

1. Introduction

Financial technology, better known as fintech,² has gained prominence in recent years with the rise of bitcoin and blockchain technology. After years of being a rebel, in May 2017 it gained mainstream acceptance with R3's announcement that it had raised a record US\$107 million. Over 40 investors including technology and finance heavyweights like Intel, Bank of America Merrill Lynch, UBS, HSBC, and the Singapore government joined forces with R3 to develop 'block-chain-like' technology to be used by major banks.³

The investor consortium represented the largest group of global financial institutions working on commercial applications for the distributed ledger technology at the heart of blockchain. R3's success in getting its existing members (clients) to invest in the company was unique – particularly in the finance industry. The fact that some of them were blue-chip technology firms positioned R3 firmly at the confluence of technology and finance. R3 took pains to emphasize that the underlying technology was 'distributed ledger' rather than blockchain. Tim Swanson, Director of Market Research, explained the difference: "In simplest terms, a blockchain involves stringing together a chain of containers called blocks, which bundle transactions together like batch processing, whereas a distributed ledger like Corda does not, and instead validates each transaction (or agreement) individually."

2. Rise of Fintech

As the line between technology and finance became increasingly blurred, one area of fintech blockchain created a particular buzz, both for its scope and security. Martin Arnold wrote in the *Financial Times*: "Blockchains allow encrypted data on anything, from money to medical records, to be shared between many companies, people and institutions. This protects data from fraud while instantly updating all parties concerned."

Whenever blockchain was mentioned, the much-hyped bitcoin sprung to mind. The surge in bitcoin prices and the astronomical rise (and subsequent fall) in its value dominated media headlines.

2.1. Bitcoin

Bitcoin, first referred to in a white paper of 2008 by ‘Satoshi Nakamoto’ (a pseudonym), was the first application of blockchain technology. Although blockchain could be applied to various industries, it came to be almost synonymous with bitcoin as part of an innovative peer-to-peer electronic cash system enabling online payments to be transferred without an intermediary, also referred to as ‘cryptocurrency’. It was basically a way to bypass government currency controls and third-party payment processing intermediaries. To secure the transactions, blockchain provided the underlying technology, recording them in a public distributed ledger and creating a peer-to-peer network that was open, albeit anonymous.

2.2. Blockchain

The astronomical rise of bitcoin and other cryptocurrencies in 2017 raised public awareness of blockchain, but with numerous other applications (in finance, business, government) it clearly had much greater potential. Hailed as “Web 3.0”, blockchain technology formed the backbone of a new type of internet that allowed digital information to be distributed but not copied, and gave users the ability to create value and authenticate digital information.

The information in a blockchain is essentially a shared (and continually reconciled) database. Blockchain underpins a decentralized digital ledger – a secure, tamper-proof log of sensitive activity – where transactions are not stored in a single location but hosted by millions of computers simultaneously, accessible to anyone on the internet but safe from hackers.

Blockchain applications in banking and finance span numerous functions including international payments, transactions in capital markets and trade finance, regulatory compliance and auditing, protection from money laundering, and insurance.

2.3. Emergence of Fintech in Banking

Over the past decade, as the banking landscape became more competitive, banks faced increasing cost pressure on their products and service offerings. Traditionally, banks had controlled most end-to-end processing in-house, but the model started to change in response to regulatory pressure and a growing strategic focus on core products/services, such as customer identity checks.

Fintech entered a new phase, where incumbent financial institutions, start-ups and investors collaborated to address industry challenges and spearhead transformation. Banks and financial services firms turned to fintech as way to either continue a vertically-integrated model or move into a specialist role.

A study by Accenture and McLagan in January 2017⁴ reported that eight of the world’s ten biggest investment banks expected to implement blockchain, and estimated it could cut costs by up to 30%, saving between \$8bn and \$12bn. According to Richard Lumb, head of financial services at Accenture, “The first place we will see [blockchain] have an impact is clearing houses, such as

Deutsche Börse...Today [clearing and settlement] is managed through a myriad of messages and manual reconciliation.” He estimated that by using blockchain technology to restructure clearing and settlement, the biggest investment banks could save US\$10 billion.⁵

By 2017, fintech companies generally fell into two categories: (i) competitors to financial services companies, (ii) collaborators that provided solutions to enhance the position of existing market players. The incumbents had ceased to regard fintech as a direct threat and began to see the value of collaborating with – and even investing in them. In the past, a bank’s back-office functions served primarily as ‘support functions’ – processing payments rather than generating revenue. Now, some banks were divesting their processing units to create independent for-profit businesses that competed head-on with the banks. Concurrently, tech-focused fintech companies sought to join with large financial institutions to expand into markets, gain industry and regulatory knowledge, or even cash out. They included public companies like IBM, Accenture and Visa, and start-ups like Digital Asset Holdings, Ripple, and R3 – forming a new fintech wave.

