A TALE OF TWIN TECH: BITCOIN AND THE WWW

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ABSTRACT

Bitcoin is widely represented in the popular press, but far less so in serious academic inquiry. Researchers have analyzed Bitcoin from various discipline-specific perspectives using their own sets of theories and jargon. Yet cross-disciplinary research has been muddled by the inaccurate interpretation of terminology across fields of research. This results in polarized assessments. In an effort to examine the Bitcoin phenomenon in a more holistic and multidisciplinary manner, this paper compares Bitcoin with another innovative technology – the World Wide Web – as first envisioned by Tim Berners-Lee. By exploring the early development of the World Wide Web, we seek to compare and contrast its development with that of Bitcoin and blockchain technology. The goal of this study is to show similarities and differences in their historic development, in order to identify key success factors related to the adoption of these technologies. Through identification of these factors we seek to guide both academics and practitioners towards fruitful avenues of research and development.

Key Words: Bitcoin, blockchain, World Wide Web, WWW, internet, technology, technology acceptance

1. INTRODUCTION

Bitcoin is a new technology, with a novel combination of features and attributes, and yet technological developments of similar magnitude and potential have happened with a certain regularity. It may thus prove beneficial to analyze the phenomenon of Bitcoin in the context of previous developments of a similar qualitative nature. The particular historical development that we feel shares many of the characteristics of Bitcoin is that of the World Wide Web, developed and pioneered by Tim Berners-Lee back in the early 1990s. We are not the first researchers to observe these similarities. Dr. Jerry Brito, formerly of the Mercatus Center at George Mason University in his testimony before the New Jersey Assembly's Financial Institutions and Insurance Committee made this analogy (Brito, 2015). In this paper we will explore the historical parallels in much greater detail in order to determine how these parallels may aid us in understanding the Bitcoin phenomena.

2. WORLD WIDE WEB FORMATION

In March 1989, Berners-Lee submitted the first official proposal to develop the World Wide Web (at the time simply referred to as "Mesh"), to his bosses at CERN - The European Organization for Nuclear Research - where he was a contractor working on documentation systems (Berners-Lee, 1989). His goal was conceptually simple: create a platform independent, hypertext based system that would enable all the world's scientific articles to be linked to one another (Berners-Lee, 1998). He desired a system in which repetitive questions could be replaced with a FAQ (or Frequently Asked Questions) page so as to avoid redundancy and increase efficiency in the distribution of information (Berners-Lee, 2015). Yet the World Wide Web (hereafter WWW) was not entirely new. Rather, like most successful technological developments, Berners-Lee's creation, to paraphrase Newton, "rested on the shoulders of giants".

The key technologies underlying the proposed WWW, the Internet and its TCP/IP protocols, and the idea of hypertext, were by that time decades old. The Internet protocols were developed by Vinton Cerf, Robert Kahn, and others in 1970s (Cerf & Kahn, 1974), and have been used for information exchange over higher-level protocols (such as FTP, news, email) for many years. The idea of hypertext, that of having links from within text to other documents, is even older, with the basic idea in computer context described by Nelson (1965), and presaged even earlier by Bush (1945) in the context of microfilm, and used in many software document organization systems since. The actual network that carried Berners-Lee's WWW creation had been originally developed as a project by the US Defense Department in the 1960s (Hafner, 1998).

The key innovation of the WWW was to develop protocols to allow for easy hypertext linking between disparate systems over arbitrary distances, relying on the Internet as a transport mechanism. Though there were several hypertext systems in existence, Berners-Lee was unsuccessful in convincing any of them to add Internet functionality. Instead, similar to old-fashioned CD-ROM based encyclopedias, these "walled garden" hypertext systems existed solely within their own environment. Unlike Berners-Lee, these hypertext system creators lacked the vision to understand the potential for creating value if hyperlinks could be made to data housed anywhere in the world (Berners-Lee, 1996). Through a process of “technological grafting” (Lennon, 2008), Berners-Lee was able to integrate his new hypertext protocols onto the existing Internet hardware and software technologies and incorporate their functionality to create a novel and extraordinarily valuable method of sharing information in the form of web pages.

The protocols and specifications that enabled these web pages – HTTP (HyperText Transfer Protocol), HTML (HyperText Markup Language), and the URI (Uniform Resource Identifier) – were developed by Berners-Lee in the space of several months in 1990 on the NeXT platform. This code for the browser and the server became the de-facto implementation standard. HTTP specified a protocol for orderly request/response data interchange over the Internet; HTML was a simplified version of the existing SGML (Standard Generalized Markup Language) specification (ISO, 1986), which allowed for an easy, portable way to define document structure; and the URI specification defined how a pointer to external resources is to be interpreted and followed (Berners-Lee, Cailliau, Groff, & Pollermann, 1992).

