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PAYROLL TAX & THE BLOCKCHAIN

Richard T. Ainsworth
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The Internet is entering its second era. The transition is from a system that transfers *information*¹ to one that transfers *value*.² Anything of value – goods, services or intangibles – can be transferred through the Internet. Value can be money (Bitcoin, or the rights to fiat currency), but it can also be titles, deeds, music, art, scientific discoveries, or intellectual property.

There are a number of ways of looking at this development

Seen from the technology side, what we are looking at is the appearance of a new *foundational technology*. The transmission control protocol/ internet protocol (TCP/IP) that was introduced in 1972, laid the foundation for the *information era* of the Internet. In much the same way blockchain, introduced in 2008 along with its most famous application (Bitcoin),³ is laying the foundation for the *value era*.⁴

Seen from a purely business application perspective – Google, Facebook, and Twitter are the hugely profitable platforms that dominate the *information era*. A consensus is forming in the leading business and technology schools that we will see new (different) platforms dominating the *value era*. Stated differently, academics are pondering if Ethereum, or some other start-up, or perhaps an established company newly transformed will be the next Google?

Seen from the perspective of the common press, there are two different blockchain discussions. From one perspective blockchain is characterized as an inherently disruptive technology, which is rapidly forcing dramatic business and societal changes. A second thread argues that we are only seeing hype; real change will not occur. For the later group blockchain will only bring “change at the margins.” When it is all over this group believes what we will see is something akin to e-mail replacing

¹ The *information era* is best characterized by e-mail. Information is being passed among parties in this era in a new highly efficient manner. Search, messaging, and social media are all variations on the same theme.

² The *value era* is best characterized by Bitcoin. Value is being passed among parties in this era in a highly efficient, exceptionally secure manner. Crypto-currencies, and smart contracts are all part of the transformative process.

³ Satoshi Nakamoto, *Bitcoin, A peer-to-peer electronic cash system* (2008) available at: <https://bitcoin.org/bitcoin.pdf> (note: Satoshi Nakamoto is a pseudonym).

⁴ This paper presumes a basic understanding of blockchain technology, how blocks are formed, linked through a consensus mechanism, and how the design of the blockchain produces an immutable distributed ledger that replaces multiple centralized ledgers bringing efficiencies and trust among parties who might not otherwise trust one another. See: Andrea Pinna & Wiebe Ruttenberg, *Distributed Ledger Technologies in Securities Post-Trading: Revolution or Evolution?* EUROPEAN CENTRAL BANK, Occasional Paper Series No. 172 (April 2016); Marc Pilkington, *Blockchain Technology: Principles and Applications* (September 18, 2015) available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2662660

written letters, or Wikipedia replacing the Encyclopedia Britannica.⁵ These are interesting changes indeed, but not really transformative at the highest levels.

This paper accepts the technological assessment that blockchain represents a new *foundational technology*, and traces the implications of this observation into the payroll tax compliance space. It endeavors to predict and place on a time line the kinds of changes that will occur in this industry. It will assess both the business transformation and governmental impact.

Why select payroll taxation? Payroll compliance is an ideal space for blockchain. Not only is the payroll calculation exceedingly complex, occasionally involving matching contributions from employers, but the data involved is collected and stored centrally by multiple regulatory agencies each of whom can and do audit the data files. More than this, anti-money laundering (AML) and know your client (KYC) regulations, can readily be confirmed with immutable blockchain records. This is an environment where a distributive ledger should thrive. The payroll space appears ready for blockchain.

This analysis agrees with Professor Christian Catalini of MIT that, even though “there are a number of systemic issues that need to be resolved before [blockchain] can be implemented at scale [in payroll],”⁶ the barriers are rapidly being overcome. When this transformation is complete, blockchain’s efficiencies will inevitably overtake the payroll industry. There will be a shake-out of providers, and a search for value-added offerings by those remaining within the field.

New competitors will come from unexpected places. Service providers, notably those providing their customers with blockchains for commercial supply chains, will encroach on the payroll space by offering to append smart wage contracts to their pre-existing chains. This will occur sooner, rather than later. Financial services have a natural affinity for blockchain solutions. Payroll will flock to available blockchains in a company as a value-added service. That is of course, if payroll service providers are not

⁵ Jamie Redman, *Gartner Executive: Blockchain is ‘Over-Hyped,’* Available at: <https://news.bitcoin.com/gartner-blockchain-hyped/> (indicating that blockchain technology is a fascinating area to “keep an eye on,” but there are too many technical problems right now); Izabella Kaminska, Simon Taylor & Carola Hoyos, Bitcoin and Blockchain: the future of money or just hype? Financial Times (September 22, 2016) available at: <https://www.ft.com/content/3bea303c-7a7e-11e6-b837-eb4b4333ee43> (in a point-counterpoint article/ interview Izabella Kaminska argues that bitcoin and blockchain are flawed solutions to a problem that does not exist.

There is no proof blockchain has reduced costs at scale so it is all hypothetical at this stage. In financial services, blockchain does nothing but circumvent the rules we have imposed on banks to keep them honest. There are real moral hazards as a result, akin to those that plagued Libor. Meanwhile the taxonomy created around blockchain is out of control. The term has lost all meaning. It is a propaganda tool, most of all – a marketing gimmick to imply innovation.

Simon Taylor, the co-founder and director of 11:FS, a London-based fintech company in contrast believes cryptocurrencies will play an important economic a business role within two decades, and that blockchain itself is a collection of valuable ideas and technology that can solve problems of provenance and state.

⁶ Professor Christian Catalini (January 3, 2017) responding to a personal inquiry about the likely impact of blockchain in payroll tax compliance.

there first, in which case we will witness a reverse migration – payroll service providers will be offering to place commercial supply attributes on their wage-based blockchains.

FOUNDATIONAL TECHNOLOGY

Foundational technologies support critical (transformative) applications. Enduring and effective applications functionally define and then re-define business (and social) relationships within economic ecosystems. As a foundational technology, blockchain facilitates applications like Bitcoin, which in turn disrupts traditional value transferring structures. It is very clear that Bitcoin (and other crypto-currencies) directly threaten the global commercial banking system. This challenge is being felt from Central Banks all the way down to the individual consumer. Blockchain transformations will extend well beyond finance as other applications are developed for the blockchain.

This paper marks the pathway of foundational technologies as they embed themselves in business structures. It reasons that we can expect blockchain (as a foundational technology) to follow this common development path. It further observes that even though we would expect *payroll applications* placed on the blockchain to develop in a manner similar to that followed by the *bitcoin application*, the complexity and coordination demands of payroll has forced it into a modified development path. After some slow development, payroll seems ready to leapfrog early development phases, and begin *replacing* traditional payroll service as early as 2018-2021.

Foundational technologies are initially understood mainly through the applications they support. This can cause some confusion. For example, Blockchain (a foundational technology) is so closely associated with Bitcoin (an application) that the best articles in the field always take time to clearly distinguish them.⁷ As a foundational technology, Blockchain, like all similar foundational technologies, is going through a four phases development process. There are two sets of variables guiding the development:

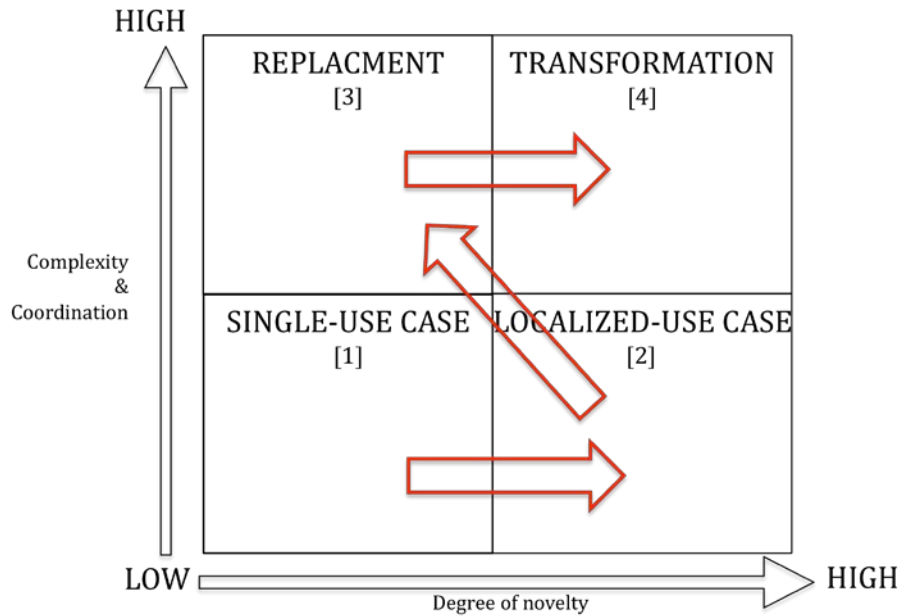
- (a) the degree of perceived novelty in the technology or application, and
- (b) the level of complexity and the degree of coordination required to use the technology or application at each stage of development.

Processes and procedures that are too new are resisted. So too are complex applications that require a high degree of coordination. Figure 1 below sets out the four phases, following from block [1] through [4] in sequence.⁸

⁷ See for example Carla L. Reyes, *Moving Beyond Bitcoin to an Endogenous Theory of Decentralized Ledger Technology Regulation: An Initial Proposal*, 61 VILLANOVA LAW REVIEW 191, 196-8 (2016).

⁸ Marco Iansiti & Karim R. Lakhani, *The Truth About Blockchain*, HARVARD BUSINESS REVIEW (January-February 2017) at 1 (presenting the four phase matrix to explain Blockchain's development pattern).

Figure 1: Four phases of establishing foundational technology



[1] *Single-Use cases*. The lower left quadrant is where we begin. Foundational technologies enter the market on the back of an application (a single-use) that appears to the user to be uncomplicated, and “not much different” from what is currently available.

For example, sending an e-mail on ARPAnet was not much different than sending a message by letter or computer notation before the ARPAnet existed. E-mails delivered messages faster from one computer to another, but the unique method of delivery was not at all apparent to the user. The level of complexity and coordination needed was low. A sender needed no more than a computer connected to the ARPAnet and the e-mail address of the recipient.

The concept of an e-mail message was not new when ARPAnet adopted it. It was a small advance on what we know today as sharing a file directory.⁹ Ray Tomlinson is sometimes credited with inventing e-mail in 1972, when he worked as contractor for ARPAnet, but his overall contribution was small. He is credited with picking the @ symbol from the computer keyboard to denote sending messages from one computer to another. All other technology was already in place.

Similarly, there is not much difference between transferring funds in Bitcoins, and transferring funds in traditional (fiat) currency through electronic fund transfers (EFT) or

⁹ Ian Peter, *The History of Email* in IAN PETER’S HISTORY OF THE INTERNET, available at: <http://www.nethistory.info/History%20of%20the%20Internet/email.html> (indicating also that the first e-mail system was MAILBOX, used at MIT from 1965, and that prior to this email was more like a “post-it note” left on a computer screen when multiple “dumb terminals” were connected to the same mainframe.)

automated teller machines (ATM). EFT is simply the application of computer and telecommunication technology to payment processing.¹⁰ ATMs became popular in the mid-1960's and were able to handle account transfers, accept deposits, and dispense cash using a standard magnetic strip card and personal identification number (PIN). By 2008 when Satoshi Nakamoto published his White Paper on Bitcoin, ATMs were ubiquitous.

