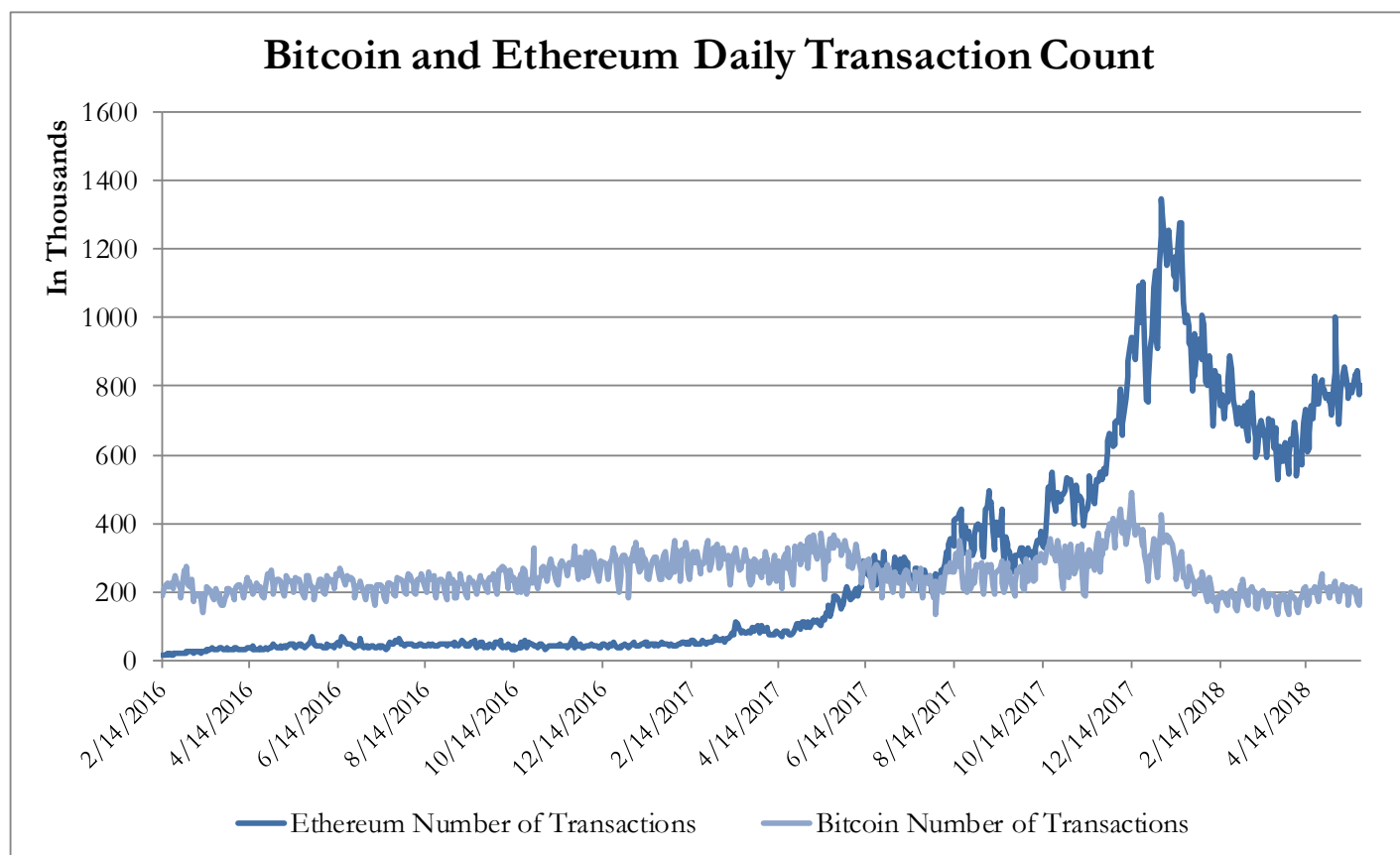


## Ethereum: The Leading Public Blockchain and Platform for Smart Contracts and dApps

While Bitcoin is a store of value and arguably a transaction mechanism, **Ethereum is a blockchain-based distributed computing platform, featuring a decentralized virtual machine (EVM) that can execute smart contracts in real time.** Ethereum is best known for enabling the creation of ERC-20 tokens to enable ICOs to raise money directly from investors without an intermediary. Right now it is also the blockchain platform of choice for decentralized applications, known as dApps. We are still waiting for scale economics and the killer applications.

Ethereum smart contracts are auto-executing depending on criteria coded by the smart contract developer at set up. An event or condition (stock price, strike price, rent, expiration date) triggers the smart contract to execute and fulfills the duties within the contract. The use cases for smart contracts are limitless, and apply to virtually every industry. The future could involve autonomous smart contracts, known as Decentralized Autonomous Organizations that run without human intervention.

**Exhibit 25: Bitcoin and Ethereum's Daily Transaction Count**



Source: Etherscan.io, Blockchain.info

At its peak, Ethereum handled ~1.3M tx/s per day, which coincided with the release of the popular dApp CryptoKitties. Since then, transactions per day have declined as Ethereum is lacking a killer application and the CryptoKitty craze has softened.

Several startups, such as Agrello are making plain English smart contracts for greater usability by any party, including non-lawyers. Smart contracts may have the ability to disrupt major industries such as stock trading/execution, insurance, banking at significant cost savings.

Ethereum's token is Ether, and is currently trading at \$550 and was originally released in July, 2015 by its founder Vitalik Buterin through an \$18M ICO. Ethereum is currently valued at \$37.2B, and 97.2M ethers are in circulation. Smaller denominations of Ether are called Gas and are akin to pennies and dimes versus dollars.

Ethereum has numerous innovative scaling initiatives under way, which we detail later in the report, although it is still a few years away from offering transaction cost/quality that is on par with a private model. We expect a start-up "in a garage" to solve this problem sooner. We are seeing innovative startups like Blockstack offer developers the tools to create decentralized applications with their choice of storage, including using the private clouds or "Grid" based clouds. Blockchain storage startups (Storj, Filecoin, and Sia) offer a "Grid" shared storage service, that currently costs 1/10<sup>th</sup> public cloud costs, but they represent less than 0.01% of total cloud/data center storage capacity, and have not been tested in storing content *en masse*.

#### Ethereum's Statistics

- **dApps:** 1,400+ distributed applications built on top of Ethereum's network, and this is the long-term focus on the platform.
- **ICOs:** Have raised \$4B in 2017, and the total value of ICO tokens stands at \$62B with the majority (98%) established on Ethereum's platform.
- **Transactions:** ~600k transactions per day on Ethereum's network and growing. This is ~3x the number of transactions on the single use Bitcoin network as of April 4, 2018
  - The number of daily transactions on Ethereum surpassed Bitcoin's on June 10, 2017

#### Exhibit 26: Ethereum Benefits

Cost Of An Ethereum Based Smart Contract (Escrow)					
Transaction	Description	Gas Price*	Gas Used	Transaction Cost (\$)	Time (min)
1) Create Contract	Initializes the contract and desposits 0.5 ETH into the contract	4 Gwei	536467	\$1.131	0.49
2) Sender Confirms	The sender calls <i>Confirm</i>	4 Gwei	46,746	\$0.098	0.49
3) Arbitrator Confirms	The arbitrator calls <i>Confirm</i> , and the funds are dispered to the receipt	4 Gwei	82377	\$0.174	0.49
<b>Total</b>				\$1.403	1.47

\*Edited to 4 Gwei from 20 Gwei (highest current gas price in April 2018 to ensure speed) ETH price edited from \$300 to \$520

Source: Danny Ryan, Hackernoon: *Costs of a Real World Ethereum Contract*. Also [ETHgasstation.com](http://ETHgasstation.com)

Costs are cut dramatically through automation, verification and monitoring required as the contract is shared across all parties and executed automatically. Consulting firm Capgemini found that consumers could save \$480-960 per loan when purchasing a home through smart contracts due to lower processing costs.

While keeping in mind the high costs of using the Ethereum virtual machine for storage and compute, there are several benefits users do gain. For example, user's compute/storage are censorship/fraud resistant as there is no third party control by banks or governments. Further, decentralized applications are interoperable with other

blockchains so applications cannot be shut down on a whim; for example Facebook can shut down third parties or applications at will, crushing established business models overnight.

#### Exhibit 27: Ethereum Blockchain Benefits







Blockchain Benefits over Centralized Systems	
Benefit	Description
Censorship Resistance	No interferences by governments, banks or third parties.
Fraud Resistance	No first party interferences, or exit scams
Transparency	Ledger is visible to all parties
Robustness	System wont go offline due to a computer or data center failure
Interoperability	Decentralized applications can survive regardless of blockchain changes. I.e. third parties on Facebook can be shut down instantly, which is not the case on blockchain.

Source: Vitalik Buterin, Deconomy 2018.

**Using The Ethereum Network:** MetaMask is a browser (Chrome, Firefox, Opera, Brave) plugin that allows users to run Ethereum dApps without running a full Ethereum node. To use the Ethereum network any user can convert their Ether into Gas, which is the unit of currency used to power the network, and is paid to the miners who compete to clear new transactions (mining described later on). Users can increase the amount of gas in their transactions so their transaction is picked up first, and the miners can increase/decrease their gas requirements in processing transactions to meet market demands. This effective market makes network utilization more efficient and secure, for example, it negates problems like DDoS attacks, spamming etc. that would require payments in gas.

**Ethereum Is Moving Fast To Achieve True Scalability** Ethereum currently utilizes PoW (proof of work mining) like Bitcoin, but is planning to switch over to a proof-of-stake (PoS) protocol that would not require the massive electricity consumption of PoW while also making the platform faster and cheaper to operate. Both PoW and PoS are methods to reach consensus in the network to add new blocks and move the blockchain forward. **As distributed applications are built on Ethereum, the underlying platform must be scalable to enable these transactions and dApps to work in real time, and the move to PoS is critical.**

**Exhibit 28: Comparing Proof of Work and Proof of Stake**

Proof of Work vs Proof of Stake	
Proof of Work (Bitcoin Mining)	Proof of Stake (Ethereum's Future)
 <p>The probability of mining a block is dependent on how much work is done by the miner</p>	<p>A user can mine (be a validator) depending on how many coins they stake (set aside in escrow)</p>
 <p>Payouts become smaller and smaller for bitcoin miners and there is less incentive to avoid a 51% attack</p>	<p>The PoS system of staking makes any 51% attack much more expensive if not impossible</p>
 <p>The transaction speed is slower and slower depending on the transaction fee</p>	<p>Transactions are very fast, and transaction costs come down significantly; PoS is more scalable</p>
 <p>The PoW system favors powerful miners and mining pools</p>	<p>PoS is fair and fast and can deliver finality (idea that transactions are final)</p>
 <p>Miners receive block rewards</p>	<p>Validators only receive transaction fees</p>
 <p>If a miner spends energy mining on the wrong chain (a 51% attack) or behaves badly, they simply lose the cost of the electricity and the opportunity cost of block rewards</p>	<p>If a validator acts badly, their stake is "slashed" or taken away, ensuring trust in the system</p>

Source: [Bitcointalk.org](http://Bitcointalk.org), OPCO

The need for scalability can be demonstrated through the viral release of CryptoKitties, a popular decentralized application that allowed users to buy, sell and breed digital virtual kittens on the Ethereum blockchain. Although due to lack of scale in the system, CryptoKitties itself accounted for ~12% of all Ethereum transactions and clogged up the network.

**PoS Dynamics:** Ethereum’s Proof-of-Stake plan aims to have users set aside a certain amount of ether, basically in escrow, to act as a validator. The number of ether set aside (staking ether) has not been set in stone but may be in the 1,000 Ether range (~\$1M). The older the age of a validator, and the more ether staked, the better chance the validator will be chosen which increases trust in the system.

PoS is more efficient than PoW since the main effort in PoW, thousands of miners competing to find the next valid block, is removed. Instead, PoS works by randomly selecting a validator who has enough ether staked who then chooses which block comes next. Validating the transactions themselves is a computationally light process, which will likely be done on an automatic software client which validators can download. Validators “validate” blocks by placing bets on which block they believe is correct/will come next and if correct they are rewarded with transaction fees. If a user bets maliciously, their stake is taken away or “slashed” which ensures a reliable system that rewards good actors and punishes those acting maliciously.

## Exhibit 29: Proof of Stake's Technical Process

Example Technical Proof of Stake Process		
Step	Simplified Process	Required Definitions:
1	Add a coinbase transaction and a staking transaction (in most coins, this must be hardcoded as the second transaction)	A <b>coinbase transaction</b> is created by a miner, has no inputs and is created with each new block that is mined on the network. This is the transaction that rewards a miner with the block reward for their work
2	Prepare the block normally, compiling transactions from the network	
3	Compute the PoS "Kernel"	Generally the kernel contains "a stake modifier, the current block's timestamp and data from the "txPrev". The txPrev is the transaction of the output which is spent by the staking transaction. The data pulled from the txPrev includes blocktime, transaction time, hash and output number.
4	Compute the "staking difficulty" which is the base difficulty, reduced by a ratio of how many coins you are staking.	At the end a signature is made, proving that the staking transaction actually belongs to the person creating the block. This signature goes into the blockheader so that it is part of the blockhash.
5	Compare the kernel's hash against the staking difficulty	
6	If the hash meets the difficulty then continue, otherwise go back to step 1 trying other UTXO's in your wallet that are suitable for staking	
7	Now you have a valid PoS block. The final step is to sign the block header, proving that you own the staking transaction from step 1.	

Note: PoS is still nascent, and a continually evolving field of study, so changes will likely arise.

Source: <http://earlz.net/view/2017/03/24/1901/proof-of-stake-mining-how-it-actually-works>

PoS for Ethereum solves numerous problems: 1) energy efficiency, 2) greater decentralization; and 3) larger scale. This consensus method is a continually evolving and nascent field of study, although we touch on the complex process below in a simplified manner.

**Ethereum's Scaling Propositions**

With BTC processing ~7 TX/s and Ethereum at 15, this is well below the level of mainstream platforms such as Visa which has the capacity to process 56,000 transactions per second. Ripple has improved this processing capacity specifically for financial transactions.

**Exhibit 30: Transaction Speed by Entity**

<b>Crypto/Mainstream Transaction Speeds</b>	
<b>Entity</b>	<b>Tx/second</b>
Visa*	24,000
Ripple	1500
NEO**	1000
Paypal	193
Bitcoin Cash	60
Litecoin	56
Dash	48
Ethereum	20
Bitcoin	7

\*Has the capacity to reach 56,000 per second

\*\*10,000 tx/s theoretical

Source: HowMuch.Net, Hackernoon.com

Ethereum's developers have proposed numerous scaling innovations for the platform, which we describe briefly in the next table. We note that the space is constantly changing, with new scaling propositions and changes to current concepts surfacing regularly, and we have seen large improvements in a short period of time; without better scale all future use cases and interoperability with cloud computing/storage are null and void. Over time we expect Ethereum's developers to continue innovation on the platform to achieve true scalability, at speed, with low transaction fees, although this will take time and is subject to moving timelines.

### Exhibit 31: Ethereum's Scaling Propositions

Ethereum's Scaling Propositions					
Upgrade Proposition	Description	On/Off Chain	Estimated Scaling Improvement	Status	Optimistic Launch Date
Raise Gas Limit	Miners Increase Gas Limit	On Chain	2-8x	Needs Miner Adoption	2018
Parallel Transaction Processing	Transactions can be processed by nodes simultaneously instead of one at a time	On Chain	2-8x	Concept	2018
Swap Virtual Machines	Swapping the EVM for a WASM	On Chain	3-10x	Code In Progress	2018
Payment Channel Networks	Parties exchange signed transactions off chain, allowing infinite transactions with only an initial and closing transaction on the main chain	Off Chain	10-100x	Code In Progress	2019
Truebit	Off-chain smart contract execution through a verification game with dispute resolution	Off Chain	10-100x	Concept	2019
Proof Of Stake	Changes the consensus algorithm from PoW to PoS	On Chain	2-5x	Code In Progress. Two part process.	2019-2020
Plasma	Tree hierarchy of blockchains where only fraud proof are reported up the tree. Plasma Cash has been proposed as a more scalable version where users simply track the plasma tokens linked to specific contracts instead of downloading and verifying the all of the data - this limits the data that must be downloaded making plasma more scalable	On Chain	10-100x	Concept	2020
Sharding	Validators only need to validate some, not all, of the network's transactions	On Chain	10-100x	Unlikely Before PoS	2020

Source: Fred Ehrasm, Cofounder of Coinbase, published on Medium.com - June, 2017. Edited and Updated by OPCO

### Ethereum's Decentralized Applications

Ethereum, the common trait within the majority of these applications is the removal of intermediaries. These applications vary from social networking applications that enable consumers to control their data, and sell it if they would like, to news sites where paying in tokens curates the feed to avoid fake news.

**Exhibit 32: Innovative Blockchain Based Entities**

Innovative Blockchain Based Entities		
Entity	Description	Where Does This Reside
Factom	Distributed record keeping platform	Open Source - can be used on private blockchain networks. Also has a public layer linked to the bitcoin network for immutable public trust
Gnosis	Decentralized model for the creation of any prediction market - participants can bet on the outcome of any future event.	Runs on the Ethereum's network. Uses its own tokens specific to Gnosis for transactions in creating and investing in different prediction markets on the platform
OpenBazaar	P2P e-commerce platform with no intermediaries	Runs on Ethereum's network, uses its own token as inputs for smart contracts and acts to monetize users "channels" or stores.
SmartContract	Enables smart contracts to easily link with external data sources, so the smart contracts know when to execute, or not.	A technology company that is working to develop its "smart oracle" to make it easier for developers to link their smart contracts on any blockchain to secure data sources, so these contracts know when to execute, or not to.
Datum Networks	A decentralized data marketplace for storing, selling and buying data.	Leverages the Ethereum network (blockchain layer), BigChainDB (blockchain database) and IPFS (peer to peer distributed file system)

Source: Gartner, Company Websites

Numerous new decentralized social media applications have surfaced with the promise of giving consumers their data, privacy and identity back versus sharing it for free with social media giants. Decentralized social networks like Steemit where posts are up voted in the site's native currency vs. algorithms on Facebook which could perpetuate fake news, have been gaining consumer interest. The appeal to users is clear; some consumers want more control over their data versus having a centralized social network control and monetize the data through advertisements.



**Exhibit 33: Select Ethereum Based Decentralized Applications**

Selected Ethereum Based Decentralized Applications	
Name	Description
Decentralized News Network (DNN)	A news network that is curated by users to prevent biased or fake news. Fact checkers are paid in tokens for their work and writers are rewarded by the quality of their content.
uPort	Gives a unique digital identity to each user; allowing for secure way to identify credentials while also acting as a universal password for a user.
Leeroy	A Twitter style platform with no central authority or advertisements. Status can be upvoted with tokens to curate quality content.
Ethlance	A decentralized job board for freelancers. In competition with Upwork.com, and Ethlance does not charge a cut from the freelancer's profits.