While these various software terms and acronyms may seem arcane, these components are in fact all relatively straightforward, with minimal complexity. For instance, basic HTML (hypertext markup language) is quite easy to learn, and can be written with a plain text editor. Any computer user can readily make a basic web page. While separately they may be conceptually simple, together these technologies form a sophisticated system of great value.

Combined, all of these components allow for a portable, "universal" way to link disparate systems together. Where other systems for information organization failed to take off in a meaningful way, the WWW succeeded, for a number of reasons. In addition to its simplicity, it has a deliberately decentralized nature. Nobody needs to ask permission to create a webpage and link to other websites. There is no central database or authority which needed to be updated or maintained. It was a lack of such a central database that gave rise to Internet search engines like Google (Brin & Page, 1998). Yet another reason was its ability to link multiple sources of information across the world with the help of the Internet, and its embrace of previously existing protocols as part of the URI specification.

2.1. OPEN SOURCE KEY TO DISRUPTION

Another important move by Berners-Lee was the deliberate choice of open licensing – the protocols and the software implementation thereof was released by CERN into the public domain, at his request (Berners-Lee, 2015). A competing protocol for information linking and organization, "Gopher", which was developed by the University of Minnesota (Anklesaria et al., 1993), was also a product of the late 1980s, and by early 1990s when the WWW was in its nascent stages, was relatively more established and widespread. One major reason why Gopher was largely abandoned in favor of the WWW was the decision in early 1993 by the University of Minnesota to charge licensing fees for the use of its implementation of the gopher server. This led to broad concerns that the University might go after independent implementations as well, which in turn pushed people to look for alternative technologies (Ward, 2006).

Learning from this experience, Berners-Lee petitioned for and received a declaration from CERN, allowing anyone to use the Web software and protocols without any constraints. This caused the WWW to act as a “disruptive technology” (Bower & Christensen, 1995) and enabled it to unseat Gopher as the predominant technology. In 2000, the University of Minnesota backpedaled and released its gopher software under the permissive share-alike GNU General Public License (GPL), but by that time, Gopher had turned into merely a footnote in the annals of Internet history (Frana, 2004).

Despite its ascendency over its rival gopher, like other new technologies and products, the WWW initially had a classic slow start. As a new product with a limited number of users and benefits, it had issues related to network externalities (Liebowitz & Margolis, 1994) and the technology acceptance model (Venkatesh & Davis, 2000). The value of the WWW to a potential new user depended on the amount of information accessible via the medium, and how easy it was to access it. At the same time the usefulness of making information available via the Web and making it easy to use depended on the number of users one could reach on the WWW.

An additional bottleneck was the fact that the initial implementation by Berners-Lee was on the NeXTStep system, a computer platform that was relatively less widespread than the PC, Mac, and Unix systems at that time. Through continuous efforts of Berners-Lee and his team to promote the WWW technology, port the software to other systems, and, very importantly, through tapping the broader Internet community to help with the project, via alt.hypertext and other newsgroups, adoption of the WWW technology gradually snowballed (Ward, 2006).

2.2. ESTABLISHMENT OF WWW STANDARDS BODY

Several key events occurred which promoted the proliferation of the WWW. First, a number of third-party web browsers for various platforms were created, among them NCSA Mosaic (Andreessen, 1993), the precursor to the (in)famous Netscape, which later became one of the first dot-com era IPOs (Kelly, 2005). Since different browsers could support different components of the Web protocols, and thus could potentially cause fragmentation of the WWW ecosystem, in 1994 Berners-Lee started an independent standards body to maintain and further develop the protocol specifications for common use. Known as the World Wide Web Consortium (W3C), it exists to serve this function to this day (Giampietro, 2014).

Additionally, the growth of the WWW as a "universal" mechanism for information access, even in its early days, caused disruption to several connectivity and information providers that existed at the time, such as those of Prodigy and Compuserve (Fleming, 1995). These companies provided communication and access to their subscribers, but rather than providing general-purpose Internet access, they created their own "walled gardens" of information, via proprietary forums, message boards, messaging, and even e-commerce. As the Web grew, these service providers started offering general purpose Internet connectivity, and over time their walled-garden communities atrophied (Carlson, 2003). In response to this “disruptive technology” of the WWW, all of these firms were forced to change their business models (Johnson, Christensen, & Kagermann, 2008)

3. BITCOIN FORMATION

The creation and development of Bitcoin mirror that of the WWW in a number of respects. Just like the Web, Bitcoin had a multitude of precursors, relied on a unique combination of existing technologies, and succeeded where others failed for many similar reasons.