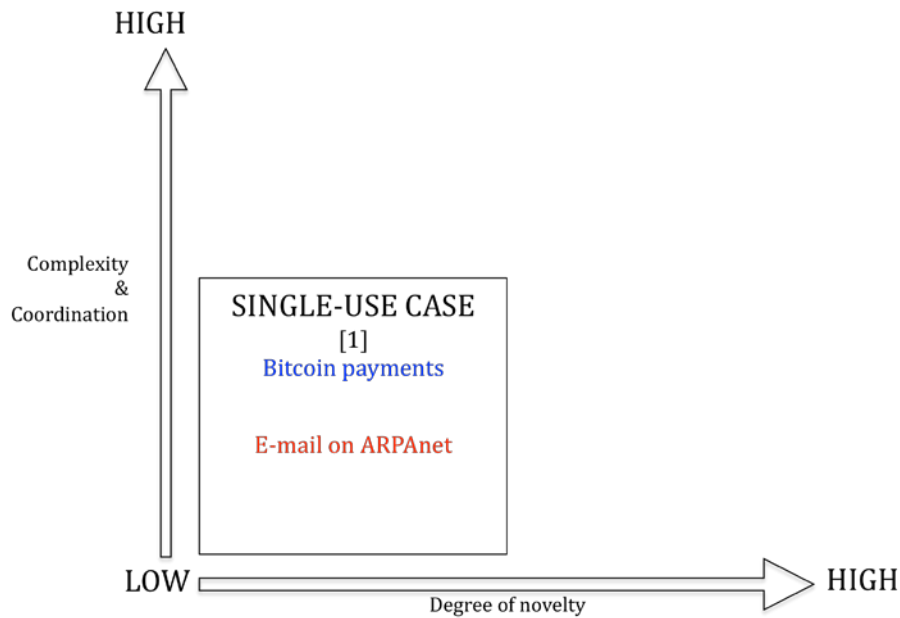
ATM networks covered the country, and extended internationally.¹¹ As a result, the earliest Bitcoin transactions did not appear to be exceptionally novel nor were they technically complex or require a great deal of co-ordination. Users who were familiar with ATM machines, and had a liking for technology, could easily move into Bitcoin. The only real difference was that Bitcoin transactions were done on your own computer with crypto-currency, and not at the local ATM with fiat currency.

Thus, both the Bitcoin application and the ARPAnet's e-mail application were quickly assimilated into the financial ecosystem of the day. These applications arrived on the back of less visible *foundational technologies*, which were truly revolutionary. TCP/IP brought in ARPAnet's e-mail; Blockchain brought in Bitcoin. Very few users knew or understood this. Figure 2 presents the Single-Use Case. Text in red indicates applications developed on TCP/IP, the foundational technology of the *information era*; the text in blue indicates applications developed on Blockchain, the foundational technology of the *value era*.

¹⁰ In the US ATM's were restricted to in-state activity until the US Supreme Court upheld an earlier US Court of Appeals decision allowing interstate EFT networks to develop. *Independent Bankers Association of New York State v. Marine Midland Bank*, 583 F. Supp. 1042 (W.D.N.Y., 1984, rev'd. in part, vacated in part, and remanded, 757 F.2d 453 (2nd Cir., 1985), cert. denied, 476 U.S. 1186 (1986).

¹¹ Stan Sienkiewicz, *The Evolution of EFT Networks from ATMs to New On-Line Debit Payment Products*, Federal Reserve Bank of Philadelphia (April 2002) available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=927473

Figure 2: Single-Use Case



It is helpful to consider the initial appearance of both of these foundational technologies and their single-use applications in a little more detail.

TCP/IP & ARPAnet's e-mail application. The Advanced Research Project Agency Network is a classic single-use case effort. The entire ARPAnet effort was focused on the singular effort to develop a decentralized communication system. ARPAnet was an early packet switching network designed by the US Department of Defense.¹² Previously, telecommunications architecture used circuit switching. Connections between parties were pre-established, and sustained throughout the exchange.

TCP/IP approached computer-based communications differently. The transmission control protocol/ internet protocol (TCP/IP) digitized information, and broke it into small packets. Each packet had address information. Once released into the network each packet could take any route to the recipient. Smart sending and receiving nodes at each end of the ARPAnet disassembled and reassembled the packets and interpreted the data.

¹² ARPAnet was developed primarily for military purposes. At the height of the Cold War, the military was seeking a communication system without a central core. They wanted something without a headquarters or base of operations that could be attacked and destroyed by an enemy who would then be able to black out the entire network in one fell swoop. Ronda Hauben, Jay Hauben, Werner Zorn & Anders Ekeland, *The Birth and Development of the ARPAnet*, in *THE ORIGIN AND EARLY DEVELOPMENT OF THE INTERNET AND OF THE NETIZEN: THEIR IMPACT ON SCIENCE AND SOCIETY* (Chapter 8) January 2007, available at: <http://www.columbia.edu/~rh120/ch106.x08>

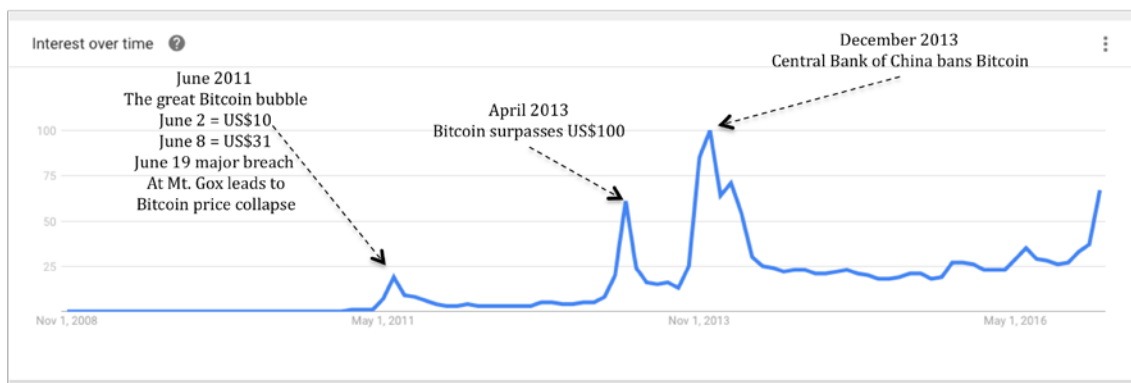
This communications approach did not need dedicated lines, nor did it need massive infrastructure, nor were there privacy concerns. TCP/IP created an open, shared, public network without the need for a central authority or the need for anyone to maintain it. At the time, the traditional telecommunications industry was skeptical of TCP/IP and its application. All the early user saw was an improved e-mail system.

Blockchain & Bitcoin. Blockchain is a peer-to-peer network that sits atop the internet, and is fully compatible with the internet’s design. Blockchain rejects central authority. It is open, distributed, and shared. Bitcoin was its single-use case.

Bitcoin caught on with a small community of enthusiastic users. Not everyone was attracted to Bitcoin. But, if an individual felt comfortable with Bitcoin as a surrogate fiat currency, and if he experimented with its use, then it soon became apparent that Bitcoin dramatically lowered the cost of transferring *value*. Bitcoin grew in popularity within this community, but it still was a commodity (not a true currency).

Google Trend analysis shows searches for Bitcoin rising and falling when good or bad news breaks on the status of Bitcoin as a surrogate currency.

Figure 3: Google Trends Analysis
 “Bitcoin”
 From the publication date of Satoshi Nakamoto’s
Bitcoin, A peer-to-peer electronic cash system (October 31, 2008)



Blockchain is a different story. A Google Trend analysis of global searches for the term “blockchain” shows no search activity from the 2008 publication of Satoshi Nakamoto’s white paper on *Bitcoin* until April 2013. The great Bitcoin Bubble came and broke and still there were no searches for blockchain. Two more years go by in silence. The *foundational technology* behind the single-use case (bitcoin) was functionally invisible, even though its single-use was anything but invisible. This all changed when

Bitcoin's value reached US\$100. Suddenly, there is very measurable interest in Blockchain.

This moment marks the beginning of the second phase in the development of blockchain as a *foundational technology*. It's almost like a light went on in the technology world. People woke-up some time in April 2013 and said: "Wow, if a Bitcoin can go up in value from US\$1 to US\$100 in 27 months, there must be some powerful technology here that's really worth looking into."¹³ Blockchain was discovered.

Google trend analysis picks up a steady rise search activity around *blockchain* after April 2013. Most likely, the searches were largely from academic researchers, and software developers who were looking for additional *localized-use* cases – applications and adaptations of blockchain technology that could be used to accomplish very different things from what Bitcoin was accomplishing.

At least seventeen very significant blockchain service companies formed in the three years that follow April 2013. A full count of the new firms would easily number in the hundreds, if large and small as well as successful and failed firms are included. For our purposes comparing these seventeen with the three significant blockchain firms formed before April 2013 is the important point to be made.¹⁴ There is a rising tide of firms formed to help established companies capture efficiencies by adopting blockchain solutions. Some of these firms designed permissionless (or public) blockchains,¹⁵ like Satoshi Nakamoto's original blockchain, while others developed permissioned (or private) blockchains.¹⁶ Several were hybrid (public/private) blockchains.¹⁷

The important thing to note is the steady, consistent rise in blockchain interest, and contrast it with the commodity-like rise and fall in bitcoin interest. Once the *foundational technology* is identified, and the single-use case shows considerable financial promise there is a constant rise in blockchain interest. In other words, although there is still a close tie between bitcoin and blockchain it appears that blockchain is responding more to technology professionals building multiple *localized-use cases*, whereas bitcoin reflects the activity of speculative investors.

¹³ Bitcoin reached parity with the US dollar for the first time on February 9, 2011. *History of Bitcoin: The World's First Decentralized Currency*, available at: <http://historyofbitcoin.org>

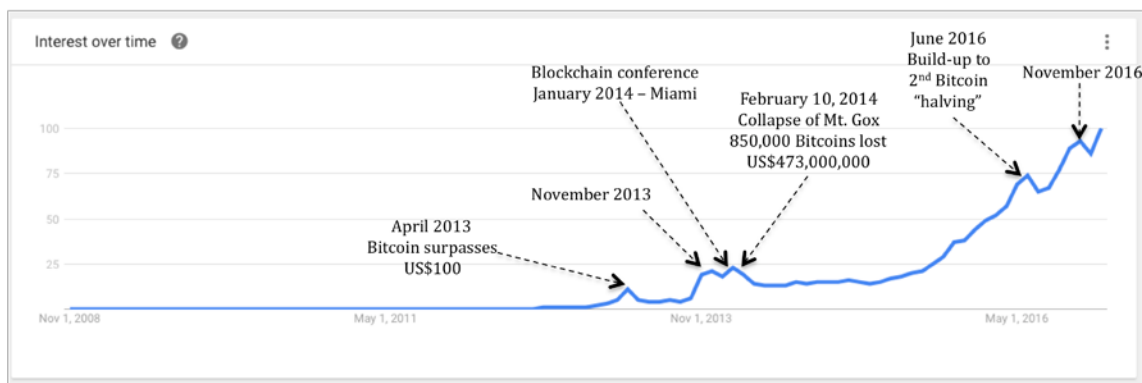
¹⁴ Firms established before April 2013 include: NXT (founded August 2012); Litecoin (founded October 2011); Ripple (founded October 2012).