Source: Cryptoslate

**Exhibit 34: Select Blockchain Based Social Media Networks**

Top Blockchain Based Social Media Networks	
Name	Description
Steemit	Decentralized blogging and social networking website build on top of the Steem Blockchain. Steem produces Steem Dollars which are used to posting discovering and commenting on interesting content
Indorse	Positioned like LinkedIn; users can create their own content, profiles and connections and get paid for their contributions. Tokens are used to validate users' skills (decentralized consensus).
Obsidian Messenger	End to end encrypted messaging platform that stores data in a decentralized system that is not used for analytics or advertising.
Mastodon	Largest free, open-source, decentralized microblogging network

Source: Company Websites, CryptoTomorrow

**Decentralized Application Building Blocks**

The building blocks of a dApp feature compute on public blockchains, decentralized storage providers and payment methods in cryptocurrencies. The dApp stack could completely remove cloud providers from the equation, but there will be hybrid approaches. There is no reason why Azure/AWS cannot be the storage layer of Web 3.0; our logic surrounds our opinion that users do not care where the storage itself is located (Azure data center vs 100 nodes) but rather that the protocol or dApp itself is decentralized (i.e. a decentralized social media site with storage on Azure).

Notably the monetization of dApps is vastly different, as users will likely have more control of their information they can decide to keep or sell their own data, rather than have a third party (FB, GOOG) sell ads/information on it. The token model in dApps also serves as a curation method, one of the main issues in platforms, as users can reward quality content or posts so information is real.

The limiting factor in dApps is scalability. Fred Eshram, the co-founder of Coinbase, calculated Facebook handles 175K requests per second, which has undoubtedly grown since his report posted on the news site Medium last summer. This compares to

Ethereum’s current 13 transactions per second speed, which gets cut in half for tokens as the gas requirement is ~2x for token transactions. But as shown above there is massive innovation occurring and there will likely be new blockchain platforms that are optimized for specific transaction types.

**Exhibit 35: Decentralized Application Stack**

Decentralized FOG Application Building Blocks			
	Web 2.0	Web 3.0 (dApps)	Status
Computation	Amazon EC2	Ethereum, Truebit, NEO	In Progress (Need Scaling etc)
File Storage	Amazon S3	Filecoin, Storj, Sia, MaidSafe	In Progress (Storj Is live)
External Data	3rd Party APIs	Oracles (Augur)	In Progress
Monetization	Ads, Selling Goods, Monetizing User Data	Token Model	Live
Payments	Credit Cards, Paypal	ETH, BTC	Live

Source: Fred Ehrasm, co-founder of Coinbase, OPCO Updated

**Funding Ethereum’s Innovation**

The funding for Ethereum’s research comes from The Ethereum Foundation, whose mission is to promote and support the Ethereum platform and R&D. The Foundation frequently awards grants to support research; applicants apply on the foundation’s website when there is a need for new research. For example, on March 8, 2018 it awarded \$1.5M to 13 projects focused on scalability, security and development. Currently, the Ethereum foundation has \$261M worth of ETH at the price of \$389.59, which was set aside during the original ICO for Ethereum.

**Exhibit 36: EIP Process**

EIP Process	
Step	Description
1	A change should be presented as a pull request. As a pull request, changes can be easily made onto the proposal, and community feedback is welcomed. Here, it also falls under the scrutiny of the EIP editors.
2	If the EIP editors find the request to be technically correct and in tune with the "ethereum philosophy," they can "merge" it as the draft into the next stage.
3	Once merged, software implementations, in the form of various ethereum clients such as Geth and Parity, can occur, and if they work, the proposal can be finally "accepted."
4	Once accepted, the platform can be updated with the EIP-- providing the various nodes running ethereum software decide to upgrade.

Source: Rachel Rose O’Leary, CoinDesk.com

Since Ethereum is open source, any developer can submit an Ethereum Improvement Proposal (EIP) to the community concerning a new feature, process or change. The authors of an EIP are responsible for convincing the community of the rationale for the change. Each EIP must go through an approval process, detailed below. The EIP editors,

composed of ETH's founder and several other high profile developers some of whom work for the Ethereum Foundation, do not pass judgment on any new EIPs, they simply do the administrative and editorial work.

While a complex process, EIPs need to be accepted by the community, especially miners, to be successfully implemented. A major EIP could cause a hard fork if it is contentious or is not backwards compatible with the old chain, splitting ETH into two chains and tokens. An EIP can also cause a soft fork if it is not contentious and is backwards compatible leaving the current chain, and token, intact.

Hard forks can occur when there is a contentious upgrade and a majority or large enough minority of nodes do not upgrade their protocol software to the new version. Anyone running a node has the option to upgrade their software to include new EIPs, which democratizes the absolute approval process for upgrades. In essence varying nodes will be running old/new software which leads to two chains moving forward, hence the birth of two chains, two tokens and two communities. The goal is always for the large majority of the community to accept changes, leading to proactive blockchain improvements. A hard fork called Byzantium occurred in October 2017 with nine EIPs which improved privacy, scalability and security.

#### **Ethereum Is The Primary Blockchain ICO Platform**

ICOs through blockchain platforms such as Ethereum and Neo enable companies to raise hundreds of millions of dollars in a fast (minutes) and easy (no current regulations) manner. This opens the door to funding ideas on the smaller level which was previously only open to accredited investors. Most important, developers can sell tokens which effectively monetize open source software, since specific tokens are required to interact with their specific platform, which is revolutionary, in our opinion.

#### **Exhibit 37: Largest ICOs To Date**

<b>The Ten Largest ICOs</b>		
<b>Name:</b>	<b>Total Raised</b>	<b>Focus:</b>
Telegram	\$1,700,000,000	Encrypted Messaging Application
EOS	\$700,000,000	Blockchain that enables the horizontal/vertical scaling of dApps
Filecoin	\$257,000,000	Blockchain based storage network
Tezos	\$232,319,985	Future-proof smart contract system
Paragon	\$183,157,275	Goal is to legitimize and provide transparency for the Cannabis Industry
Bancor	\$153,000,000	The standard for creating Smart Tokens
Kin Kik	\$97,041,936	Token launched to encourage developer activity and user participation on the Kik Chat App and store.
Status	\$90,000,000	Open source messaging platform and mobile browser to interact with dApps on the ethereum network
TenX	\$64,000,000	Cryptocurrency payment platform
MobileGO	\$53,069,235	Crypto-centric mobile gaming platform and store

Source: Coinschedule.com

Many, if not all, ICO projects brand their own digital tokens as utility tokens, which have a specific use case tied to the project; such as using your STEEM tokens to reward an author on its publication platform for a post. Long term, we believe the SEC will brand ICO tokens as securities, not just utilities, which is the correct route and allow legitimate founders to secure funding through the ICO process.

Ethereum offers a standardized way to create new tokens, and fund dApps, on its blockchain using its ERC-20 protocol, which are guidelines that facilitate the integration of various crypto currencies. Before ERC-20, each new token has to have its own system for account varication/transfers, but ERC-20 changes this as all ERC-20 tokens can be interchanged with other ERC-20 tokens.

Major red flags have been put forward on many ICOs being fraudulent, and we note that many are. On the flipside, ICOs provide not only an simple way to fund new ideas, but also the ability to monetize the protocol layer, IP or software of a startup by tokenizing the company—that we note is revolutionary. Never before has open source software had the ability to be monetized.

Filecoin, a distributed storage network is the largest ICO to date that took place on Ethereum. Due to the large increase in Ethereum’s price, the value of these companies is understated. I.e. Ethereum’s price was up ~100x in 2017, so the value of ETH which ICO’s hold has increased substantially.

**Evaluating The Utility of Tokens and Token Economics**

The current use case for crypto tokens has been to raise funds for new ICO-related projects. In the long term, legitimate tokens will be used to self-govern these companies’ business models, allow users to interact with and use these platforms, and facilitate network effects to drive network usage.

**Exhibit 38: ConsenSys Universe of Blockchain Applications and Services**

A Guide To Crypto Token Usage and Value		
Role	Purpose	Features
<b>Right</b>	Bootstrapping Engagement	Product Usage, Governance, Contribution, Voting, Product Access, Ownership
<b>Value Exchange</b>	Economy Creation	Work Rewards, Buying, Spending, Selling Something, Active/Passive Work, Creating a Product
<b>Toll</b>	Skin In The Game	Running Smart Contracts, Security Deposit, Usage Fees
<b>Function</b>	Enriching User Experience	Joining a Network, Connecting with users, Incentive for Usage
<b>Currency</b>	Frictionless Transactions	Payment unit, Transaction Unit
<b>Earnings</b>	Distributing Benefits	Profit Sharing, Benefits Sharing, Inflation Benefits

Source: William Mougayar

Crypto tokens that are designed for use on a specific protocol or project have varying use cases. These range from owning a token to allow in protocol governance or usage or even simply access to the protocol or platform itself. Tokens can also be used to pay for usage, connecting with other users, pay for products or services, or for distribution. For example, Ethereum's token Ether is expended to use for smart contracts, while Gladius' token is used to buy decentralized CDN/DDoS protection. In both cases, these respective tokens are paid to the other side of the service; in Ether is distributed to the winning miner who cleared the transaction and Gladius' tokens are distributed to the users running nodes who provided the CDN/DDoS protection services.

Determining if a crypto token has actual utility or is asset backed is not clear in many cases. Utility tokens are generally tied to product usage, granting governance or enabling access to the platform or to facilitate network usage. A crypto token that is a security is generally one that raises money for the project with no link to usage of the network, and is focused more as asset or future cash flow ownership like a regular stock or asset-backed debt.



The only ownership of a virtual wallet, such as on MEW is the private and public keys provided, if this key is lost funds are not recoverable. A user then installs an application to access their virtual wallet, we note we have tried several and MetaMask is the easiest. A user then sends their ETH from coinbase to their "Ether Wallet" and uses MetaMask (a Google Chrome Plugin) to access their ETH. From MetaMask, a user inputs the contract address for a live ICO, sends their desired ETH and in turn receives the tokens of the target ICO.

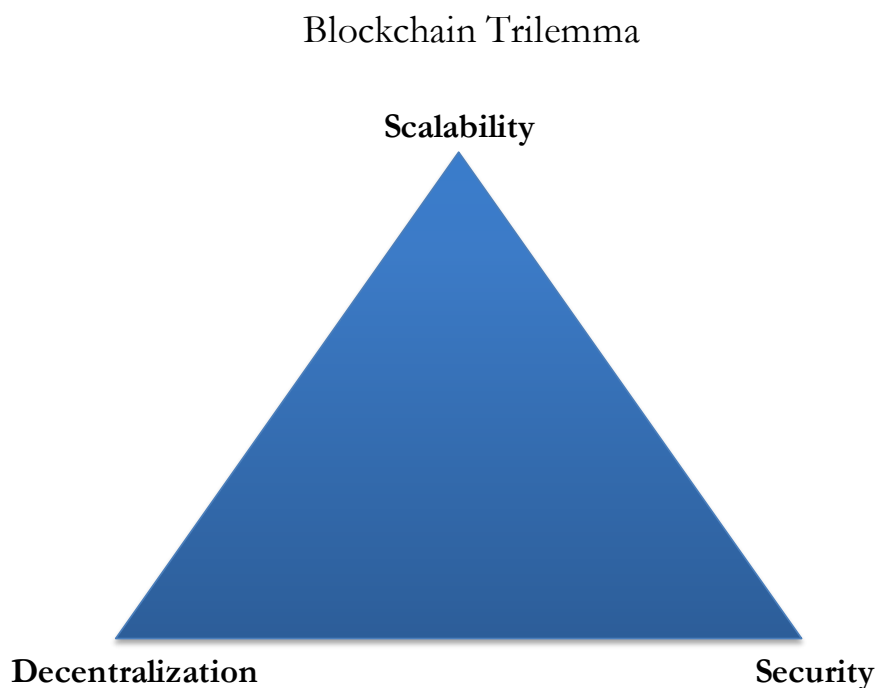
ICO tokens can be used for whatever current/future use case the ICO issuer is planning, such as to use that protocol's network services, or are tradeable on a major exchange such as Binance if it is listed.

### **Blockchain Trilemma: Room For Multiple Winners**

While Ethereum is currently the leading public blockchain, we ultimately believe there will be numerous successful blockchain platforms each suited to address the blockchain trilemma. This trilemma states that blockchain systems can have at most two of the following three properties (scalability, decentralization and security). We detail two other public blockchains (NEO, EOS) later in this report.

#### **Exhibit 40: Blockchain Trilemma**

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Source: Vitalik Buterin, Sharding FAQ

## Blockchain Currently Requires Expansive Infrastructure

We believe as dApps are developed on top of the infrastructure layer (Ethereum, NEO) will require larger amounts of bandwidth, processing and data storage. BTC and Ethereum do use a lot of compute processing/electricity and low end datacenter space, but it is not a bandwidth intensive operation. We will also see increased utilization of consumers used storage and processing like we have for some grid compute applications.

### Monetizing Consumers' Unused Compute

Gladius.io is a blockchain-based startup which recently completed a \$12.5M ICO on the Ethereum blockchain. Gladius' goal is to create a fully decentralized peer-to-peer serverless node network to utilize consumers' own compute to enable DDoS and CDN services that content providers want, essentially this is a way to monetize P2P.

The below sample earnings table is a hypothetical calculator provided by Gladius and the service has not yet been fully deployed. Also this is solely for compensating users for their spare compute power, and we believe the ISPs could move to prevent what is basically the reselling of their services.

#### Exhibit 41: Gladius' Earnings Calculator

Gladius Earnings Calculator		
Upload Speed	Daily Uptime	Monthly Earnings
6 Mbps	8 Hours	\$9.77
15 Mbps	8 Hours	\$24.49
35 Mbps*	8 Hours	\$57.20
<p><b>About Gladius:</b> Gladius' goal is to create a fully decentralized, peer to peer, serverless node network to connect bandwidth and storage pools to websites looking for DDoS protection and expedited content delivery.</p>		

\*Comcast / Charter Gigabit internet offers upload speeds of 35 Mbps

\*\*\*Estimated profits based off of a \$.03/GB rate. Gladius cannot guarantee this rate, or any profits. This is an estimate based on favorable market conditions and should be treated as such. Source: Gladius.io/#Calculator

## Bitcoin Mining Explained and PoW Environmental Concerns Described

**Bitcoin:** Bitcoin (BTC) is a cryptocurrency with a rudimentary global payment system. It was the first peer-to-peer transaction system that eliminated intermediaries (government, bank). Bitcoin's transactions are verified by network nodes through mining and the use of cryptography, with all transactions recorded in the public ledger known as the blockchain. Bitcoin was originally released as open source software in 2009 and created by Satoshi Nakamoto, an unknown individual or group.

Bitcoin was created to be an alternative store of value versus fiat currency, or legal tender that is backed by a government. It was not designed to solve weaknesses in the traditional electronic payments systems which includes the irreversibility of payments, no third-party intervention, no fraud, no double spending, faster transaction times, openness to everyone, and unbeatable security. There are currently 16.8M bitcoins in circulation, with a hard cap of 21M.



### Bitcoin Mining

Bitcoin mining is the process for which transactions are verified and added to the blockchain. In order to process transactions, bitcoin miners run computationally intense algorithms to validate transactions and are rewarded bitcoin for doing so. The award amount released with each mined block is known as the block award.

#### Exhibit 42: Hash Outputs

Text	Hash
Cloud	b977b950c1ae31e5aeb9ef778cc20a66fc034eb81e738e0206104b677962c465
Cloud and Communications	0aec9f0bc4cf95eb1ac023d4109b3673792d4e9fd10abd136c8de1b8925de5ab

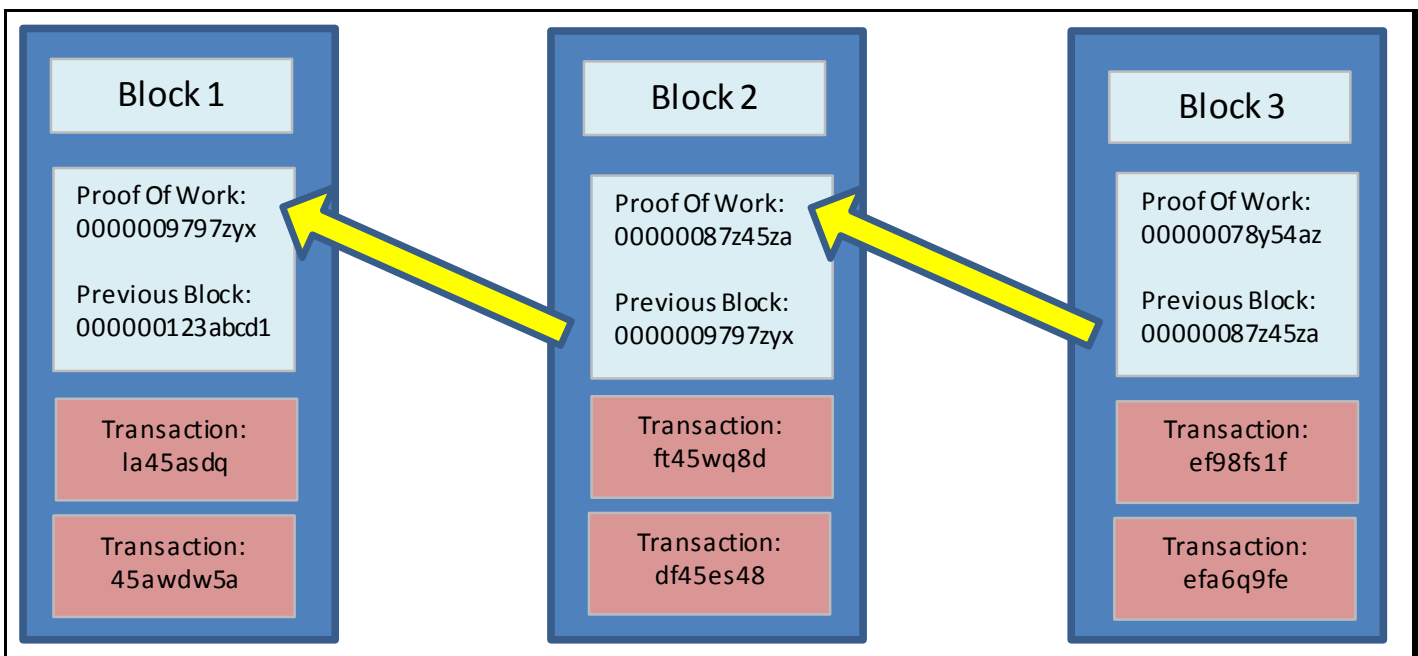
Source: Xorbin.com

To understand bitcoin mining, one to start with hash functions. A hash function it a mathematical algorithm that takes an input and returns an output and is a form of cryptography. Hash functions are used in proof-of-work (mining) since it is impossible to predict the outcome of an input. Bitcoin utilizes SHA-256 cryptographic hash functions, originally designed by the NSA, to secure its network.

There are certain properties of hash functions that are necessary such as taking variable sized inputs and returning them into outputs of a fixed size. For example, using a SHA-256 hash calculator, the two text forms return the same length hash.

The goal is for a miner to use their compute resources to guess at mathematical solutions until it comes up with a hash value that starts with a certain number of leading zeros. Miners must generate many hashes with different nonces until they happen to find one that works. If a miner is able to do this, they have successfully mined the block and wins the current block reward of 12.5 bitcoins, and the block becomes part of the bitcoin blockchain. Miners form mining pools to aggregate their compute power and split the block rewards to increase their probability of winning something.

#### Exhibit 43: Blockchain Process



Source: Bitcoin.Org, rebuilt by OPCO

Each block is created in sequence and includes the hash of the previous block which proves the sequence is linear. In some cases, two competing blocks are formed by different miners, although the block with the largest proof of work embedded into it is chosen for the blockchain.