On November 1, 2008, the cryptography mailing list received a post from one Satoshi Nakamoto, describing a proposal for a new kind of digital currency – one that would be decentralized, and would not rely on any central authority or record-keeper – a first for a digital currency (Nakamoto, 2008). Some discussion ensued, with most being skeptical, but in early 2009, the first version of the Bitcoin software was released, and the Bitcoin blockchain was born with the first (genesis) block containing the message "The Times 03/Jan/2009 Chancellor on brink of second bailout for banks", which was a headline on the front page of the London Times on January 3, 2009 (Brito & Castillo, 2013). While the blockchain, the decentralized, public ledger is a novel concept, much like the WWW Bitcoin relied on a number of existing technologies.

The actual cryptographic algorithms used in Bitcoin are US Government standards that had been developed nearly a decade earlier. Bitcoin relies on the Elliptic Curve DSA as the transaction signing mechanism (Johnson, Menezes, & Vanstone, 2001), the SHA-256 as the hash function (FIPS, 2002) and the Hashcash technique as its proof of work mechanism (Back, 2002). Just as the innovation in the WWW is not hypertext, the innovation of Bitcoin was not in novel cryptography.

Instead the true innovation was in an ingenious combination of existing tools and techniques, which together defines the "blockchain protocol", which assured transaction authenticity, integrity, and ordering. Even the idea itself was not new – similar proposals (but not implementations) for virtual currencies had been discussed on mailing lists (Cypherphunks, 1999) and written about (Dai, 1998) as far back as the late 1990s. Just like with Berners-Lee and his integration of the hypertext related protocols onto existing Internet technologies, Nakamoto’s genius was to “technology graft” (Lennon, 2008) these existing cryptographic technologies together to form something unique, the blockchain public ledger and its system of record keeping and maintenance.

3.1. BITCOIN TECHNICAL ACHIEVEMENT: NO CENTRAL AUTHORITY

Nakamoto (2008)’s major technological contribution is to solve the "double spending problem" inherent in digital currency (Jacobs, 2011), without relying on a central clearing house. With physical currency, giving someone a unit of money automatically removes it from ones possession. With money usually having the property of being difficult to reproduce, this maintains a limited supply of currency and thus maintains its value and purchasing power. In an entirely digital currency scheme, where a currency unit is simply a string of bits, duplication of currency becomes trivial, wherein you can give a copy of a currency unit to multiple parties. This would obviously destroy any value the scheme might have as a currency (ECB, 2012).

One ready solution, first employed by a number of early electronic currency systems, such as DigiCash, eGold, loom.cc, and others (Weiner, 1999) is to maintain a central database of who owns how many units of currency. This replicates a traditional banking system in which both the spender and receiver must register with a central third party system. When a spender sends a unit of currency to a receiver, the central authority will deduct the unit from the source and add it to the target's account. Just like a traditional bank ledger, the central authority must manage the debits and credits for all parties (Grinberg, 2011).

But the requirement for a central authority brings with it a number of problems, including the ability for the central issuer to arbitrarily inflate the money supply (Brito & Castillo, 2013), and the dependence of the entire scheme on the continual survival of the central authority (Grinberg, 2011). Nakamoto (2008) proposes an ingenious and elegant solution to the "double spending problem" without the use of a centralized third party record keeper. By putting together known cryptographic functions already widely used by the US government and adopted as a standard by the US Commerce Department (Jacobs, 2011), he develops an algorithm which allows multiple parties to use CPU power to agree on a unique sequence of events, and lock it in an auditable ledger, the "blockchain" (Becker et al., 2013). This auditing process is automatically conducted by all participants in the network who are running the Bitcoin software; agreement on new transaction sequencing is locked in by "bitcoin mining", wherein processing power is used to "cast your vote" for your view of the timeline (Velde, 2013).

Crucially, the system also has a reward mechanism built in to encourage users to participate in the consensus building process. A "miner" who successfully creates a new blockchain entry (a "block") that everyone can agree upon, is rewarded with a quantity of newly-issued coins (Nakamoto, 2008). Additionally, the algorithm enforces a geometrically declining rate of new bitcoin issuance, with a finite total number of units that will ever be issued, thus offering a guarantee against future devaluation. This is in contrast to previously tried centralized systems, where there was scant incentive for people to use the new currency, besides maybe whatever rewards the central issuer proffered using its VC funding, and no guarantees whatsoever about inflation (Trautman, 2014).