3. R3 and its Mission in Distributed Ledger Technology

3.1. A Brief History of R3

R3 started out as a family office in 2014, investing in early-stage start-ups in the fintech space. When the term ‘cryptocurrency’ began to repeatedly crop up on the radar, the founders organized a series of industry roundtables, starting in September 2014, in New York City, where representatives of early fintech players (DRW, Align Commerce, Perkins Coie, Boost VC, and Fintech Collective) were invited to give a talk. Representatives from eight banks showed up to hear about cryptocurrency from the experts. A second round table, this time on the West Coast (Palo Alto), brought together Silicon Valley players like Stanford, Andreessen Horowitz, Xapo, BitGo, Chain, Ripple, and Mirror. Representatives from 11 banks showed up. Several speakers agreed to become advisors to R3. By the end of 2014, the family office had invested in several fintech start-ups including Align Commerce.

In the first quarter of 2015, R3 launched LiquidityEdge, an electronic trading platform for the US Treasury, and it incorporated the Distributed Ledger Group (DLG) in Delaware. Henceforth it focused its efforts on these two. A final roundtable was held in May 2015, with presentations by Hyperledger (the company), Blockstack, Align Commerce and the Bank of England. This time, 15 bank representatives as well as a market infrastructure operator and a fintech VC firm joined in. DLG transitioned from a working group to a commercial entity and by the end of 2015 it had admitted 42 members and changed its name to R3.

3.2. Putting the Fin back in Fintech

Unlike other blockchains or distributed ledger technology (DLT), Corda was launched by R3 as a DLT platform specifically for the finance industry. It was geared towards reducing industry pain

points at a time of increasingly complex transactions. Privacy (even secrecy) was critical; access to transaction data was restricted to a 'need-to-know' basis within the network. The consortium's efforts led to the creation of an open-source distributed ledger platform with the following characteristics:

1. Engineered for business: R3 wanted Corda to be a leading distributed ledger platform, designed by the world's largest financial institutions to manage legal agreements on an automatable and enforceable basis.
2. Restricted data sharing: Corda only shared data with those with a need to view or validate it; there was no global broadcasting of data across the network.
3. Easy integration: Corda was designed to make integration and interoperability easy. Users could query the ledger with SQL, join external databases, perform bulk imports, and code contracts in a range of standard languages.
4. Pluggable consensus: Corda was the only distributed ledger platform to support multiple consensus providers employing different algorithms on the same network, enabling compliance with local regulations.

R3's CTO Richard Brown insisted: "We are not building a blockchain. Unlike other designs in this space, our starting point is individual agreements between firms ('state objects' governed by 'contract code' and associated 'legal prose'). We reject the notion that all data should be copied to all participants, even if it is encrypted."

R3 believed that distributed ledger technology had the potential to transform the financial services industry. It envisioned a future in which financial agreements were recorded and automatically managed without error and contracts were transacted seamlessly. It strove to eliminate existing problems like duplication, reconciliation, failed matches and breaks.

Unlike other fintech firms, R3 did not originate from a financial services nor a technology firm. It saw itself as a perfect hybrid – a firm that created technology solutions focused on finance, which resolved confidentiality and other issues of existing blockchain technologies. It built a new operating system (Corda) from scratch, geared to financial markets using a blockchain-based distributed ledger platform that met the stringent standards of the financial industry and could be tailored to any commercial scenario.

