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## Bitfury: Blockchain for Government

*The world is changing fast. Blockchain is like electricity. Some are stuck making candles and refuse to change; only those that embrace change will prevail.*

— George Kikvadze, Bitfury vice chairman

In the Republic of Georgia, legend had it their land was a precious gift from God he had intended to keep for his mother. But over time the land had been under intermittent threat from without and within. In 2017, the Bitfury Group, which Valery Vavilov had co-founded, had helped publish 300,000 Georgian land titles onto the blockchain, making them immutable and, many believed, unhackable. What came next, Vavilov's team envisioned, were smart purchase and sale contracts via the blockchain; and from there, a full suite of property-related services and, eventually, blockchain as the foundation for a transformation in government services. Vavilov, who had co-founded Bitfury and expanded it substantially from its bitcoin mining roots, felt a blockchain-driven makeover of this sort would take place not just in Georgia's government, but around the world. It was not a matter of "if?" anymore; although that still left the question of "when?"

And "when" mattered in determining how much of Bitfury's resources Vavilov should direct into the effort in late 2017. Bitfury's focus had spread from bitcoin mining and transaction validation, to blockchain hardware and support services, to blockchain infrastructure. Building up a government services operation on top of that would require adding to the company's roster of 300 people in a handful of offices spread across Tbilisi, Amsterdam, San Francisco, Washington D.C., London and elsewhere. It would mean devoting some of the \$30 million of venture capital they had raised at the beginning of the year (of more than \$90 million raised since 2014) to communications, government relations, sales, and marketing efforts aimed at governments around the world. If the timing was right for blockchain for government, Bitfury's efforts in that domain would have to come alongside the rollout of Exonum, a new blockchain platform they had built to address speed, storage capacity, and security issues of the existing technologies.

And "when" wasn't just a question of parcelling out scarce resources, but also how hard the lift would be right now with government leaders. The Chairman of Georgia's Public Registry had been an eager partner in the blockchain pilot, and his boss, Georgia's Justice Minister, Tea Tsulukiani, had been willing to go along. But she had her limits and they sometimes stopped short of her tech-savvy team's. She said, "I am determined to follow them, but they also need to follow me."

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Professor Mitchell Weiss and Assistant Director Elena Corsi (Europe Research Center) prepared this case. It was reviewed and approved before publication by a company designate. Funding for the development of this case was provided by Harvard Business School and not by the company. HBS cases are developed solely as the basis for class discussion. Cases are not intended to serve as endorsements, sources of primary data, or illustrations of effective or ineffective management.

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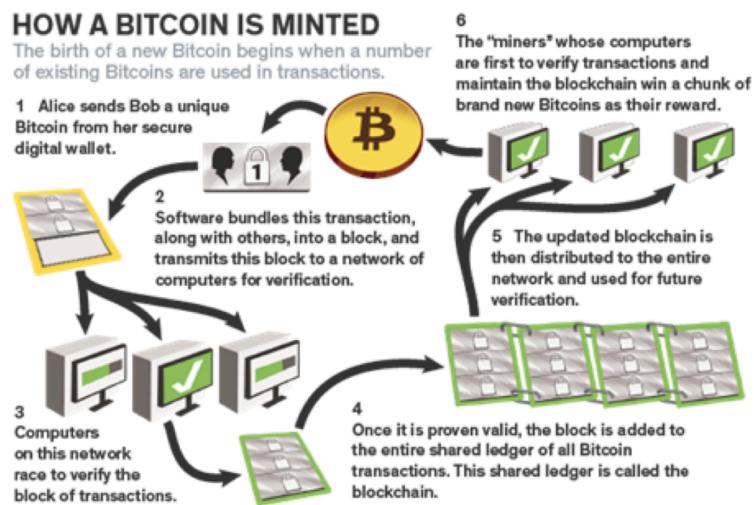
Vavilov and Tsulukiani had seen change come slowly and then swiftly in their own lives. Both had been born under Soviet rule and both had grown up to see their nations achieve independence. Tsulukiani remembered the day as a teenager she learned that private property existed at all. Vavilov recalled how his family lost everything when the Soviet Union fell because the records of their wealth were all on paper. Those memories were part of the impetus for them each to try the titling project together and reason to be glad that it had gone so well. But was the world really ready for them to bring the blockchain to government services in earnest? Was it time?

## Blockchain Background

### *Origin*

Blockchain's conceptualization largely dated back to 2008, when Satoshi Nakamoto (a pseudonym) published a nine-page white paper describing the bitcoin digital currency as a mode for peer-to-peer transactions. Bitcoin, Nakamoto wrote, would require neither a bank to act as intermediary or a government to issue currency through the central bank. In January 2009, Nakamoto released the Bitcoin open-source software that launched the bitcoin and its blockchain. That same month he mined the first block of the chain, which had a reward of 50 bitcoins (BTC).<sup>1</sup>

**Figure 1** How a Bitcoin Is Minted



Source: Avi Salzman, "Beyond Bitcoin, How Blockchain Is Changing Banking," Barrons.com, July 1, 2017, at <http://www.barrons.com/articles/beyond-bitcoin-how-blockchain-is-changing-banking-1498890463>, accessed October 2017.

### *A Decentralized Ledger*

The blockchain was a decentralized ledger.<sup>2</sup> It stored transaction data in the computers ("nodes") of the members of the community. A few members of the community ("miners") would verify the transactions and add them, grouped in chronological "blocks", to the blockchain. By doing so, they unlocked new bitcoins. As compensation for their work, in addition to the bitcoins that they had unlocked, miners received transactions fees, which were set by the bitcoin vendors and purchasers, and were almost \$3 per transaction on October 10, 2017.<sup>3</sup> The blockchain software pre-defined the

amount of bitcoins miners received for each new block (12.5 BTC in July 2017) The system was programmed to generate only 21 million bitcoins by 2140.<sup>4</sup> Miners and the nodes participants were pseudonymous: anyone with a computer could create an account and download the Bitcoin software. The ledger was public (see **Exhibit 1** for key principles).

### *Validation*

The validation process started with the miners verifying the data of the transactions. To make bitcoin payments, users had to connect to the web, insert the address of the receiver (called the “public key”) and the amounts transferred; next they would digitally sign the transaction by using their “private key.” The Bitcoin software then generated a hash (a sequence of numbers), which included the public keys of the sender and receiver (never the private ones) and the amounts exchanged, and notified the record to the network (see **Exhibit 2** for an example of a hash).<sup>5</sup> Every miner would check the hash against the data stored on the blockchain to verify that the sender had the money for the transaction. Miners would then group into a block all the verified transactions that had happened since the last block had been added (about 10 minutes).

### *The Chain, Proof of Work, and Security*

To attach the new block to the blockchain, miners had to run through a cryptographic hash function—the United States National Security Agency SHA-256 hash function—all the transaction hashes, and compute a unique hash that met certain criteria. Solving this algorithmic challenge, which represented a “Proof of Work,” required significant amounts of processing power and substantial amounts of electricity.

The first miner who solved the problem could attach the block to the chain, adding it to his local chain version and propagating it all over the network. If the miners validated the new block, they would add it to their chains and start mining the new one. Gleb Palienko, project lead at Bitfury in Georgia said, “It is theoretically possible (and it has happened) that the network splits as two different blocks are propagated at the same time. If there is a split, the chain where miners find the next block quicker wins and the miners of the other chain lose the reward. That is why some services accept bitcoin payments only after three or five blocks are mined on top of the one containing your transaction.”

The Bitcoin Blockchain had never been successfully hacked, although some hackers had managed to steal bitcoins by accessing the private keys of individuals and accessing their bitcoin “wallets.” To modify a block, it was necessary to hack 51% of the nodes, which experts estimated would cost about \$2.5 billion in equipment and power. In addition, the more blocks were added to the chain, the more difficult and costly it became to modify data stored in older blocks, making it almost impossible to hack the system.<sup>6</sup>

### *Evolution, Growth, Congestion, and Competitors*

The blockchain developed rapidly from its origins. Initially, bitcoin mining was more like a hobby, with miners using their computers’ graphics processor to run the mining process in the background and earning a few bitcoins a week.<sup>7</sup> The value of the first bitcoin transactions were negotiated by individuals on the bitcointalk forums. In May 2010, a developer bought two pizzas for 10,000 BTC (or \$48 million by October 10, 2017).<sup>8</sup> In 2011, the arms race began, as miners upgraded their machines and new chips, built only for mining, were developed.<sup>9</sup> The cryptocurrency saw its value increase from a few cents in 2010 to \$30 in June 2011 and \$100 in early 2013 (see **Exhibit 3** for price history). The blockchain’s pseudonymity attracted those engaged in illicit activities, such as drug trafficking, as some of its earliest adopters.<sup>10</sup> The Silk Road, an anonymous network that sold all sorts of illicit goods, from drugs to fake

passports, used bitcoins for its trades and contributed to the currency's growth until U.S. federal authorities shut down the Silk Road in 2013. Nevertheless, as word spread that bitcoin could be readily used for legitimate purposes, its use also grew in legal trades.<sup>11</sup> On December 30, 2013, bitcoin traded at \$752 and had a market capitalization of \$9.1 billion.<sup>12</sup> Some of the early users cashed out.<sup>13</sup>

In theory the blockchain could be used also for other transactions, such as for smart contracts, or self-executing transactions like self-payable invoices.<sup>14</sup> Vavilov explained, "You should think of the blockchain as the rails on which you could have bitcoins going through, as well as all sorts of other documents." The use of the Bitcoin Blockchain for smart contracts was limited though by several factors, including the capacity of the Bitcoin blocks, or 1MB of data every 10 minutes, which meant only 7 transactions per second.<sup>15</sup>

As the number of bitcoin transactions increased, other cryptocurrencies were launched. Some developed their own blockchain, which ran in parallel to the Bitcoin one. In particular, Ethereum<sup>16</sup> positioned itself as a global, decentralized computer and a platform to develop services that would eliminate all forms of intermediaries, from publishing houses to boards of directors. The cryptocurrency Ethereum went live in 2015. Its value grew from \$1.30 in September 2015, to \$11.50 by September 2016. By then, it had a market capitalization of \$1 billion, while BTC's was still at approximately \$9 billion.<sup>17</sup>

Bitcoin's popularity led to congestion, with transaction times and processing fees soaring.<sup>18</sup> Some miners advocated for increasing the block size. Others were against it as they claimed that larger blocks meant more hardware investments. In 2017, the Bitcoin community released a software update that would allow the recording of part of the metadata of the transactions outside of the ledger, which would benefit scalability, as a first step. The second step, to be implemented by November 2017, asked miners to increase the storage capacity of the Bitcoin blocks to 2MB.<sup>19</sup> In August 2017, a group of bitcoin miners refused the changes, and caused the bifurcation of the blockchain into Bitcoin and Bitcoin Cash.<sup>20</sup> A movement to possibly change the "Proof of Work" mechanism in the Bitcoin Blockchain—and thus replace the SHA256 algorithm—to one that some claimed would be more energy efficient was met with objections by others in the community, including Bitfury's Kikvadze. On Twitter, he called discussion and speculation of those changes, "super irresponsible."<sup>21</sup>

## Blockchain in October 2017—“What Year Are We?”

By October 2017, there were 1,150 cryptocurrencies, with a total market capitalization of \$154 billion (see **Exhibit 4** for more data).<sup>22</sup> Several companies offered online portfolios of cryptocurrencies, which users could acquire via credit cards or bank transfers. The blockchains were not connected to one another, and the currencies could not be directly exchanged.<sup>23</sup>

Bitcoin was still the most used cryptocurrency. On October 10, the bitcoin had a value of \$4,825.<sup>24</sup> Its blockchain ledger had reached a size of 160 GB; 16.6 million BTC had been mined.<sup>25</sup> Miners needed increasingly more hardware and power to store the database and compute the "winning hash" as the complexity of the system increased. The compensation for adding a block had decreased from 25BTC in 2012 to 12.5BTC in 2016 and would halve again to 6.5BTC in 2020 and 3.25BTC in 2024. Transaction fees had increased in the last six months. Several miners worked in pools, sharing their processing power and splitting the reward according to the amount of work they contributed to solving a block.<sup>26</sup> Some miners were instead part of mining clouds, where they mined bitcoins remotely and without owning the hardware.<sup>27</sup> Small miners struggled to remain in business.<sup>28</sup>

Some companies, and in particular financial institutions, looked with more interest at private blockchains. Private blockchains included only authorized nodes and validators (or miners for the Bitcoin Blockchain)—such as the computers of a company and had more throughput capacity. Nevertheless, they were also more vulnerable: hackers could more easily compromise the nodes of a small network.