¹⁵ Firms with permissionless ledgers include: Ethereum (founded January 2014); Augur (founded March 2015); Tendermint (founded 2016); Namecoin (founded June 2013); Darkcoin (founded January 2014)

¹⁶ Firms with permissioned ledgers include: Clearmatics (founded January 2015); CryptoCorp (founded 2014); Eris Industries (founded December 2014); Hyperledger (founded 2014); Tembusu Systems (founded October 2013); Tezos (founded 2014); Tillit (founded 2014).

¹⁷ Firms with hybrid ledgers include: SKUChain (founded September 2014); Blockstream (founded March 2014); Pactum (founded December 2014); Symbiont (founded January 2015); Vennd (founded July 2015).

Figure 4: Google Trends Analysis
 “Blockchain”
 From the publication date of Satoshi Nakamoto’s
Bitcoin, A peer-to-peer electronic cash system (October 31, 2008)



[2] *Localized-Use cases*. We are moving to the lower right quadrant of Figure 1. This is where foundational technologies and their applications move next. Development tends to come first along the “degree of novelty” axis, not the “complexity and coordination” axis – although payroll applications appear to be developing differently. Payroll applications may be ready to leap-frog the *localized-use case* step.

TCP/IP. In the early days of TCP/IP key companies in Silicon Valley – Sun Microsystems,¹⁸ NeXT Computer (founded by Steve Jobs in 1985),¹⁹ Hewlett-Packard,²⁰

¹⁸ Computer History Museum, *Internet History of the 1980's* in INTERNET HISTORY 1962 TO 1992, available at: <http://www.computerhistory.org/internethistory/>

At Berkeley, Bill Joy incorporates the new TCP/IP suite into the next release of the Unix operating system. The first ‘portable’ computer is launched in the form of the Osborne, a 24-pound suitcase-sized device. ...Having incorporated TCP/IP into Berkeley Unix, Bill Joy is key to the formation of Sun Microsystems. Sun develops workstations that ship with Berkeley Unix and feature built-in networking.

¹⁹ NeXT computers came fully equipped with TCP/IP functionality. They were expensive, but designed primarily for the academic research market, so the e-mail functionality was critical. When Jobs returned to Apple in 1985 TCP/IP became a standard part of the operating system.

²⁰ Robert A. Burgelman, Webb McKinney & Phillip E. Meza, *Sidebar: Emergence and Development of HP's Networking Business*, in BECOMING HEWLETT PACKARD: WHY STRATEGIC LEADERSHIP MATTERS (2016).

Until the early 1980s, HP's three major computer divisions each developed its own networking technologies and protocols. In 1985 the Information Networking Group was formed, and led by Wim Roelandts, to consolidate the independent networking

and Silicon Graphics²¹ – all created localized private e-mail networks *within their own organizations*. In doing so, they developed the building blocks and tools that broadened TCP/IP applications beyond e-mail. Development occurred in a stable, controlled environment. As these companies gradually replaced their traditional information networks with TCP/IP-based email they saw dramatic gains in productivity.

These *localized-use cases* did not attract much attention. They were internal corporate “experiments.” They passed “under the radar,” and were not discussed widely in the press. The *foundational technology* (TCP/IP) only became visible (in the popular press) in the next phase. That is not the case with Blockchain. Blockchain is highly visible at stage [2].

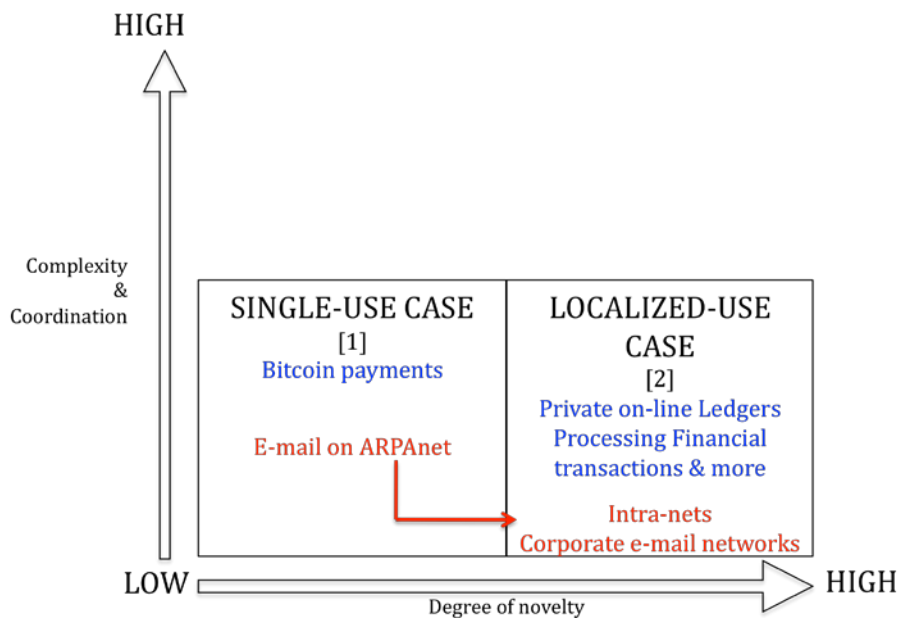
It is recommended that payroll service providers make an effort to develop localized-use cases. Internal experiments are needed. Blockchain technology should be tried on company payroll. It is possible that one or more clients (most likely technology clients that enjoy being on the “cutting edge”) might also provide a technology “sandbox” for the industry. There is no indication that this is happening, but it should be. See figure 5 below.

businesses. HP had to be able to connect their computer systems to those of IBM and DEC, and this created a problem. According to Roelandts, “I had fewer resources than IBM and DEC but I had to create protocols to interact with their systems and HP’s systems. That’s why we started playing with TCP/IP, because it was an opening standard.

HP’s success with open standards created its own momentum. Roelandts’s successor was quite bullish on HP’s opportunity in networking. As early as 1988 he thought it could be \$1 billion for HP.

²¹ Olivier Bonaventure, *COMPUTER NETWORKING: PRINCIPLES, PROTOCOLS AND PRACTICE* (2011) at 5: In the US, the ARPANET started in 1969 and continued until the mid 1980s ... workstations such as Sun or Silicon Graphics included TCP/IP in their variant of Unix. ... In the end, TCP/IP became the de facto standard that is not only used within the research community.

Figure 5: Localized-Use Case



Blockchain. Blockchain has developed through a set of *localized-use cases* [phase 2]. There are no payroll applications (yet). Blockchain localized-use cases are far more numerous than their predecessors in TCP/IP. They are also much more public (there are literally thousands of *localized-use* blockchain cases that have developed and have been followed in the press over a three year period). Blockchain is moving faster and more publicly through the TCP/IP development curve.

One measure of Blockchain’s spread is the proliferation of copy-cat cryptocurrencies. Special currencies, modeled on Bitcoin, were designed by a number of firms to work with unique Blockchain applications. These are all *localized-use cases*.

Since Bitcoin’s launched in 2008 more than 700 new crypto-currencies came to the open market. Blockchain was spreading and developing. Its dominant application was multiplying.²²

Twenty-five of the *new* crypto-currencies are very significant. Each has a market capitalization in excess of \$10 million. Two examples are Ether and Emercoin.²³ Ether is the cryptocurrency that executes peer-to-peer smart contracts in the Ethereum Virtual

²² For the 25 largest *see*: CoinMarketCap, *Cryptocurrency Market Capitalizations*, available at: <https://coinmarketcap.com>

²³ Other major cryptocurrencies are no more than Bitcoin derivatives. For example PotCoin services the legal cannabis industry with the hope of becoming a global currency in the cannabis trade, and Auroracoin which is an alternative to the fiat currency in Iceland.

Machine (EVM) on the Ethereum blockchain;²⁴ Emercoin is a leading cryptocurrency used in a distributed, censorship-proof technology platform (the Emercoin blockchain) for scalable services.²⁵

It took TCP/IP about thirteen years to develop a modest set of *localized-use cases*. Blockchain followed the same path, but it developed thousands of *localized-use cases*. It accomplished this in less than eight years (2008 – 2016). Blockchain’s localized-use cases are not limited to Silicon Valley, as were TCP/IP’s localized-use cases. They are spread over many US and foreign jurisdictions. Business models are shaping up around blockchain very fast. There is a consortium of blockchain service providers, and a wide array of blockchain clients adopting solutions.

Blockchain activity in the financial sector is highly visible. Financial transactions are easily digitized and consequently present ideal localized-use cases. Some of the most visible financial applications are listed below. Note the date-stamps on these applications. These developments are very current:

- On December 30, 2015, NASDAQ enabled a (first-ever) private security issuance with Blockchain – the Blockchain developer used by NASDAQ was Chain.com (founded 2014);²⁶
- On January 28, 2016 the US Patent and Trademark Office announced that in the 18 months prior Bank of America had filed 15 finance-related Blockchain patents; 20 more were pending – Bank of America is largely collaborating with Microsoft in developing its blockchain solutions;²⁷

²⁴ EVM runs on the Ethereum open source public blockchain, a distributed computing platform that features smart contract functionality.

²⁵ Among the services offered are (a) a micropayment library for streaming media, (b) a storage service for electronic business cards, (c) trusted storage for digital timestamps on the blockchain, (d) decentralized, uncensored domain name system, and (e) a decentralized trust store of hash sums for client SSL-certificates. The suite of Emercoin services runs on top of the Emercoin blockchain. Yahoo! Finance, *First Bitcoin Capital Corp. Signs Evaluation Agreements with Emercoin International Development Group, To Develop and Market Solutions to Provide Distributed Blockchain Services For Business and Personal Use*, available at: <http://finance.yahoo.com/news/first-bitcoin-capital-corp-signs-185600316.html>

²⁶ Will Briganti & Ryan Wells, *NASDAQ LINQ Enables first-ever Private Securities Issuance Documented with Blockchain Technology*, NASDAQ Press Release (December 30, 2015) available at: <http://ir.nasdaq.com/releasedetail.cfm?releaseid=948326> (Chain.com, an inaugural Nasdaq Linq client and blockchain developer issued shares to a private investor which enabled Chain.com to digitally represent a record of ownership, with significantly reduced settlement time, and elimination of the need for paper certificates. Clearing and settlement time was reduced from three days to ten minutes, reducing settlement risk exposure by 99%, as well as dramatically reducing capital costs and systemic risk. The administrative cost of the current manual process was reduced in this multi-step transaction process.) The planned pilot with Chain.com (which was newly formed in 2014) was announced six months earlier. Laura Shin, *Nasdaq Selects Bitcoin Startup Chain to Run Pilot in Private Market Arm*, FORBES (June 24, 2015) available at: <http://www.forbes.com/sites/laurashin/2015/06/24/nasdaq-selects-bitcoin-startup-chain-to-run-pilot-in-private-market-arm/#1fe8647752d7>

²⁷ Arjun Kharpal & Julia Chatterley, *Bank of America is Going Big on Blockchain*, CNBC (January 28, 2016) available at: <http://www.cnn.com/2016/01/28/bank-of-america-is-going-big-on-blockchain-plans-to-file-20-patents.html> (indicating that BoA has “create teams within their organization to look into how to develop cryptocurrency” that they are “trying to steal a march on the latest developments” and that two of them concern a “cryptocurrency risk detection system” and a “suspicious user alert system.” There is an 18 month publication delay by the USPTO on new patent filings.) Samburaj Das, *Microsoft Partners Bank of*