Just like the World Wide Web, which allowed for decentralized, permissionless participation and innovation in the information space (Thierer, 2014), the Bitcoin system allowed for the same in the currency space. Shortly after the publication of the 2008 paper, Nakamoto released a software implementation of the system, licensed under the liberal MIT software license which allows the use, modification, and distribution of the software with no restrictions. As we saw earlier in the comparison between gopher and WWW, this licensing clarity was an important component in encouraging community participation. Table 1 summaries the parallel success factors between the WWW and Bitcoin.

TABLE 1: PARALLEL SUCCESS FACTORS OF WORLD WIDE WEB & BITCOINS

SUCCESS FACTOR	WWW	Bitcoins
Proposed via White Paper	▪ Berners-Lee (1989)	▪ Nakamoto (2008)
Technology Grafting	▪ TCP/IP ▪ Hypertext ▪ SGML	▪ SHA-256, ▪ ECDSA, ▪ Hashcash
Ubiquity	▪ Hardware platform independent ▪ Similar user experience across platforms	▪ Hardware platform independent ▪ Similar user experience across platforms
Open Source Software	▪ No licensing fees required ▪ Many free and paid implementations of standards available	▪ No licensing fees required ▪ Many free implementations available

Decentralized Nature	▪ No need for permission to join ▪ Anyone can build a website, link to any other part of the WWW	▪ No need for permission to join ▪ Anyone can start mining or transacting bitcoins
Standards Body	▪ Creation of protocol specifications assures continued compatibility of systems ▪ Pooling of resources promotes efficient innovation	▪ Creation of protocol specifications assures continued compatibility of systems ▪ Pooling of resources promotes efficient innovation

Source: Authors' Research

3.2. CHALLENGES FOR BITCOIN

Similar to the WWW, Bitcoin had (and still has) issues of network externalities and technology adoption: why should someone use bitcoins if no one else is using them? The mechanism of payment is useful to the buyer if many sellers accept it, but only useful to the merchant to bother accepting if he can count on many buyers to use it (Jacobs, 2011). The reward mechanisms mentioned earlier, along with its decentralized nature, have certainly helped take Bitcoin further than any other digital currency has gone before, but only time will tell whether it will achieve greater acceptance (Brito & Castillo, 2013; Grinberg, 2011; Velde, 2013).

The Bitcoin community has also followed the steps of Berners-Lee in setting up an organization to shepherd the course of the digital currency ecosystem, fund development, interface with regulatory authorities, and try to avoid fragmentation. Founded in September 2012, about four years after the creation of the Bitcoin system (amusingly enough, about the same time between the creation of the WWW and the founding of the W3C), the foundation's mission was to "standardize, protect and promote the use of Bitcoin" (Bitcoinfoundation.org, 2012)

Compared to the WWW, however, which was a nascent technology that initially presented relatively non-controversial text based web pages, the acceptance of Bitcoin technology has been far more problematic. Given its financial nature, critics ranging from Nobel Prize Winning Economists like Paul Krugman have denounced Bitcoins as 'Evil' (Krugman, 2013) and famed investors like Warren Buffet have condemned them as "a mirage" (Hurlburt & Bojanova, 2014) as they perceive nefarious motives by the pseudonymous inventor Nakamoto. The technology continues to be plagued by an image problem due to its use in illicit web based transactions (Christin, 2013; Meiklejohn et al., 2013) and high profile failures of early trading exchanges like MT Gox in Tokyo (Ron & Shamir, 2013; Villar, Knight, & Wolf, 2014). The proliferation of Bitcoin in comparison to the WWW has also been hampered by the desire by regulators to create legal mechanisms for consumer protection as bitcoins are integrated into the rest of the financial system (Kaplanov, 2012).