Some developers were focused on finding solutions to overcome the cost and capacity limits of the Bitcoin Blockchain without increasing the block sizes. For example, a few were developing Lightning, an overlay network that would enable small transactions at a low cost. The network would store only a synthesis of the transactions on the Bitcoin Blockchain and would reduce transaction fees. Lightning could also be utilized with other blockchains.<sup>29</sup>

Some industry participants and watchers believed the blockchain was poised to become “the next internet.” Dan and Alex Tapscott opened their new book, *Blockchain Revolution*, with this passage: “It appears that once again, the technological genie has been unleashed from its bottle. Summoned by an unknown person or persons with unclear motives, at an uncertain time in history, the genie is now at our service for another kick at the can—to transform the economic power grid and the old order of human affairs for the better. If we will it.”<sup>30</sup>

Vavilov said of the expansive opportunity he saw, “With blockchain we can reduce the time and improve the efficiency of all the services where you need an authorization of some sort.” Analogies to the invention of TCP/IP, the communications protocols for the internet, were common. Two scholars wrote in a *Harvard Business Review* article on the blockchain:

The parallels between blockchain and TCP/IP are clear. Just as e-mail enabled bilateral messaging, bitcoin enables bilateral financial transactions. The development and maintenance of blockchain is open, distributed, and shared—just like TCP/IP’s. A team of volunteers around the world maintains the core software. And just like e-mail, bitcoin first caught on with an enthusiastic but relatively small community.

TCP/IP unlocked new economic value by dramatically lowering the cost of connections. Similarly, blockchain could dramatically reduce the cost of transactions. It has the potential to become the system of record for all transactions. If that happens, the economy will once again undergo a radical shift, as new, blockchain-based sources of influence and control emerge.<sup>31</sup>

Jamie Smith, Bitfury’s global chief communications officer, elaborated. “We asked around: ‘Compare blockchain to the evolution of the internet. What year are we?’ No one said later than 1993, but they did say we are moving faster.” (See **Exhibit 5** for the history of the internet.)

Blockchain users visualized a world where all sorts of transactions would take place on the blockchain, extending well beyond financial services. Several pilot projects had been launched to improve real estate transactions, global logistics, drug administration, and manufacturing processes (see **Exhibit 6** for examples).<sup>32</sup> The Tapscotts wrote in their book:

This new digital ledger of economic transactions can be programmed to record virtually everything of value and importance to humankind: birth and death certificates, marriage licenses, deeds and titles of ownership, educational degrees, financial accounts, medical procedures, insurance claims, votes, provenance of food, and anything else that can be expressed in code.<sup>33</sup>

Blockchain startups and investors joined the fray. CB Insights reported that more than \$1.5 billion had been invested in Bitcoin and blockchain startups around the world between 2012 and February 2017. There had been more than 270 funding rounds in the U.S. alone.<sup>34</sup> The pace picked up through 2017, and took a new twist as more companies in the ecosystem raised capital in cryptocurrencies, and not cash, via token generation events, also called by some investors Initial Coin Offerings (ICOs). One venture capitalist called it "The Summer of ICO's" after it was reported that in excess of \$1 billion had been raised through these events during the summer of 2017, "more than the total amount of venture capital raised during the same period."<sup>35</sup>

Not everyone shared the rosy blockchain forecasts. Some still pointed to the Bitcoin blockchain capacity limit of 7 transactions per second and its cost for users, at \$2.60 per transaction on October 10, 2017.<sup>36</sup> Others were worried that the blockchain would be less secure if only a handful of concentrated miners remained in the community.<sup>37</sup> Some business and political leaders questioned the new currencies that had risen alongside the blockchains. In September 2017, J.P. Morgan CEO Jamie Dimon called cryptocurrencies "not a real thing" and Bitcoin a "fraud"; compared them to "the Tulip Bulb crisis" and concluded, "Eventually, it will be the emperor without clothes."<sup>38</sup>

## The Bitfury Group

### *From Mining to Services*

Vavilov had established the Bitfury Group in 2011, together with his friend Valery Nebesny. Vavilov was passionate about information technology and had learned to code at the age of six. He was fascinated by the blockchain in its early days and believed in the transformational power of the technology. The two partners were based in Ukraine, but set up an 8.5MW datacenter in Iceland, where electricity costs were low and the cold weather helped to cool the numerous servers that were working day and night to unlock bitcoins.

In May 2014, Bitfury raised \$20 million in its first funding round.<sup>39</sup> Reported as one of the largest funding rounds in the Bitcoin ecosystem of the time, it included multiple investors, venture capitalist Bill Tai and the \$6 billion private equity fund Georgian Co-Investment Fund, among them. Two months later, Bitfury opened a new 20MW datacenter with 3,000 servers in Georgia, one of the largest Bitcoin computing datacenters of the time.<sup>40</sup>

By October 2014, Bitfury had raised another \$20 million, mainly from its existing investors, to launch a new, energy-efficient mining chip the company had developed.<sup>41</sup> In 2015, Bitfury acquired from the Georgian Ministry of Economics an 18-hectare land plot in the suburbs of Tbilisi.<sup>42</sup> The company also secured from the Georgian government Free Industrial Zone (FIZ) status for that land and invested \$30 million to set up a 30MW datacenter and to develop the FIZ area.<sup>43</sup> Eprem Urumashvili, who provided tax and legal advice to Bitfury in Georgia, said, "The FIZ and the presence of high-tech companies made Georgia remarkable. They were a signal to investors that our country is not just for tourism. We had low taxes. It was easy to do business. And now we hosted Bitfury...which could become the next Google if blockchain becomes as popular as the internet."

At the end of 2015, the company's evolution from mining to chip manufacturing had expanded to a new business: developing services. Bitfury started working on software offerings that would allow the collection and analysis of blockchain statistics, or to track nefarious uses of bitcoin transactions, as well as developing a new algorithm that allowed transactions through the Lightning network. It also looked at the possibility of providing services to governments. "When the Soviet Union fell, Valery went from being a wealthy kid to having, as he says, no toys," explained Smith. "His family lost almost

everything because all the records were on paper, and easily corruptible. If all the data had been stored on blockchain this would not have happened." Vavilov saw in blockchain for governments a tool to reestablish trust in institutions, improve efficiency, and also business potential.

Rachel Pipan, senior communication manager at Bitfury, recalled the reaction at the time, "The community was surprised by our move into Blockchain software and Blockchain as a service for governments. We were known just as a bitcoin miner, not a software company."

The years 2015 and 2016 brought another move for Bitfury. The company invested considerably in shoring up the public image of blockchain technology and the ecosystem around it. Bitfury hired new communications people, like Smith. It organized annual blockchain summits on the renowned entrepreneur Richard Branson's Necker Island. Smith said, "Let's give it that mentality of a Branson moonshot."

For their June 2016 Blockchain Summit, Bitfury included for the first time politicians and NGO leaders next to blockchain experts and journalists. Together with many other leaders in the blockchain ecosystem, Bitfury created the Global Blockchain Business Council (GBBC), with Smith as CEO and with the mission to educate regulators and business leaders on the blockchain. Bitfury and its partners announced its launch during the World Economic Forum in Davos in January 2017. "We had to find a way to create the right messaging content, and then deploy it in the most strategic way we could," Smith recalled.

During the 2016 Summit, Bitfury also launched a second initiative, the Blockchain Trust Accelerator (BTA). BTA was a partnership with the New America and the National Democratic Institute and was designed to generate pilot projects that deliver positive social impact and promote concrete moves to the blockchain by governments, NGOs and companies to make the world a better and more functional place for all. "The best way we can tell a convincing story, is to have concrete examples of real work," Smith explained. "We could go to an NGO that distributes vaccines, but loses inventory around the world and offer to build for free, via the blockchain, the rails to better track their supply." Bitfury could directly work on the project or find another company willing to take over. Smith said, "We know who does what in this industry and who the reliable players are. The costs for these projects are low, and go from \$50,000 to \$100,000. We can also find a sponsor who cares about supply chain to fund it. The NGO would keep the IP; if they don't like the system they don't have to use it. But if it works, we can explain the blockchain instead of through 'nodes' and 'hashes', as 'vaccines' and 'babies'."

Combined, the full scope of activities had proved profitable for Bitfury. A July 2017 article in *CoinDesk*, the blockchain news outlet, reported that the company had earned \$24.7 million in EBITDA in fiscal year 2017, on \$93.7 million of revenue.<sup>44</sup> The article noted Bitfury's proficiency in mining: "The company also lists a total of 500,000 BTC 'generated to date' from the protocol's block rewards. At today's prices of about \$2,600 that would amount to \$13 billion earned from mining, though there is evidence some of those bitcoins have been sold."<sup>45</sup>

### *Bitfury in Georgia*

The first service to governments offered was the Georgia land titling pilot project. Smith explained why Bitfury targeted Georgia first: "Kikvadze, Bitfury's vice chairman, has several relationships in Georgia. We already had two datacenters there. Georgia had in place a good digitalized system of registering property, and had developed the FIZ." In addition, the Georgian government was highly interested in the blockchain technology. Kikvadze remembered, "It takes two to tango. We needed a partner willing to dance, so to speak. We approached the government with the idea to showcase Georgia. The Minister of Justice was skeptical, but then she educated herself on the technology and

was convinced. She had the full support of the government.” The pilot was a partnership between the National Agency of Public Registry (NAPR), the economist Hernando de Soto, a specialist on property rights and a member of Bitfury’s advisory board, and Bitfury. In the first phase of the implementation, the Georgia land titling pilot project focused on registering a small number of property titles directly on the blockchain, while Bitfury worked at developing software more adapted to the needs of governments.

## Georgia – “We Want to Move Further Up”

Over the centuries, Georgia had experienced invasion from Arabs, Persians, Mongols, and Russians.<sup>46</sup> It had long been a Russian province and then a member of the Soviet Union. The country had finally regained independence in 1991. In 2017 Georgia was a representative semi-presidential republic, with the President as the head of state, and the Prime Minister as the head of government, but it had struggled to move from a communist state to a democracy, hampered over time by corruption and government inefficiency.<sup>47</sup>

In 2004, Mikheil Saakashvili, was elected President and started a new era of reforms. During his decade as president, he adopted several measures to eradicate corruption and liberalize and boost the economy (see **Exhibit 7** for GDP rates). Yet, the central government was challenged by independence movements fomented by Russia in the regions of South Ossetia and Abkhazia.<sup>48</sup> In 2008, the tense relationship between the two countries culminated in the South Ossetia war, which also led to a drop in investments and declining GDP. At the end of the war, Russia withdrew its army from Georgia’s territory, though Georgia never regained full control of the disputed regions.<sup>49</sup>

By 2017, Georgia had managed to radically reduce red tape and corruption, had largely liberalized its economy and had improved the business environment. In 2012, the World Bank had already recognized Georgia as one of the world’s fastest reforming economies and as a leader in fighting corruption. Georgia later ranked 16<sup>th</sup> in the 2016 World Bank’s Ease of Doing Business (EDB) index, 13<sup>th</sup> in the 2017 Economic Freedom Index, and 59<sup>th</sup> out of 128 global economies in the Global Competitiveness Report. According to Transparency International, Georgia had the lowest corruption rate in the region.<sup>50</sup> In the EDB index, Georgia was number three for ease of registering property (see **Exhibit 8** for the EDB index composition).