The concept of a decentralized database sought to overcome the shortcomings of shared and distributed databases. The novel features provided by the Corda platform included new transaction types, execution of transactions in parallel, direct peer-to-peer communication between nodes in the network, the presence of multiple notaries employing various consensus algorithms, elimination of global broadcast, and the sharing of data on a need-to-know basis.⁶

3.3 Distributed Ledger Technology versus Traditional Banking Architecture

Financial institutions were typically early adopters of technology and, for the most part, their physical and manual processes had been digitalized and automated. However, opportunities remained to improve costs and efficiency by redesigning the systems architecture. For example, each bank maintained its own ledgers, which formed the basis of its view of agreements and positions with respect to its customer set and its counterparts. This resulted in duplication of records (by other banks) and inevitably inconsistencies and errors, that required reconciliation. It was these inefficiencies that enabled distributed ledger technology (DLT) to gain traction in the industry. DLT was made possible by three innovations: peer-to-peer networks, public key cryptography, and consensus algorithms.⁷

A distributed ledger was basically an asset database that could be shared across a network of multiple sites, geographies and institutions. All participants ('nodes') within the network had an identical copy of the ledger; entries could be updated by one, some or all participants according to agreed rules. Updates were visible on all copies within minutes (in some cases seconds). To ensure the accuracy and security of the assets in the ledger, entries were encrypted through the use of 'keys' and signatures to control 'who could do what'.

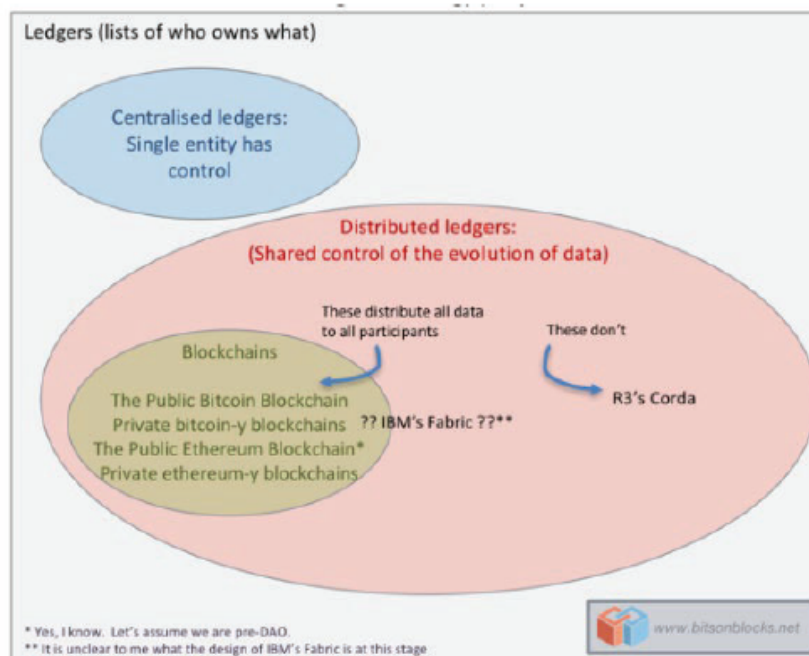
Cutting across functions/processes such as trade finance, cross-border payments, re-insurance, clearing and settlement – was an evolution of other peer-to-peer concepts. It gave Corda's blockchain platform increased flexibility and offered the following advantages:

- Operational simplification – eliminating the need to perform reconciliation manually and resolve 'disputes'
- Regulatory efficiency – enabling real-time monitoring of financial activity between regulators and regulated entities
- Risk reduction – counterparts no longer had to be trusted to fulfil their obligations as agreements were codified in a shared, immutable environment
- Reduction in clearing/settlement time
- Improvement in liquidity/capital
- Minimization of fraud

An important distinction lay in the fact that in other DLT data was distributed to all participants, whereas in Corda data was shared only between the two parties involved in the transaction. While

a centralized ledger was controlled by a single entity, participants in a distributed ledger had shared control of the data's evolution (see Figure 1).

Figure 1: Other Distributed Ledger Technology vs. Corda



Source: R3

In short, Corda created a private or 'permissioned blockchain' – that was expected to eventually dominate the majority of commercial applications, particularly in the capital markets. Permissioned variations added a layer of privileging to determine who could participate in the chain. Goldman Sachs anticipated that the majority of commercial applications would use some form of permissioned model⁸ based on the principle that the only parties with access to the details of a financial transaction should be the parties themselves and others with a legitimate 'need to know'.

In most blockchains, all participants had to reach consensus over the order of the transactions that had taken place, irrespective of whether they had taken part in a particular transaction or not. The order of the transactions was crucial for the consistency of the ledger. If a definitive order could not be established, there was a risk of double-spending – i.e., that two parallel transactions transferred the same coin to different recipients, thus making money out of thin air. As the network might involve mutually untrustworthy or anonymous parties, a consensus mechanism was required to protect it from fraudulent participants attempting double-spending. Typically, this mechanism was established by data mining based on proof-of-work (PoW). All participants had to agree upon

a common ledger and had access to all entries ever recorded. However, PoW unfavourably affected transactions processing performance; albeit anonymized, they were nevertheless accessible to all participants, which was problematic for applications that required a higher degree of privacy.