- On October 3, 2016 J.P. Morgan Chase announced that it was working on Quorum (it was founded in 2014). This new blockchain is built on top of the publicly accessible Ethereum network code, and will be “private” for traders, but “public” for regulators;²⁸
- As of March 2016 there are at least six global stock exchanges using or planning to adopt blockchain technology to perform basic exchange functions:²⁹
 - Korea Exchange (South Korea) is working with Blockco (a Korean startup);³⁰
 - NASDAQ (USA);³¹
 - London Exchange (UK);³²
 - Australian Securities Exchange (Australia) is working with New York base Digital Asset Holdings (founded 2014);³³
 - Takkinn Stock Exchange (Estonia)³⁴
 - Tokyo Exchange (Japan)³⁵

Blockchain is not limited to the financial sector. Blockchain applications (many of which have only been worked out in the past two years) are creating marketplaces, authenticating goods, services, intangible assets and identities. They are even being used to keep track of complex document flows and prevent voter fraud. Examples are:

America on Blockchain to “Transform” Trade Finance, (September 28, 2016) CRYPTOCOINS NEWS available at: <https://www.cryptocoinsnews.com/microsoft-partners-bank-of-america-on-blockchain-to-transform-trade-finance/>

²⁸ Telis Demos, *J.P. Morgan Has a New Twist on Blockchain*, WSJ (October 3, 2016) available at: <http://www.wsj.com/articles/j-p-morgan-has-a-new-twist-on-blockchain-1475537138>

Skeptics say that blockchain may ultimately be a hyped-up version of banks’ existing, struggling systems. But for the first firms to devise a new system, success could be very lucrative, resulting in big cost savings and possibly new revenue from selling software services.

²⁹ *How these Six Stock Exchanges are getting on Board with Blockchain*, NEXCHANGE FINTECH NEWSLETTER (March, 2016) available at: <https://nexchange.com/article/8637>

³⁰ Nam Hyun-woo, *KRX Seeks Share Trading Through Blockchain*, THE KOREA TIMES (January 8, 2017) available at: http://www.koreatimes.co.kr/www/news/biz/2016/02/488_199315.html (initially for the off-board traders, a 56 trillion won market).

³¹ See above, note 21.

³² Samburaj Das, *London Stock Exchange, Banks and Trading Firms Create Blockchain Group*, CRYPTOCOINNEWS (November 18, 2015) available at: <https://www.cryptocoinsnews.com/london-stock-exchange-banks-and-trading-firms-create-blockchain-group/> (referencing a European consortium that’s trying to “catch up” with blockchain developments elsewhere).

³³ *ASX Media Release* (January 22, 2016) available at: <http://www.asx.com.au/documents/about/ASX-Selects-Digital-Asset-to-Develop-Distributed-Ledger-Technology-Solutions.pdf> (announcing that the US firm Digital Asset Holdings, LLC, which it took a 12% interest in, will develop a blockchain for the Australian exchange. ASX is one of 13 global financial services leaders participating in Digital Assets).

³⁴ John McCrank, *NASDAQ Says to Develop Blockchain Services in Estonia*, Business Insider, Reuters (November 13, 2015) available at: <http://www.businessinsider.com/r-nasdaq-says-to-develop-blockchain-services-in-estonia-2015-11> (indicating that the NASDAQ plans to develop blockchain applications for the Estonian exchange, which is owned and operated by NASDAQ.)

³⁵ *Japan Exchange Group to Test out Decentralized Ledger* NIKKEI ASIAN REVIEW (February 16, 2016) available at: <http://asia.nikkei.com/Japan-Update/Japan-Exchange-Group-to-test-out-decentralized-ledger> (indicating that IBM Japan and Mitsubishi UFJ Financial Group will team up to produce a public distributed ledger for the exchange).

- *Blockchain marketplaces.* On April 4, 2016 OpenBazaar, a peer-to-peer digital marketplace went live after public testing (3,000 vendors in 126 countries) after raising \$1million in capital. OpenBazaar created a *localized-use case* with its' March 3, 2016 pilot.³⁶ This application is a “distributed eBay.”³⁷ OpenBazaar is expected to be highly disruptive to established e-commerce businesses like eBay and Amazon.³⁸
- *Blockchain authentication (manufacturing).* In the Spring of 2016 Petrodvorets Watch Factory, one of Russia’s oldest luxury watchmakers began using Emercoin’s blockchain to prevent counterfeiting of the elite Raketa brand (the most expensive type of watch made by Petrodvorets).³⁹
- *Blockchain authentication (fashion).* During Shanghai Fashion Week (April 8-15, 2016) the independent, trendy fashion label Babyghost used Shanghai based BitSE, and VeChain (cloud management) to put a unique ID on the blockchain for each clothing item. When in proximity to the clothing Near Field Communication (NFC) cell phone apps verify the clothing’s authenticity. The scan would also show previous owners of the clothing, or whether it had been worn at a fashion show.⁴⁰

³⁶ Daniel Palmer, *How OpenBazaar’s Early Adopters Are Testing the Online Market*, COINDESK (March 24, 2016) available at: <http://www.coindesk.com/7-vendors-early-adopters-openbazaar/>

³⁷ Stan Higgins, *Decentralized Bitcoin Market OpenBazaar is Now Live*, COINDESK (April 4, 2016) available at: <http://www.coindesk.com/openbazaar-live-version-bitcoin-market/> (explaining that anyone in the world can use the Blockchain platform to exchange goods and service with Bitcoin); .

³⁸ Ferdinand Reyes, *Decentralized Market Kills E-commerce Stars: OpenBazaar*, BITCOIN MAGAZINE (November 30, 2014) available at: <https://bitcoinmagazine.com/articles/decentralized-markets-kills-e-commerce-stars-openbazaar-1417320255> (Comparing eBay and Amazon.com with OpenBazaar:

OpenBazaar is free, you don’t need to pay a listing fee to list as many products as you have to sell, and when you sell your products your transaction costs are minimum compared to the ones you pay in those traditional markets, which have business models that either charge you a commission, or a monthly fee to have your store up and running. With OpenBazaar you list your product, and you transact directly with your customer; all you might have to pay is a minimum arbitration fee (which will be set by the marketplace and competition, not a centralized entity with power to dictate a non-negotiable price, and which also passes down their overly expensive merchant fees, aka, credit card fees) and the Bitcoin miner transaction fee which is just cents (no matter what amounts you transact, small or large)

³⁹ Iyke Aru, “*Blockchain Watch: Manufacturers Start Using Blockchain To Confirm Authenticity of Luxury Goods*,” COINTELEGRAPH, (June 8, 2016) available at: <https://cointelegraph.com/news/blockchain-watch-manufactures-start-using-blockchain-to-confirm-authenticity-of-luxury-goods> (Stan Polosov, the COO of the Emercoin’s Blockchain Engine indicated:

All luxury watches have a serial number, issued in the production stage and applied directly to the products themselves, making them the perfect candidate for a digital registry. For each watch, information will be recorded in the blockchain in regard to the date of manufacturing, its assembler and about any repair history, as well as information about the owner, if the owner chooses.

Rebecca Campbell, *Raketa Watches Trials Blockchain Technology to Fight Counterfeiting*, BITCOIN MAGAZINE (July 7, 2016) available at: <https://bitcoinmagazine.com/articles/raketa-watches-trials-blockchain-technology-to-fight-counterfeiting-1467905237>

⁴⁰ Rebecca Campbell, *Babyghost and VeChain: Fashion on the Blockchain*, BITCOIN MAGAZINE (October 18, 2016) available at: <https://bitcoinmagazine.com/articles/babyghost-and-vechain-fashion-on-the-blockchain-1476807653>; BlockVerify performs the same service for pharmaceuticals, luxury manufactured

- *Blockchain commercial document controls.* On August 10, 2016 Bank of America, HSBC & the Singapore government's IT agency built a blockchain application to replicate letter of credit transaction processes between banks, exporters and importers;⁴¹
- *Blockchain healthcare document controls.* The Department of Health and Human Services received more than 70 proposals responding to the *Use of Blockchain in Health IT and Health-related Research Challenge* on September 1, 2016. Several papers dealt with placing patient records on the blockchain.⁴² The Ethereum blockchain was preferred for balancing patient privacy with research access.
- *Voter fraud prevention.* FollowMyVote (founded July 4, 2012) is the first blockchain startup in the voting space.⁴³ Expanse Borderless joined on November 1, 2016,⁴⁴ and immediately ran a mock voting blockchain (a proof of concept) where people were asked to vote for president (as if the voting were part of the current US presidential election).⁴⁵ But the real money in a voting blockchain application is in commercial applications (proxy voting, and services that would allow shareholders to vote at investor meeting they were not able to attend in person). As of October 6, 2016 Broadridge, the financial services company, has begun investing heavily in blockchain voting technology to be "the first to market a complete proxy blockchain solution."⁴⁶

The breadth of *localized-use case* development in blockchain coupled with its speed is truly breathtaking. It is easy to see how some analysts predict imminent, transformative change everywhere. That has not happened (yet). If it had, there would be an abundance of Blockchain examples in the next section of this paper.

[3] *Replacement.* The third quadrant identifies developments that are a low degree of novelty (building on single-use and localized-use applications), but require a significant degree of coordination. Enterprises in this quadrant are replacing traditional businesses, reducing cost, and increasing availability of goods or services.

goods, diamonds and electronics. The blockchain identifies counterfeits, finds diverted goods, and tracks fraudulent transactions.

⁴¹ Pete Rizzo, *Bank of America, HSBC unveil Blockchain Supply Chain Project*, COINDESK (August 10, 2016) available at: <http://www.coindesk.com/hsbc-bank-america-blockchain-supply-chain/#>

"Many people are talking about the theory of blockchain, but for the first time we can start to see how this technology might be used to solve the real world challenges our customers face," Vive Ramachandran, global head of product for HSBC's trade and finance business, said.