The current economic plan aimed to accelerate those gains. Leaders hoped to increase the competitiveness of the country by improving the business environment further (especially for technology companies) and investing in infrastructure.<sup>51</sup> Urumashvili said, “We have a developed financial system and a good banking sector, and it’s easy to set up a business today. Yet we want to further move up the ranking.” At the same time, the reforms aimed at boosting the high-tech industry. Giorgi Isakadze, editor-in-chief at *Forbes Georgia*, and associated with Bitfury in Georgia added, “Georgia needs to move further and open its market to new technologies. We are implementing the first steps and amending local laws to attract as many companies worldwide to the Georgian market as possible. We are making the laws more flexible, simpler, and more appropriate for companies working with the internet and blockchain.” Particularly attractive for companies in this second bucket were the low electricity costs, as Georgia had access to cheap hydropower. Urumashvili continued: “Bitfury’s datacenters have increased local awareness concerning the blockchain. Several people mine bitcoins in their garages today and a few of them have created a local cryptocurrency. Georgia will attract these types of companies, and other investors will follow.”

## NAPR – “We Are the Guarantors”

Before the creation of NAPR, two institutions managed property registrations in Georgia. The Bureau of Technical Inventory (BTI) surveyed and registered apartments and buildings and had local offices that stored the information and were managed by local municipalities. The State Department of Land Management (SDLM) covered a wide range of other functions, from property registry for agricultural and non-agricultural land to privatizing and leasing state-owned land as well as general land management functions. SDLM had a centralized structure, distributed in several regional offices.<sup>52</sup> The dual role of land management and land administration at SDLM gave rise to conflicts of interest and corruption practices while officials in both institutions could easily modify the registry. In addition, SDLM had overlapping functions with other departments and the dual system of property registry caused confusion. In 2004, it took 39 days and 8 steps to register a property in Georgia.<sup>53</sup> Similarly, it took 30 days and 9 steps to set up a business, at a cost of \$171. All the documents and the registry were on paper.<sup>54</sup>

In 2004, NAPR was created; it took over the property registration functions of BTI and SDLM and their registries, and its functions were gradually expanded to include also the business registry, and other registries.<sup>55</sup> Part of Georgia’s Ministry of Justice, NAPR’s main task was to eliminate the lines and corruption. Papuna Ugrekhelidze, chairman of the NAPR, said, “We are the guarantors that property rights will be protected in Georgia.” NAPR worked hard to eliminate corruption. Ugrekhelidze offered, “At the beginning, the agency was the most corrupt, bureaucratic and blunt instrument in government. For example, just to change your number in the line you had to pay \$100.” First, NAPR centralized the registry. Second, while it left the task of recording local transactions to the former SDLM’s regional offices, it directly controlled their activities from the central office. Third, all former SDLM officials were fired and invited to re-apply for their position in a transparent and public recruitment process. At the same time, NAPR had authorized notaries, commercial banks, real estate agencies, legal consultants, land surveyors and entities involved in land-related services to act as a “front office” for NAPR, accepting all the documents needed to register properties. These entities could connect to NAPR’s website, insert all the information, and issue a property certificate. Finally, NAPR simplified the procedures and introduced legislative changes that allowed drafting and certifying property transactions and business founding documents not only through notaries but also at NAPR’s office.<sup>56</sup>

A crucial component of the reforms had been the move to a digitalized database, enabled by NAPR’s investment in IT. Ugrekhelidze said, “The Ministry of Justice and NAPR decided to use technology to solve the inefficiencies and corruption problems. Yet it was very important not to outsource IT. We developed an internal team. We used open-source products and implemented best international practices at low prices. The ICT Business Council of Georgia named us the best IT agency in the Caucasus Region four times.” NAPR’s IT team moved all the documents to digital formats and developed its own property registration software, called “NAPReg,” containing data such as property ownership, satellite photos of the property, and other property related data. The database allowed searches by name, surname, address, cadastral code, and by any other specification supported by the database. In 2009, the registry became accessible from NAPR’s website.<sup>57</sup>

As a consequence of these reforms, NAPR became a one-stop shop for property registration. In addition, since 2010, in Tbilisi and in certain cities, NAPR took over further responsibilities such as releasing birth and wedding certificates, ID cards and passports. These “Houses of Justice” (as these NAPR offices were called) were organized in three different areas: “self-service,” “quick service” and “long service,” with an average waiting time of 48 seconds (see **Exhibit 9** for a picture).<sup>58</sup>

Besides reducing waiting times, the reforms cut the number of employees needed and improved efficiency. One report described how NAPR was transformed into a self-financed public agency.

Before the reform program, the annual budget for Georgia's property registration system was \$370,000; within two years into the reform process, NAPR's income totaled \$6.4 million and was able to pay back to state budget more than \$250,000 in income and other taxes – without increasing registration fees by a single GEL. NAPR's budget surplus was a classic example of doing well by doing good: To satisfy the Government's original mandate of eliminating queues and corruption, the agency streamlined procedures and pursued other efficiencies, which, in turn, led to reducing the number of employees the agency needed by three times, which increased the agency's bottom line. The addition of fast-track services for an extra fee boosted earnings even more – with the unintended consequence of depriving unethical employees of the opportunity to facilitate applications for an extra fee, which they would then pocket. Thus was born a "best practice" for the fight against corruption in property registration systems.<sup>59</sup>

In the new system, property registration required from one to four days, and cost from \$4 to \$80 for the fast track option.<sup>60</sup> Citizens who were selling and acquiring property, could formalize and register the contract with a notary, or simply present themselves at the local NAPR's offices with their ID cards and the money.

Business registration, which was the first step to set up a business, took from one hour to one day. Once registered at NAPR, entrepreneurs still needed to open up a bank account and register at the Revenue Service; starting a business still required about three days overall for a total cost of between \$40 and \$81.<sup>61</sup> As the Houses of Justice also included branches of three Georgian banks, entrepreneurs could open the bank account while registering their business at NAPR, thus reducing the waiting time.<sup>62</sup> All Georgian citizens and businesses could check their property registration on NAPR's website, by entering their ID number.

## Blockchain at NAPR – "Erasing Shadows of Distrust"

Ugrekhelidze and his staff at the NAPR didn't stop with this progress. He felt the blockchain would add to the efficiencies and add another layer of protection. "People ask us why we wanted to use the blockchain technology, as if our property rights were not sufficiently protected already. They were protected, but only within the boundaries of Georgia. With blockchain, protection is granted globally, and at higher level." Palienko, explained, "If someone tried to modify the data, the hash for the transaction would be different from the one that was written on the blockchain. On the Bitcoin Blockchain you cannot rewrite the hash. It would cost more than \$500 million to change something on one block. If it was written one week ago, it would be almost impossible."

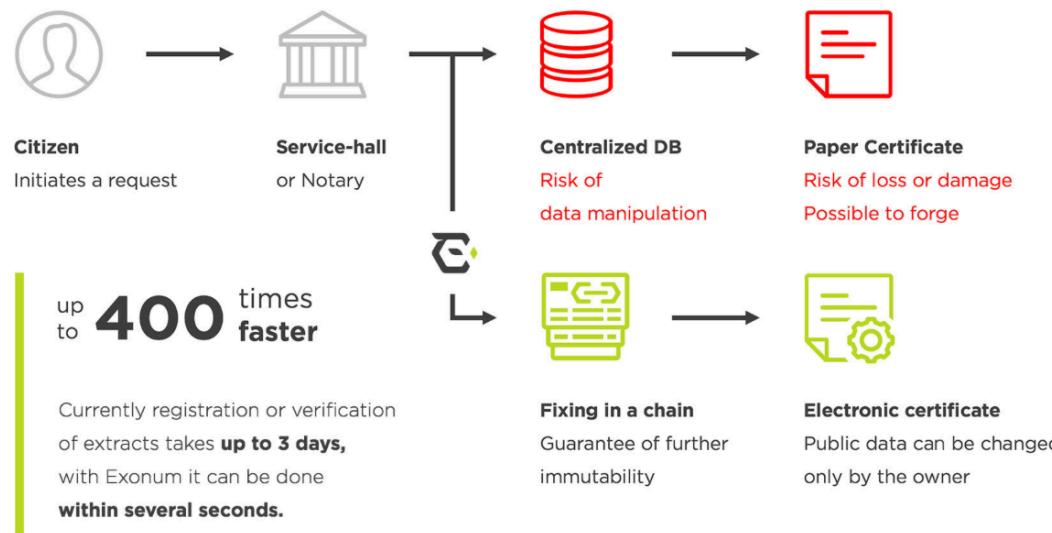
Tsulukiani concurred on this. "Six years ago there was a general distrust towards politicians in Georgia and people felt that politicians could influence transactions. When you have shadows of distrust wandering the streets, the whole system is in question. In addition, it was theoretically possible to hack our database. Everything is possible when you live in a geographical corridor like ours." She also believed her ministry could successfully carry out the pilot. "When the team approached me saying that we should move to blockchain I said, 'Why not?' We had the most advanced IT team. We could accomplish it. To introduce such a technology, you need to have a 100% clean system, otherwise you encounter more problems than benefits. We had invested in that."

So, with an eye towards solidifying property rights and with broader opportunities in mind, Bitfury signed a memorandum to start the one-year pilot in April 2016. They began to move the country's property registry to the blockchain. Isakadze said, "We started by recording only a few cases as there were a lot of expected challenges that had to be resolved. Bitfury needed a 'test' period to ensure that the system was on track before moving the entire database. We were the first to move the land registry on blockchain worldwide."

Four IT specialists from Bitfury and three from NAPR worked on the project. Within the pilot project, NAPR was in charge of the content. Palienko said, "We did not develop a totally new system, which needed new applications and new websites. We only provided the blockchain layer." Ugrekhelidze added, "We designed the pilot with Bitfury in a way that if the blockchain malfunctioned, the previous IT infrastructure would continue working as usual." Tsulukiani said, "I am a lawyer by background, and a bit old-fashioned. It was crucial for me that while we used this technology, we kept the old system running. We don't know what can happen to the blockchain, and we should keep doing this even in the future, once the pilot phase is over."

Bitfury reported that the pilot "reduced service delivery time from one to three business days to several seconds"; that "operational costs were reduced 90%" (for the registration service); and that the innovations enabled the real-time audit capabilities that could prove invaluable if property rights came into question.

**Figure 2** Blockchain Registry at NAPR



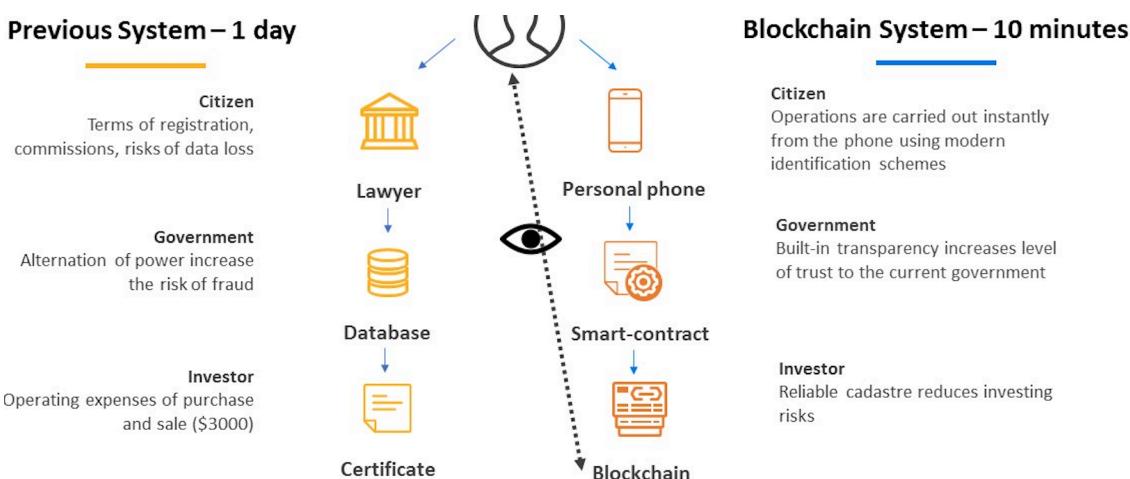
Source: Company documents.