In contrast, Corda's interpretation of consensus was more refined - based neither on PoW nor data mining. Operating in permission mode, Corda provided more fine-grained access to records, enhanced privacy and consensus at the transaction level by involving only relevant parties. It used special notary nodes to solve transaction races (i.e. reach consensus) – and different consensus algorithms could be used on the same network – by offering a transaction ordering and timestamping service. Notaries were identified/signed with composite public keys made up of multiple mutually distrusting parties who used standard consensus algorithms such as BFT and Raft (depending on the scenario). Notaries accepted a transaction by returning a signature over the transaction, or returned a rejection error. Notarization was triggered after all signatures were obtained and the transaction was stored in the database once the finality flow was complete. Consensus was needed only for notaries⁹ (Byzantine Fault Tolerant or Raft algorithms).¹⁰ Consensus on transaction validity was performed only by those who were a party to it, hence data was only shared with those required to see it.

Transactions – one of the basic data structures on the Corda platform – could be passed around to be signed and verified by third parties. They were constructed on the assumption that a transaction formed an entity with input and output states, commands and attachments. Sensitive data was not revealed to other nodes that took part in the transaction on the validation level (as illustrated by the Oracle which validated only embedded commands).

Corda used a well-known cryptographic schema to convince the other party that the data sent for signing was a part of the transaction by providing proof of inclusion and data inclusion using Merkle trees – as used in peer-to-peer networks, blockchain systems and *Git* – whereby transactions were split into leaves, each containing either input, output, command or attachment. Other fields like timestamp or signers were not used in the calculation.¹¹

3.4 Applications of Corda

Corda's architecture was heavily influenced by the three most common use-cases, each conceived of by R3 as a financial agreement:

- A cash balance (e.g., “The following bank and I agree that they owe me \$1 million”)

- A security under custody (e.g., “The following custody bank and I agree that I own 1000 shares of the following corporation”)
- A bilateral derivative agreement (e.g., “Banks A and B agree that they are parties to the following Interest Rate Swap (IRS), which means they agree to exchange the following cashflows (netted) at predetermined scheduled times with an agreed payoff formula”)

Taking the first of these examples, Corda’s cash design explicitly modelled the notion there was no such thing as ‘money in the bank’ – only a cash claim by an owner with respect to a named institution. Corda’s core cash contract was extremely simple but powerful: it recorded the legal identity of the cash issuer, the currency, amount, owner (and information about the nature of the claim, with an explicit link to the legal prose governing the agreement setting out resolution procedures in the event of dispute), and used that identity to build up all other cash-related concepts (payments, netting, and so forth).

In August 2017, 11 eleven global banks announced a major milestone in the digitization of documentary trade finance: joint development of a prototype application on R3’s Corda with the potential to significantly reduce inefficiencies and costs by streamlining the processing of letters of credit. They included Bangkok Bank, BBVA, BNP Paribas, HSBC, ING, Intesa Sanpaolo, Mizuho, RBS, Scotiabank, SEB and U.S. Bank. IT consultancy CGI also took part.

In May 2018, a soybean trade between two arms of Cargill using letters of credit from HSBC and ING showed the R3 Corda platform was finally set to scale up. Acting on behalf of Cargill, the two banks successfully executed a live trade-finance transaction for international food and agriculture conglomerate Cargill using R3’s Corda blockchain platform. This was for a bulk shipment of soybeans from Argentina, through Cargill’s Geneva trading arm, to Malaysia, with Cargill’s Singapore subsidiary as the purchaser through a letter of credit (LC) issued using Corda by HSBC to ING.

4. R3’s Strategy Going Forward

R3 differentiated itself in the fintech industry with three unique features: (1) Having customers as its investors (2) Expanding the usage of DLT as crucial technology to synchronize ‘Fin and Tech’ (3) An open source platform to allow growth.

4.1 Customers as Investors

Since the launch of its DLT initiative in September 2015, R3 had grown from a staff of eight finance and technology veterans with nine bank members to a global team of over 110 professionals serving over 80 global financial institutions and regulators on six continents. Over 2,000 technology, financial, and legal experts drawn from its global member base supported the company’s work. That base included banks, clearing houses, exchanges, market infrastructure providers, asset managers, central banks, conduct regulators, trade associations, professional services firms and technology companies.