⁴² #5, #6 #9 #10 #12

⁴³ FollowMyVote.com blog, *Founded on the 4th of July*, available at: <https://followmyvote.com/founded-on-the-4th-of-july/>

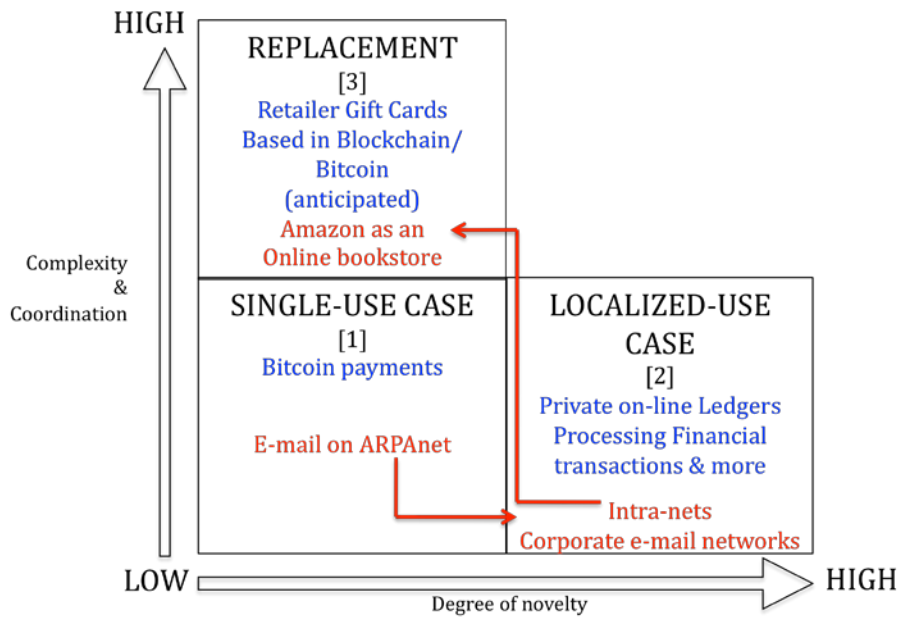
⁴⁴ Marcia Danzeisen, *Expanse Project [EXP] Announces Blockchain-based Voting Platform Prototype with Borderless.tech*, BITCOIN PR BUZZ (November 1, 2016) available at: <http://bitcoinprbuzz.com/expanse-project-exp-blockchain-voting-platform-borderless-tech/>

⁴⁵ Iyke Aru, *Americans Are Already Voting on Blockchain*, THE COINTELEGRAPH (November 3, 2016) available at: <https://coindesk.com/news/americans-are-already-voting-on-blockchain>

⁴⁶ Michael del Castillo, *Why Broadridge is Investing Millions in Blockchain Voting*, COINDESK (October 3, 2016) available at: <http://www.coindesk.com/broadridge-investing-blockchain-voting/>

The standard here is to offer functionality *as good as, if not better than* a traditional solution. It must be *as easy to use, if not noticeably more convenient*. This functionality allows a new application of the foundational technology to actively replace (not just co-exist with) traditional business operations. See figure 6 below.

Figure 6: Replacement



TCP/IP. Amazon.com (as an online bookstore) fits these requirements. Founded in 1994, it went online in 1995 selling books because of the large demand for literature worldwide, the favorable price point, and the large supply of titles available. In two months sales were \$20,000 per week, and Amazon could offer seven to ten times the number of titles of a brick and mortar store. By 2001 it made a \$5 million profit on sales of \$1 billion.

The Internet, the creation of TCP/IP has facilitated the creation of the virtual bookstore, and Amazon.com has stepped in to take advantage. As of March 2014 Amazon’s share of new book purchases was 41%. It had a 65% market share of all new online book sales (globally) in print and digital format.⁴⁷ It is reasonable to conclude that Amazon.com has *replaced* close to 50% of the brick and mortar bookstores.

Blockchain. It is difficult to find a *replacement application* comparable to Amazon built on the blockchain. It appears to be too early in the development curve.

⁴⁷ Polly Mosendz, Amazon Has Basically No Competition Among Online Booksellers, The Atlantic (May 30, 2014) available at: <http://www.theatlantic.com/business/archive/2014/05/amazon-has-basically-no-competition-among-online-booksellers/371917/>

One promising application appears to be Gyft, a virtual gift card provider that was acquired on July 30, 2014 by First Data Corp. (FDC).⁴⁸

Gyft brings two attributes to FDC: (1) fraud prevention through blockchain,⁴⁹ and (2) bitcoin functionality, which greatly reduces costs when retailers accept bitcoin.⁵⁰ Gift card fraud occurs when someone in the chain of ownership uses a card, and then sells it on.⁵¹ The retailer who eventually receives the stolen card is in a difficult position if he declines a card with his name on it from a good customer who either paid for it or was given it by a friend who had paid for it.

Before Gyft and its blockchain application there was no way to trace the chain of card ownership back to the fraudster. FDC can now identify the thief. This competitive advantage will soon put the whole gift card market on the blockchain. Either competitors will adopt blockchain, or their customers will migrate to FDC/Gyft. There are no published reports that confirm that blockchain gift cards have *replaced* traditional gift cards yet, but the replacement is inevitable.⁵²

[4] *Transformation*. The last phase in the development of a *foundational technology* is when the technology supports completely novel (unforeseen) applications that fundamentally change the nature of business and government systems. Their adoption frequently comes with major social, legal and political change. Co-ordination demands are high. Applications are complex.

⁴⁸ Michael Carney, *EXCLUSIVE: Payment Giant First Data Acquires Gyft in an effort to bring digital cards to the masses*, PANDO (July 30, 2014) available at: <https://pando.com/2014/07/30/payments-giant-first-data-acquires-gyft-in-an-effort-to-bring-digital-gift-cards-to-the-masses/> (indicating that FDC paid \$6 million for the two year old Gyft and plans to use Gyft's technology to develop the gift card market. FDC's share of this market is \$100 billion. FDC processes payments for over 6 million merchants and 3,500 financial institutions. It is the world's largest card processor with \$1 trillion annual transactions.

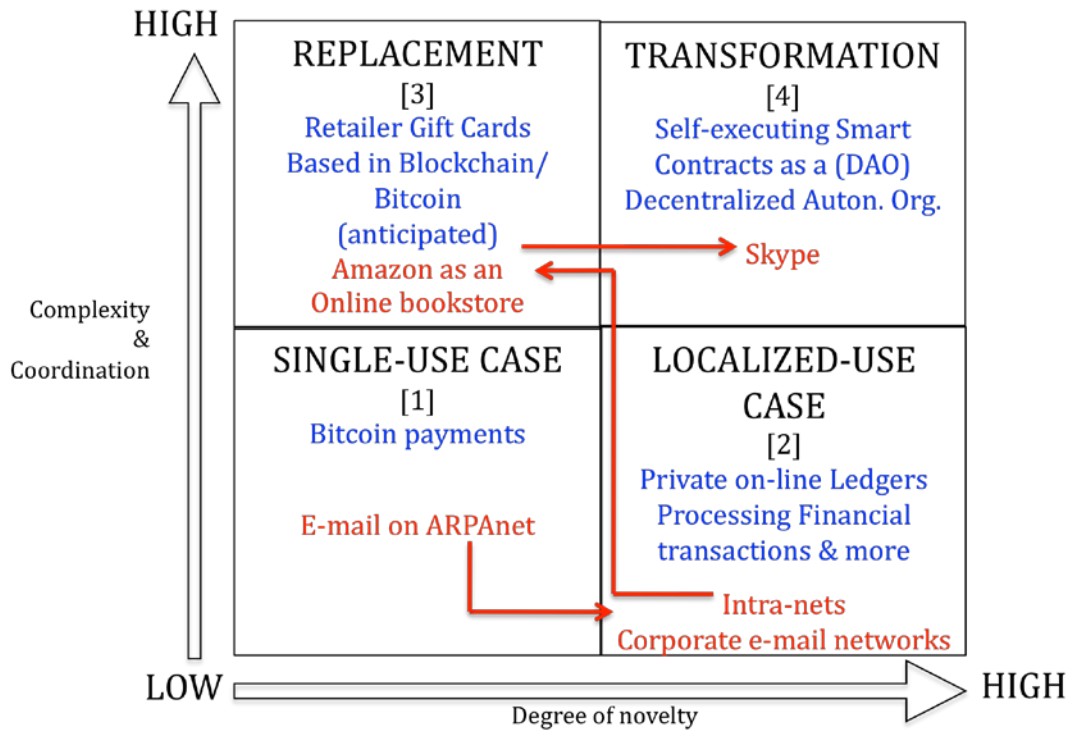
⁴⁹ InfoSec Institute, *Gift Card Fraud: A Profitable Business*, as posed in, HACKING, PHISHING (December 24, 2015) available in: <http://resources.infosecinstitute.com/gift-card-frauds-a-profitable-business/#gref> (indicating that the National Retailers Federation estimates gift card fraud at \$11 billion per year).

⁵⁰ Guillaume Lebleu, *Building Gift Cards 2.0 on the Block chain*, MEDIUM (June 15, 2015) available at: <https://medium.com/@giyom/building-gift-cards-2-0-on-the-block-chain-3ae9e7cf4152#.3vd6yh3cd> (calculating card processing fees for a \$25.00 gift card with Bitcoin at \$0.97 whereas the same transaction would normally charge fees at \$1.50 at an exchange rate of \$250 = 1 BTC).

⁵¹ 62% of gift card losses are believed to be employee-related. Robin Sidel, *Gift Cards Feel Pinch of New Rules*, WSJ (March 7, 2016) available at: <http://www.wsj.com/articles/gift-cards-feel-pinch-of-new-rules-1457393943>

⁵² FDC has targeted the gift card market as growth area. 25% of consumers purchase more plastic gift cards, and 41% purchased more virtual gift cards than the year before. First Data Corporation, *New Insights. New Opportunities to Seize: The 2015 Prepaid Consumer Insights Study*, available at: https://www.firstdata.com/en_us/all-features/prepaid-infographic.html

Figure 7: Transformation



TCP/IP. The classic example of an unforeseen internet-based communication development is Skype. Founded in 2003,⁵³ Skype is an application that provides video chat and voice call services where users may exchange digital documents (images, text, and video). Three are over 700 million users of Skype with over 300 million active each month (as of August 2013).⁵⁴ In September 2005 eBay acquired Skype for \$2.6 billion.⁵⁵ It is highly unlikely that anyone associated with ARPAnet saw Skype coming.

Measuring from the birth of TCP/IP in 1972 to the appearance of Skype in 2003, the full development of TCP/IP as a *foundational technology* took 31 years. If Blockchain, as a *foundational technology*, takes as long to reach its transformational phase the year will be 2039.

Blockchain. The furthest over the blockchain horizon that anyone has seen so far points to the potential development of *decentralized autonomous organizations* (DAOs). If this occurs, then blockchain as a *foundational technology* would truly be transformative. The argument that DAOs will develop out of blockchain is as follows:

⁵³ Founders: Niklas Zennström (Sweden) and Janus Friis (Denmark) with software development by Ahti Heinla, Priit Kasesalu, and Jaan Tallinn (Estonia).

⁵⁴ STATISTA: THE STATISTICAL PORTAL, available at: <https://www.statista.com/statistics/272014/global-social-networks-ranked-by-number-of-users/>

⁵⁵ Bharat Rao, Bojan Angelov & Oded Nov, *Fusion of Disruptive Technologies: Lessons from the Skype Case* 24 EUROPEAN MANAGEMENT JOURNAL 174 (2006).

- *smart contracts*⁵⁶ are the most visibly transformative aspect of blockchain at the moment,
- corporations are not much more than a bundle of contracts,⁵⁷ therefore
- business theory suggests that the corporation could be/will be rendered fully digital (re-constituted as a bundle of smart contracts) by the transformative power of the blockchain.

Aaron Wright and Primavera De Filippi, two of the leading thinkers on DAOs, have a very optimistic view of these structures.⁵⁸ We have numerous examples of DAOs. Bitcoin itself is the first DAO, all others are built on the Ethereum platform.

Unfortunately for Wright and De Filippi's optimistic forecast, the largest of the Ethereum AOs (called *The DAO*) was hacked.⁵⁹ *The DAO* was crowdfunded (the largest in history), raising over \$150 million in 28 days for the German start-up Slock.It (a company that builds smart locks so people can share cars, boats, apartments). Within 20 days after completion of the funding an attacker drained 3.6 million of Ether (the digital currency used on the Ethereum platform) worth \$55 million into a "child DAO."