In February 2017, Ugrekhelidze felt that the land registry pilot program was working well and that his team could apply the technology to property transactions more broadly with so-called "smart purchase and sale contracts." NAPR and Bitfury signed a new memorandum of understanding, marking a second phase of the pilot. At the time, it took one to four days to transfer property in Georgia, and issues could arise, in particular if citizens did not formalize the transaction by going to NAPR's office. Ugrekhelidze explained, "When NAPR receives the application to register a change of ownership, it checks that the property is owned by the seller and that there are no encumbrances on it before transferring the property. But while we check, the seller has the right to ask to end the process

and in case the buyer has already paid the money, the seller could for example leave with the money or the buyer could refuse to pay once we register the transaction. It takes a long time at court to get the money back." Citizens could still protect their interests by engaging notaries and banks as intermediaries, but it was expensive, especially considering that a standard property was valued at \$168,345.<sup>63</sup> Ugrekhelidze added, "In a blockchain system, citizens would log on NAPR's website, access the data concerning their property and put it on sale. If they receive an offer that matches the expectation, they would authorize the transaction. The information would be sent to the bank and NAPR, the nodes would check that the buyer has the money and the seller has the property, and the transaction will be concluded. The information would be publicly available on blockchain." At the same time, they also agreed to study the possibility of extending the system to other registries or business processes, such as notary services.<sup>64</sup>

By April, Bitfury's Exonum blockchain framework was ready, and the land titling pilot project moved to the new software. Once a day Bitfury would create a hash digest of the entire Exonum blockchain powering the project and publish it on the Bitcoin Blockchain. Palienko said, "We can guarantee that we will put the data on the Bitcoin Blockchain. In a block, we can store 4,000 transactions so one hash per day is nothing. We are doing this free of charge for Georgia. We can bear the cost of \$2 per day to put one transaction on the Bitcoin Blockchain."

**Figure 3** Land Titling in Georgia



Source: Company documents.

To move to Exonum, NAPR acquired a few additional servers. They managed the coordination between the data in the server and their website, which allowed users to check the status of their property on the web. Palienko continued, "In Exonum we have two types of servers: validators (servers) that participate in the consensus algorithm and validate transactions; and auditors which have access to the data but do not participate in the consensus process. There is a trade-off in terms of the number of validating servers you need (and, therefore, increased security) and speed of the system. Our advice is to have from 4, which is ideal for a pilot project, to 10 validators." Bitfury suggested placing as many auditors as possible. He continued, "Auditor nodes can also be placed at Transparency International, for example."

The land transaction part of the second phase of the pilot project was still at an early phase; technicians at NAPR, Bitfury, and the Bank of Georgia were studying how to make it work. Palienko said, "Exonum will manage all the business logic. A land sales deal includes several transactions: informing you want to sell the property, the offer, when the bank puts the money in the escrow, and the exchange of the money and the property. Exonum is designed so that each piece of data inside Exonum is built into a final cryptographic proof that goes up to the hash that is saved in the Bitcoin Blockchain." Bank of Georgia had already offered to host auditing nodes.

When the system was up and running, citizens could authorize property transactions directly online, and almost instantly. Citizens would receive a hash and a copy of the metadata (such as sale price and property description), which they could use to prove their property rights in case someone hacked NAPR's more traditional database.

Once the land registry and land transaction pilots were concluded and the system was up and running, Bitfury planned to charge NAPR and the Bank of Georgia for the service. It was likely NAPR would levy a fee on their users.

## Blockchain for Government

Bitfury employees who had been involved in some fashion in the Georgia pilot looked ahead to bigger projects. Smith said, "The name of the game is security and data integrity. On top of this critical issue, almost every government is facing three challenges: Trust toward governments is low. Governments lack funds. Governments want to grow their economies. Blockchain is cheap technology, and can be used to move assets out of the black market, and increase transparency and efficiency." Vavilov said of the opportunity, "If citizens can securely connect through smartphones and a government has in place the proper legislation that allows them to use hashes as legal proof, services could move to blockchain, starting from land registry to voting systems."

Other governments, in the meantime, were studying the blockchain technology for land registry and more. According to de Soto, "Of the 7.3 billion people in the world, only 2 billion have a title that is legal, effective and public regarding their control over an asset."<sup>65</sup> In June 2017, Sweden, which already had its land registry on digital format, was experimenting to move it to the blockchain. The project's second phase was to move land transactions to the blockchain, reducing the typical one month waiting period of such deals in Sweden and saving taxpayers \$106 million per year.<sup>66</sup> Dubai had announced that it would move most of the government data and services to the blockchain by 2020. Gartner had documented a dozen other blockchain projects in development with governments around the world, including citizen payments in the U.K., contracts in U.S. state of Delaware, identity in Estonia, and voting in Denmark.<sup>67</sup> The General Services Administration in the U.S. government, through its Emerging Citizens Technology program, had launched several modernization initiatives on artificial intelligence, virtual and augmented reality, and social technologies; it had now added blockchain to that mix and in July 2017 held the first U.S. Federal Blockchain Forum.<sup>68</sup>

Several blockchain companies offering services to governments and companies were emerging, though not without complications. Palienko said, "Most of the blockchain software companies are working on Ethereum which is a public blockchain. Some companies are trying to create private blockchains on Ethereum or develop consensus algorithms suitable for private blockchains, but for now no main player has succeeded." The U.S. technology company IBM was working on Hyperledger Fabric, a platform for private distributed ledger solutions and was currently partnering with the Dubai authorities (see **Exhibit 10** for details on the Hyperledger Fabric platform).<sup>69</sup> Palienko said, "IBM is our closest competitor. Nevertheless, the Hyperledger Fabric does not provide cryptographic proofs to

verify blockchain responses on the client side and does not have built-in the anchoring to the blockchain function as we have, which results in a lower level of auditability and security. We are probably the only ones offering this service, at least for now.”

Some governments were discouraged by the complexity of the technology. In 2016 the U.S. state of Vermont studied the possibility to use blockchain to keep track of land titles, but concluded: “The costs and challenges associated with the use of blockchain technology for Vermont’s public recordkeeping outweigh the identifiable benefits.”<sup>70</sup> Honduras, where 80% of the privately held land was untitled or improperly attributed, had looked into blockchain for its land registry back in 2015 in cooperation with the Texas startup blockchain company Factom. The project had stalled.<sup>71</sup> Smith said, “When Bitfury approaches governments, some tell us, ‘We have just moved to Oracle, why is blockchain’ different? ‘A few also do not understand the technology. It requires political will to move forward. But once they understand the security, they cannot ignore the potential.’” Deloitte published a report declaring the blockchain quite relevant for governments, but governments unready for the technology. Other trends like integrating IT systems with the governments’ daily operations or managing and using unstructured data sources such as tweets and videos were at a more advanced stage (see **Exhibit 11** for more details). The same Gartner report that cited government-specific uses cases of blockchain reported that only 7% of government CIO’s they surveyed “indicated blockchain would be a big driver of change for their organization within the next five years.” Was blockchain for government, the report’s authors wondered, “a solution in search of a problem?”<sup>72</sup> One observer at the Centre for Public Impact adapted Gartner’s Hype Cycle map into one on government innovation. He placed the blockchain at the “peak of inflated expectations.” (see **Exhibit 12**).<sup>73</sup>

## Is it Time?

As the pilot project in Georgia advanced, the demand for Bitfury’s government services increased. In March 2017 it launched a new pilot program in Ukraine, to move the country’s e-auction system for State owned and seized goods and property to the blockchain.

By 2017, Bitfury had become a full service blockchain technology company and one of the largest private infrastructure providers in the blockchain ecosystem. Its business was organized in two units (see **Exhibit 14** for a description of Bitfury’s software and hardware offerings). The infrastructure business was producing and selling chips (valued for their low-energy consumption) and data mining mobile units, processing transactions and providing security for the Bitcoin blockchain. Bitfury held 10% of the mining segment, still the company’s most profitable business. The software business was small by comparison, employing about 70 developers. Though Vavilov and others saw it as a growing business, and saw governments as, potentially, large drivers of the new business. He laid out part of that case: “When you do a project with a government, if it’s successful, it becomes your marketing page and you do not need to spend money and time to find new clients.” Smith said, “This is the Wild West. It’s exciting, but there is no parachute. You have to take big risks and you need to be aware that word spreads fast.”

Tsulukiani was more circumspect. Was she representative of governments’ views? Some local newspapers, she observed, were criticizing the move to blockchain. “They claim that it has become already too big in Georgia and nobody knows what shape blockchain can take one day.” She seemed to want to pace her staff. “The IT team would like to put everything on blockchain. But we work in the field of human rights, ownership, personal data, and politics. We cannot just move everything to the blockchain; we should proceed step by step.” Was blockchain ahead of its time for government customers?

Or was it a “technological genie”?

## Exhibit 1 How Blockchain Works

Five basic principles underlying the technology.

1. **Distributed Database.** Each party on a blockchain has access to the entire database and its complete history. No single party controls the data or the information. Every party can verify the records of its transaction partners directly, without an intermediary.
2. **Peer-to-Peer Transmission.** Communication occurs directly between peers instead of through a central node. Each node stores and forwards information to all other nodes.
3. **Transparency with Pseudonymity.** Every transaction and its associated value are visible to anyone with access to the system. Each node, or user, on a blockchain has a unique 30-plus-character alphanumeric address that identifies it. Users can choose to remain anonymous or provide proof of their identity to others. Transactions occur between blockchain addresses.
4. **Irreversibility of Records.** Once a transaction is entered in the database and the accounts are updated, the records cannot be altered, because they're linked to every transaction record that came before them (hence the term "chain"). Various computational algorithms and approaches are deployed to ensure that the recording on the database is permanent, chronologically ordered, and available to all others on the network.
5. **Computational Logic.** The digital nature of the ledger means that blockchain transactions can be tied to computational logic and in essence programmed. So users can set up algorithms and rules that automatically trigger transactions between nodes.

Source: Marco Iansiti and Karim Lakhani, "The Truth About Blockchain," *Harvard Business Review* (Vol. 95, no. 1), pp. 118-127.

## Exhibit 2 The Hash Function in Mining

### a) The Hash Function and the Secure Hash Algorithm (SHA)-256

**A hash function** is a function that allows mapping data of arbitrary size to data of fixed size, usually a string of numbers and/or letters. Hash function could be cryptographic, and thus generate a hash that does not allow reconstructing the input data if the latter is unknown.

Designed by the United States National Security Agency, the SHA-256 is a cryptographic hash function, which can be used as a unique fingerprint for a text or a data file as it generates an almost-unique, fixed size 256-bit (32-byte) hash of 64 characters long, and which cannot be reversed.