R3 embarked on its fundraising journey in a unique fashion, limiting the first two tranches of Series A to R3 members, and opening the third (and final) tranche to non-R3 investors. In May 2017, it announced raising a record \$107 million, the largest single investment in a blockchain company to date, that included 40 of its members. Investors represented an equal geographical split across Europe, Asia-Pacific and the Americas from over 15 countries (see Appendix I). In an industry where competition was often cut-throat and rivalries intense, R3 CEO David Rutter observed:

“This investment is unprecedented. Many of the world’s largest financial firms have come together not just with capital support, but with a robust commitment to work with R3 in developing industry solutions that will be the building blocks of the new financial services infrastructure. We’ve got unparalleled momentum.

R3 has proven the collaborative model can successfully drive innovation in financial services to a degree never before seen... In the space of less than two years, we have built a network of over 80 members, launched an open-source distributed ledger platform specifically for wholesale financial markets, conducted over 60 detailed use cases across a variety of asset classes, led the way in regulatory engagement on behalf of the broader DLT community and are ahead of schedule for initial commercial deployments this year. We are on our way to becoming a new operating system for financial services.”

In addition to its ‘user-investors’, more than 80 banks and financial institutions now used the Corda platform, making it the largest banking-centric blockchain consortium in the finance industry. Having its users/customers as investors ensured that its development was demand-driven and relevant to the changing needs of the industry. Users were incentivized to provide immediate feedback on Corda while generating relevant data for future development of the software, as well as setting the direction for R3’s continued growth. Regulators were also part of its investor/client base. If a Corda-based banking platform needed regulations as commonly agreed among the users, the function could be implemented through notaries.

4.2 Leveraging DLT to Synchronize Fin and Tech

Unlike other blockchain platforms (e.g., Fabric, Ethereum), Corda was specifically developed as a DLT for the financial services industry,¹² which allowed R3 to simplify its architectural design and take into account the highly regulated environment by augmenting smart contracts with the necessary legal jargon. In a distributed ledger, the mode of participation (permissionless or permissioned) had a profound impact on how consensus was reached. In Corda, participation was permissioned and the network was restricted to participants selected in advance and given access to the network. Consensus was reached at transaction level by the involved parties, and validity and uniqueness were verified by running the associated smart contract codes, checking for all required signatures, and assuring that any other transactions referred to were also valid.

4.3 An Open-Source Platform

In December 2016, R3 caused a stir in the fintech industry by releasing the Corda platform as an open-source free-of-charge product to the global developer community. Henceforth, banks and other financial institutions could build their own in-house applications on top of the platform. Moreover, as Corda was built from the ground up to enable legal contracts and other shared data to be synchronised between mutually distrusting parties, it had a potential to be used in a wide range of industries. CEO Rutter shared the rationale:

“The successful application of distributed ledger technology to financial services relies on new solutions being able to integrate and work seamlessly with each other, otherwise the disjointed infrastructure financial markets are forced to operate with today will simply be replicated with different technology. The applications being built therefore need to be based on common, open, interoperable platforms – much like the common protocols on which the internet operates today. Open sourcing Corda is the next step in making Corda one of these platforms.”

Although applications on the platform were kept separate, they were still able to ‘talk’ to each other by connecting investor and member nodes on the software. The open-source platform gave R3 the unique advantage of being able to see what type of applications were developed and their popularity. In a major coup, Amazon Web Services (AWS) announced in December 2017 a partnership with R3 to allow the Corda platform to become the first-ever distributed ledger technology solution on AWS. In April 2018, LenderComm launched a platform for the syndicated lending community underpinned by Corda, used by top global banks including BNP Paribas, BNY Mellon, HSBC, ING and State Street.

4.4 Fintech in Emerging Markets and Other Industries

Fintech’s rapid rise in China stemmed from a unique confluence of three factors: mass adoption of smartphones, a large underbanked but tech-savvy population, and a ‘grey’ financial regulatory environment. Unlike their financial counterparts in developed economies, Chinese companies did not have to work around legacy systems – they simply ‘leap-frogged’ to the latest technologies available such as mobile payments and blockchain applications. For companies like Tencent and Alibaba, in addition to conquering the domestic Chinese market, their fintech applications were increasingly rolled out in other emerging markets.