**Exhibit 44: Bitcoin Hashing Process**

<b>Simplified Bitcoin Hashing Process:</b>	
<b>Step</b>	<b>Process</b>
1	Collect New Transactions Into A Block
2	Hash the block to form a 256-Bit Block Hash Value
3	If the block starts with enough zeros, the block has been successfully mined and is set to the bitcoin network, and the hash becomes the identifier for the block
Caveat	Often the hash is not successful, so a miner modifies the block slightly and tries again (billions of times). About every 10 minutes a block is solved and the process starts over.

Source: Righto.com

Bitcoin mining has expanded from enthusiasts to more powerful corporate entities and mining pools. While mining pools are an excellent way for everyday people to share their spare compute power to validate blockchain transactions, it is in essence a form of centralization which is what BTC is trying to avoid.

**Exhibit 45: Bitcoin Mining Pools:**

<b>Largest Bitcoin Mining Pools:</b>	
<b>Pool</b>	<b>Percentage</b>
AntPool	25.20%
BTC.TOP	11.20%
BTC.com	10.20%
Bixin	8.10%
BTCC Pool	7.30%
Other	38.00%

Source: BuyBitcoinWorldwide

Bitcoin's mining frameworks is built so the mining difficulty, or how hard it is to find a hash below a given target, increases over time. Every 2,016 blocks, the network difficulty changes and adjusts to reach a target goal of 6 blocks per hour. It generally takes two weeks to solve 2,016 blocks, so the network difficulty is adjusted to keep this output steady. The difficulty level has increased exponentially and is correlated with the price of bitcoin and the efficiency of compute.

**Mining Concerns:**

**Electricity:** The main concern with mining is the extraordinary amount of electricity required as the mining difficulty continually increases and competition from other miners increases. Currently Bitcoin mining uses an estimate 44..89 TWh of electricity per year which equates to the entire country of Iraq at the time of writing.

**51% Attack:** The largest concern on bitcoin, and other PoW networks, is where an entity has 51% control over the blockchain and is able to create a new chain that is amended or different from the true chain. This is mitigated in proof-of-stake mechanisms through slashing, and would require an enormous amount of compute power which is currently not feasible.

**Hard Forks:** A hard fork enables a rule change to the underlying protocol, and makes the new chain not backward compatible with the old chain. As such a hard fork is a permanent split from the old chain. The first hard fork of bitcoin was on August 1, 2017 and resulted in the creation of Bitcoin Cash.

Bitcoin Cash was created as enough of the community wanted to increase bitcoin's block size from 1MB to 8MB to fit more data in each block. While speed varies per transaction, Bitcoin cash transactions take ~10 minutes vs ~100 minutes for bitcoin and have a median transaction fee of \$0.20 vs \$10.63 for Bitcoin. As such, Bitcoin Cash is positioning to be a system for payments while Bitcoin is positioned as a store of value.

**SoftForks:** A softfork is backward compatible with the underlying protocol, as such, these are usually meant for improvements to the network that are not contested. Soft forks generally do not result in a chain split.

**Regardless, forks allow for innovation to happen in real time, with the consensus of the community, to enable upgrades to continually evolve the protocol layer.**

**Bitcoin's Future:**

The Bitcoin community is currently in the process of implementing two upgrades to increase scalability; SegWit (segregated witness) and the Lightning Network, detailed below:

**Exhibit 46: Bitcoin's Scaling Propositions**

<b>Bitcoin's Scaling Upgrades</b>			
<b>Name</b>	<b>Type of Fork</b>	<b>Description</b>	<b>Status</b>
<b>SegWit</b>	Soft-Fork	Allows more transactions to be added to each block, increasing Bitcoin's transaction speeds. Splits a transaction into two segments, moving the unlocking signature ("witness" data) from the	Bitcoin's code updated to accept SegWit transactions, but has not been widely adopted. On February 5, 2018, Coinbase stated it would begin SegWit implementation
<b>Lightning Network</b>	An additional layer, not a fork	Lets bitcoin users create payment channels between themselves. In these channels, bitcoin transactions can be sent near instantly because they are not posted on the main bitcoin blockchain. Afterwards the final balances of the channel's operations are posted to the bitcoin blockchain. Fees are envisioned to be extremely low.	An Alpha version for public testing was released on January 10, 2018 and the first ever Bitcoin purchase was completed using the Lightning Network in Late January 2018. Development is ongoing.

Source: Motherboard, Cryptocurrencyfacts.com

## Innovative Blockchain Platforms and Protocols

### Polymath: The Leading Platform For Security Tokens

Polymath offers a simple platform for businesses to tokenize any asset using a standardized token protocol ST-20 and to restrict secondary trading of these tokens.

**Exhibit 47: Notional Values of Major Markets**

Notional Values of Major Markets	
Market	Value
Equities	\$67 Trillion
Debt	\$99 Trillion
Real Estate	\$217 Trillion
Derivatives	\$1.2 Quadrillion

Source: Polymath, Fortune

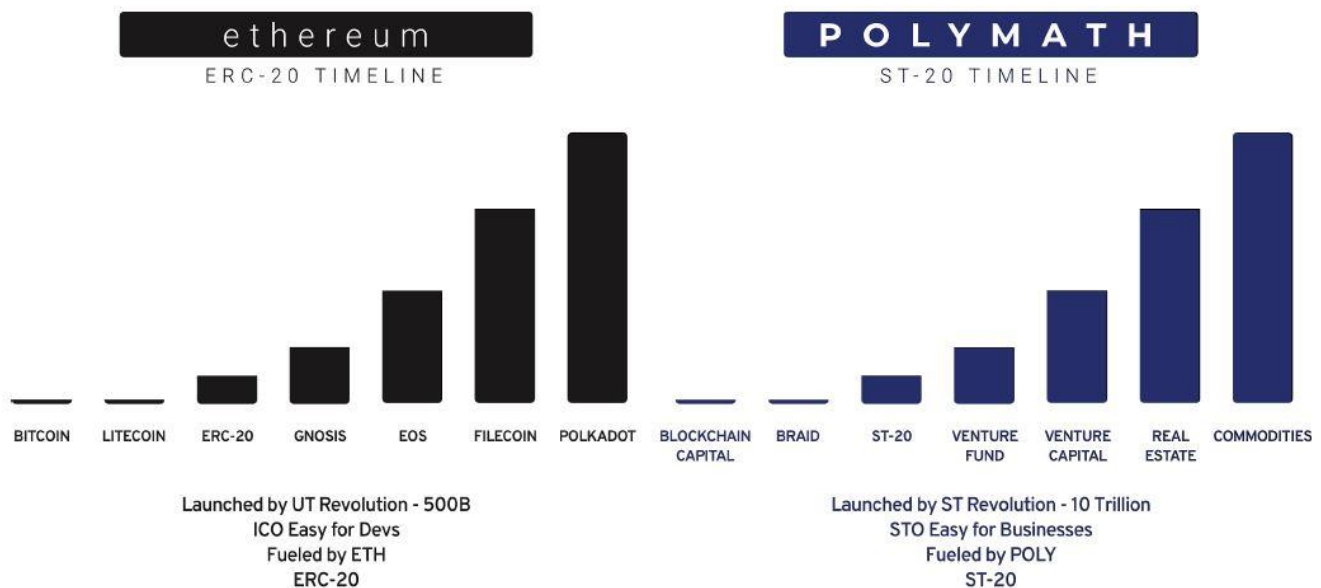
Polymath is focused on tokenizing real estate, funds, commodities and any illiquid assets and offering the ability to do so in an easy to launch manner through a simple platform. To put the size of the discussed markets in context, the equities market has a notional value of \$67 trillion.

While the majority of current ICOs are for utility tokens issued on Ethereum, Polymath is focused on security tokens. Security tokens are comparable to shares in a public company, whereas utility tokens are used to power a network or platform.

**Exhibit 48: High Level View of Polymath and Ethereum**

## The Ethereum Polymath Equivalency

What Ethereum did for Tokens, Polymath will do for Securities.



Source: Polymath

Polymath has identified numerous issues with our current primary market system including the increased costs, complexity and annual reporting requirements for public companies. Costs associated with an IPO can range from 5-10% of the amount raised and on secondary markets transaction costs are estimated to be in the \$250B range. Polymath is using its protocol to eliminate the need for middlemen, auditing system sand long settlement times to make it faster and cheaper for businesses to raise capital through security tokens.

The network has its own token, POLY, which are used to fuel the platform itself and interact with its smart contracts and ecosystem.

**Exhibit 49: Polymath’s Token Use Cases**

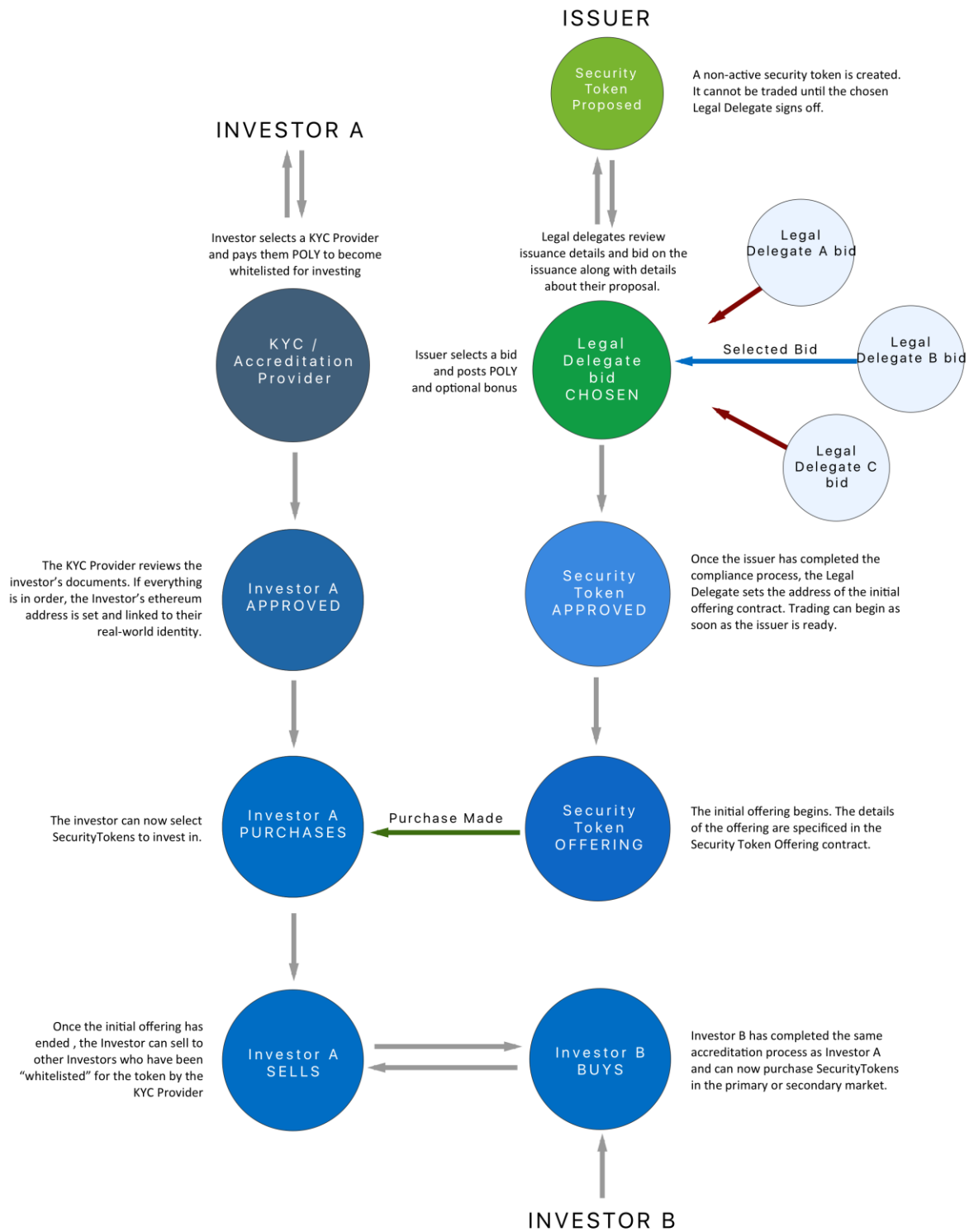
Polymath Tokens Use Cases	
Party	Use
Issuers	Issuers can post bounties (compensation for reporting bugs) in POLY
Developers	Developers earn POLY for creating Security Token Offering Contracts
KYC Providers	KYC providers pay a fee to join the network
Investors	Investors seeking to purchase security tokens will be required to pay a POLY fee to KYC providers for verification
Legal Delegates	Earn POLY by being selected by the issuer to take responsibility for the issuance

Source: Polymath

First generation ICOs have come under scrutiny for potentially failing to comply with current financial regulations, namely KYC/AML provisions. Polymath’s platform addresses this by matching individuals with KYC providers who offer coalition and accreditation services. A KYC/AML provider validates a person’s Ethereum address, ultimately linking the person with their address. This allows only approved users to take part in security token sales. Further, each security token offering has its own smart contract that ensures the tokens are traded only with other approved parties, restricting secondary trading to other approved users. Additionally, all securities must go through the legal delegate process to ensure the issuance details are legitimate. The process is detailed on the next page.

In May, 2018 at Consensus 2018 Polymath announced a partnership with Overstock's tZero to be the exchange for its security token securities. This could provide a dedicated destination for the discovery and trading of security tokens. Polymath has partnered with Corl Financial Technologies, a blockchain startup focused on offering revenue sharing tools for companies, as the first potential Polymath Security Token to represent equity ownership for token owners.

Exhibit 50: Polymath Process



Source: Polymath

**Polymath's Competitors:**

- **Harbor:** Harbor offers its R-Token standard, which is an open source standard to develop securities tokens that work with the existing Ethereum ecosystem. The framework allows only whitelisted users to trade these securities which embed KYC/AML rules. Harbor does not have its own token, and we believe this limits the network effects, automation and growth of the overall entity. Harbor is Polymath's largest current competitor.
- **Swarm Fund:** Swarm Fund is a blockchain for private equity, enabling previously illiquid asset classes to be available to mainstream investors. Swarm Fund uses its proprietary SRC20 protocol to tokenize assets and the protocol is run on the Stellar blockchain. Like other entities focused on security tokens, Swarm Fund states that its security tokens are designed to pass several key aspects of the Howey Test, the applicable legal benchmark for security regulation in the US. We note the SEC has not provided any rulings on security tokens to date.
- **Coinlist:** Coinlist is a platform that aims to connect accredited investors with blockchain projects. Coinlist has already processed over \$400M in cryptocurrency investments through its infrastructure and stated it has thousands of accredited investors already. We note Coinlist is not focused solely on security tokens as it featured utility tokens (Filecoin, Blockstack), but offers AML/KYC checks on potential investors which is a key tenant of security token platforms.
- **Templum:** Templum is a financial technology company focused on creating a platform for the initial sale of tokenized securities and a centralized platform for secondary trading.

**Security Token Risks**

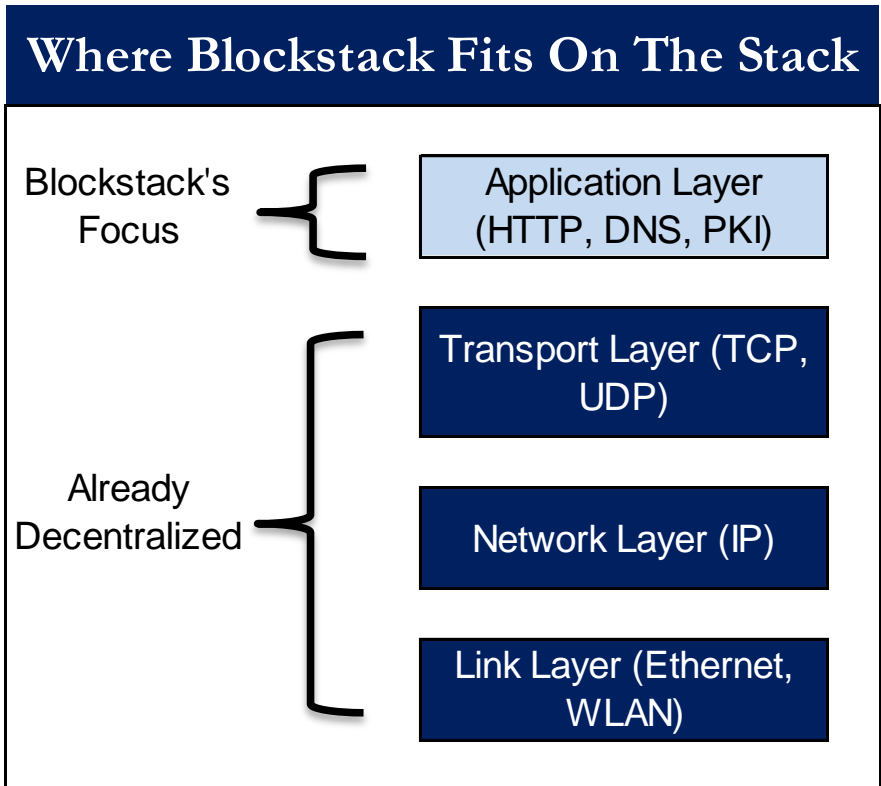
- While addressing KYC/AML unlike normal ICOs, Security Token providers still face the risk of negative SEC regulation.
- It's logical for major exchanges (NYSE, Nasdaq etc.) or banks to offer their own security token standard in the future.
- Legacy crowdfunding sites (Kickstarter, WeFunder, GoFundMe) will likely offer security offerings/tokens in the future if the space develops which would be competitive to Polymath/Harbor due to their large existing user bases.



**Blockstack: Creating A New Internet For Decentralized Apps**

Computing systems have moved back and forth from centralized to decentralized architectures in three different cycles. Mainframe computing in the 1960s-70s was centralized, desktops in the 1980s-90s were decentralized, and we have been moving back to centralized with cloud computing in the past 20 years. Blockstack is now at the forefront of decentralization, through the use of blockchain technologies.