**SHA-256 hash** example:

7f83b1657ff1fc53b92dc18148a1d65dfc2d4b1fa3d677284addd200126d9069

**The hash rate** measures how powerful a miner's machine is as it measures the number of times a hash function can be computed per second. Some machines can compute trillions of hashes every second. The miner's expected profit is directly proportional to the hash rate.

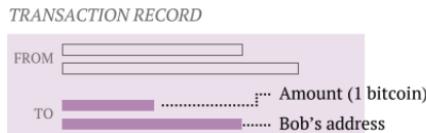
Source: Developed by casewriters from Ritchie S. King, "By Reading This Article You Are Mining Bitcoins," Qz.com, December 13, 2013 at <https://qz.com/154877/by-reading-this-page-you-are-mining-bitcoins/>; "What Does Bitcoin Has Rate Mean," posts on blog Quora.com <https://www.quora.com/What-does-Bitcoin-hash-rate-mean>, accessed October 2017.

## b) An Example of a Bitcoin Transaction Hash

When Alice clicks a button to send the money to Bob, the transfer is encoded in a chunk of text that includes the amount and Bob's address. Here's what that text actually look like:

```
Input:  
Previous tx: f5d8ee39a430901c91a5917b9f2dc19d6dia0e9cea205b009ca73dd04470b9a6  
Index: 0  
scriptSig: 304502206e21798a42fae0e854281abd38bacd1aeed3ee3738d9e1446618c4571d10  
90db022100e2ac980643b0b82c0e88fffdfecc6b64e3e6ba35e7ba5fdd7d5d6cc8d25c6b241501  
  
Output:  
Value: 5000000000  
scriptPubKey: OP_DUP OP_HASH160 404371705fa9bd789a2fed52d2c580b65d35549d  
OP_EQUALVERIFY OP_CHECKSIG
```

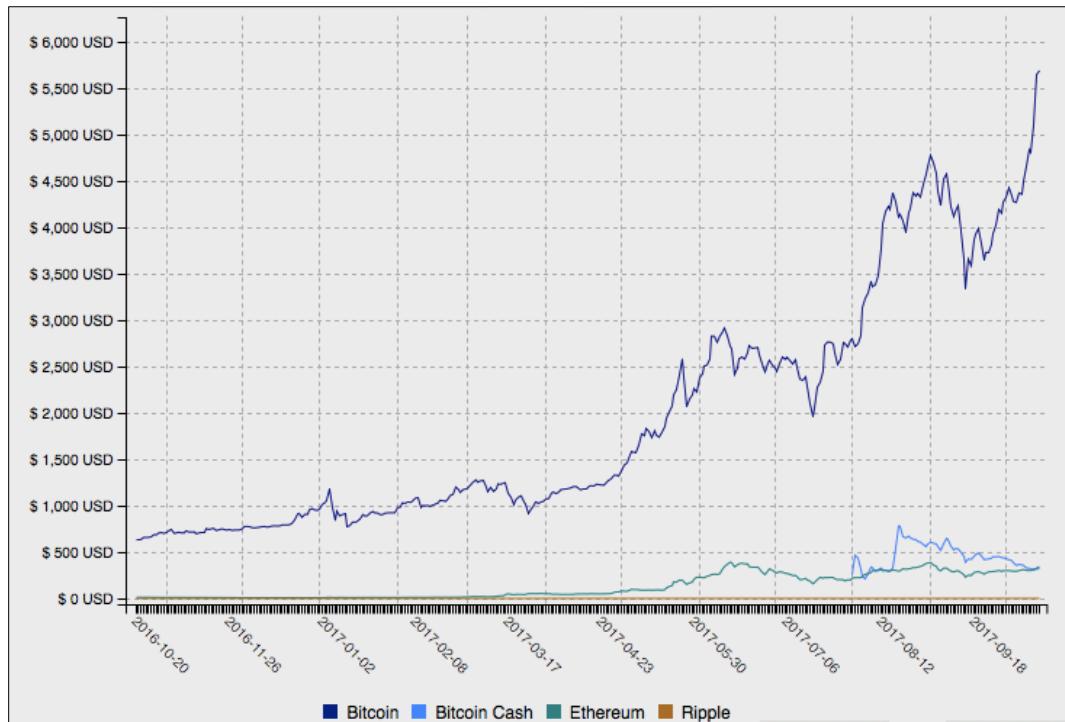
And here's a more digestible diagram of it:



That transaction record is sent to every bitcoin miner—i.e., every computer on the internet that is running mining software—and if it's legit, it gets added to the ledger. Let's assume it goes through.

Source: Ritchie S. King, "By Reading This Article You Are Mining Bitcoins," Qz.com, December 13, 2013 at <https://qz.com/154877/by-reading-this-page-you-are-mining-bitcoins>, accessed October 2017.

**Exhibit 3** Bitcoin (BTC) Price History alongside Ethereum, Ripple, and Bitcoin Cash



Source: "Cryptocurrency Chart," website [cryptocurrencychart.com](http://www.cryptocurrencychart.com/top/10), at <http://www.cryptocurrencychart.com/top/10>, accessed October 14, 2017.

**Exhibit 4** The Blockchain Market, October 10, 2017

Cryptocurrency	Market Cap (\$bn)	Price (\$)	Circulating Supply (n. units)	Volume (24h)
Bitcoin	80.46	4,842.71	16,615,175	\$2,103,520,000
Ethereum	28.85	303.58	93,039,766	\$556,457,000
Ripple	9.71	0.25	38,600,451,446	\$527,776,000
Bitcoin Cash	5.36	321.40	16,679,500	\$414,864,000
Litecoin	2.70	50.77	53,312,282	\$150,640,000
Dash	2.18	287.24	7,612,871	\$47,184,900
NEM	1.94	0.21	8,999,999,999	\$6,385,080
NEO	1.48	29.76	50,000,000	\$86,001,700
IOTA	1.34	0.48	2,779,530,283	\$18,439,900

Source: Developed by casewriters from "Cryptocurrency Market Capitalization," website [coinmarketcap.com](https://coinmarketcap.com/), <https://coinmarketcap.com/>, accessed October 2017.

Note: Data as of October 10, at 3:30pm.

**Exhibit 5** History of the Internet and Internet Services (abbreviated)

<b>Abbreviated Internet Timeline</b>	<b>Internet Company Founding Dates</b>
<b>1969:</b> ARPANET utilizes “packet switching”	<b>1985:</b> AOL
<b>1974:</b> TCP/IP Invented	<b>1994:</b> Amazon
<b>1979:</b> Usenet	<b>1995:</b> eBay
<b>1983:</b> ARPANET to TCP/IP transition	<b>1995:</b> Hotmail
<b>1984:</b> Domain Name System	<b>1996:</b> Expedia
<b>1988:</b> Internet Relay Chat	<b>1997:</b> Netflix
<b>1989:</b> AOL Launched/WWW proposal	<b>1998:</b> Google
<b>1990:</b> First commercial dial-up ISP	<b>1998:</b> PayPal
<b>1990:</b> WWW Protocols finished	<b>1999:</b> Napster
<b>1991:</b> First web page created	<b>2000:</b> Trip Advisor
<b>1991:</b> MP3 Standard	<b>2001:</b> Wikipedia
<b>1993:</b> Mosaic—first graphical web browser	<b>2001:</b> iTunes
<b>1994:</b> Netscape Navigator	<b>2002:</b> LinkedIn
<b>1995:</b> Commercialization of the internet (SSL)	<b>2004:</b> Facebook
<b>1996:</b> Hotmail—first webmail	<b>2005:</b> YouTube
<b>1998:</b> Google search engine	<b>2006:</b> Twitter
<b>1998:</b> Internet Protocol version 6	<b>2007:</b> Dropbox
<b>2000:</b> Dot-com bubble burst	<b>2007:</b> Hulu
<b>2004:</b> Web 2.0	<b>2008:</b> Uber
<b>2007:</b> iPhones and the mobile web	<b>2008:</b> Airbnb
<b>2009:</b> ICANN policy changes	<b>2008:</b> Groupon
	<b>2009:</b> Kickstarter
	<b>2010:</b> Instagram
	<b>2010:</b> Snapchat
	<b>2011:</b> Coursera

Source: Abbreviated Internet Timeline compiled and adapted by Rhys Sevier, Baker Research Services, from: Brief History of the Internet <https://www.internetsociety.org/internet/history-internet/brief-history-internet/>, accessed 11/28/2017; Internet History Timeline: ARPANET to the WWW, <https://www.livescience.com/20727-internet-history.html>, accessed 11/28/2017; The History of the Internet in a Nutshell, <https://www.webpagefx.com/blog/web-design/the-history-of-the-internet-in-a-nutshell/>; accessed on 11/28/2017. Internet Company Founding Dates compiled by Kathleen Ryan, Baker Research Services, from: Standard & Poor's Capital IQ, accessed 11/28/2017; Gale International Directory of Company Histories, accessed 11/28/2017; Encyclopedia of Social Networks. Ed. George A. Barnett. Vol. 2. Thousand Oaks, CA: SAGE Reference, 2011. pp. 946-948.

## Exhibit 6 Examples of Blockchain Applications

**Land Use**—Ownership and history of property currently requires the investigation of many different document sources such as Grantor-Grantee index, Land Records or Deed Records. The goal is to find any records related to property liens, easements, covenants, conditions and restrictions, agreements, resolutions and ordinances. This a time consuming and laborious process, in which important information can be missed. Several states were testing blockchain.

**Identity**—In 2013, almost 40 million “travel” documents were reported as lost or stolen since 2002, according to Interpol. Dubai is working on a digital passport with a London-based company called ObjectTech. The digital passport is based on Blockchain.

**Global Logistics and Shipping**—The second largest port in Europe, Belgium-based Port of Antwerp, announced a blockchain pilot to automate and streamline the port’s container logistics operations. Moving containers from point to point often involves more than 30 different parties, including carriers, terminals, forwarders, haulers, drivers, and shippers. This process results in hundreds of interactions between those parties, conducted through a mix of e-mail, phone and fax.

**Automotive**—German automaker Daimler AG has issued a corporate bond worth €100 million as part of a Blockchain pilot project. “According to Daimler, the entire transaction cycle—from origination, distribution, allocation and execution of the loan agreement, to the confirmation of repayment and of interest payments—was automated digitally through the blockchain network.”

**Aviation**—Accenture was currently studying how to use blockchain to track engine parts.

**Manufacturing**—Blockchain could be used to identify products instead of using QR and bar codes, which can be copied. According to the Organization for Economic Co-Operation and Development (OECD), the imports of counterfeit and pirated goods are worth nearly half a trillion dollars a year, or around 2.5% of global imports.

**Prescription Drugs**—The U.S. Center for Medicine in the Public Interest estimates that the worldwide sales of counterfeit medicines would top US\$ 75 billion in 2017, a 90% rise in five years. A San Francisco-based startup called Chronicled has launched a ‘track and trace’ pilot using blockchain to build a system to identify and track prescription drugs distributed in the United States.