⁵⁶ A smart contract is a computer protocol that facilitates, verifies, or enforces the negotiation or performance of a contract, or that makes a contract unnecessary. The term is used to identify a specific technology – a code that is stored, verified, and executed on a blockchain. Josh Stark, *Making Sense of Blockchain Smart Contracts* COINDESK (June 4, 2016) available at: <http://www.coindesk.com/making-sense-smart-contracts/> For example IBM and Samsung built a demonstration model of an internet enabled washing machine that automatically ordered a product by executing a smart contract when the machine ran out of detergent. *Adept Demo By IBM/Samsung*, YOUTUBE (January 13, 2015). <https://www.youtube.com/watch?v=un0vmoQmlqU>

⁵⁷ Michael C. Jensen & William H. Meckling, *Theory Of The Firm: Managerial Behavior, Agency Cost And Ownership Structure*, 3 JOURNAL OF FINANCIAL ECONOMICS 305 (1976) (the leading formulation of the corporation [the firm] as a collection of consensual relationships [contracts] among shareholders, creditors, managers, and others); Frank H. Easterbrook & Daniel R. Fischel, *THE ECONOMIC STRUCTURE OF CORPORATE LAW* (1991) (continuing this argument comprehensively throughout corporate law as a whole).

⁵⁸ Aaron Wright & Primavera De Filippi, *Decentralized Blockchain Technology and the Rise of Lex Cryptographia*, available at: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=2580664 (emphasis in original)

... the blockchain has the possibility to fundamentally change the way people organize their affairs. The technology can be used to create new software-based organizations referred to as *decentralized organizations (DO's)* and *decentralized autonomous organizations (DAOs)*. These organizations can re-implement certain aspects of traditional corporate governance using software, enabling parties to obtain the benefits of formal corporate structures while at the same time maintaining the flexibility and scale of informal online groups. The organizations can be operated autonomously, without any human involvement. They can own, exchange, or trade resources and interact with other humans or machines, raising novel questions around traditional notions of legal personality, individual agency, and responsibility.

⁵⁹ David Siegel, *Understanding the DAO Attack*, COINDESK (June 25, 2016) available at: <http://www.coindesk.com/understanding-dao-hack-journalists/> (further indicating that *The DAO* was designed to fund projects that would be voted on by the members, and at the time of the hack there were 50 projects waiting to be voted on by 11,000 members).

Technically the hacker could not access the Ether for 28 additional days. The price of Ether immediately dropped by 38%.⁶⁰

The lesson to be learned from *The DAO* hack may be that in the world of *smart contracts* what happened on the Ethereum platform may not have been a theft at all.⁶¹ The hacker did not tamper with *The DAO's* code; the hacker just used it in an unexpected manner. The legal description on *The DAO's* web site clearly states that the code controls the outcome.⁶² What the marketers of the DAO intended, and what any particular investor intended is irrelevant, as long as the code is followed everything is OK. In other words, Larry Lessig's most famous slogan applies: "Code is Law."⁶³

What this means for the development of the blockchain as a *foundational technology* is – there remains a lot of work to do before we can safely call blockchain *transformational*. The HACKER NEWS records a similar comment:

I always wondered why there was such a rush to launch *The DAO*. As opposed to what Ethereum itself did: develop a proof of concept for over a year, then release a beta version and provide bounties for security bugs, all the while collaborating with testers and security researchers to stress the software.⁶⁴

PAYROLL ON THE BLOCKCHAIN

Why are there no major payroll applications on the blockchain? Payroll is fully digitized. Payroll interacts with multiple regulatory agencies each of which collects duplicate data, holds it centrally, and performs overlapping compliance audits. On top of this, AML and KYC regulations apply to each transaction. This is the classic efficiency environment for a distributed ledger.

⁶⁰ Paul Vigna, *Digital Money Fund Hacked*, WSJ (June 18, 2016) (suggesting that anyone with a short position on Ether (maybe the hacker) would have been able to make a great deal of money without accessing the hacked funds).

⁶¹ Matt Levine, *Blockchain Company's Smart Contracts Were Dumb*, BloombergView (June 17, 2016) available at: <https://www.bloomberg.com/view/articles/2016-06-17/blockchain-company-s-smart-contracts-were-dumb>

⁶² Swarm, *DAO'S, Hacks, and the Law* (June 17, 2016) available at: <https://medium.com/@Swarm/daos-hacks-and-the-law-eb6a33808e3e#.s6nho34s7>

The terms of The DAO Creation are set forth in the smart contract code existing on the Ethereum blockchain at 0xbb9bc244d798123fde783fcc1c72d3bb8c189413. Nothing in this explanation of terms or in any other document or communication may modify or add any additional obligations or guarantees beyond those set forth in The DAO's code. Any and all explanatory terms or descriptions are merely offered for educational purposes and do not supersede or modify the express terms of The DAO's code set forth on the blockchain; to the extent you believe there to be any conflict or discrepancy between the descriptions offered here and the functionality of The DAO's code at 0xbb9bc244d798123fde783fcc1c72d3bb8c189413, **The DAO's code controls and sets forth all terms of The DAO Creation.**

⁶³ Lawrence Lessig, *CODE AND OTHER LAWS OF CYBERSPACE* (1999); Lawrence Lessig, *Cyberspace and Privacy: A New Legal Paradigm?* 52 *Stanford Law Review* 987 (2000)

⁶⁴ Infodroid 214 days ago, HACKER NEWS, available at: <https://news.ycombinator.com/item?id=11922271>

One would expect to see a large number of start-ups and traditional service providers applying blockchain solutions to payroll, but presently, there are very few. There seems to be a vacuum. Two reasons for the vacuum come to mind: there are (1) significant barriers to entry, which are compounded by (2) the lack of a fiat cryptocurrency to make international payroll transactions proceed smoothly without significant foreign exchange risks. The first issue keeps potential entrants away; the second encourages those willing to enter the market to wait. In short:

- the barriers to entry keep technology start-ups from entering the field, while they simultaneously provide a (false) sense of security to the current payroll service providers who (may) feel they are immune to this technology. Some of the specific barrier-raising issues are:
 - the payroll service field is dominated by a small number of very large institutional providers, and their presence raises a very high competitive bar for the technology start-ups who might enter the field;⁶⁵
 - to perform well in the payroll services field requires a deep technical tax knowledge base that controls complex withholding calculations based on government regulations that are constantly in flux, which makes it necessary to continually re-program to get the calculations right;
 - the regulatory agencies (notably those in the US) that oversee this area have enacted serious (high risk and high penalty) financial service regulations (largely as a reaction to use of anonymous crypto-currencies by criminals);⁶⁶ and

⁶⁵ Jill Bowers, *The Best Online Payroll Services of 2017*, TOP TEN REVIEWS, (December 6, 2016) available at: <http://www.toptenreviews.com/business/accounting/best-online-payroll-services/> (indicating that four companies dominated the field, “During our research and testing, the top performers quickly emerged. [They were] Intuit ... ADP ... IOIPay ... and Paychex ...”)

⁶⁶ There are proposals for more technology-cooperative financial regulations. There is a “law-lag” in getting an effective regulatory structure in place that melds well with the technology. See: Carla L. Reyes, *Moving Beyond Bitcoin to an Endogenous Theory of Decentralized Ledger Technology Regulation: An Initial Proposal*, 61 VILLANOVA LAW REVIEW 191 (2016).

Under the weight of various historical indicators and in the wake of significant recent events, regulators adopted an increasingly aggressive approach to enforcing existing regulations against the drastically new, different, and emerging technology. The resulting barriers to entry and climate of legal stigma are stifling the nascent decentralized technology industry and preventing further innovation. In response, the decentralized virtual currency industry and other businesses interested in exploring the potential uses of decentralized technologies in commerce call for self-regulation. Current literature, for its part, suggest a variety of regulatory models with each approach varying in light of the characteristics of the underlying technology that the commentator suggesting the model considers to threaten the most potential harm.

History intimates that the self-regulatory approach is unlikely to sufficiently resolve the market failures that will ultimately allow illicit and fraudulent uses of decentralized technology to occur. Meanwhile, the regulatory approaches suggested in the literature each impose a new regulatory barrier to entry even while trying to alleviate the inefficiencies of the current landscape. This article suggests a different approach, one designed to encourage organic regulation that both addresses the potential market and governance failures and takes into account the unique nature of the technology at issue.

This Article lays the foundation for adopting an endogenous theory of decentralized technology regulation. Drawing on theories of endogenous economic regulation, endogenous development, and functional financial regulation, this article

- the large number of government agencies that would necessarily be involved in a comprehensive blockchain of the payroll space presents an extreme level of coordination complexity domestically, which is compounded many times over when international payroll is considered.
- the lack of a fiat crypto-currency (hopefully a temporary situation):
 - encourages anyone who is planning on developing a technology-intensive global payroll services solution on the blockchain to “wait and see” what develops before making sizeable resource commitments to a project like this, especially when there are other applications that are not so risky promising a steady return on investment (low hanging fruit) .

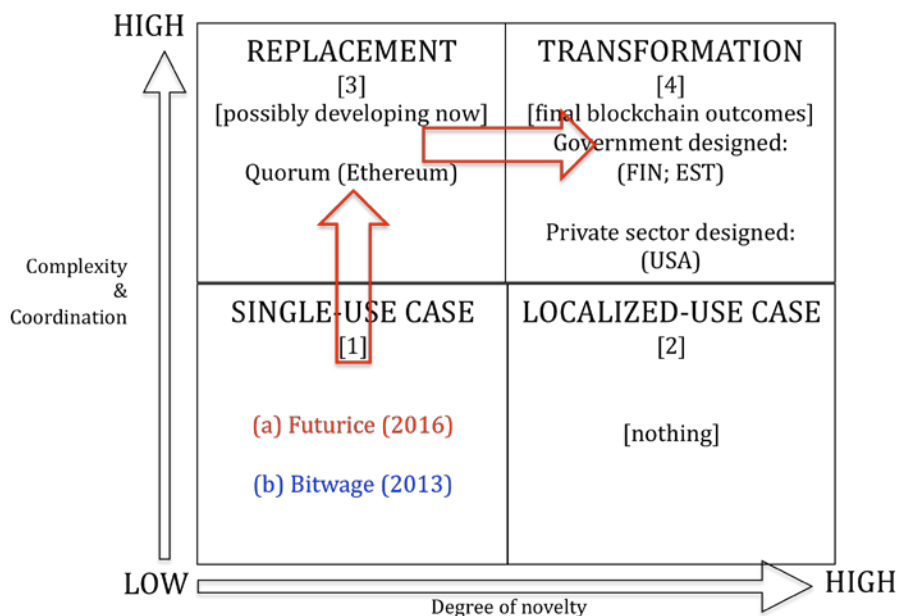
Currently, the payroll space has (only) two *single-use case* blockchain applications – one in Finland (Futurice), and the other in the US (Bitwage). There are no *localized-use cases*, and no *replacement* or *transformative* applications, although it is easy to imagine how a blockchain application could *replace* much of what a payroll service provider supplies today (once a workable blockchain is constructed).

Blockchain, as a *foundational technology*, has simply not developed sufficiently so that it can easily allow *replacement*-type applications to flourish in any space, much less in the technically complex and demanding, government/enterprise coordination-dependent payroll space.