**Exhibit 51: Blockstack's Position On The Internet Stack**

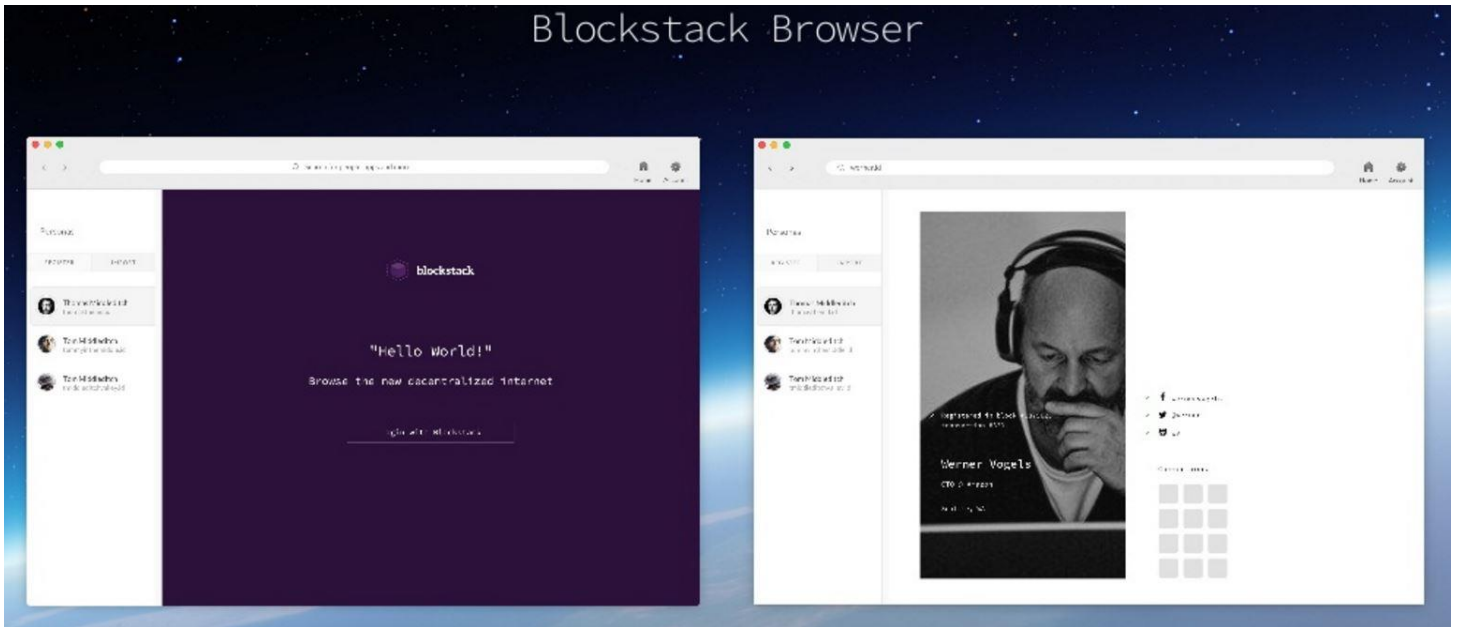


Source: Blockstack

Specifically, Blockstack is a platform making decentralized applications accessible through the Blockstack Browser that streamlines the decentralizing application development process for engineers and developers. The goal is to disrupt Facebook, Google etc. by leveraging the internet and existing compute infrastructures. Blockstack has identified numerous issues with centralized applications (data lock-in, high platform fees, and censorship) that it is looking to help address. In May, 2018, Blockstack released its decentralized app store which could act as a gateway for consumer uptake of these applications.

Blockstack's founders have a goal of giving users control over their data, instead of applications having control over user data, unlike, for example, Airbnb and Facebook, whom now own the data. Users create an account and a keychain sits on the user's device itself, allowing users to encrypt and store files locally and granting access only to sources that they want. Applications plug into user APIs for data, not the other way around; the new application world revolves around the user, not the application. In this dApp world, anyone can add new features to Blockstack's platform.

**Exhibit 52: Blockstack's Browser**



Source: Blockstack

Blockstack enables users to decide where their data is stored; either locally or on the cloud (Amazon, Dropbox), but cloud providers do not have access to users data. In many ways this is a natural reversion to common carrier communication networks only for data as opposed to voice.

Unlike Ethereum, Blockstack puts minimal logic into the blockchain itself and handles scalability outside of the blockchain using the existing internet infrastructure. Ethereum is a blockchain that handles everything with all logic and complexity run on chain; which has the issue of scalability currently.

In May, 2018, Blockstack released its decentralized dApp store, App.co, which could act as an entry way to the decentralized world the way the Apple App store did so on iOS.

**Exhibit 53: Blockstack's Browser**

App.co [What's a Dapp?](#) [About App.co](#) [Add your Dapp](#)

# Universal Dapp Store

Discover Decentralized Apps

**Hot Social Dapps**  
Our curated list of notable Dapps changing the way we communicate.

- SteemIt**  
Blockchain-based rewards platform for publishers.
- Stealthy**  
Decentralized communication platform on Blockstack.
- Peepeth**  
Open, decentralized, & uncensorable microblogging.
- Mastodon**  
Free, open-source and decentralized microblogging.
- Diaspora**  
Privacy-aware, decentralized social network.
- DTube**  
Crypto-decentralized video platform.


Source: Blockstack, App.co

### Blockstack's Technology Explained

Blockstack states it provides the tools for developers to enable decentralized storage, authentication and identity. As such developers can build applications in Javascript and plug into users' APIs, which blockchain manages and which eliminates centralized intermediaries. Users in turn run dApps through the blockstack browser and give read/write permissions to these dApps, with all information encrypted and stored on user devices. As such there are no middlemen, passwords or data silos that can be breached.


#### Exhibit 54: Featured Decentralized Applications On Blockstack

### Featured Apps on Blockstack




**Casa**

Casa is the world's first open source homesharing protocol and decentralized network. Book rooms without platform fees or trusted intermediaries and securely transact with encrypted chat and multi-party escrow.




**Ongaku Ryoho**

Ongaku Ryoho is a music player and decentralized media network that empowers both artists and consumers. Publish music and get paid for downloads without platform fees. Download music and it's truly yours.




**OpenBazaar**

OpenBazaar is a different way to do online commerce. It's a peer to peer application that doesn't require middlemen, which means no fees & no restrictions. Sell anything to anyone in any country around the world.



**Afia**

Afia gives individuals the power to own and manage their personal health records. Keep your health data safe on your personal encrypted cloud storage and securely share your data with healthcare providers as you see fit.



**Guild**

Guild is a blogging network where you own the content you create and can share your favorite posts with others. No longer will you be restricted to a single company's walled gardens. Your writing will live on and travel with you.

Blockstack already has numerous applications on its platform, such as Casa, a home sharing platform, and OpenBazaar, a P2P version of eBay, both without any middlemen.

### Exhibit 55: High Level Blockstack Infrastructure

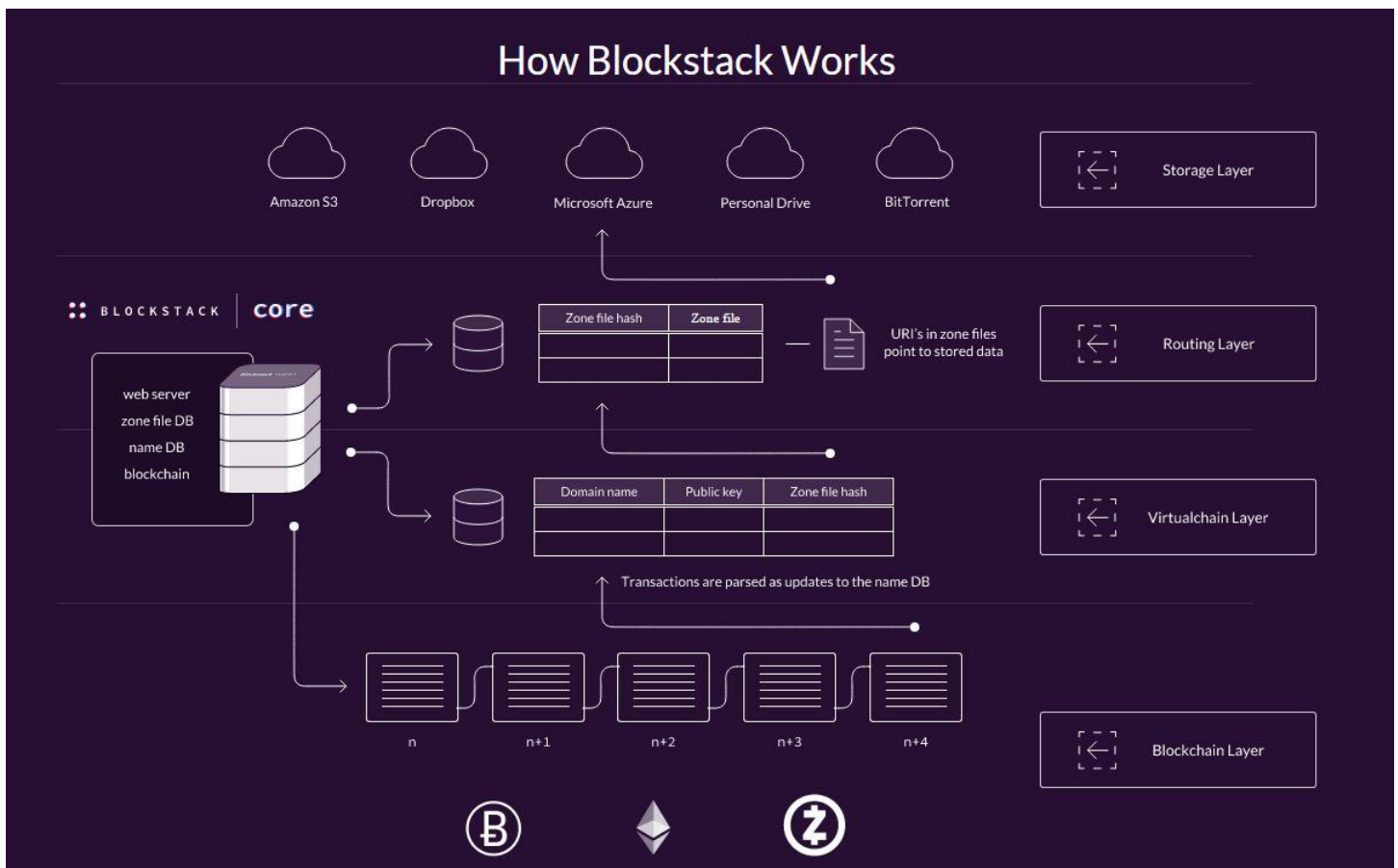
High Level Blockstack Infrastructure	
<b>Blockstack Blockchain and P2P Network</b>	The Blockstack blockchain and peer-to-peer network form the secure backbone of the Blockstack network. Protocol operations are embedded in the blockchain and additional data is stored in the peer-to-peer network, known as the Atlas network.
<b>Blockchain Name System</b>	The Blockchain Name System (BNS) is a replacement for DNS and is meant to provide similar functionality without any central root servers. In BNS, names are owned by cryptographic key pairs. Protocol operations (registrations, transfers, zone file updates, etc.) are written to the underlying blockchain. All Blockstack nodes pick up and process these operations to construct a state machine that gives BNS global state.
<b>Blockstack API</b>	The Blockstack API provides methods for identity, storage and tokens to make it easier for developers to deploy decentralized applications faster.

Source: Blockstack

Blockstack's infrastructure is composed of three key components: 1) Blockstack Blockchain and P2P network which form the backbone of the blockstack network, 2) the naming system which is a replacement for DNS where names are owned by cryptographic key pairs and stored on the blockchain instead of a central repository; and 3) the Blockstack API which handles identity, storage and tokens to deploy dApps faster.

Blockstack is also focused on frameworks for business models for decentralized applications. The company has identified three main models engineers can use; 1) percentage of mining rewards in a system are distributed to popular applications based upon usage, 2) payments for name registrations within a decentralized application (i.e. like a username on Twitter) are paid to the applications creators and 3) app specific tokens where tokens are required to interact with the platform itself. Only interacting with those who have a licensed token ensures security between users. The crypto economics of dApps also ensure proper usage. An example is if email cost money per email, it would be expensive to spam users, leading to efficient use of the system by users. *A more detailed framework of how blockstack works is below.*

**Exhibit 56: How Blockstack Works:**



**Peepeth: The Decentralized Twitter Running on Ethereum**

In March, 2018, Peepeth went live; a blockchain powered microblogging website (dApp) with a user interface that is similar to Twitter. Peepeth is uncensorable with no central control/authority. This service uses an open source smart contract running on the Ethereum blockchain. Peepeth charges a small amount of ETH which equate to fractions of a cent per post. Peepeth allows users to bulk save actions (Peeps, likes, shares etc.) so users can pay one fee to the Ethereum network to post their updates. Links to the data are stored on the blockchain while the data itself is on IPFS, to lower costs.

Peepeth.com is the front end user interface for the smart contract. Although this is a centralized domain platform, any developer can create another front end and restore the back-end's incorruptible data since the smart contract is open source.

To use the service, users access the front end on Peepeth.com to interact with other users. Once ready to post their interactions, a user clicks to post their actions to the Ethereum blockchain, so the interactions are immutable. This costs ETH, and is accomplished through a linked MetaMask account that runs in a user's browser to allow users to pay ether for these transactions. The interface is simple, once a user chooses to publish their interactions to the blockchain, MetaMask's plugin pops up and allows users to communicate their data to the blockchain for the miners to include in the next block.

Currently Peepeth's revenue model is charging for social media verification (verify a user is who they say they are, costs 0.025 ETH) and taking a percentage of this fee. Also, users can receive verified badges for donations to the founder in the range of 1-1,000 ETH. We note having to pay for each post cuts down on spam and is a form of curation. Since all interactions are on the Ethereum blockchain, they are all viewable on Etherscan.io instead of sitting within a centralized server.

## Exhibit 57: Peepeth User Interface

The screenshot displays the Peepeth user interface. On the left, there is a navigation sidebar with a penguin logo at the top. A blue banner reads "Cannot connect to Ethereum." Below it, a section titled "To use Peepeth:" provides instructions to install MetaMask or download Toshi, Trust, or Cipher on mobile, and to get some ether. A "Get an invite" section follows, with the text "Shape the future of social media." and a "Request an invite" button. The main content area is a social media feed. The top post is by Jvck (@jvck) from 7m ago, replying to Brady Dale (@BradyDale) from 13m ago. Brady Dale's post discusses tracking via cookies and the "like" button. Below this, Luis (@Luis) from 16m ago responds, mentioning he was never logged on Facebook on his browser but could track searches via his phone app. Jvck (@jvck) from 19m ago replies to Luis, asking if he made searches on Google and noting that cookies can track habits. On the right, a "Who's Peepin'" sidebar lists several users with their profile pictures and short bios: Bevan Barton, Call Me Gwei, Hannah Lincoln, Taylor Monahan, Andrew B Coathup, and Davis. At the bottom of the sidebar is a "Stay informed" section with an email input field and a "Submit" button. A "Feedback" button is located at the bottom right of the main content area.

Source: Peepeth.com, April 16, 2018

### 0X: An Open Protocol For A Decentralized Exchange; Allowing For Abstracted Interoperability Between dApps

0X is an open protocol for a decentralized exchange on the Ethereum blockchain. The protocol enables the ability to transfer cryptocurrency and ERC20 tokens without an intermediary, offering true interoperability between different decentralized applications many of which have their own tokens. Decentralized exchanges are necessary as centralized exchanges are open to hacks; demonstrated by the Mount Gox, Shape Shift and Bitfinex hacks.

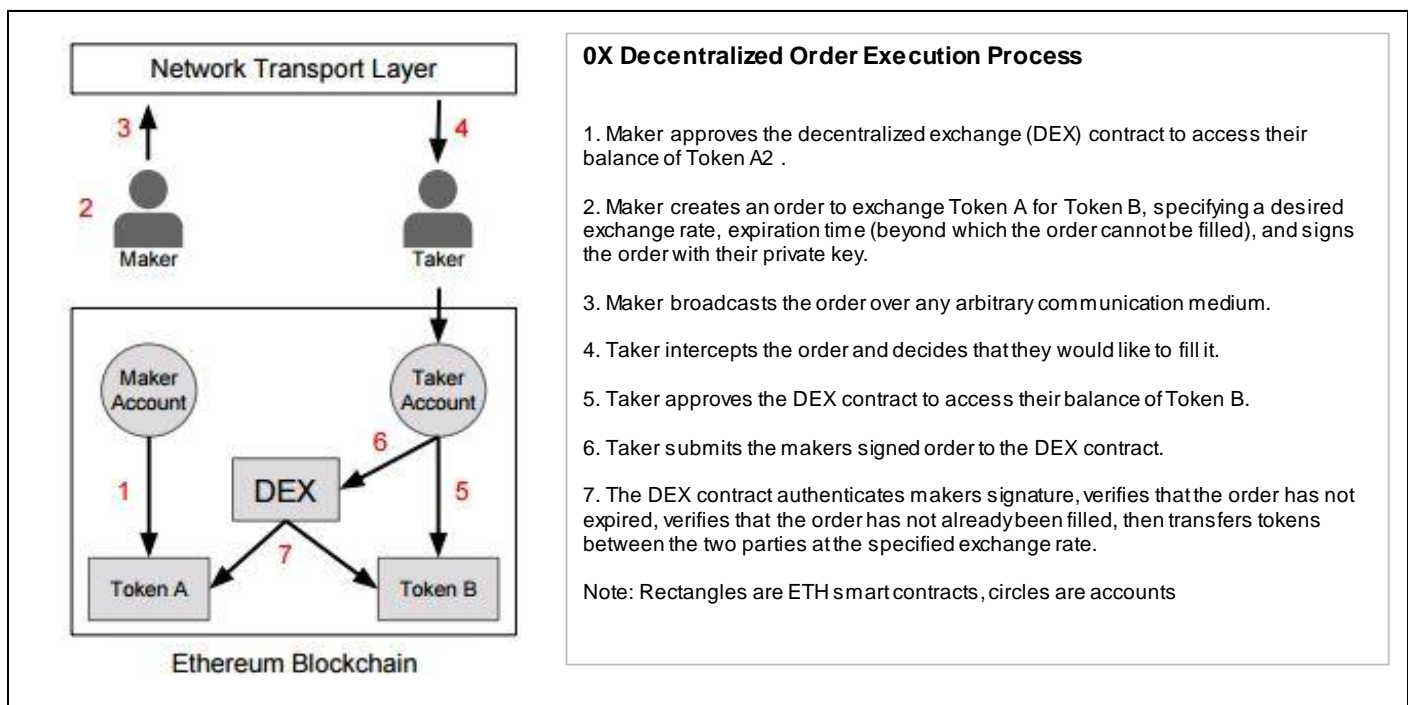


0X's protocol enables the transfer of tokens to be abstracted from the user, so the user can interact with a variety of dApps without having to deal with exchanging tokens at each step.

**How The Protocol Works:**

The simplest use of the protocol is an exchange of ERC20 tokens between two parties. Point to point orders allow users to exchange tokens using any medium, as the packet of data that makes up the order can be sent through text, Facebook message, email or any medium. 0X's protocol does not include a centralized order book, but instead incentivizes individual relayers to take part in the protocol by offering them transaction fees which they set. These relayers host and propagate an order book to act as a decentralized intermediary between two parties, although the relayer does not execute any orders, the parties do if terms are agreed to. The steps of this process and infographic are demonstrated below.

**Exhibit 58: How The 0X Protocol Works**



Source: 0x Whitepaper, February 21, 2017

This is a person to person example, but the protocol is set to work between DAAPs, providing token abstraction for users, and reducing the need to handle potentially thousands of tokens while preserving each application's crypto-economics and governance.

**IPFS: The Leading P2P Storage Architecture Used by Filecoin to Create a Decentralized Storage Marketplace**

The InterPlanetary File System (IPFS) is a global, peer-to-peer distributed file system protocol that aims to connect all computing devices through a platform to deploy applications and large data files. IPFS aims to upgrade P2P networks (BitTorrent which still has tens of millions of nodes) with improved functionality using HTTP without degrading the user experience. Numerous projects already leverage IPFS including DTube, a decentralized video platform and Bloom a decentralized credit scoring system.

Filecoin, which raised \$257M in its ICO, is leveraging IPFS to create a decentralized storage network that features an algorithmic market that runs on a blockchain with its



native token. FileCoin monetized IPFS by introducing token economics to consumers with excess computer storage to rent it out.