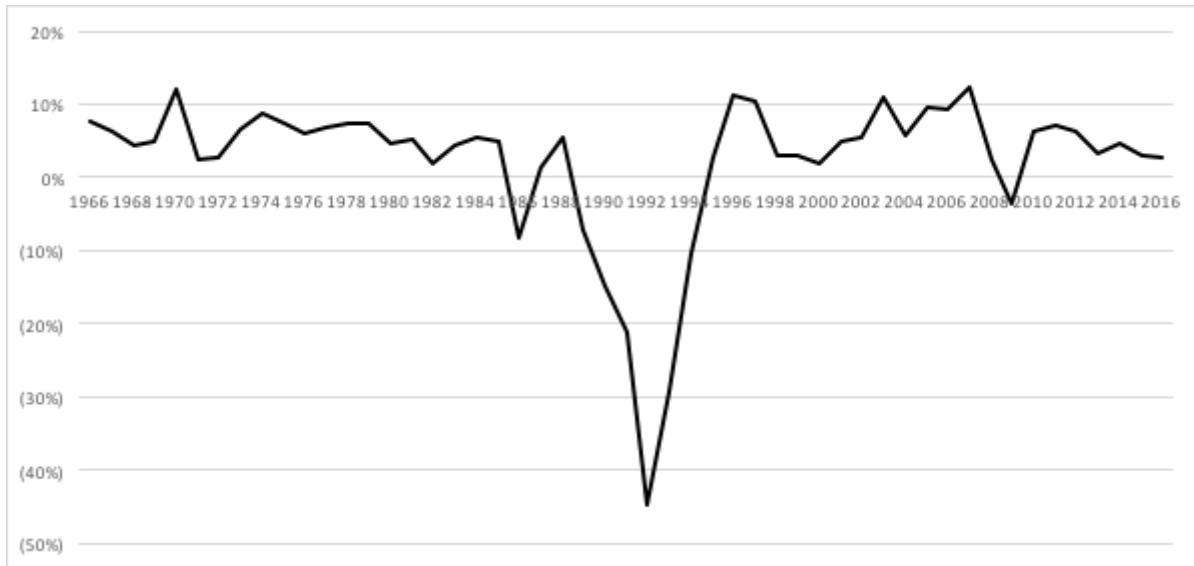
**Finance**—Visa has a blockchain effort called “Visa B2B Connect” partnering with blockchain infrastructure company Chain to optimize near real-time funds transfer system for high value bank-to-bank and corporate payments. The payment solutions company Ripple works with banks to optimize how they send money around the world using blockchain. IBM Global Finance works on one of the largest blockchain implementations.

**Government**—The US Navy’s Naval Innovation Advisory Council (NIAC) will test blockchain in their 3D printing, to securely transfer data during the manufacturing process.

**Banking**—According to an Accenture survey, “Nine in ten executives said their bank is currently exploring the use of Blockchain.” Some of the focus is on transforming payments at scale and reducing the risk of failure.

**Blockchain as a Service**—Several enterprise software vendors have announced Blockchain as a service offering in which customers can leverage blockchain in a cloud environment.

Source: Adapted by casewriters from Vala Afshar, “Blockchain Will Disrupt Every Industry,” Huffingtonpost.com, October 7, 2017, [http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry\\_us\\_5963868ce4b08f5c97d06b55](http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry_us_5963868ce4b08f5c97d06b55), accessed October 2017.

**Exhibit 7** Georgia's GDP Growth Rate, 1966–2016


Source : The World Bank database, at <https://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG?end=2014&locations=GE&start=1960&view=chart> accessed October 2017.

**Exhibit 8** Georgia's World Bank Doing Business Index Data, 2017

Economy	Ease of Doing Business	Dealing with				Protecting			Trading		
		Starting a Business	Construction Permits	Getting Electricity	Registering Property	Getting Credit	Minority Investors	Paying Taxes	across Borders	Enforcing Contracts	Resolving Insolvency
New Zealand	1	1	1	34	1	1	1	11	55	13	34
Singapore	2	6	10	10	19	20	1	8	41	2	29
Denmark	3	24	6	14	12	32	19	7	1	24	8
Hong Kong SAR, China	4	3	5	3	61	20	3	3	42	21	28
Korea, Rep.	5	11	31	1	39	44	13	23	32	1	4
Norway	6	21	43	12	14	75	9	26	22	4	6
United Kingdom	7	16	17	17	47	20	6	10	28	31	13
United States	8	51	39	36	36	2	41	36	35	20	5
Sweden	9	15	25	6	10	75	19	28	18	22	19
Macedonia, FYR	10	4	11	29	48	16	13	9	27	36	32
Taiwan, China	11	19	3	2	17	62	22	30	68	14	22
Estonia	12	14	9	38	6	32	53	21	17	11	42
Finland	13	28	40	18	20	44	70	13	33	30	1
Latvia	14	22	23	42	23	7	42	15	25	23	44
Australia	15	7	2	41	45	5	63	25	91	3	21
Georgia	16	8	8	39	3	7	7	22	54	16	106
Germany	17	114	12	5	79	32	53	48	38	17	3
Ireland	18	10	38	33	41	32	13	5	47	90	17
Austria	19	111	49	20	30	62	32	42	1	10	20
Iceland	20	34	70	9	15	62	22	29	66	32	14

Source: World Bank Group, "Doing Business Rankings," at <http://www.doingbusiness.org/rankings>, accessed October 2017.

**Exhibit 9** Georgia's Houses of Justice—The Tbilisi House of Justice, 2017

Source: Casewriters.

**Exhibit 10** The Hyperledger Fabric

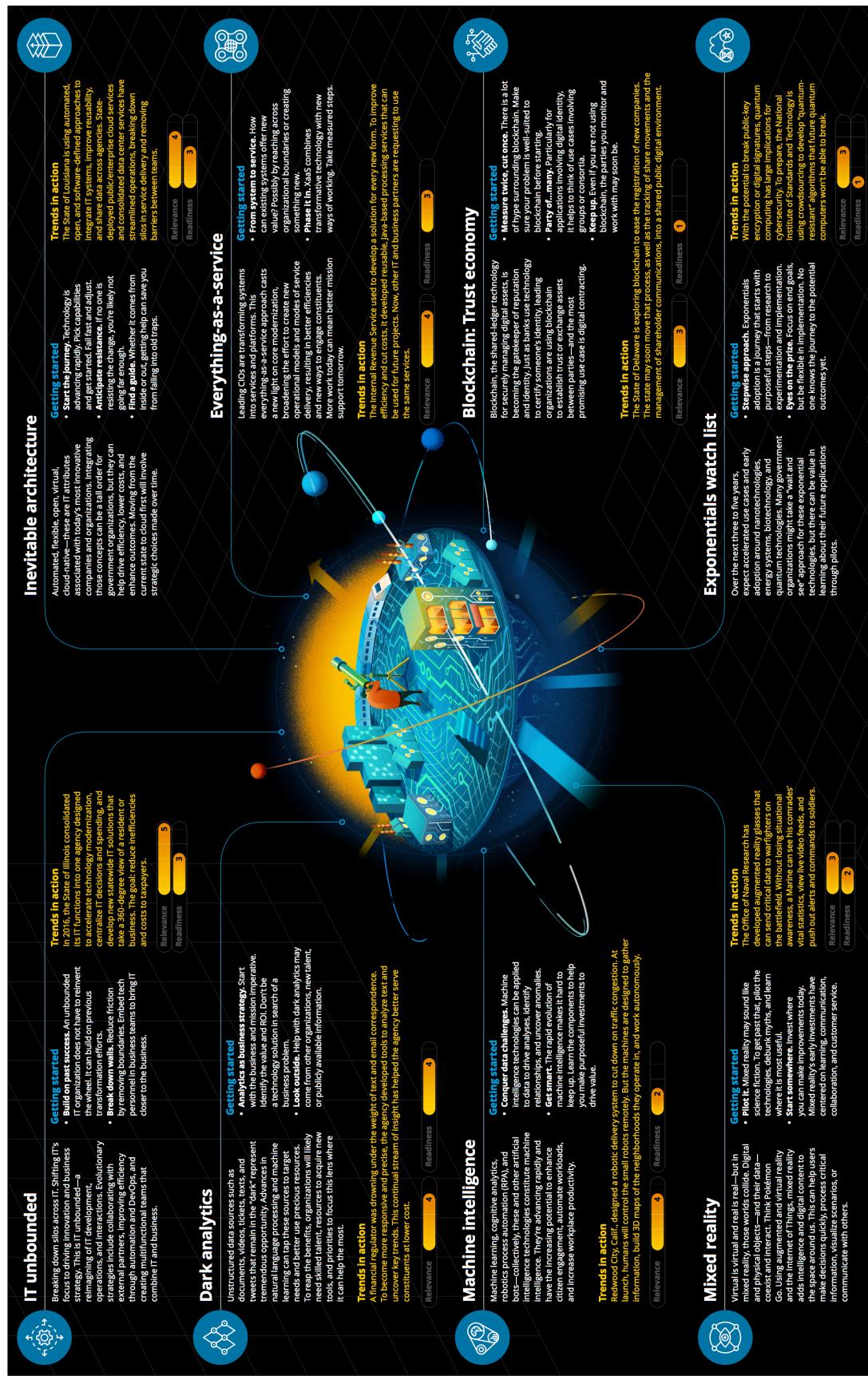
The Linux Foundation founded Hyperledger in 2015 to advance cross-industry blockchain technologies. Rather than declaring a single blockchain standard, it encourages a collaborative approach to developing blockchain technologies via a community process, with intellectual property rights that encourage open development and the adoption of key standards over time.

Hyperledger Fabric is one of the blockchain projects within Hyperledger. Like other blockchain technologies, it has a ledger, uses smart contracts, and is a system by which participants manage their transactions. Where Hyperledger Fabric breaks from some other blockchain systems is that it is private and permissioned. Rather than an open permissionless system that allows unknown identities to participate in the network (requiring protocols like Proof of Work to validate transactions and secure the network), the members of a Hyperledger Fabric network enroll through a Membership Service Provider (MSP).

Hyperledger Fabric also offers several pluggable options. Ledger data can be stored in multiple formats, consensus mechanisms can be switched in and out, and different MSPs are supported. Hyperledger Fabric also offers the ability to create channels, allowing a group of participants to create a separate ledger of transactions. This is an especially important option for networks where some participants might be competitors and not want every transaction they make—a special price they're offering to some participants and not others, for example—known to every participant. If two participants form a channel, then those participants—and no others—have copies of the ledger for that channel.

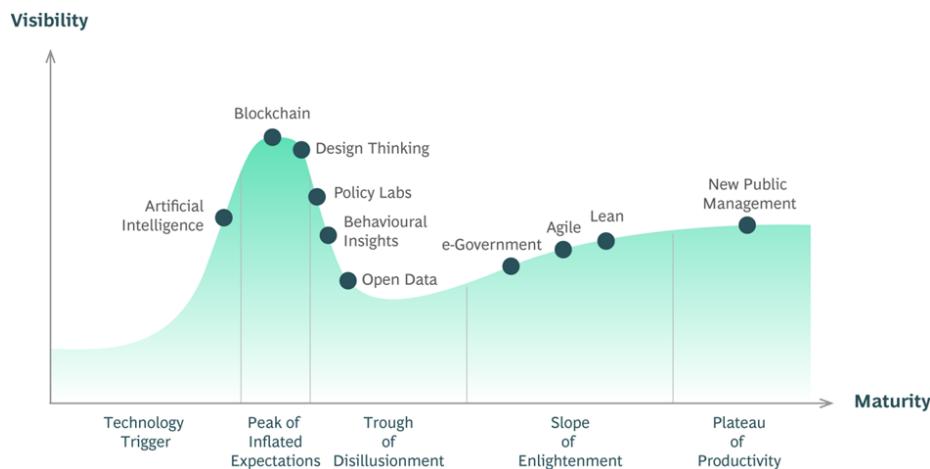
Source: "What is Hyperledger Fabric ?" post on blog Hyperledger-fabric, at <https://hyperledger-fabric.readthedocs.io/en/latest/blockchain.html#what-is-hyperledger-fabric>, accessed October 2017.

## Exhibit 11 Technology Trends in Governments, 2017



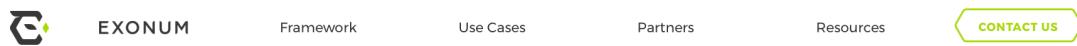
Source: Scott Buchholz, Sanjay Shah, *Tech Trends 2017: A Government Perspective* (New York: Deloitte Consulting LLP, 2017), p. 2, at <https://www2.deloitte.com/us/en/pages/public-sector/articles/government-tech-trends.html>, accessed October 2017.