It seems likely however, that the private sector will develop replacement solutions in the near term. This will likely lead to transformational changes. Those changes may involve either government-constructed blockchains which payroll service providers will be asked to populate (Finland and Estonia are likely to develop this way), or it may involve comprehensive private sector blockchains that government agencies will participate in as regulators, but not as owners/designers of the blockchain itself (the US may develop this way). See figure 8 below.

proposes that decentralized technologies, including blockchain technology underlying decentralized payment systems such as bitcoin are robust enough to support a theory of endogenous, technology-assisted regulation. Specifically, when this article proposes an endogenous theory of regulation, it suggests that regulators undertake the dual task of enacting a law or regulation via statute and then implementing that statute through code by engaging in an iterative and cooperative process with the technologies’ core developers and with consensus from the network, so that regulation is endogenously incorporated into the decentralized ledger technology and the applications running on top of the technology.

Figure 8: Payroll on the Blockchain



The nature of payroll compliance involves highly complex calculations. It requires considerable co-ordination among multiple government agencies (federal, state, local and international), as well as the employee and the employer. Payroll compliance is not free-form and flexible; it is controlled largely by government filing requirements. It does not seem likely to be receptive to the high degree of novelty inherent in most *localized-use* cases. A notable exception would be if one of the major payroll service providers decided to engage in an internal experiment and pay its own employees (domestic and international) through an application on the blockchain. There is no indication that this is happening, and as a result, payroll on the blockchain seems likely to develop in a differently than expected. It will appear as an unexpected surprise.

Payroll on the blockchain may be poised to jump directly from stage [1] to stage [3]. It will closely follow blockchain developments in other fields (notably financial services), and use this to overcome barriers in the payroll space. After this, and with the cooperation of the government agencies involved, the final *transformational* stage will likely develop directly from the *replacement* models. (The red arrows in Figure 8 above represent the proposed development pathway.)

Based on the development time line of the TCP/IP as a *foundational technology*, we can project that blockchain's development trajectory is perhaps five years away from producing *replacement* applications in payroll services (2018-2021).⁶⁷ The payroll

⁶⁷ *Foundational technology* development (the information era) in time frames of 13, 10, and 9 years:
 (1972) - TCP/IP
 (1985) – Intra-nets in Silicon Valley [+13 years]

solution is likely to borrow from applications (*localized-use cases*) currently being developed in finance. International payroll applications will likely be structured to blend with blockchain-based payment solutions, notably those that are adopting a cryptographic US dollar. This structure will likely use *smart contracts* on the Ethereum blockchain tied to a trusted price feed and a derivative contract.⁶⁸

A PAYROLL SERVICE PROVIDER'S BLOCKCHAIN SOLUTION: IN DEVELOPMENT

Each of the following elements of a payroll service provider's blockchain solution are visibly under development today:

- Employees are recording bonus hours on the Ethereum blockchain at Futurice, and are receiving compensation for those hours in the normal course of business;
- Employers are paying their global workforces with bitcoins that can be kept in bitcoin or automatically converted to local fiat currency in 60 countries around the globe with Bitwage utilizing smart contracts that blend the original bitcoin blockchain, and the Ethereum platform;
- J.P. Morgan Chase is developing Quorum, a private/permissioned blockchain based on the official Go implementation of the Ethereum protocol to coordinate payments among financial institutions that is fully visible to regulators, and fully private to participants.

These three critical elements need to be supplemented with several other advances in the payroll field before a payroll service provider can offer comprehensive payroll services through the blockchain. Missing elements include:

- Well designed smart contracts placed on the blockchain that will automatically determine the correct tax withholdings and employer contributions per employee gross wage amount; and
- Agreements with government agencies to:
 - participate in a payroll blockchain as regulators; as well as
 - acceptance of deposits/payments in crypto currencies (an element that may await the establishment of a fiat crypto-currency).

Futurice. Futurice is a Finnish technology company that provides digital services for its customers. It is one of the fastest growing technology companies in Finland.

(1995) – Amazon.com as a book seller [+10 years]

(2004) - Skype [+9 years]

Foundational technology development (value era) in an unfinished time projection with the initial link set at 5 to 8 years. Developments are running twice as fast (taking 50% less time to mature), suggesting that here are fSuggesting that the blockchain replacement phase should be here by 2021, and the

(2008) – Bitcoin released (on Blockchain)

(2013-16) – Thousands of applications from finance through voting [+5-8 years]

(2018-21) –The replacement phase [+5 years, est.]

(2023-26) – The Transformational phase [+5 years, est.]

⁶⁸ Vitalik Buterin, *Ethereum*, 2014 TEXAS BITCOIN CONFERENCE (Austin Texas: March 6-7, 2014) (17.30 – 23.35/47.33, published on January 25, 2015, available at: <https://www.youtube.com/watch?v=cahj4WJtp20>)

Headquartered in Helsinki, its core business is developing online and mobile software. It is the natural place for an experiment with a payroll blockchain application.

Futurice compensates its employees with bonuses when they work on open source and other social impact projects *on their own time*. The bonus program is called the Spice Program.⁶⁹ To pay out the bonuses Futurice has set up a reporting system on the Ethereum blockchain. Futurice indicates that the new reporting system works like this:

1. A Futurice employee accesses an internal web UI with her browser to report an open source contribution. She is authenticated with her company account while doing so.
2. She keys in the relevant information:
 - a. A title of a public URL to identify the contribution
 - b. Time spent in hours and minutes
 - c. A description of the contribution, not stored in the blockchain
3. The entered information, together with an encrypted user identifier, but sans the contribution description, gets stored in the Ethereum blockchain.
4. The same information, now complete with the description, is also sent to a company instant messaging channel.
5. At the end of each month an application is run on the blockchain to calculate and return the bonus for each employee, who has reported contributions.
6. This refined payroll information is forwarded to the people and systems who make our salaries happen.⁷⁰

Futurice allows any employee to browse the collected reports in the Spice Project, but the user identifier is encrypted to allow anyone to decouple their identity from the project they worked on. Because Futurice uses the Ethereum blockchain network, payroll data is scattered around the globe.

Spice is a *single-use case*, but Futurice proposes a development in Spice that could produce a *localized-use case* as follows: "... if we ever wanted to extend this [Spice] Program outside of our company for selected individuals, the open blockchain would provide a ready-made platform we could build on." Futurice is proposing to develop a *localized-use case* for its payroll application in much the same manner as the companies in Silicon Valley – Sun Microsystems, NeXT Computer, Hewlett-Packard, and Silicon Graphics – created *localized-use cases* for early e-mail applications (private e-mail networks).⁷¹

Bitwage. Founded in 2013, Bitwage is a Bitcoin-based payroll and international wage payment service that allows wages to be paid in either bitcoin, or local currency.

⁶⁹ Spice Program at <https://spiceprogram.org>

⁷⁰ Teemu Turunen, Building payroll system in Ethereum blockchain, what did we learn? (January 3, 2017) available at: <http://futurice.com/blog/payroll-system-in-blockchain>

⁷¹ See, *infra* at n. 18-21.

Initially established as a way for freelancers to be paid in Bitcoin, the firm soon found that international businesses with distributed work forces were heavy users of their service for cross-border (international) payroll. Global payroll disbursement is faster, cheaper, and easier with Bitwage.⁷²

Bitwage however, is not a full service payroll provider, like ADP, Intuit, IOIPay, or Paychex. As with Futurice, federal, state, and local income tax withholding calculations are still performed by the employer in the traditional manner. It is only the “net wage” after all withholdings, deductions, or reductions that Bitwage handles.

An employee wishing to be paid in Bitcoin (rather than fiat currency) would simply present a direct deposit slip to his employer’s payroll office. When payday came around some portion (up to 100%) of the employee’s net pay would be deposited in a Bitwage account. Bitwage then converts the wage to Bitcoin and re-deposits it in the employee’s digital wallet.⁷³

Quorum. J.P. Morgan Chase’s private/permissioned blockchain based on the Ethereum protocol is clearly a most interesting development.⁷⁴ Although not directly referencing a payroll application, it is clear that Quorum could easily form the backbone of a payroll service industry move into the blockchain.

Quorum employs smart contracts on a replicated, shared ledger to improve efficiency and reduce costs, but does so in a manner that provides data privacy. This privacy attribute of Quorum is one of its most attractive attributes to payroll service providers. The security and confidentiality of the payroll disbursement is critical.

Much of the logic responsible for the additional privacy functionality resides in a layer that sits atop the standard Ethereum protocol layer. ...

⁷² Jonathan Chester, the founder of Bitwage indicated that:

What happened was that some of its first clients would opt to either pay entire payrolls or receive their entire payrolls in bitcoin, then figure out on their own how to convert bitcoin back into their local currency, as a way to bypass some of the points of friction involved in cross-border wage payments.

PYMNTS.COM, *Where the Distributed Workforce Meets the Distributed Ledger*, (March 29, 2016) available at: <http://www.pymnts.com/news/b2b-payments/2016/where-the-distributed-workforce-meets-the-distributed-ledger/>

⁷³ Bitwage is similar to BitPay (a different company with a similar sounding name) founded in 2011. BitPay is a bitcoin payment processor will also remit to employees a portion of their net pay in Bitcoins.

BitPay developed the bitcoin payroll API for its own use at the request of its employees, and has been using it with their payroll provider for over six months. BitPay is pleased to announce that they have 100% participation from their employees, meaning every BitPay employee receives some of their net pay in bitcoin. Four BitPay employees, including Gallippi, receive 100% of their net pay in bitcoin.

“This also clarifies the tax question around bitcoin,” added Bryan Krohn, BitPay’s CFO. “Since all payroll and withholding taxes are taken out first from the employee’s gross income, bitcoins can be sent from the net pay tax-free, and the employer’s gross income reporting to the IRS remains unchanged.”

Get Paid in BitCoin: BitPay Announces Payroll API, ONBITCOIN (January 31, 2014) available at: <http://onbitcoin.com/2014/01/13/get-paid-bitcoin-bitpay-announces-payroll-api/>

⁷⁴ J.P. Morgan, WHAT IS QUORUM, available at: <https://www.jpmorgan.com/country/US/EN/Quorum>

Quorum uses cryptography to prevent all except those party to the transaction from seeing sensitive data. ... [There is] a single shared blockchain and a combination of smart contract software architecture and modifications to Ethereum. Smart contract architecture provides segmentation of private data. Modifications to the go-ethereum codebase include modifications to the block proposal and validation process. The block validation process is modified such that all nodes validate public transactions and any private transactions they are party to by executing the contract code associated with the transaction. For other “private transactions,” a node will simply skip the contract code execution process.⁷⁵

An example is helpful. The diagram of the Quorum network at figure 2 in the *Quorum White Paper* can be modified to demonstrate Quorum’s payroll application.

Assume a full service payroll provider has a corporate client with 100 employees, each of whom receive a weekly paycheck that is direct deposited in one of 10 different local financial institutions. Further assume that withholdings are made from each employee’s gross wages for federal, state, and local income taxes, as well as for FICA,⁷⁶ SUTA, and FUTA,⁷⁷ based on gross wages. Funds are paid from both employer and employee accounts for FICA, SUTA and FUTA. Assume further that this company offers a 401(k) with employee and employer contributions, and an employer sponsored pension plan.

All wage deductions and employer contributions are indexed to the gross wage. Smart contracts⁷⁸ can be constructed in each instance directing payments to the Federal or State Treasury, and various savings or retirement plans with the residual (net) wage deposited in the employee’s designated bank account.