FileCoin features two distinct markets; its Storage Market and the Retrieval Market. The former allows clients to pay for data storage the latter for the bandwidth to deliver the data. Both markets are priced based on a competitive auction priced in the Filecoin token in real time. Also, FileCoin enables the use of smart contracts at a lower transaction cost than what Bitcoin or Ethereum. FileCoin is still in its infancy, but is notable as it brings cryptoeconomic incentives to IPFS, a leading decentralized storage protocol. Filecoin currently has tens of thousands of early adopters who have signed up to either use Filecoin to store data, or as a supplier.

### **Social Reality Inc: Monetizing Consumers' Data**

Social Reality is a digital marketing and consumer management distribution technology platform company. The company has created its proprietary Blockchain Identification Graph (BIG) to enable the transparent exchange of digital identity and consumer data. Consumers participate in BIG through an app, and BIG tokens incentivize consumers to share their verified data in a marketplace where third parties and corporations can purchase access to their data. Management has stated that publishers and advertisers will be able to build platform integrations with the BIG Platform to facilitate data sales and purchases while being completely open and verifiable to consumers. *See the below table for how the platform works.*

### **Exhibit 59: How The Big Platform Works**

<b>How The BIG Platform Works</b>	
<b>Step</b>	<b>Description</b>
1	Consumers choose the data BIGapp collects
2	Consumers are rewarded with BIG Tokens for opting in
3	Consumers decide what personal data is shared, what personal data is purchased and who purchases it
4	Users are rewarded again with more BIG Tokens when their data is purchased
5	Users work with the community (BIGosg) to determine how the data is used and who accesses it
6	Consumers can block the ads/advertisers they don't like while giving props to those that they do.
7	Users see who is using their data and what ads have been served to you based upon that data.

Source: SRAX Presentation as of April 3, 2018

## Other Leading Public Blockchain Platforms

### NEO: Faster Than Ethereum, But Currently More Centralized

NEO's origins are in China, coupled with its similarities to Ethereum's ability to host dApps/ICOs gave rise to the tagline that Neo was a Chinese Ethereum. NEO trades at \$60 per NEO token with a \$3.0B market capitalization. NEO is positioning to create the next-generation smart economy, where the lines between physical and non-physical goods are blurred to enable seamless ownership and exchanges/transactions. NEO is similar to Ethereum with regard to being a platform for both dApps and ICOs, but is less mature.

#### Exhibit 60: NEO's Off Chain Scaling Initiative

Neo's Off-Chain Scaling Initiative						
Entity	Description	Token's Use	Comparison	Market Cap	Potential Scaling Benefit	Optimistic Launch Date
Trinity (TNC)	Trinity network leverages a state channel network that allows two users to set up a private channel and freely transact between each other without broadcasting to the main NEO blockchain. When closed, the final balance is posted to the chain.	Pay the deposit for opening up state channels, transport NEP-5 assets from one wallet to another, pay out TNC developers, pay for nodes routing transactions, pay trinity dApp developers for using their services, pay for value added services. TNC's token is not required to set up state channels (can use NEO, GAS, ONT etc).	Similar to Bitcoin's Lightning Network	\$41M	10x-100x*	2018-2019

\*State channels have the theoretical ability to offer unlimited transactions between parties once a channel is opened.

Source: InvestInBlockchain.com, Entity Websites

Two of the main benefits of NEO are the ability to write smart contracts in any major coding language (C#, Java, Python, while Ethereum uses only its own language known as Solidity) and its high transaction speed (tx/s) of 1,000 tx/s with a goal of up to 10,000 tx/s. Neo has an off-chain scaling solution that is being developed outside of NEO, called the Trinity Network which would potentially enable state channels similar to initiatives with Ethereum and Bitcoin.

NEO utilizes a Delegated Byzantine Fault Tolerance (dBFT) to reach consensus in its platform (unlike PoW or PoS), which enables greater scalability (up to 10,000 tx/s) and performance.

NEO faces the overhang that it is primarily based in China, and China has been moving to close exchanges and for more government control of the sector, which ironically is having the opposite effect. In this regard, NEO has been active in decentralizing its nodes to other countries.

#### How dBFT Works

The singular goal of every consensus method in blockchain systems is to reach consensus and guarantee fault tolerance despite non-active or fraudulent activity on the system. NEO's dBFT solves this problem called the General Byzantine problem.

In a dBFT consensus method, NEO holders elect consensus nodes which vote on the validity of transactions and the nodes are known as Bookkeepers. These bookkeepers take on either one of two roles; the Speaker (only one) who is responsible for transmitting a block proposal to the system or a delegate (multiple) which are responsible for reaching consensus on the transaction.

### Byzantine's Issue

NEO's dBFT method's goal, like other consensus methods, is to protect the network against Byzantine faults (dishonest nodes) using minimal resources while maintaining scalability. The General Byzantine problem, dictates a number of delegates which all much reach consensus based upon the results of a speaker's order. A dishonest node may not send a consistent message to each recipient, which is a disastrous situation in consensus algorithms. The solution to this problem requires delegates to identify whether or not a speaker is honest.

### Exhibit 61: NEO's Requirements for Fault Tolerance

NEO's Requirements For Consensus Fault Tolerance	
Requirement	Description
1	Delegates must reach a consensus about a transaction before a block can be committed.
2	Dishonest Consensus Nodes must not be able to persuade the honest consensus nodes of faulty transactions.
3	At least $s$ Delegates are in same state $(h,k)$ to begin a consensus activity

Source: <https://github.com/neo-project/docs/blob/master/en-us/node/consensus.md>

**NEO's dBFT Algorithm Step-by-Step:**

NEO's creators wanted to move away from PoW since they believed any centralization of compute power of 51% or more would give one user total control. NEO's dBFT consensus method is shown below, in a step-by-step manner. One of the key benefits of dBFT is that NEO will likely never Fork, since if 66% of the nodes do not agree the process is run over again.

**Exhibit 62: NEO's Algorithm Step-by-Step:**

<b>NEO'S Algorithm - dBFT Process Step-by-Step</b>	
<b>Step</b>	<b>Description</b>
1	A Consensus Node broadcasts a transaction to the entire network with the sender's signatures.
2	Consensus Nodes log transaction data into local memory.
3	The first view $v$ of the consensus activity is initialized.
4	The Speaker is identified. Waits " $t$ " seconds.
5	The Speaker broadcasts the proposal: $\langle \text{prepareRequest}, h, k, p, \text{bloc}, [\text{block}]_{\text{sigp}} \rangle$
6	<b>The Delegates receive the proposal and validate:</b>
	- Is the transaction already on the blockchain?
	- Are the contract scripts correctly executed?
	- Does the transaction only contain a single spend?(i.e. does the transaction avoid a double spend scenario?)
7	- If Validated Proposal Broadcast: $\langle \text{prepareResponse}, h, k, i, [\text{block}]_{\text{sigi}} \rangle$
	- If Invalidated Proposal Broadcast: $\langle \text{ChangeView}, h, k, i, k+1 \rangle$
7	After receiving $s$ number of 'prepareResponse' broadcasts, a Delegate reaches a consensus and publishes a block.
8	The Delegates sign the block.
9	When a Consensus Node receives a full block, current view data is purged, and a new round of consensus begins.

Source: <https://github.com/neo-project/docs/blob/master/en-us/node/consensus.md>

**Companies Leverage Crypto Investment Dividends To Pay to Run dApps as Opposed To Paying Cloud Providers Ongoing Opex:** Holding some blockchain-based tokens, such as NEO, allows the holder to obtain network utilization tokens, such as NeoGas, which is used to power the network. Some projects like NEO have chosen to decouple the main token (NEO) which has voting rights on the platform from the token used to power its network (GAS), so that ownership over a platform is uncorrelated to network usage prices.

For example, NEO pays out 8 NEO Gas with every confirmed block (15-25 seconds) split between all NEO holders. Of note, this amount decreases by 1 Gas every two million blocks with a hard cap of 100M GAS in total. In this way application users are incentivized to run or pay others to run their cloud/blockchain infrastructure.

If an app developer were to invest \$1.5M in NEO at the price of \$160 they would obtain ~1,100 NEO Gas (token used to perform network computations/storage on the NEO network) per year. This 1,100 in Neo Gas could be sold at the current price, assuming no increase/decrease at \$64 for \$64,000. If unsold, the entity could leverage its 1,100 NEO Gas for network computations for an application or any blockchain service provider not just a major hyperscale cloud one. We note this cannot persist forever as there is a hard cap on NEO gas, but this is years away and transaction fees would still be distributed to holders in perpetuity.

**NEO Node Concerns**

Unlike ETH which has thousands of nodes, NEO currently only has ten nodes. So while the platform itself from a transaction viewpoint is scalable, from a node perspective it is

not. At a high level, dBFT works with fewer nodes and there is limited data as to whether it works beyond 20-30 nodes, but it makes it much easier to process transactions. Fewer nodes does increase risks from disasters but this is still a fairly large number and NEO has begun to decentralize; City of Zion, the developer community for NEO now runs three of the ten total nodes. Also, we expect NEO's developers to continually scale tx/s and nodes as they improve upon the underlying protocol. Additionally, centralization of nodes does allow for faster network upgrades, albeit not as evolutionary as BTC/ETH's more crowdsourced forking approach.

### **EOS: A More Recent Blockchain Set To Launch**

EOS is a more recent blockchain focused on enabling vertical and horizontal scaling of decentralized applications. EOS has garnered industry attention in its goal to offer potentially millions of transactions per second, no user fees and the fast deployment of decentralized applications. The network is set to go live on June 2, 2018 and has since only existed as a white paper.

EOS' tokens are currently ERC-20 tokens run on Ethereum, but are set to be transferred over to native EOS tokens after its main launch. The EOS team did this to raise funds for development. With a market capitalization of ~\$11B, EOS is currently the fifth largest project.

EOS handles smart contracts like Ethereum but uses delegated proof-of-stake as its consensus algorithm. This consensus method leverages a form of proof-of-stake, but the validators are chosen, or delegated, randomly. Further, the number of validators is smaller (21 nodes vs. Ethereum's ~19,000) which allows each block to be validated quicker, resulting in faster transactions.

This tradeoff results in EOS having platform grade censorship resistance versus Ethereum's more secure but slower sovereign grade-censorship resistance. The only way to know if EOS' level of decentralization is sufficient is in the real world when dApps are launched on the platform. We recognize that 21 nodes may be enough to resist government censorship as if one government censors nodes in their country, the EOS community can spin up a new node from those waiting in line to become a node in another country.

Instead of transaction fees, users will be able to access network power proportionate to the EOS tokens they hold. For example, if a decentralized application holds 1% of all existing EOS tokens, it can use up to 1% of the EOS networks' total transactional power.

If EOS is successful in its mainnet launch and its network is stable, it would amount to a strong competitor to existing public blockchains.

### **EOS Concerns**

- EOS is not live and is only a white paper, as such its mainnet launch could be rocky as it has not proven that its live network can reach its promised goals.
- EOS plans to have a limited number of block producers (21 nodes) which limits the system's censorship-resistant nature.
- EOS does have transaction fees, but they are hidden in the form of inflation.
- Recently EOS had to patch a series of vulnerabilities on its platform, and the work appears ongoing.

## Blockchain Ecosystem Movements

### **Web 3.0: Facilitating the Decentralization of the Internet**

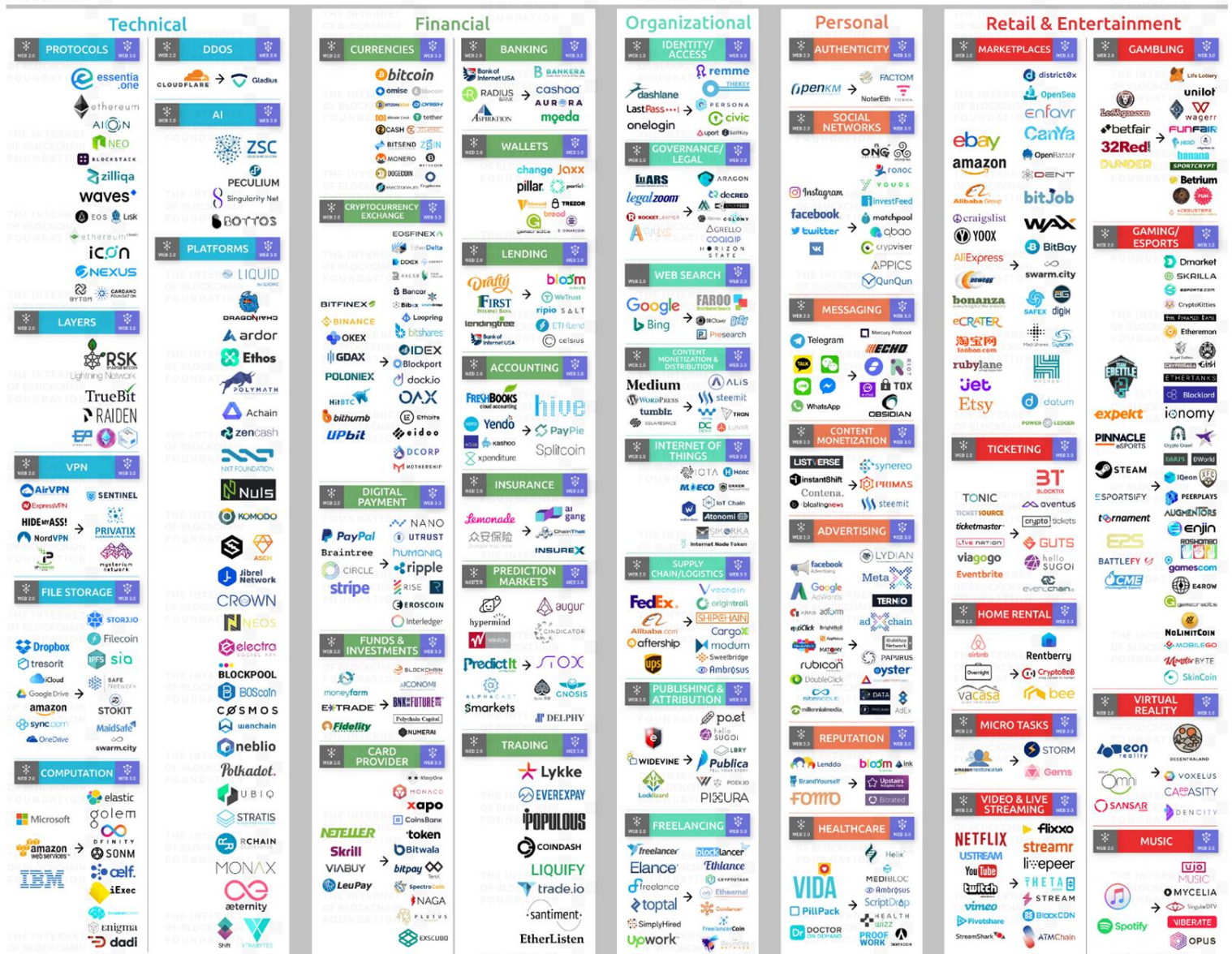
Web 3.0 apps are born out of a movement to decentralize the internet and are a product of blockchain, crypto economics and a drive to give users back control over their data and privacy. Most of these projects survive based off of token economics, and most are in their early stages and there are still questions about whether this model will succeed.



Exhibit 63: Web 3.0 Landscape

# WEB 2.0 → WEB 3.0 COMPARISON LANDSCAPE.

## WELCOME INTERNET OF BLOCKCHAINS



THE INTERNET OF BLOCKCHAIN FOUNDATION **Matteo Gianpietro Zago**

Source: Matteo Gianpietro Zago, Medium, March 17, 2018

### Calculating The Costs To Use Ethereum:

The cost of using the Ethereum network itself for storage/compute is vastly more expensive than current cloud models. The cost to run basic operations on the Ethereum network is prohibitive (~700,000x more expensive) and this does not even encompass running full-fledged applications at scale. This also uses a low gas price for ETH at 1 Gwei, and using a higher gas price would make the transaction complete faster but would

be even more expensive. Transactions are expensive as every node on the network has to process every transaction and Ethereum currently operates at limited scale.

**Exhibit 64: Ethereum Virtual Machine Transaction Cost Equation**

Estimating Transaction Costs				
<b>gasUsed</b>	<b>x</b>	<b>gasPrice</b>	<b>=</b>	<b>Total Cost</b>
<b>gasUsed:</b> The sum of all gas for all the operations executed				
<b>gasPrice:</b> The price in wei per unit of gas. Users specify how much they are willing to pay, but miners optimize their transactions by accepting transactions with higher gas prices first				

Source: ETHdocs.org

As a primer, the Ethereum Virtual Machine charges a fee per computational step; called Gas. Gas is akin to pennies compared to USD. Miners have the choice of including any transaction and collecting the fee or not, which leverages market forces to find a competitive network cost.

**Exhibit 65: Ether Denominations**

Ether Denominations		
Unit	Wei Value	Wei
wei	1 wei	1
Kwei	1e3 wei	1,000
Mwei	1e6 wei	1,000,000
Gwei	1e9 wei	1,000,000,000
Microether	1e12 wei	1,000,000,000,000
Milliether	1e15 wei	1,000,000,000,000,000
Ether	1e18 wei	1,000,000,000,000,000,000

Source: Ethdocs.org

Gas is decoupled from Ether since units of gas align with computation costs while the price of Ether varies depending on market forces. The total cost of a transaction on the network, in Ether, is based on two factors; gasUsed is the total gas that is consumed by the transaction and gasPrice (in Ether) is the price of one unit of gas specified in the transaction.



## Exhibit 66: Ethereum's Compute Costs over AWS

Compute Costs On The Ethereum Network vs AWS						
Network Used	Task	Gas Required	Gas Price (Gwei)	Cost (ETH)	Cost (USD)	Mean Time to Confirm (Seconds)
Ethereum	Add or Subtract Two Integers 1 Million Times	3,000,000	1	0.003	\$1.13	30.6
	Task	Cost Per Instance (t2.nano)	Time In Python To Run (seconds)	NA	Cost (USD)	Mean Time to Confirm (Seconds)
AWS	Add or Subtract Two Integers 1 Million Times	0.0058/hr	0.04	NA	\$0.000001611	0.04
<b>Ethereum's Expense/Time Factor over AWS</b>					<b>698,276x</b>	<b>765x</b>

Source: Calculating Costs in Ethereum Contracts (HackerNoon), ETHHasStation.com, AWS, Opco

Note: This uses the cheapest ETH Gas price, using a higher gas price would facilitate the transactions speed

Beyond compute, the cost to store data on the Ethereum network is also expensive. Although we do note that storing mass files on Ethereum's blockchain is not the goal and decentralized storage startups (Filecoin, Sia, Storj) have surfaced to address this goal. Also, storing something on Ethereum's network would mean that every node would have a copy of the data instead of the data being in 1-2 AWS data centers.

Storj is the only decentralized cloud storage provider which publishes its price, the other entities are currently under development and generally plan to offer a market price for storage based upon supply and demand. One example is The InterPlanetary File System (IPFS), a leading P2P storage system utilized by Filecoin which raised \$257M in funding, which we detail in a later appendix.