### Exhibit 12 "The Government Innovation Hype Cycle"



Source: Danny Buerkli, "10 Government Innovations and Their Place in the Hype Cycle," Centre for Public Impact, May 30, 2016, at <https://www.centreforpublicimpact.org/10-government-innovations-and-their-place-in-the-hype-cycle/> accessed December 2017.

### Exhibit 13 Bitfury's Exonum Website



#### IN A NUTSHELL

### Exonum is an extensible framework for blockchain projects

Exonum gives you a beneficial opportunity to build decentralized, secure and reliable applications. It is designed to allow you, your company or your government to build a tailor-cut private or permissioned blockchain that solves your challenges and enjoys the unmatched security of the Bitcoin Blockchain.

Exonum brings **all the advantages of a true blockchain** — auditability, transparency, and unparalleled security — and combines them with privacy, efficiency and controllability.



Your next step to blockchain is here. And it is called Exonum.

Source: Company data.

**Exhibit 14a Bitfury's Product Offerings**

Type	Product Name	Description
<b>Software</b>	Blockchain Analytics	An intelligent platform for blockchain analysis that utilizes complex machine learning and data mining tools. Applications include intelligent address clustering, transaction risk scoring, "disentangling" bitcoin mixers, and more.
	Exonum	Exonum is an extensible open-source framework for creating blockchain applications. Exonum can be used to create cryptographically powered distributed ledgers in virtually any problem domain, including FinTech, GovTech, and LegalTech. The Exonum framework is oriented towards creating permissioned blockchains, that is, blockchains with the known set of blockchain infrastructure providers.
	Lightning Network	Bitfury is contributing to the development of Lightning, a peer-to-peer network of payment channels built on top of the public Blockchain that can facilitate fast, secure and cheap transactions. It allows micro-transactions and transaction streams (as small as \$0.01 USD). In August 2017, the Lightning Network became compatible with seven different payment networks.
	Chain Hub	One-stop, custom-designed web portal will host all necessary information about the public Blockchain for all audiences. Beginners can use Chain Hub to learn more about the public Blockchain and its potential uses, while experts, investors and businesses can use Chain Hub to find news summaries, blockchain statistics and other key performance-enhancing information.
	Property Rights Registry	Uses blockchain technology and distributed timestamping services to build audit infrastructure on top of existing public registries for property rights registration. This project allows for independent audits of smart contracts as well as decentralized identity management. It also has the potential to streamline the entire public registry process and allow for ongoing maintenance through digital channels.
<b>Hardware</b>	Mining chips	Since 2016, Bitfury has been mass-producing its custom 16nm Application Specific Integrated Circuit (ASIC) chip and selling the chip directly to consumers. The chip has a particularly low power performance. BitFury partnered with GUC, a Taiwanese ASIC design service company, to design the 16nm chip. These chips can be bought even by smaller miners who would also have access to the newest, most efficient, and cutting-edge chips developed by the large chip manufacturers
	BlockBox AC	An Air Cooled Mobile Datacenter developed for Bitcoin mining. It has the scale of a full-size data center (petahash-scale), allowing for easy access to the Bitcoin network. One of the most powerful and cost-efficient Bitcoin mining units available on the market, with up to 7.5PH/s of compute power served through Bitfury's unique 16nm ASIC. A complete, self-contained bitcoin mining solution, housed with Bitfury's innovative air cooling systems in a 40-foot marine container. Custom built, installed and managed 24/7 by our expert engineering team. Easy and swift set-up.

Source: Company data.

**Exhibit 14b** Bitfury's Hardware Details: The 16nm ASIC Chip

Welcome to the future of mining.

Bitfury custom-designed our new 16nm SHA256 ASIC for even more effective Bitcoin mining. Boasting 8162 hash cores on a single die, it is one of the best solutions available to miners.

Source: Company data.

**Exhibit 14c** Bitfury's Hardware Details: BlackBox AC**BlockBox AC – Air Cooled Mobile Datacenter**

The BlockBox AC is one of the first mobile Bitcoin mining units that has the scale of a full-size data center, allowing for easy access to the Bitcoin network. For the first time, Bitcoin mining can be readily purchased at petahash-scale.

Source: Company data.

## Endnotes

<sup>1</sup> Timothy B. Lee, "Five Years of Bitcoin in one Post," January 4, 2014, post on blog The Washington Post at [https://www.washingtonpost.com/news/the-switch/wp/2014/01/03/five-years-of-bitcoin-in-one-post/?utm\\_term=.1391f1ed76fe](https://www.washingtonpost.com/news/the-switch/wp/2014/01/03/five-years-of-bitcoin-in-one-post/?utm_term=.1391f1ed76fe), accessed October 2017.

<sup>2</sup> In reality, the blockchain was "centralized" at the very beginning as it was supported only by Nakamoto, but he rapidly opened it up to other members.

<sup>3</sup> "Bitcoin Avg. Transaction fee," website bitinfocharts.com, at <https://bitinfocharts.com/comparison/bitcoin-transactionfees.html#3m>, accessed October 2017.

<sup>4</sup> Beckey Peterson, "Forget Stealing Data : These Hackers Hijacked Amazon Cloud Accounts to Mine Bitcoin," Business Insider, October 8, 2017, at <http://www.businessinsider.fr/us/hackers-broke-into-amazon-cloud-to-mine-bitcoin-2017-10/> and Ameer Rosic, "What is Bitcoin Mining? A Step-by-Step Guide," Huffingtonpost, December 21, 2016, at [https://www.huffingtonpost.com/ameer-rosic/\\_what-is-bitcoin-mining-a\\_b\\_13764842.html](https://www.huffingtonpost.com/ameer-rosic/_what-is-bitcoin-mining-a_b_13764842.html); and Bitinfocharts website at <https://bitinfocharts.com/#>, all accessed October 2017.

<sup>5</sup> Ritchie S. King, "By Reading This Article You Are Mining Bitcoins," Qz.com, December 13, 2013 at <https://qz.com/154877/by-reading-this-page-you-are-mining-bitcoins>, accessed October 2017.

<sup>6</sup> "The Cost of Hacking the Bitcoin Network," October 2, 2017, post on block cybertrust, <https://medium.com/cybertrustbank/the-cost-of-hacking-the-bitcoin-network-8172f41d1620>, accessed October 2017.

<sup>7</sup> John Biggs, "Blockchain Smashers," Techcrunch.com, October 16, 2013, at <https://techcrunch.com/2013/10/16/blockchain-smashers/>, accessed October 2017.

<sup>8</sup> Rob Price, "Someone in 2010 bought 2 pizzas with 10,000 bitcoins – which today would be worth \$20 million," Businessinsider.com, May 22, 2017, at <http://uk.businessinsider.com/bitcoin-pizza-day-passes-2000-20-million-2017-5>, accessed October 2017.

<sup>9</sup> Marco Santori, "Silk Road Goes Dark: Bitcoin Survives Its Biggest Market's Demise," coindesk.com, May 5, 2017, <https://www.coindesk.com/ bitcoin-milestones-silk-road-goes-dark-bitcoin-survives-its-biggest-markets-demise/>, accessed October 2017.

<sup>10</sup> International Finance Corporation (IFC), "Blockchain in Development, Part I, A New Mechanism of Trust?," *EMCompass*, July 2017 (Note 40), at <https://www.ifc.org/wps/wcm/connect/6e79f6c3-dac6-4e94-8cea-2bb21185df92/EMCompass+Note+40+Blockchain+Part+I.pdf?MOD=AJPERES>, accessed October 2017.

<sup>11</sup> Marco Santori, "Silk Road Goes Dark: Bitcoin Survives Its Biggest Market's Demise," coindesk.com, May 5, 2017, <https://www.coindesk.com/ bitcoin-milestones-silk-road-goes-dark-bitcoin-survives-its-biggest-markets-demise/>, accessed October 2017.

<sup>12</sup> "Cryptocurrency Market Capitalizations," website Coinmarketcap.com, at <https://coinmarketcap.com/currencies/ bitcoin/>, accessed October 2017.

<sup>13</sup> Marco Santori, "Silk Road Goes Dark: Bitcoin Survives Its Biggest Market's Demise," coindesk.com, May 5, 2017, <https://www.coindesk.com/ bitcoin-milestones-silk-road-goes-dark-bitcoin-survives-its-biggest-markets-demise/>, accessed October 2017.

<sup>14</sup> "Governments May Be Big Backers of the Blockchain," *The Economist*, June 1, 2017, at <http://www.economist.com/news/business/21722869-anti-establishment-technology-faces-ironic-turn-fortune-governments-may-be-big-backers>, accessed October 2017.

<sup>15</sup> Guy Brandon, "Can the Blockchain Scale?" February 13, 2017, post on blog due.com, <https://due.com/blog/can-the-blockchain-scale/>, accessed October 2017.

<sup>16</sup> Luke Lombe, "There's More To Gain From Blockchain Than Just A Bit Of Coin," Huffingtonpost.com, September 7, 2017, at [http://www.huffingtonpost.com.au/luke-lombe/theres-more-to-gain-from-blockchain-than-just-a-bit-of-coin\\_a\\_23198273/](http://www.huffingtonpost.com.au/luke-lombe/theres-more-to-gain-from-blockchain-than-just-a-bit-of-coin_a_23198273/), accessed October 2017.

<sup>17</sup> "Ethereum Price," Ethereumprice webpage, at <https://ethereumprice.org/>; "Cryptocurrencies Market Capitalization;" coinmarketcap web page, at <https://coinmarketcap.com/currencies/ bitcoin/>, both accessed October 2017.