The payroll service provider would need to secure the cooperation and participation of each of the banks, investment firms, and government agencies involved in this system. Participation would not be passive. Included in the allocated responsibilities would be a requirement that some “nodes” within the network (banks, financial institutions, and government agencies) would be allocated the

⁷⁵ *Quorum White Paper* (November 22, 2016) available at: <https://github.com/jpmorganchase/quorum-docs/blob/master/Quorum%20Whitepaper%20v0.1.pdf>

⁷⁶ FICA is the acronym for Federal Insurance Contributions Act. It refers to be combination of the Social Security Tax and the Medicare Tax. Both taxes are levied at a flat rate. The Social Security Tax is 6.2% of wages, and the Medicare Tax is 1.45% of wages. Individuals earning more than \$200,000 are charged an additional 0.9% Medicare surtax. Employers match the Social Security Tax of 6.2%, and the Medicare Tax of 1.45%. Social Security Tax is subject to a cap (adjusted each year for inflation). There is no wage cap on the Medicare Tax

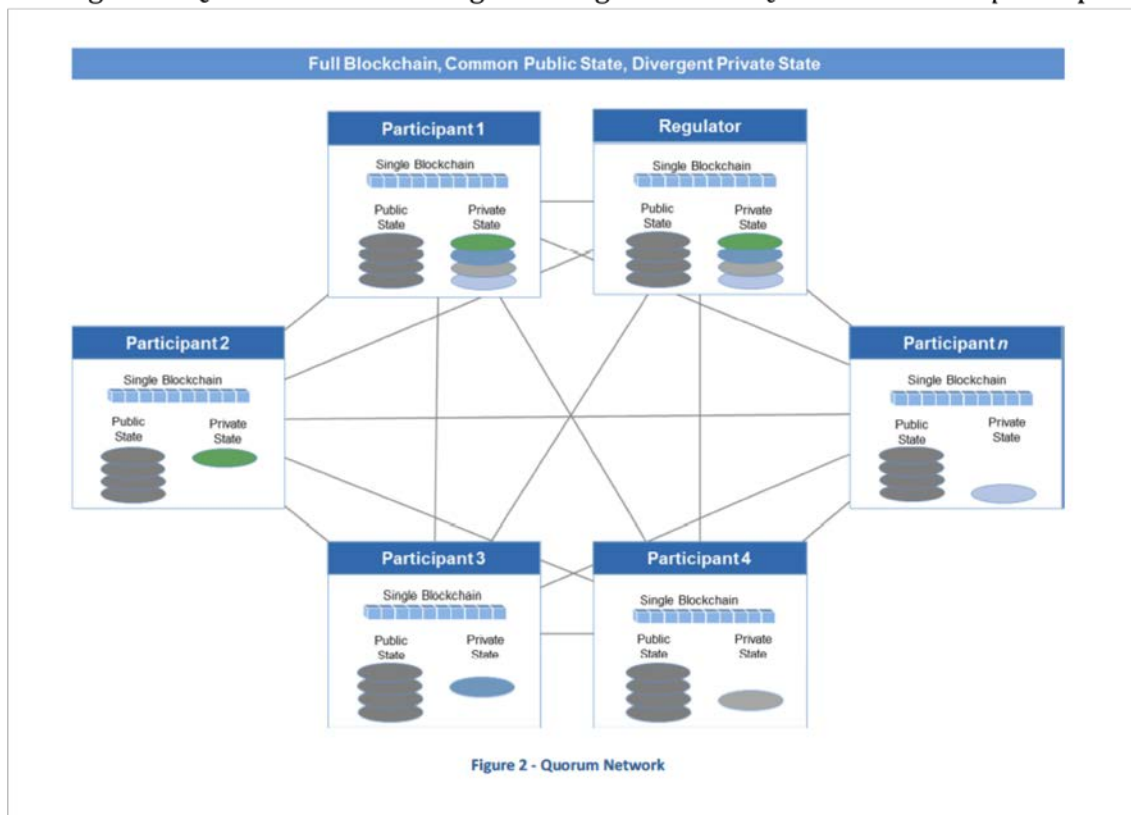
⁷⁷ SUTA and FUTA are the acronyms for State Unemployment Tax and Federal Unemployment Tax. The FUTA rate is 6.2%, subject to a credit of 5.4% for the SUTA taxes paid. FUTA is paid by employers on wages paid to employees, up to \$7,000 of wags per employee (roughly \$434.00 per employee per year). Each state has a wage base for their SUTA, which is also paid by the employer. The state rate is variable depending (in pat) on the number of unemployment claims made by former employees.

⁷⁸ See *infra*, note 56 for a definition of smart contract.

ability/responsibility to “vote” on the blocks, and others would be allocated “maker” roles. “Makers” create blocks, and “voters” (by majority vote) determine the linking of one block to another in the chain. This is the QuorumChain Consensus mechanism.⁷⁹

In the diagram of the Quorum network at figure 2 in the *Quorum White Paper* the position occupied by Participant 1 would represent the employer. Participants 2, 3, 4 and n would represent the various banks and investment firms in which employees had depository accounts. Instead of one Regulator (as in the *Quorum White Paper*) the payroll example would have three (Federal, State and local Treasuries).

Figure 9: Quorum network diagram – Figure 2 from *Quorum White Paper* at p. 2



⁷⁹ *Quorum White Paper* (November 22, 2016) at 2 indicates:

Quorum uses a majority voting protocol dubbed QuorumChain, where a subset of nodes within the network are given the ability to vote on blocks. The voting role allows a node to vote on which block should be the canonical head at a particular height. The block with the most votes wins and is considered the canonical head of the chain.

Block creation is only allowed by nodes with the maker role. A node with this role can create a block, and in doing so, will sign it such that, on block import, other nodes can verify that a block was signed by one of the nodes that have permission to make blocks.

QuorumChain is implemented in a smart contract – a novel concept for managing consensus, and importantly, the consensus-upgrade process. The smart contract tracks voter and block maker lists, both of which can be maintained through standard transactions, thereby providing further control and clarity over how and by whom the network is managed.

The key to Quorum’s ability to keep some data private and yet allowing each participant in the Quorum network to receive a complete copy of the entire chain of transactions is represented by the set of small blocks designated “single blockchain” within each participant’s box.

The single blockchain in the diagram represents the fact that each participant on the given Quorum network has the same copy of the chain of transactions (even if a given participant is not party to every transaction)... For those transactions that should be private to a subset of participants, *privacy is achieved by replacing the original details of such transactions with a hash of the encrypted original transaction data/payload.* This simultaneously ensures that the each participant can receive these transactions (thereby giving rise to the single chain of transactions) and the relevant sensitive data is in fact kept private.⁸⁰

In the Quorum diagram both the Regulator and Participant 1 have full access to each transaction in the system, just as in the payroll example both the Employer and every relevant tax authority will have complete access to all of the payroll data. Each of the other Participants in the Quorum diagram has limited access to the “Private State” data (these are transactions that they are parties to), while they have full access to “Public State” data. The same would be true of each bank and investment firm in a comparable payroll diagram. The payroll case is simply more complicated. The coordination is more complex than the basic Quorum diagram. However, the technical problems are not more difficult.

This is not the end of the complexity in the payroll blockchain hypothetical, because in this case we are only looking at one employer, 100 employees, and 10 financial institutions. Consider that a company like ADP serviced 620,000 businesses in 125 countries in 2014 processing paychecks for millions of employees.⁸¹ If ADP adopted a blockchain payroll compliance model, Quorum could handle it, but the complexity of the platform would be enormous.

If building the payroll blockchain was a project undertaken by the Independent Payroll Providers Association (IPPA), which has over 240 payroll bureau members,⁸² or the National Association of Professional Employer Organization (NAPEO), which as the “voice of the PEO industry” represents just under 1,000 small and medium sized businesses in the US with around 30,000 employees,⁸³ the complexity would multiply yet again.

This is the way we are going. The blockchain is coming to payroll.

⁸⁰ Tyrone Lobban at Quorum Info (tyrone.lobban@jpmorgan.com) personal communication January 19, 2017 (responding to a series of questions about Quorum). *Emphasis added.*

⁸¹ ADP – Who we are, available at: <https://www.adp.com/who-we-are/history.aspx>

⁸² <https://www.ippa.net>

⁸³ <http://www.napeo.org/what-is-a-peo/about-the-peo-industry/industry-statistics>

CONCLUSION

It seems reasonably clear that payroll compliance will be an application on the blockchain somewhere between 2018-2021 as blockchain develops as a *foundational technology*. This is the trajectory. Developments led by J.P. Morgan Chase with Quorum, a replicated shared ledger built on the official Go implementation of the Ethereum protocol, makes this more likely than was the case several years ago.

Huge cost reducing efficiencies (not covered in this article) will overtake traditional payroll service providers as this application is developed. The question will be whether or not one or more of the traditional payroll service providers, an industry group like IPPA, or the government will provide the blockchain that hosts this application. Financial transactions have a natural affinity for blockchain. The banking industry is moving very strongly in this direction, and a partnership between J.P. Morgan Chase and a major payroll service provider is almost a foregone conclusion.

Peter Nichol, Principal, PA Consulting Group as has Simon Peffers, Senior Software Architect, INTEL have some good advice. Both responded to a question from MIT Sloan Professor Christian Catalini –

CATALINI: Where do you think there is too much hype right now – the press and even people in the field right now are talking about things that will really take a long time to deploy?

NICHOL: A lot of it is challenges right now. What is it going to take to get blockchain up and running? And probably one the biggest [challenges] one is not technical, is organizational alignment – how are companies really going to figure out how to really use [blockchain]? And probably a fast second is education. How are you going to bring the level of knowledge up across the organization to realize that there really is a benefit here?

And we talked a little bit about this earlier with the legal risk, but most CFOs, Controllers, and General Counsel are comfortable with the level of contracts they have in place, how they run, and why they are written in a certain way, *and they are not self-executing smart contracts*. So I think this is going to be a challenge [moving contracts over to smart contracts] ...

SIMON: I would draw out a couple more [challenges] ... there's a lot of hype around, "Let's think about *all* the places where we could possibly apply blockchain." I think this needs to be a little bit more toned down to, "Where *should we apply it*, where's the really common place to add value where today's technology doesn't [add value]?" There may be some places that simply need to upgrade to today's technology. ... The other piece is that there are a lot of legacy systems that will have to be migrated

to adopt blockchain ... and that's just going to take time, money and motivation⁸⁴

How does a payroll provider apply these observations? It probably needs to do what countless start-ups and transitioning business have done. Futurice in Finland is a good example. It needs an internal pilot payroll blockchain project.

A subset of employees (maybe volunteers) need to step forward and allow their payroll to be placed on a private blockchain, perhaps in cooperation with J.P. Morgan Chase. It would be good to try to draft the smart contracts for payroll deductions, it would be good to work with the immutable, permanent record of the blockchain and it would be good to approach the government agencies and see if a workable payroll model on the blockchain could be developed.

It would not be hard to find companies who would want to move their payroll to the blockchain. Admittedly they will probably be smaller technology companies (like Futurice) that simply like to be on the cutting edge of technology.

⁸⁴ Christian Catalini (moderator) with Anders Brownworth, Peter Nichol, Simon Peffers & Matthew Utterback, *How Blockchain Will Transform the Digital Economy* (July 23, 2016) 39:49 – 41:58/1:02:03, available at <http://blockchain.mit.edu> (emphasis added)