## Exhibit 67: Ethereum's Compute Costs over AWS

Storage Costs On The Ethereum Network vs AWS					
Network Used	Task	Gas Required	Gas Price	Cost (ETH)	Cost (USD)
Ethereum	Save 1MB to Storage	625,000,000	1 Gwei	0.625	\$234.38
	Task	Cost Per Instance (\$3)	NA	NA	Cost (USD)
AWS	Save 1MB to Storage	\$0.0245/GB	-	-	\$0.000023926
<b>Ethereum's Expense Factor Over AWS</b>					<b>9,795,918x</b>

Source: Calculating Costs in Ethereum Contracts (HackerNoon), ETHHasStation.com, AWS, Opco

Decentralized storage is gaining traction generally due to its lower cost, but also because it offers complete thousands of nodes with true redundancy. These entities argue that storage is harder to hack if bits are split up between dozens of nodes with better disaster recovery. Currently, decentralized storage is in the early stages as it makes up under 0.01% of the total cloud/data center storage market.

Storj has a straightforward pricing model and charges \$0.015 per GB/Mo, which is a 53%/23% discount over AWS/Azure. However, AWS/Azure offer hundreds if not thousands of additional services on top of storage to build applications and solutions beyond storage. The other issues are: 1) the model is in its infancy and has not been

tested in providing storage for applications, or users, at scale, 2) enterprises and businesses are unskilled and may not want to interact with a decentralized storage provider purchasing service with their crypto tokens; and 3) AWS/Azure already have the majority of the cloud storage market and are benefiting from data gravity. Last, popular user devices are currently set up to work with existing cloud providers, not decentralized ones. For example, iCloud backs up to Apple, not Storj.

All of the leading decentralized storage providers (Filecoin, Storj, Sia) employ marketplaces where users/hosts can buy/sell storage. Put simply, storage providers, which could be anyone with spare storage space, are compensated with each entity's native tokens for offering secure storage as a node. Filecoin takes this a step further and also compensates nodes (hosts) for continuously replicating files for more secure storage and for distributing content quickly; which requires high bandwidth speeds.

Storj is the only current provider offering fixed prices for storage, the other two are set to feature a marketplace dynamic to find the optimal price between those looking for storage and those offering spare space. Our early channel checks of users on some of these entities denote low payout ratios. Or checks of users point to payouts of \$1.50-\$3; as such it may be difficult for these decentralized platforms to attract dormant storage from consumers if payouts remain low.

Bandwidth is important for the timely delivery of stored content. Storj has stated that low upload speeds will limit the amount of data a host (user storing data) can store and serve in a timely manner. We expect both users and farmers on decentralized storage entities to opt for higher bandwidth internet plans to interact with the platforms effectively, but regardless AWS/Azure's data centers undoubtedly have faster connections than consumers.

### Exhibit 68: Decentralized vs Centralized Storage Providers:

Decentralized Storage Breakdown								
Entity	Description	Storage Capacity (TBs)	Used Storage (TBs)	Active Hosts	Pricing Per TB/Mo	Uses Its Own Blockchain	Protocol Make Money?	ICO % For Devs
<b>Storj</b>	Storj is an open-source distributed cloud storage platform based on blockchain technology where anyone can sell their extra hard drive space.	?	30,000	20,000	\$15	Uses Ethereum Blockchain	No. Economic transaction between storage providers and requestors	70% will be put into a non-profit to Manage Storj Labs' tokens to fund long term development
<b>Filecoin</b>	Leveraging an incentivized version of IPFS to create its decentralized storage network that features an algorithmic market that runs on a blockchain	Not Live	Not Live	1000's of pre-signed storage users/miners	Will be a marketplace	Yes	No. Economic transaction between storage providers and requestors	15% of ICO went to Protocol Labs (Founder) or \$39M
<b>Sia</b>	Sia combines a peer-to-peer network with blockchain technology to create the world's first decentralized storage platform.	4,800	210	891	~\$2	Yes	3.9% of contract creation costs are distributed to holders of <i>SiaFunds</i> . Nebulous Inc, a for-profit company controls 88% of the <i>SiaFunds</i> .	No ICO. SIA Coins are created through mining.

<b>AWS</b>	Existing Cloud Storage	\$23
<b>Azure</b>	Existing Cloud Storage	\$21

Total Data Center and Cloud Storage Capacity	663,000,000	397,000,000
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Decentralized as a Percent of Total Datacenter and Cloud Supply	NA	0.0076%
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Sources: CoinCentral, Protocol White Papers, CiscoVNI, Storj.io,

We do note that Ethereum's network is still in the early stages, has numerous scaling initiatives that are under way to reduce costs and the public cloud model has a ten-year head start, but we believe heavy workloads will inevitably remain with the cloud providers as logically it is easier to run compute loads in a centralized manner than have every node on a decentralized network run the computations.

### Blockchains' Offer Cost Savings In Specific Use Cases

There are some cases where using the EVM can save businesses significant amounts of money, in the area of cutting out the middleman instead of performing large compute workloads or storing large files.

Hackernoon published an analysis on the cost to issue an Escrow using a smart contract. Revising this analysis for the current gas price (1 Gwei, not 20 as used), we can see the costs of the contract.

According to Escrow.com, the escrow costs for selling a \$500,000 home is \$4,450 and it can take weeks to complete, versus ~\$1.40 on the Ethereum Virtual Machine and execution in less than two minutes.

## Blockchain and Cryptocurrency Risks

- There is extreme volatility in the cryptocurrency space.
- The crypto space is a nascent field, and the failure for platforms to reach scalability or desired technical specifications (i.e. proof-of-stake for Ethereum) are wild cards.
- Countries have begun cracking down on crypto trading and ownership, although eventually we believe set rules will be beneficial for the area.
- If ICOs are outlawed, or deemed investment securities by the SEC, this could be a short-term negative event for the space as ICOs must then return “investor” assets.
- The security of exchanges (Mount Gox was an exchange hacked for hundreds of millions in Bitcoin) is a growing concern as they are a target for hackers.
- Those inexperienced with hot/cold wallets risk losing their funds forever if they are not careful in securing their tokens.
- There are frequently fraudulent ICOs trading on marketing hype over true innovation.
- If invalid data is posted to the blockchain it could be posted there forever; which drives the need for honest oracles (data sources).
- Any security vulnerabilities on a blockchain platform could negatively impact the platform.
- Governments need to communicate clear tax laws for tokens; i.e. it’s doubtful an enterprise will acquire NEO to acquire NEO Gas over time for network utilization if the enterprise has to pay taxes on its utility tokens. **See below table for noteworthy negative news items.**

**Exhibit 69: Recent Negative Crypto Related News**

<b>Recent Noteworthy Negative Crypto News:</b>		
<b>Date</b>	<b>Target</b>	<b>Reason</b>
5/1/2018	Operation Crypto Sweep	U.S. and Canada investigate 70 crypto and ICO related scams
2/28/2018	SEC Launches Probe Into Cryptocurrencies	The SEC issued numerous subpoenas and information requests of tech companies and advisors involved in the market for digital tokens
1/30/2018	Bitfinex and Tether Subpoenaed By U.S. Regulators	Concern that each Tether token is not backed by an equal amount of USD and Tether/Bitfinex (Hong Kong's largest Crypto exchange have the same CEO)
1/30/2018	AriseBank's \$600M ICO Halted By SEC	SEC seized Dallas-based AriseBank's \$600M in crypto assets related to its ICO after the SEC stated it fraudulently misled investors about ownership of a federal insured bank
1/30/2018	Facebook Bans All Crypto/ICO Ads	FB wants to avoid Ads that are frequently associated with misleading or deceptive promotional practices
1/23/2018	South Korea Bans Anonymous Crypto Trades	SK wants to bring the country's crypto market in line with other financial rules
9/4/2017	China Bans ICOs	China stated ICO funding has disrupted financial/economic order

Source: SeekingAlpha, Bloomberg, Techcrunch

There have been major Bitcoin and crypto related hacks, although these dealt with problems securing confidential or wallet related information, and was not the product of security flaws in the underlying blockchain itself. For example, hackers were able to obtain Bitflood's private keys it used for backups to transfer funds to their address.

### Exhibit 70: Major Crypto Hacks

Major Bitcoin/Crypto Related Hacks					
Entity	Date	Amount Hacked	Dollar Value At Time Of The Hack	Dollar Value Today	Description
<b>Mt. Gox</b>	June 19, 2011	850,000 Bitcoins	\$450,000,000	\$6,800,000,000	Hackers got ahold of Mt. Gox's auditors credentials and transferred Mt. Gox's holdings to another address.
<b>BitFloor</b>	September 1, 2012	24,000 Bitcoins	\$250,000	\$192,000,000	Hackers got ahold of Bitfloor's unencrypted private keys used for online backups
<b>Bitstamp</b>	January 4, 2015	19,000 Bitcoins	\$5,100,000	\$152,000,000	Hackers breached the company's operational wallets
<b>Bitfinex</b>	August 1, 2016	120,000 Bitcoins	\$72,000,000	\$960,000,000	Attackers were able to exploit a vulnerability in the multisignature wallet architecture of Bitfinex and Bitgo
<b>Coincheck</b>	January 26, 2018	500M NEM Tokens	\$400,000,000	\$164,000,000	Details not released as of writing.

Counsutra.com, Fortune.com,

\*Bitcoin price of \$8,000 and NEM price of \$0.328 used to find values, as of April 16, 2018.

## Blockchain Predictions and Possibilities:

We share several of our ideas on the future of the crypto and blockchain space over the next decade.

- As the internet has disrupted many “middle men” businesses (music, newspapers, travel, maps, etc.) blockchain is set to do the same (financial, real estate transactions etc.)
- AWS or Azure builds out its own open-source blockchain on its own data centers or partners with an established public blockchain to do so. They will each seek to dominate specific industry verticals (logistics, asset securitization) that benefit from network effects.
- We see order of magnitudes more processing and storage required which will be both decentralized (grid or bitcoin-like) and centralized from the large cloud providers.
- Killer decentralized applications come to fruition, such as a decentralized version of Facebook or Google using the blockchain technology stack that automates the misplaced “trust” we have in these companies.
- There will be a consolidation of the thousands of blockchain projects to the top 2-3.
- Businesses implement private blockchains to share data, automate systems, remove intermediary frictions and cut costs drastically.
- Public blockchains achieve true scalability, opening the door to unthinkable and innovative use cases.
- In a decentralized world, consumers will demand faster broadband speeds to connect to one another faster.
- ICOs get regulated by the SEC, the correct route, and the ICO market divides into one for utility tokens and one for security tokens.
- The cloud is the main storage arm for dApps as consumers don't care where the data is physically stored as long as the controlling entity (FB, GOOG) is disintermediated.

## Appendix 1: The 20 Largest Cryptocurrencies and Descriptions

Twenty Largest Cryptocurrencies (May 21, 2018)				
Name	Symbol	Market Cap	Price	Definition
Bitcoin	BTC	\$143,443,762,185	\$8,414.95	The world's first decentralized digital currency and worldwide payment system
Ethereum	ETH	\$69,613,431,976	\$699.09	Open-source public blockchain based distributed computing platform and OS system featuring smart contract functionality
Ripple	XRP	\$26,587,610,962	\$0.68	A centralized, real time gross settlement system, currency exchange and remittance network.
BitcoinCash	BCH	\$21,076,963,456	\$1,229.69	Bitcoin fork, focused on faster and cheaper payments. The changes were a larger block size of 8MB from 1MB to fit more transactions in each block
EOS	EOS	\$11,687,253,029	\$13.42	A cryptocurrency token and blockchain that operates a smart contract platform. EOS is an Ethereum competitor but has not yet launched.
Litecoin	LTC	\$7,619,884,946	\$134.55	Inspired by Bitcoin, Litecoin is a P2P currency that is focused on speed; as a new block is processed every 2.5 minutes vs. Bitcoins 10 minutes.
Cardano	ADA	\$6,439,273,166	\$0.25	A distributed computing platform that runs the blockchain for Ada' cryptocurrency.
Stellar	XLM	\$5,927,281,355	\$0.32	An open source protocol for exchanging money. Its goal is to connect the worlds banks, payment systems and people at extremely low costs.
TRON	TRX	\$5,237,448,550	\$0.08	Blockchain based open source protocol for the digital entertainment industry. TRON's goal is to be a P2P exchange between content creators and content consumers by eliminating the middlemen.
IOTA	MIOTA	\$4,825,070,004	\$1.74	A cryptocurrency designed for IoT, to enable the secure sharing and sale of data streams where micro and nano payments exist
NEO	NEO	\$3,996,193,500	\$61.48	Scalable blockchain focused on decentralized applications. NEO supports multiple programming languages, can support up to 10,000 tx/s, and allows developers to deploy smart contracts.
Monero	XMR	\$3,154,166,202	\$196.48	Extremely private currency transactions that obscures the sender, recipients and amounts of all transactions
DASH	DASH	\$3,150,606,340	\$389.77	A P2P cryptocurrency that aims to be the most user friendly and on-chain-scalable in the world. It currently offers instant transactions and private transactions.
NEM	XEM	\$2,786,778,000	\$0.31	P2P blockchain platform that has introduced innovative new features such as its proof-of-importance algorithm, multi-signature accounts and encrypted messaging.
Tether	USDT	\$2,511,653,667	\$1.00	A cryptocurrency referenced to the USD.
VeChain	VEN	\$2,313,993,882	\$4.40	A blockchain platform targeting the IoT. VeChain aims to provide visibility into supply chain management by allowing manufacturers to assign product with unique identities (RFID, sensors) which are able to be broadcasted to the VeChain blockchain for all parties to see.
Ethereum Classic	ETC	\$1,798,493,380	\$17.67	Ethereum classic is an Ethereum fork that was born out of a disagreement with the Ethereum Foundation regarding The DAO, an organization that was hacked.
Bytecoin	BCN	\$1,653,600,213	\$0.01	Bytecoin is a private, decentralized cryptocurrency with open source code that allows everyone to take part in the Bytecoin network development.
BinanceCoin	BNB	\$1,609,099,795	\$14.11	Binance exchanges token that powers its exchange. The token can be used to pay for trading fees on the exchange, buy virtual gifts or to park funds prior to exchanging them for other tokens.
Qtum	QTUM	\$1,442,419,234	\$16.28	A Chinese hybrid platform built using a fork of Bitcoin's core, an account abstraction layer allowing for multiple VM's including Ethereum, and a PoS consensus mechanism.

Source: Techerunch, Entity websites, Coinmarketcap.com. Data as of 5/21/2018

## Appendix 2: The 20 Largest Crypto Utility Tokens and Descriptions

Twenty Largest Crypto Utility Tokens (May 21, 2018)				
Name	Platform	Market Cap	Price	Definition
EOS	Ethereum	\$11,680,113,542	\$13.42	A new blockchain architecture designed to enable vertical/horizontal scaling for decentralized applications.
TRON	Ethereum	\$5,255,601,604	\$0.08	Attempting to bridge the gap between content creators and consumers by eliminating the middlemen.
Tether	Omni	\$2,512,957,380	\$1.00	A cryptocurrency refereced to the U.S. Dollar. 1 USDT = 1 USD.
VeChain	Ethereum	\$2,313,483,620	\$4.40	VeChain is the worlds leading blockchain platform offering Blockchain-as-a-Service to enterprises for products and information By leveraging on blockchain technology, VeChain strives to build a trust-free and distributed business ecosystem, which is self-circulating and scalable.
Binance Coin	Ethereum	\$1,616,341,417	\$14.17	Binance exchanges' unit of currency; offers users discounts for using Binance Coins.
ICON	Ethereum	\$1,337,907,543	\$3.46	ICON aims to build a decentralized network that allows independent blockchians to transact with one another without intermediaries
OmiseGO	Ethereum	\$1,276,307,420	\$12.51	An open payment platform and decentralized exchange issued on Ethereum
Zilliqa	Ethereum	\$1,033,415,083	\$0.14	Zilliqa is a high-throughput public blockchain. The entity is known to be the first blockchain to use sharding for scalability while running its nodes on AWS. Zilliqa's team achieved transaction speeds of 2,488 tx/s using 3,600 Amazon EC2 instances to serve as nodes.
Ontology	NEO	\$901,206,959	\$7.86	A new high performance blockchain project and distributed trust collaboration platform. Ontology is able to customize difference public blockchains for different applications
Aeternity	Ethereum	\$888,201,803	\$3.81	An open source, decentralized apps platofrm leveraging highly scalable blockchain technology with built in oracles.
Bytom	Ethereum	\$711,463,158	\$0.72	Aims to be the public blockchain bridging the physical and digital world, to build a decentralized network where digital and physical assets can be registered and exchanged
0x	Ethereum	\$709,450,980	\$1.34	0X is an open protocol for a decentralized exchange on the Ethereum blockchain. The protocol enables the ability to transfer ERC20 tokens without an intermediary, offering true interoperability between different decentralized applications which have their own tokens.
Populous	Ethereum	\$625,194,136	\$16.90	A P2P invoice finance platform build on blockchain's distributed ledger technology
Augur	Ethereum	\$571,017,700	\$51.91	An open source, decentralized, P2P oracle and prediction market platform built on the Ethereum blockchain
Maker	Ethereum	\$563,938,717	\$912.19	Maker holders govern DAI, which is a cryptocurrency that is price stabilized against the value fo the U.S. dollar.
RChain	Ethereum	\$561,064,100	\$1.56	A fundamentally new blockchian platform rooted in a formal model of concurrent and decentralized computation
Golem	Ethereum	\$435,095,010	\$0.52	Golem is a global open source, decentralized supercomputer that anyone can access
IOStoken	Ethereum	\$420,320,040	\$0.05	The Internet of Services (IOS) offers a secure & scalable infrastructure for online service providers.
Status	Ethereum	\$399,660,913	\$0.12	Status is a browser, messenger, and gateway to the decentralized web.
Waltonchain	Ethereum	\$395,109,617	\$12.69	Waltonchain is a genuine, trustworthy and traceable business ecosystem with complete data sharing and absolute information transparency. It is created through a combination of the RFID and blockchain technologies, which pushes forward the blockchain and IoT integration

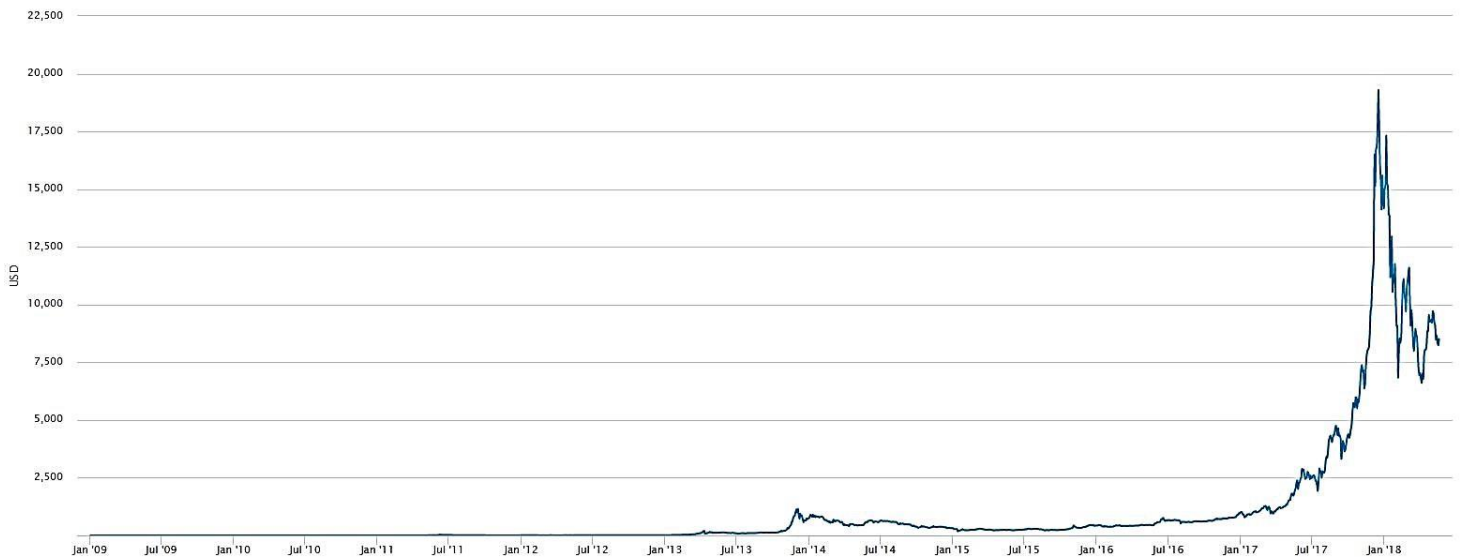
Source: Techcrunch, Entity websites, Coinmarketcap.com. Data as of 5/21/2018