4. MARKET REACTIONS

The emergence of the World Wide Web, like that of many past technology innovations, has caught the attention of businesses and investors. Since Netscape, the producer of the first mass-market browser, went public in the summer of 1995, investment in Internet-related business soared over the next few years, as have market valuations of technology companies. The NASDAQ Composite index, heavy in Internet technology firms, rose rapidly from 1,005 on August 9, 1995, the date of Netscape's IPO, to a high of 5048 on March 10, 2000. From then, it only took a few weeks for the prices to crash to 3321 on April 14, 2000.(Finance.Yahoo.com, 2015)

Market "bubbles" are by far not a new phenomenon, with the most famous example being the Dutch Tulip Mania, back in the 1600s. According to the Minsky (1992)'s model of the credit cycle, a typical bubble goes through five stages: displacement (technological disruption), boom (increase in investment), euphoria ("irrational exuberance"), profit taking, and finally, panic. Many market manias, unlike the Tulip Bubble, happen in response to actually productive new technological developments. While manias/bubbles result in an exciting speculative roller coaster, and a certain amount of mal-investment, at the end of the day if the underlying technology is useful, the built-up infrastructure ends up beneficial in the long run.

For instance, the British Canal Mania of the late 1700s/early 1800s was a response to the gradually improving canal technology, which resulted in significant overinvestment in canal-building, causing plenty of financial losses when the bubble popped (Dyos & Aldcroft, 1969). But at the end of the day, the country was left with significantly improved transportation network. A similar pattern can be observed with the railway mania of the mid-1800s in Britain (McCartney & Arnold, 2003) and that in the United states in the late 1800s (Shachmurove, 2011), which financed the build-out of railroad networks in the respective countries which were beneficial in the long run. Likewise, the Florida land boom of the 1920s (Vanderblue, 1927) left a lot of real estate improvements in its wake.

Similarly, the Internet boom (also known as the "dot-com bubble") that culminated in 2000 was no exception. During the boom, companies invested heavily in Internet infrastructure, not least of which was investment in long-range fiber optic connectivity (Odlyzko, 2010). The easy availability of low-cost bandwidth in subsequent years was a boon to post-bubble companies seeking Internet capacity, and is oft cited as a driving facilitator for globalization (Friedman, 2006).

The case of Bitcoin is similar to other technological investment bubbles. The Bitcoin system uses its own currency unit, the eponymous bitcoin, to keep its ledger of accounts, so one must control some bitcoins in order to have the privilege of making an entry in the distributed blockchain. With bitcoins being in limited supply by design, investing in the units of currency is an obvious mechanism to speculate on the future prospects and usefulness of the Bitcoin system.

Since Bitcoin's release in January 2009, bitcoins could be mined easily with consumer-grade CPUs, or had for free for the asking on the discussion forums, for about a year. The watershed event in the history of bitcoin price is the first exchange of bitcoins for something of value – a trade of 10,000 bitcoins for two large pizzas (Bitcointalk.org, 2010), although there were occasional trades in exchange for money some months earlier. In October 2009, a bitcoin dealer posted an exchange rate of $1 for 1300 bitcoin (En.Bitcoin.it, 2010).

The price history of bitcoin, as short as it is as of this writing, has already undergone three investment cycles. Rising from nothing in January 2009, to $30 in June 2011, then back down to $2 by November 2011, completes the first cycle. From there, rising to $250 in April 2013, and then dropping back down to $60 in short order within the same month and meandering there until July 2013, marks the second cycle. Finally, rising from $60 in July 2013 to $1200 in December 2013, then falling to $230 by January 2015, marks our third cycle (Bitcoincharts.com, 2015).

5. FUTURE OF BITCOIN

While these price gyrations are exciting and news-worthy, there are more important things afoot. A lot of real infrastructure development has taken place, with a number of companies developing easier-to-use wallets, merchant payment systems, and other innovations using the Bitcoin blockchain system. In 2014, more than $300 million of VC funding has been invested in bitcoin-related companies, which is triple the amount invested in 2013 (Wong, 2014). Both merchant and user populations are gradually increasing, now including even such household names as Dell and Microsoft (Hayes, 2014).

Alternative uses for the blockchain technology beyond just a remittance system are also under development, with emerging academic research about it. Possible blockchain applications include the creation of smart contracts (Buterin, 2014), the tracking of real property and securities (Rosenfeld, 2012), and crowd funding and tracking of donations (Brito & Castillo, 2013). The potential applications are only starting to be appreciated.

The WWW has transformed the world in many ways that Berners-Lee did not foresee as he was developing the Web. And even though many of the early dot-com firms, including Netscape, no longer exist – even as a browser – the creation of the WWW truly was a “creative gale of destruction” (Schumpeter, 1934) which left in its wake unimaginable products, services, and industries. Like Netscape, Bitcoin as a particular system/currency may or may not survive for the long term. But like the WWW, the blockchain technology upon which Bitcoin is built, with the ability to validate and timestamp events without relying on a central authority, is here to stay. It is a platform for innovation whose history is only beginning.

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