China was the most active filer of blockchain patent applications globally in 2017, as technology and financial services groups rushed to claim exclusivity on the ‘mutually distributed ledger’ that could revolutionise finance and other supply chains. Data collated by Thomson Reuters from the World Intellectual Property Organisation (Wipo) database showed that in 2017, more than half of the 406 blockchain-related patent applications were from China. Patent applications for blockchain, spanning everything from cryptocurrencies such as bitcoin to the tracking of chickens, trebled in

2017. Patents specific to cryptocurrencies which are not included in the blockchain patent category rose 16% to 602 in 2017.¹³ Could R3 gain recognition and expand its business in China?

5. Concluding Questions

R3's history gives rise to interesting questions. Designed from the ground up as a distributed ledger platform to record, manage and synchronise financial agreements between regulated financial institutions, R3 spearheaded the third wave of blockchain platforms targeting these critical shortcomings other blockchain platform. As the company had specifically developed Corda as a blockchain platform to provide an enterprise-level DLT to financial institutions, its features solved some of the inconsistencies of other blockchain platforms in meeting the demands of the finance industry. Since fintech seeks to seamlessly merge tech-oriented innovations with finance, it needs to give more weight the latter: What are the most important institutional features of the financial services industry? Are these features consistent with recent developments in blockchain-type of fintech? Could Corda improve consistency? Could such innovations help emerging markets to develop their financial institutions?

Appendix 1

List of Investors in R3

Banco Bradesco [1]	Itaú Unibanco S.A.
Bangkok Bank	Mitsubishi UFJ Financial Group (MUFG)
Bank of America Merrill Lynch	Mizuho
Bank of Montreal	Natixis
Bank of New York Mellon	Nomura
Barclays	Nordea Bank
BBVA	Northern Trust
BNP Paribas	OP Cooperative
B3 (BM&FBOVESPA and Cetip)	Ping An
Canadian Imperial Bank of Commerce	Royal Bank of Canada
Citi	SBI Group
Commerzbank	SEB
Commonwealth Bank of Australia	Societe Generale
Credit Suisse	Sumitomo Mitsui Banking Corporation
CTBC Financial Holding	TD Bank Group
Daiwa Securities Group	Temasek
Danske Bank	The Bank of Nova Scotia
Deutsche Bank	The Royal Bank of Scotland
HSBC	U.S. Bank
ING	UBS AG
Intel Capital	Wells Fargo
Intesa Sanpaolo [2]	Westpac

[1] Investment made indirectly through an investment fund, FIP InovaBra I, of which Banco Bradesco BBI S.A., a controlled subsidiary of Banco Bradesco S.A., is a quotaholder.

[2] Intesa Sanpaolo will invest through its affiliate Neva Finventures, the Corporate Venture Capital of the Group

Source: R3

Appendix 2

Timeline of R3

September 15, 2015: The consortium starts with nine financial companies, including Barclays, Credit Suisse, Goldman Sachs, J.P. Morgan, Royal Bank of Scotland and UBS, followed by others in the months that follow.

March 3, 2016: R3 announces completion of a trial involving 40 banks held in the last two weeks of February, testing the use of blockchain solutions offered by Monax, IBM, Intel and Chain to facilitate the trading of debt instruments.

November 2016: Goldman Sachs, Santander and Morgan Stanley withdraw from the consortium. In April 2017, JPMorgan Chase quits R3 to pursue its own blockchain strategy.

May 23, 2017: R3 publicly announces it has secured the largest ever investment for distributed ledger technology, with USD107 million as part of its Series A funding round, from over 40 institutions, spanning 15 countries.

May 2017: In October 2017, R3 announces a new version of its blockchain platform, Corda. It helps financial institutions to apply emerging technology more conveniently.

December 2017: Amazon Web Services (AWS) announces a partnership with R3 to allow the Corda platform to become one of the first ever distributed ledger technology solutions on AWS. Corda allows users to deploy DApps on the AWS platform and create new apps directly.

February 2018: R3 announces the creation of a Legal Center of Excellence (LCoE) with an initial team of ten law firms that will educate lawyers globally about new fintech and blockchain technologies.

March 2018: Credit Suisse and ING complete the first live securities lending transaction, worth €25 million, using an application from HQLAx, a financial technology firm that was built on Corda.

April 2018: Finastra launches the first live application on R3's Corda. Fusion LenderComm is a blockchain-powered platform for syndicated loans.

July 2018: R3 is reported to be exploring IPO possibilities.

Source: Wikipedia, R3, Bloomberg