# Appendix 3: Bitcoin Charts

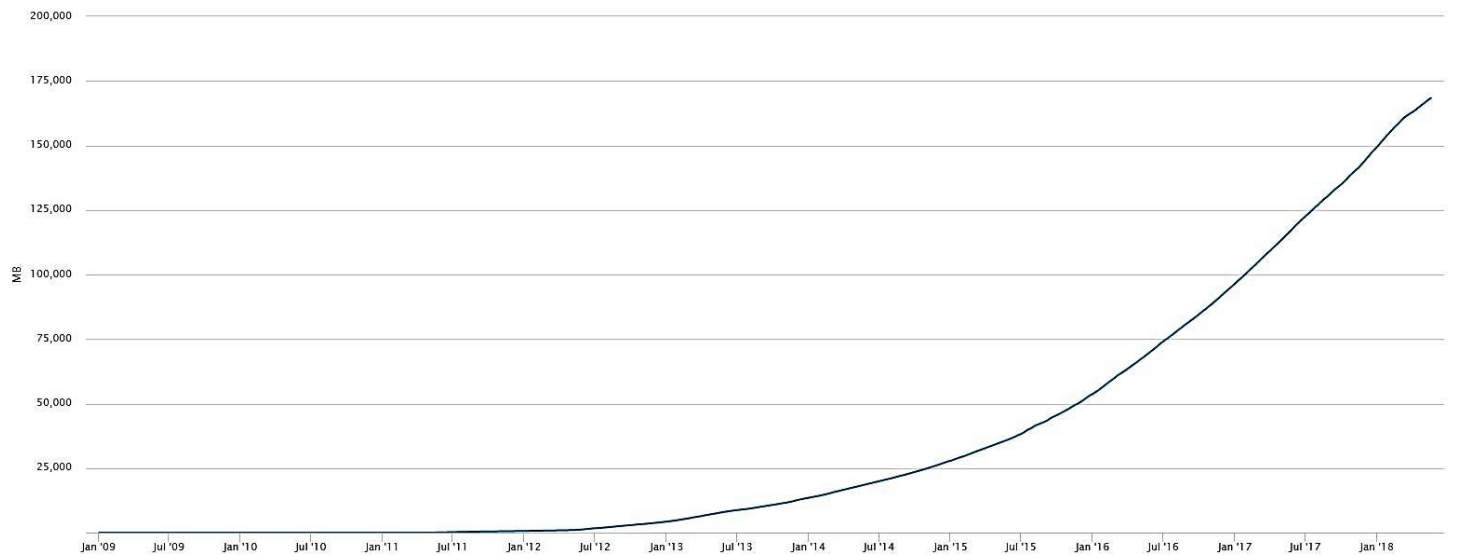
## Market Price (USD)

Average USD market price across major bitcoin exchanges.  
Source: blockchain.info



## Blockchain Size

The total size of all block headers and transactions. Not including database indexes.  
Source: blockchain.info

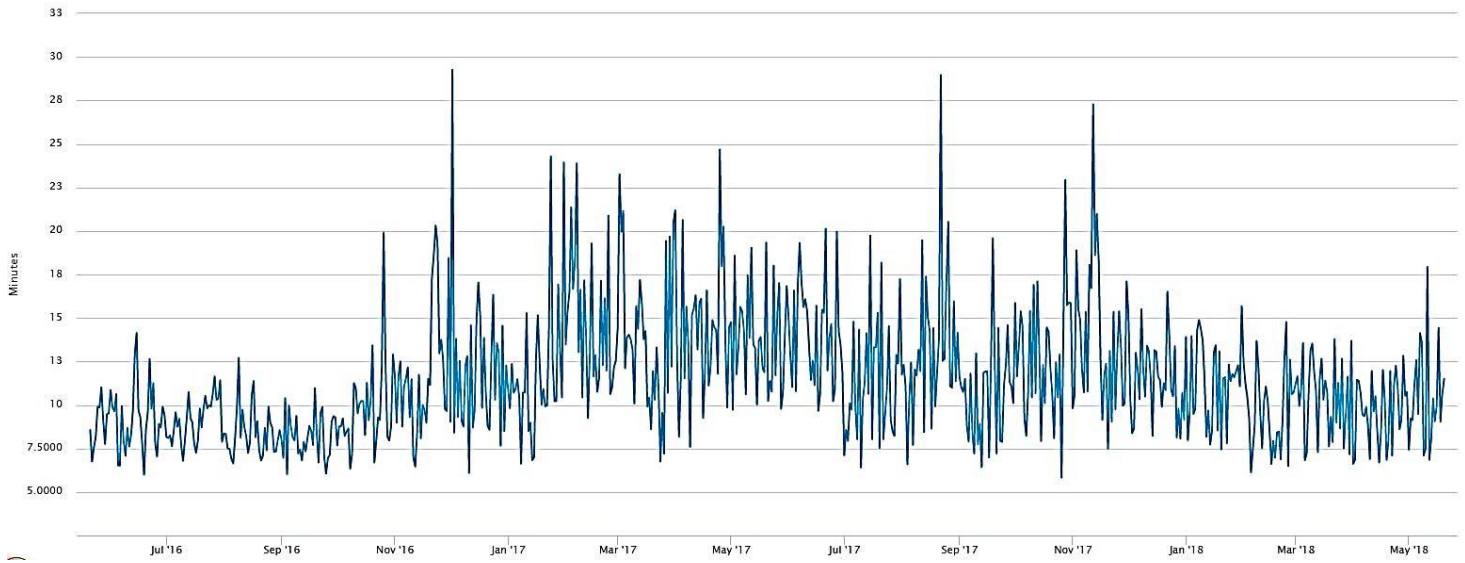


Source: Blockchain.Info – as of May 21, 2018

CLOUD AND COMMUNICATIONS

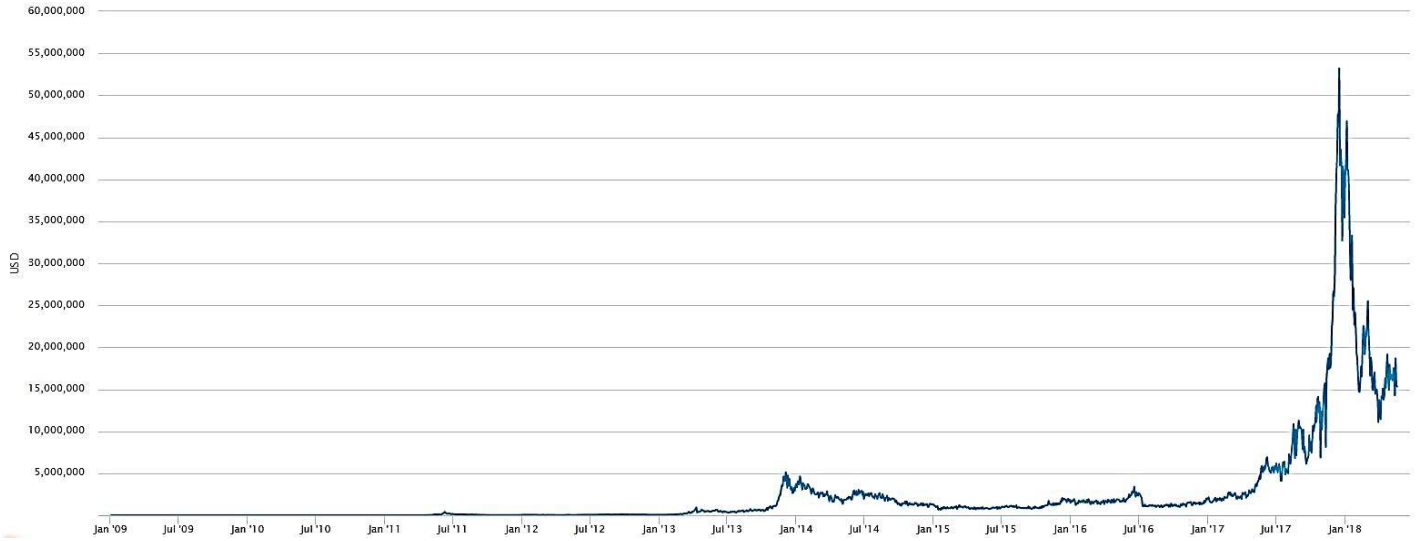
Median Confirmation Time

The median time for a transaction to be accepted into a mined block and added to the public ledger (note: only includes transactions with miner fees).  
Source: blockchain.info



Miners Revenue

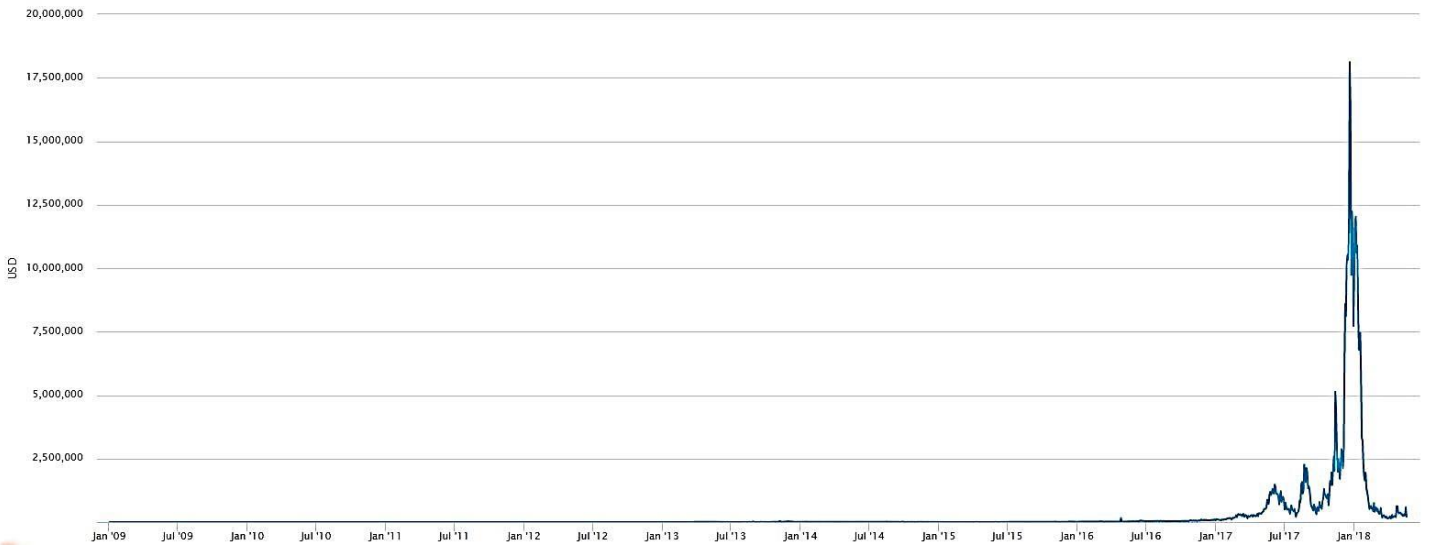
Total value of coinbase block rewards and transaction fees paid to miners.  
Source: blockchain.info



Source: Blockchain.Info – as of May 21, 2018

### Total Transaction Fees in USD

The total value of all transaction fees paid to miners (not including the coinbase value of block rewards).  
Source: blockchain.info



### Cost per Transaction

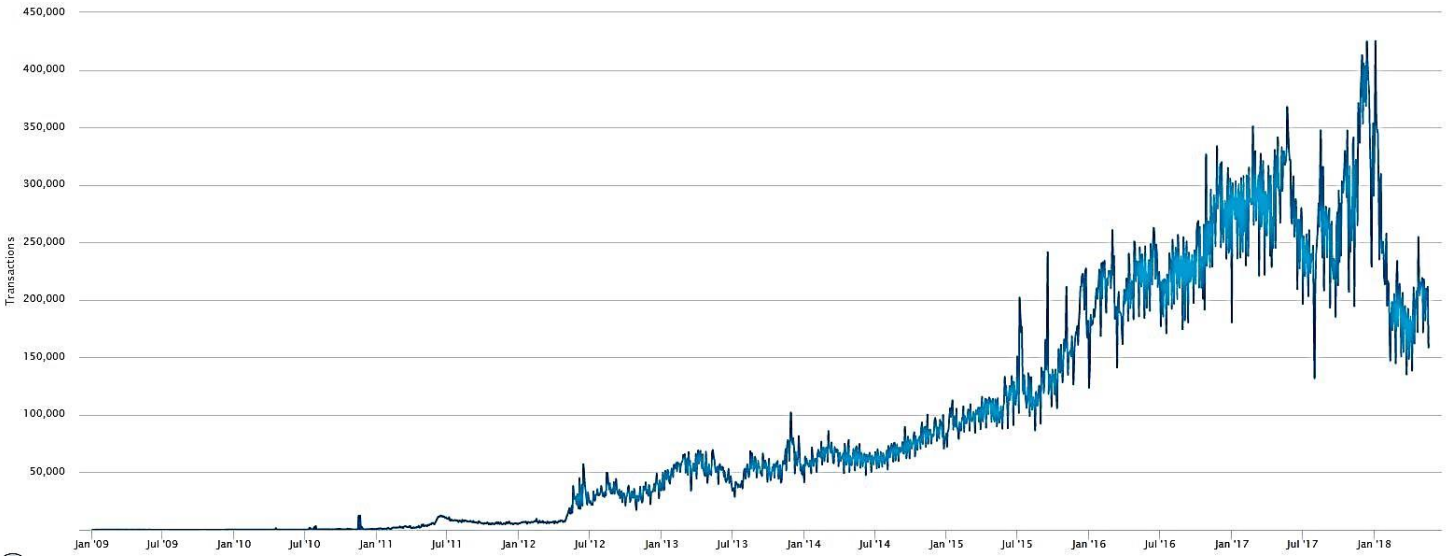
A chart showing miners revenue divided by the number of transactions.  
Source: blockchain.info



Source: Blockchain.Info – as of May 21, 2018

### Confirmed Transactions Per Day

The number of daily confirmed Bitcoin transactions.  
Source: blockchain.info

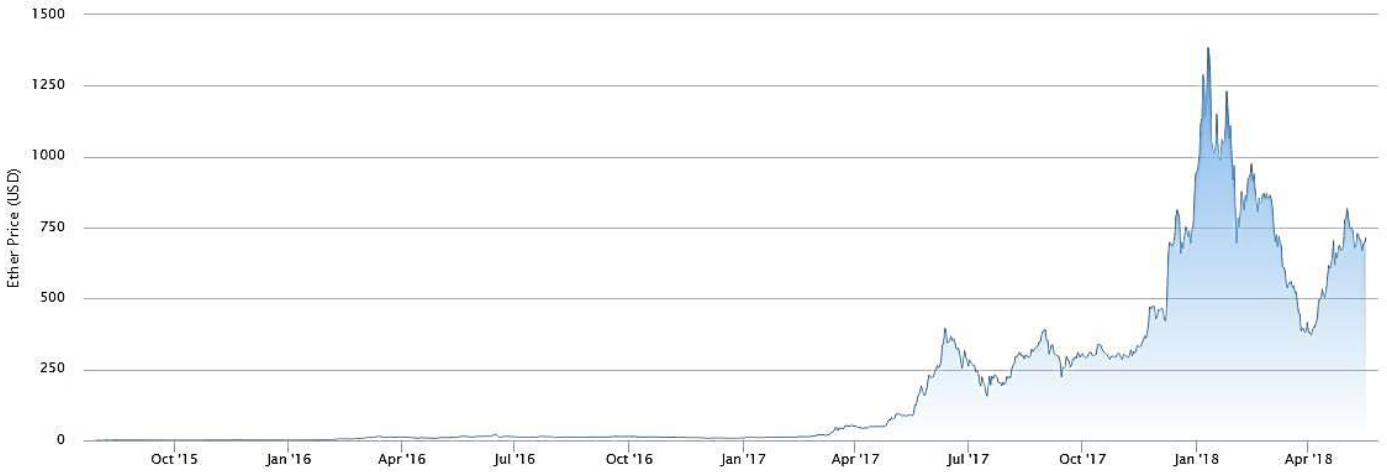


Source: Blockchain.Info – as of May 21, 2018

## Appendix 4: Ethereum Charts:

### Ether Historical Prices (USD)

Source: Etherscan.io  
Click and drag in the plot area to zoom in

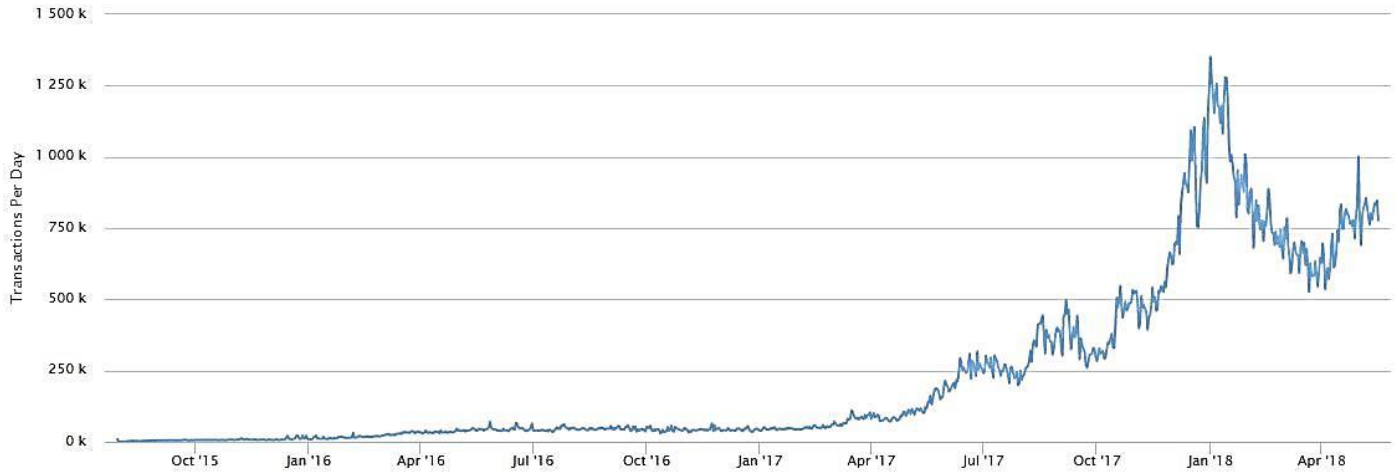


Source: Etherscan.io – as of May 21, 2018

### Ethereum Transaction Chart



Source: Etherscan.io  
Click and drag in the plot area to zoom in



### Ether Supply Growth Chart



Source: Etherscan.io  
Click and drag in the plot area to zoom in



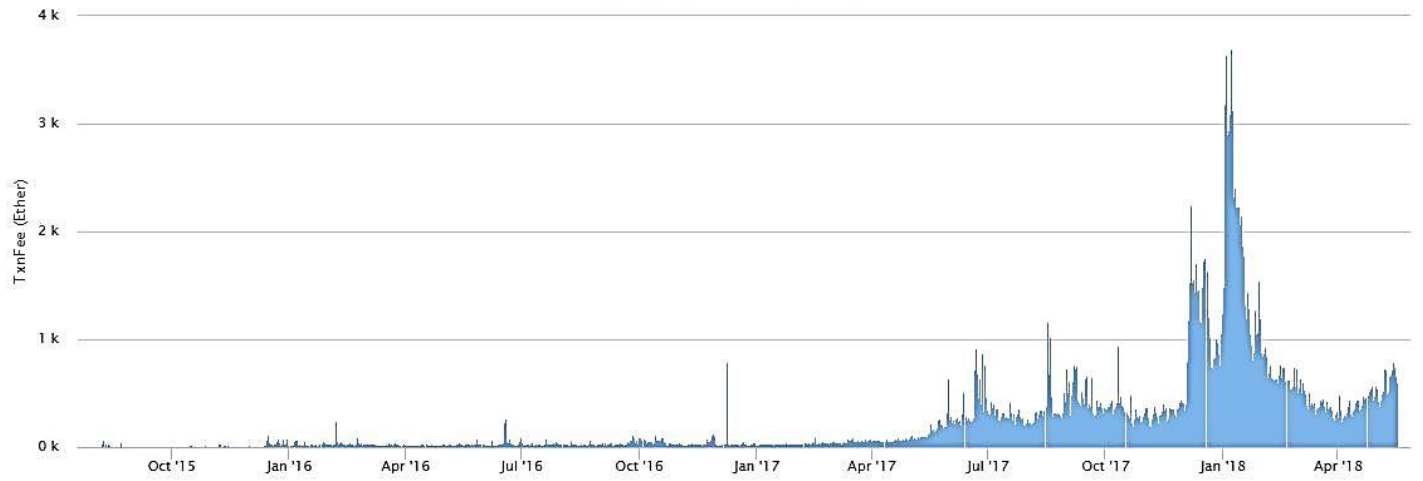
Source: Etherscan.io – as of May 21, 2018