- <sup>18</sup> Lulu Yun Chen and EricLam, "Bitcoin Is Likely to Split Again in November, Say Major Players," Bloomberg.com, September 20, 2017, at <https://www.bloomberg.com/news/articles/2017-09-20/-bitcoin-jesus-ver-sees-the-digital-currency-splitting-again>, accessed October 2017.
- <sup>19</sup> "Two Weeks Later, Bitcoin Is Forking Again," Extremetech.com, August 17, 2017, at <https://www.extremetech.com/internet/254280-two-weeks-later-bitcoin-forking>, accessed October 2017.
- <sup>20</sup> FrankChaparro, "Bitcoin Splits in 2," Businessinsider.fr, August 1, 2017, at <http://www.businessinsider.fr/us/bitcoin-price-fork-happens-2017-8/>, accessed October 2017.
- <sup>21</sup> "BitFury Becomes Desperate and Threatens to Sue Bitcoin Developers," Themerkle.com, March 19, 2017, <https://themerkle.com/bitfury-becomes-desperate-and-threatens-to-sue-bitcoin-developers/>, accessed October 2017.
- <sup>22</sup> "Cryptocurrency Market Capitalizations," website coinmarketcap.com, at <https://coinmarketcap.com/all/views/all/>.
- <sup>23</sup> Marco Iansiti, Karim R. Lakhani, "The Truth about Blockchain," *Harvard Business Review*, January–February 2017, at <https://hbr.org/2017/01/the-truth-about-blockchain>.
- <sup>24</sup> Cryptocurrency Chart website at <http://www.cryptocurrencychart.com/top/10>, accessed October 2017.
- <sup>25</sup> Bitinfocharts.com website at <https://bitinfocharts.com/#>.
- <sup>26</sup> "Public Versus Private Blockchains, Part II," Bitfury White Paper, October 20, 2015, at <http://bitfury.com/content/5-white-papers-research/public-vs-private-pt2-1.pdf>, accessed October 2017.
- <sup>27</sup> "How Does Cloud Mining Bitcoin Work?" website coindesk.com, at <https://www.coindesk.com/information/cloud-mining-bitcoin-guide/>, accessed October 2017.
- <sup>28</sup> Alyssa Herting, "Lightning's NextAct: Decentralizing Bitocin Mining?" Coindesk.com, September 8, 2017, at <https://www.coindesk.com/hub-and-spoke-could-bitcoins-lightning-network-decentralize-mining/>, accessed October 2017.
- <sup>29</sup> "Bitfury Lightning Network Algorithm Successfully Tested," post on blog Medium by Bitfury Group, at <https://medium.com/@BitFuryGroup/bitfury-lightning-network-algorithm-successfully-tested-935fd43e92b>.
- <sup>30</sup> Don Tapscott and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin Is Changing Money, Business, and the World* (New York: Portfolio/Penguin, 2016).
- <sup>31</sup> Marco Iansiti and Karim R. Lakhani, "The Truth about Blockchain," *Harvard Business Review*, January–February 2017, at <https://hbr.org/2017/01/the-truth-about-blockchain>, accessed October 2017.
- <sup>32</sup> Vala Afshar, "Blockchain Will Disrupt Every Industry," Huffingtonpost.com, October 7, 2017, [http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry\\_us\\_5963868ce4b08f5c97d06b55](http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry_us_5963868ce4b08f5c97d06b55), accessed October 2017.
- <sup>33</sup> Don Tapscott and Alex Tapscott, *Blockchain Revolution: How the Technology behind Bitcoin Is Changing Money, Business, And the World* (New York: Portfolio/Penguin, 2016).
- <sup>34</sup> "Global Ledger: Mapping Bitcoin & Blockchain Startups Around The World," CBInsights.com, March 6, 2017, <https://www.cbinsights.com/research/bitcoin-blockchain-startup-global-map/>, accessed October 2017.
- <sup>35</sup> Jeffrey Bussgang, "The Summer of ICO's" August 29, 2017 post on blog Medium, <https://medium.com/startup-grind/the-summer-of-icos-vc-implications-ead720e8efdd>, accessed October 2017.
- <sup>36</sup> "Comparison Transaction Fees," website Bitinfocharts.com, at <https://bitinfocharts.com/comparison/transactionfees-btc-eth.html>; Luke Lombe, "There's More To Gain From Blockchain Than Just A Bit Of Coin," Huffingtonpost.com, September 7, 2017, [http://www.huffingtonpost.com.au/luke-lombe/theres-more-to-gain-from-blockchain-than-just-a-bit-of-coin\\_a\\_23198273/](http://www.huffingtonpost.com.au/luke-lombe/theres-more-to-gain-from-blockchain-than-just-a-bit-of-coin_a_23198273/).
- <sup>37</sup> "What Are Blockchain's Issues and Limitations?" website coindesk.com, at <https://www.coindesk.com/information/blockchains-issues-limitations/>, accessed October 2017.
- <sup>38</sup> "Jamie Dimon Thinks Bitcoin Is a 'Fraud,' But It Can Still Hit \$100K," Fortune.com, September 12, 2017, at <http://fortune.com/2017/09/12/jamie-dimon-bitcoin-cryptocurrency-fraud-buy/>, accessed October 2017.

<sup>39</sup> Pete Rizzo, "Bitcoin Mining Giant BitFury Announces \$20 Million Funding Round," Coindesk.com, May 30, 2014, at <https://www.coindesk.com/bitcoin-mining-giant-bitfury-announces-20-million-funding-round/>, accessed October 2017.

<sup>40</sup> Bitfury Center Construction Time Scape Video," January 14, 2015, post on youtube.com, <https://www.youtube.com/watch?v=G3xRNmpty6s>; "BitFury Raises \$20 Million to Power New ASIC Chip Development," Coindesk.com, October 9, 2014, <https://www.coindesk.com/bitfury-raises-20-million-asic-development-mining-output/>.

<sup>41</sup> Pete Rizzo, "BitFury Raises \$20 Million to Power New ASIC Chip Development," Coindesk.com, October 9, 2014, <https://www.coindesk.com/bitfury-raises-20-million-asic-development-mining-output/>.

<sup>42</sup> Nino Bakradze, "Georgia Is Low Cost Home for Bitfury," Ifact.ge, December 22, 2016, <http://ifact.ge/en/bitfury/>, accessed October 2017.

<sup>43</sup> Nino Bakradze, "Georgia Is Low Cost Home for Bitfury," Ifact.ge, December 22, 2016, <http://ifact.ge/en/bitfury/>, <http://ifact.ge/en/bitfury/>, accessed October 2017.

<sup>44</sup> Michael del Castillo, "Think Bitcoin is Small Business? Bitfury Is Making Almost \$100 million Annulaly," coindesk.com, July 24, 2017, <https://www.coindesk.com/think-bitcoin-small-business-bitfury-making-almost-100-million-annually/>, accessed October 2017.

<sup>45</sup> Michael del Castillo, "Think Bitcoin is Small Business? Bitfury Is Making Almost \$100 million Annulaly," coindesk.com, July 24, 2017, <https://www.coindesk.com/think-bitcoin-small-business-bitfury-making-almost-100-million-annually/>, accessed October 2017.

<sup>46</sup> Liaquat Ali Khan, "Georgia – A Wounded Nation Seeking Self-Definition," Huffingtonpost.com, at [https://www.huffingtonpost.com/liaquat-ali-khan/georgia-a-wounded-nation-\\_b\\_3631821.html](https://www.huffingtonpost.com/liaquat-ali-khan/georgia-a-wounded-nation-_b_3631821.html), accessed October 2017.

<sup>47</sup> "Georgia: History," Lonely Planet website, <https://www.lonelyplanet.com/georgia/history> <https://www.newyorker.com/magazine/2008/12/15/marching-through-georgia>, accessed October 2017.

<sup>48</sup> Wendell Steavenson, "Marching Through Georgia: Has Mikheil Saakashvili Overreached?" *New Yorker*, December 15, 2008, <https://www.newyorker.com/magazine/2008/12/15/marching-through-georgia>, accessed October 2017.

<sup>49</sup> Wendell Steavenson, "Marching Through Georgia: Has Mikheil Saakashvili Overreached?" *New Yorker*, December 15, 2008, <https://www.newyorker.com/magazine/2008/12/15/marching-through-georgia>, accessed October 2017.

<sup>50</sup> "Georgia Market Overview," post on blog export.gov, August 4, 2017, at <https://www.export.gov/apex/article?id=Georgia-Market-Overview>, accessed October 2017.

<sup>51</sup> Government of Georgia, "Social Economic Development Strategy of Georgia: Georgia 2020," at <https://www.adb.org/sites/default/files/linked-documents/cps-geo-2014-2018-sd-01.pdf>, accessed October 2017.

<sup>52</sup> David Egiashvili , "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>53</sup> David Egiashvili , "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>54</sup> *Doing Business Annual Report 2004* (Washington: World Bank, 2004) <http://www.doingbusiness.org/~media/WBG/DoingBusiness/Documents/Annual-Reports/English/DB04-FullReport.pdf>.

<sup>55</sup> "Functions," NAPRS website at <https://translate.google.fr/translate?hl=en&sl=ka&u=https://napr.gov.ge/&prev=search>, accessed October 2017.

<sup>56</sup> David Egiashvili, "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>57</sup> David Egiashvili, "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>58</sup> David Egiashvili, "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>59</sup> David Egiashvili, "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>60</sup> "Georgia: Registering Property," website doingbusiness.com, at <http://www.doingbusiness.org/data/exploreconomies/georgia#registering-property>, accessed October 2017.

<sup>61</sup> "Georgia: Registering Property," website doingbusiness.com, at <http://www.doingbusiness.org/data/exploreconomies/georgia#registering-property>, accessed October 2017.

<sup>62</sup> David Egiashvili, "LGAF: Georgia; The Best Practice Property Registry Reform," The World Bank, 2012 at [http://siteresources.worldbank.org/INTLGA/Resources/LGAF\\_Georgia\\_BestPractice\\_PropertyRegistryReform\\_Oct2012.pdf](http://siteresources.worldbank.org/INTLGA/Resources/LGAF_Georgia_BestPractice_PropertyRegistryReform_Oct2012.pdf), accessed October 2017.

<sup>63</sup> "Georgia: Registering Property," website doingbusiness.com, at <http://www.doingbusiness.org/data/exploreconomies/georgia#registering-property>, accessed October 2017.

<sup>64</sup> Laura Shin, "The First Government To Secure Land Titles On The Bitcoin Blockchain Expands Project," Forbes, February 7, 2017, at <https://www.forbes.com/sites/laurashin/2017/02/07/the-first-government-to-secure-land-titles-on-the-bitcoin-blockchain-expands-project/#15b261fe4dc4>, accessed October 2017.

<sup>65</sup> Laura Shin, "Republic Of Georgia To Pilot Land Titling On Blockchain With Economist Hernando De Soto, BitFury," Forbes.com, April 21, 2016, at <https://www.forbes.com/sites/laurashin/2016/04/21/republic-of-georgia-to-pilot-land-titling-on-blockchain-with-economist-hernando-de-soto-bitfury/#6c7f265e44da>, accessed October 2017.

<sup>66</sup> "Sweden Tests Blockchain Technology for Land Registry," Reuters, June 16, 2016, <https://www.reuters.com/article/us-sweden-blockchain/sweden-tests-blockchain-technology-for-land-registry-idUSKCN0Z22KV>; Vala Afshar, "Blockchain Will Disrupt Every Industry," Huffingtonpost.com, October 7, 2017, [http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry\\_us\\_5963868ce4b08f5c97d06b55](http://www.huffingtonpost.com/entry/blockchain-will-disrupt-every-industry_us_5963868ce4b08f5c97d06b55), accessed October 2017.

<sup>67</sup> Rick Holgate, David Furlonger, and Rick Howard, *Toolkit: Government Use Cases for Blockchain* (New York: Gartner, February 21, 2017).

<sup>68</sup> "Blockchain," website GSA.gov, at <https://www.gsa.gov/technology/government-it-initiatives/emerging-citizen-technology/blockchain>, accessed October 2017.

<sup>69</sup> Ron Miller, "IBM Unveils Blockchain as a Service Based on Open Source Hyperledger Fabric Technology," March 19, 2017 post on blog Techcrunch, <https://techcrunch.com/2017/03/19/ibm-unveils-blockchain-as-a-service-based-on-open-source-hyperledger-fabric-technology/>, accessed October 2017.

<sup>70</sup> James Condo, Williamh Sorrell, and Susan L. Donegan, "Blockchain Technology :Opportunities and Risks," Vermont, January 15, 2016, at <http://legislature.vermont.gov/assets/Legislative-Reports/blockchain-technology-report-final.pdf> and Stan Higgins, "Vermont Says Blockchain Record-Keeping System Too Costly," Coindesk.com, January 20, 2016, at <https://www.coindesk.com/report-blockchain-record-keeping-system-too-costly-for-vermont/>, all accessed October 2017.

<sup>71</sup> Rina Chardran, "Modernizing Land Records in Honduras Can Help Stem Violence, Says Analyst," Reuters, August 11, 2017, at <https://www.reuters.com/article/us-honduras-landrights-tech/modernizing-land-records-in-honduras-can-help-stem-violence-says-analyst-idUSKBN1AR151>, accessed October 2017.

<sup>72</sup> Rick Holgate, David Furlonger, and Rick Howard, *Toolkit: Government Use Cases for Blockchain* (New York: Gartner, February 21, 2017).

<sup>73</sup> Danny Buerkli, "10 Government Innovations and Their Place in the Hype Cycle," Huffingtonpost.com, May 18, 2016, at [https://www.huffingtonpost.com/danny-buerkli/10-government-innovations\\_b\\_10031858.html](https://www.huffingtonpost.com/danny-buerkli/10-government-innovations_b_10031858.html), accessed October 2017.