### Ethereum Network Transaction Fees



Source: Etherscan.io

Click and drag in the plot area to zoom in

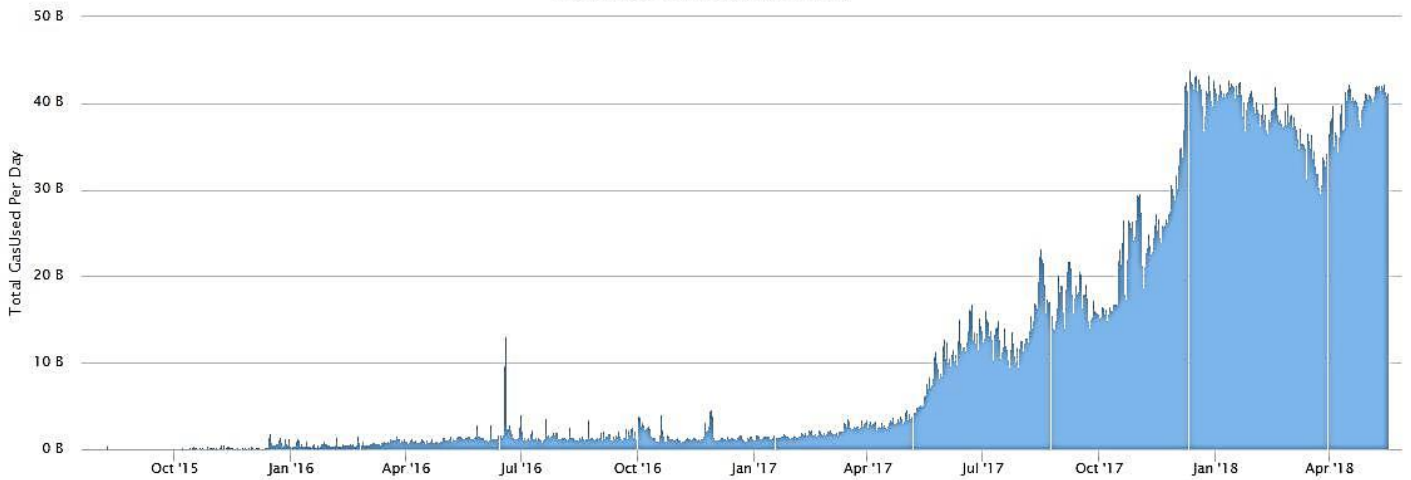


### Ethereum Total Daily GasUsed Chart



Source: Etherscan.io

Click and drag in the plot area to zoom in



Source: Etherscan.io – as of May 21, 2018

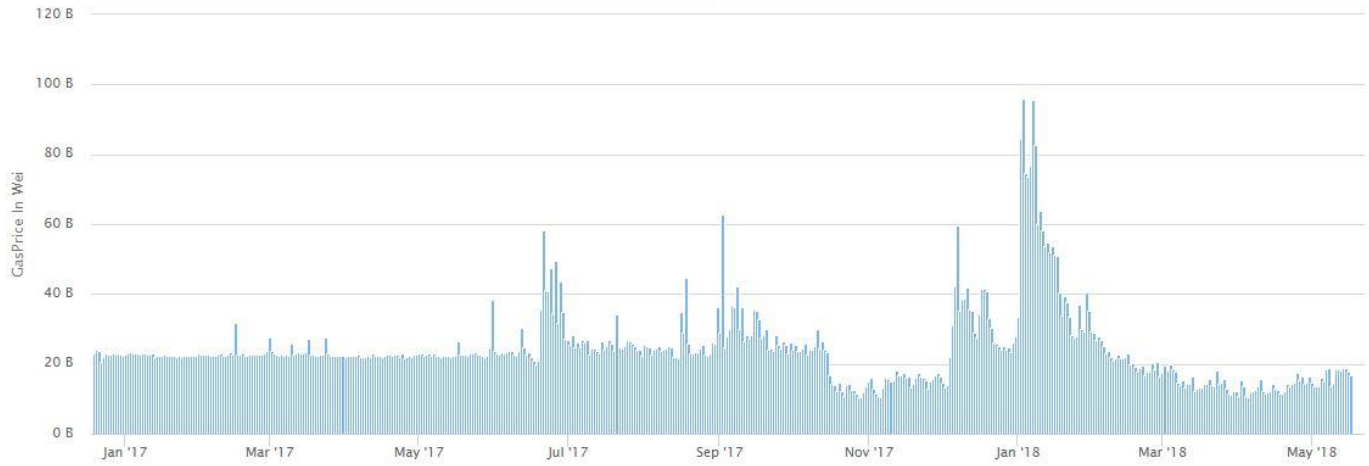
### Ethereum Average GasPrice Chart

Reset zoom



Source: Etherscan.io

Click and drag in the plot area to zoom in



Source: Etherscan.io – as of May 21, 2018

## Appendix 5: Detailed Blockchain Use Cases By Industry:

Blockchain Use Cases By Industry		
Industry	Use Case	Description
<b>Banking</b>	Cross-border payments and settlements	Tracking, trading, and managing cross-border/international payments and settlements; creates alternate payment and settlement "rails" built for immediate payment and settlement
	Custody and asset tracking	Maintain immutable records of financial agreements and asset ownership; blockchain is used to digitally represent a record of ownership in order to significantly reduce settlement time and eliminate the need for paper; and includes the record management of various assets such as cash, loans, and mortgages property
	Identity management	Identity management and confirmation (includes digital signature management); authenticate identities, manage personal and financial data, and assist in identity as a service
	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and includes post-transaction settlement processes (e.g., loan contract paperwork, payments, and other financial assets)
	Transaction agreements	Enforce and execute commercial transactions and agreements through smart contracts such as smart property contracts; enforceable agreements that are automatically executed on a distributed ledger when conditions set by all involved parties are met
	Others	Includes all other blockchain use cases in banking not elsewhere classified, such as loyalty programs
<b>Insurance</b>	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Others	Includes all other blockchain use cases in insurance not elsewhere classified, such as claims processing/management, risk provenance, asset usage history, parametric insurance management, and identity management
	Custody and asset tracking	Maintain immutable records of financial agreements and asset ownership; blockchain is used to digitally represent a record of ownership in order to significantly reduce settlement time and eliminate the need for paper; and includes the record management of stocks and bonds and their associated certificates of ownership
<b>Securities and investment services</b>	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Others	Includes post-trade settlements, sharing ownership records, investment analysis, and all other blockchain applications in securities and investment services not elsewhere classified
	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; includes monitoring the movement of merchandise, goods, and materials and registering each leg of a trip or movement throughout the supply/value chain or manufacturing process
<b>Discrete manufacturing</b>	Cross-border payments and settlements	Tracking, trading, and managing cross-border/international payments and settlements; creates alternate payment and settlement "rails" built for immediate payment and settlement
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking equipment that is used within the manufacturing process or supply/value chain and monitoring product parts and services that were performed
	Lot lineage/provenance	Verify origin and authenticity of a product as it moves throughout the value chain; captures information about all inputs of a product, enabling accurate visibility and traceability into the history of a product; includes product and brand counterfeit/fraud detection, reduction and prevention, and maintaining records to assist in quality control; and can include environmental impacts on the product such as storage container conditions as the product is transported
	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and can include banks, financial institution, brokers, suppliers, manufacturers, retailers, wholesalers, and others involved in the transaction
	Warranty claims	Track, maintain, and validate virtual warranties and warranty claims
	Others	Includes all other blockchain use cases in discrete manufacturing not elsewhere classified



<b>Process manufacturing</b>	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; and includes monitoring the movement of merchandise, goods, and materials and registering each leg of a trip or movement throughout the supply/value or manufacturing process
	Cross-border payments and settlements	Tracking, trading, and managing cross-border/international payments and settlements; creates alternate payment and settlement "rails" built for immediate payment and settlement
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking equipment that is used within the manufacturing process or supply/value chain and monitoring product parts and services that were performed
	Lot lineage/provenance	Verify origin and authenticity of a product as it moves throughout the value chain; captures information about all inputs of a product, enabling accurate visibility and traceability into the history of a product; includes product and brand counterfeit/fraud detection, reduction, and prevention and maintaining records to assist in quality control; and can include environmental impacts on the product such as storage container conditions as the product is transported
	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and can include banks, financial institution, brokers, suppliers, manufacturers, retailers, wholesalers, and others involved in the transaction
	Warranty claims	Track, maintain, and validate virtual warranties and warranty claims
	Others	Includes all other blockchain use cases in process manufacturing not elsewhere classified
<b>Retail</b>	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; and includes monitoring the movement of merchandise, goods, and materials and registering each leg of a trip or movement throughout the supply/value chain
	Cross-border payments and settlements	Tracking, trading, and managing cross-border/international payments and settlements; creates alternate payment and settlement "rails" built for immediate payment and settlement
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking equipment that is used within the supply/value chain and monitoring product parts and services that were performed
	Lot lineage/provenance	Verify origin and authenticity of a product as it moves throughout the value chain; captures information about all inputs of a product, enabling accurate visibility and traceability into the history of a product; includes product and brand counterfeit/fraud detection, reduction, and prevention and maintaining records to assist in quality control; and can include environmental impacts on the product such as storage container conditions as the product is transported
	Loyalty programs	Maintain loyalty program memberships and rewards system
	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and can include banks, financial institution, brokers, suppliers, manufacturers, retailers, wholesalers, and others involved in the transaction
	Warranty claims	Track, maintain, and validate virtual warranties and warranty claims
	Others	Includes all other blockchain applications in retail not elsewhere classified
<b>Wholesale</b>	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; and includes monitoring the movement of merchandise, goods, and materials and registering each leg of a trip or movement throughout the supply/value chain
	Cross-border payments and settlements	Tracking, trading, and managing cross-border/international payments and settlements; creates alternate payment and settlement "rails" built for immediate payment and settlement
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking equipment that is used within the supply/value chain and monitoring product parts and services that were performed
	Lot lineage/provenance	Verify origin and authenticity of a product as it moves throughout the value chain; captures information about all inputs of a product, enabling accurate visibility and traceability into the history of a product; includes product and brand counterfeit/fraud detection, reduction, and prevention and maintaining records to assist in quality control; and can include environmental impacts on the product such as storage container conditions as the product is transported
	Regulatory compliance	Assist in maintaining records for regulatory compliance and checks
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and can include banks, financial institution, brokers, suppliers, manufacturers, retailers, wholesalers, and others involved in the transaction
	Others	Includes all other blockchain use cases in wholesale not elsewhere classified
<b>Professional services</b>	Land registry	Maintain real estate transactions on a blockchain once the buyer and seller agree on a deal and a contract is made; allow all parties involved in the transactions to track the progress of the deal once it is completed
	Others	Includes all other blockchain use cases in professional services not elsewhere classified, such as staff recruitment and management, audit for accounting, and general ledger for accounting

**CLOUD AND COMMUNICATIONS**

<b>Personal and consumer services</b>	Loyalty programs	Maintain loyalty program memberships and rewards system
	Others	Includes hotel inventory or property management, identity management, and all other blockchain use cases in personal and consumer services not elsewhere classified
<b>Healthcare provider</b>	Identity management	Identity management and confirmation (includes digital signature management); authenticate identities of both patients and healthcare providers, manage personal and medical data, and assist in identity as a service
	Others	Includes tracking patient consent and authorization, clinical trials, claims processing and filing, and product fraud detection such as counterfeit drugs, equipment and service/parts management, health record exchange, master patient index, and all other blockchain use cases in healthcare provider
<b>Transportation</b>	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; includes monitoring the movement of trains, planes, and other transportation vehicles and their contents/cargo and registering each leg of a trip
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking repaired equipment and monitoring product parts and services that were performed
	Loyalty programs	Maintain loyalty program memberships and reward system
	Others	Includes all other blockchain use cases in transportation not elsewhere classified, such as shared use management and big data market transaction management
<b>Telecommunications</b>	Others	Includes cellular network management, internal processes management, roaming management, connectivity provisioning, asset management for infrastructure/mobile devices, identity management, and all other blockchain use cases in telecommunications
<b>Media</b>	Others	Includes royalty payments/management, content copyright management, and all other blockchain use cases in media
<b>Utilities</b>	Energy settlements	Maintain transactions and tracking the energy that is being produced and consumed; facilitate peer-to-peer energy transactions and global trade automation
	Others	Includes carbon certificate trading, security management, infrastructure asset management, electric vehicle charging payment network, and all other blockchain use cases in utilities
<b>Construction</b>	Others	Includes material provenance, equipment and service/parts management, regulatory compliance, and all other blockchain use cases in construction
<b>Resource industries</b>	Asset/goods management	Monitor the movement of assets or goods, creating a full track and trace system or registry; creating a digital paper trail of the movement of goods; and includes monitoring the movement of merchandise, goods, and materials and registering each leg of a trip or movement throughout the supply/value chain
	Equipment and service/parts management	Collecting/maintaining inspection and maintenance information of equipment involved in general operations and/or goods production or distribution; includes tracking equipment that is used within the supply/value chain and monitoring product parts and services that were performed
	Trade finance and post-trade/transaction settlements	Provide a record of transactions in payments between parties involved in the transaction; in addition, facilitate the movement or flow of trade receivables and provide trade delivery and payment confirmation; and can include banks, financial institution, brokers, suppliers, manufacturers, retailers, wholesalers, and others involved in the transaction
	Others	Includes all other blockchain use cases in resource industries not elsewhere classified, such as regulatory compliance
<b>Federal government</b>	Identity management	Identity management and confirmation (includes digital signature management); authenticate identities; manage personal data; maintain citizenship records; manage government-issued credentials such as passports, SSN, refugee status and birth certificates; and assist in identity as a service
	Others	Includes asset registration, voting, taxes, regulatory compliance, and all other blockchain use cases in federal government
<b>State and local government</b>	Others	Includes asset registration, identity management, voting, taxes, regulatory compliance, and all other blockchain use cases in state/local government
<b>Education</b>	Others	Includes education records management, student debt, activity and cost management, and all other blockchain use cases in education
<b>Consumer</b>	NA	NA

Source: IDC's Customer Insights and Analysis Group, 2018

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Webjet Limited (WEB – ASX, 12.38 AUD - Not Covered)

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 Amazon.Com, Inc. (AMZN - NASDAQ, \$1,624.89, OUTPERFORM)  
 Crown Castle International (CCI - NYSE, \$104.02, PERFORM)  
 Cogent Communications (CCOI - NASDAQ, \$51.30, OUTPERFORM)  
 Charter Communications, Inc. (CHTR - NASDAQ, \$266.94, PERFORM)  
 Comcast (CMCSA - NASDAQ, \$31.48, OUTPERFORM)  
 CenturyLink (CTL - NYSE, \$18.31, OUTPERFORM)  
 Amdocs Ltd. (DOX - NYSE, \$68.49, OUTPERFORM)  
 Equinix Inc. (EQIX - NASDAQ, \$401.29, OUTPERFORM)  
 Facebook, Inc. (FB - NASDAQ, \$187.67, OUTPERFORM)  
 General Electric Co. (GE - NYSE, \$14.17, UNDERPERFORM)  
 Alphabet Inc. (GOOG - NASDAQ, \$1,067.80, OUTPERFORM)  
 GTT Communications, Inc. (GTT - NYSE, \$46.95, OUTPERFORM)  
 International Business Machines (IBM - NYSE, \$142.62, PERFORM)  
 Microsoft Corporation (MSFT - NASDAQ, \$98.95, OUTPERFORM)  
 Netflix, Inc. (NFLX - NASDAQ, \$353.54, OUTPERFORM)  
 Oracle Corporation (ORCL - NASDAQ, \$47.05, PERFORM)  
 QUALCOMM Incorporated (QCOM - NASDAQ, \$58.39, PERFORM)  
 Sprint (S - NYSE, \$5.22, NOT RATED)  
 Snap Inc. (SNAP - NYSE, \$10.97, PERFORM)  
 AT&T, Inc. (T - NYSE, \$32.57, PERFORM)  
 T-Mobile (TMUS - NYSE, \$56.33, OUTPERFORM)

Twitter, Inc. (TWTR - NYSE, \$34.36, PERFORM)  
 Vonage Holdings Corp. (VG - NYSE, \$11.43, OUTPERFORM)  
 VMware, Inc. (VMW - NYSE, \$138.02, OUTPERFORM)  
 Verizon (VZ - NYSE, \$48.60, PERFORM)  
 Boingo Wireless, Inc. (WIFI - NASDAQ, \$21.99, OUTPERFORM)  
 Walmart Inc. (WMT - NYSE, \$84.12, PERFORM)  
 Zayo Group (ZAYO - NYSE, \$34.77, OUTPERFORM)

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Rating	IB Serv/Past 12 Mos.			
	Count	Percent	Count	Percent
OUTPERFORM [O]	346	62.57	155	44.80
PERFORM [P]	205	37.07	70	34.15
UNDERPERFORM [U]	2	0.36	2	100.00

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