HOW TECHNOLOGY IS CHANGING FINANCE

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Introduction

Currency exists to facilitate trade. Finance helps to better manage that trade. In today's international community, trade has become increasingly intricate, leading to financial booms as well as market busts. Technology combats this occurrence by playing a key role in deciphering finance's complexities and propelling economic development. The union of finance and technology has created a progressive market structure and become the sole proprietor of the global economy.

In this article, we examine financial fundamentals alongside disruptive technological concepts to showcase how to forecast a shift in both financial markets and financial industry. We seek to explore diverse tech opportunities within finance, and share our knowledge of how these opportunities are changing the current paradigms of money.

These topics include: how Cloud is developing financial institutions, how Big Data is changing the financial markets, and how cryptocurrencies are changing the dynamics of trade.

This article will begin with a short definition of financial terms and institution that will be utilized throughout the article when addressing how disruptive technologies impact them.

Introduction to Finance

Finance is defined as a branch of economics concerned with resource allocation as well as resource management, acquisition, and investment. Simply, finance deals with matters related to money and their markets(1). These matters of both money and markets are managed by what are known as financial institutions (or financial services).

A financial institution is an establishment that conducts financial transactions such as investments, loans, and deposits(2). Everything that deals with the transaction of money goes through financial institutions, whether it be an owner taking out a loan to start a new business, depositing money in a savings account, to exchanging currencies for a trip abroad.

Below are the major categories of financial institutions, as well as a brief look into their roles in the financial system:

Commercial Banks

Commercial banks are those which the average citizen transacts with in their everyday life. Commercial banks accept deposits and provide security and convenience to their customers. Due to the risk of loss due to theft or accidents for the owner when keeping physical cash, banks retain large amounts of currency for their clients, allowing them to handle their; transactions with checks, debit cards, or credit cards, instead(1).

Commercial banks also make loans to businesses (either to start a new effort or for short-term purchases) as well as individuals (such as mortgages or car loans). If banks can lend money at a higher interest rate than they have to pay for funds and operating costs, they make money(1).

Capital Markets

The success of the US economy is due (in large part) to the free flow of capital between corporations, governmental bodies, and investors. This flow is made possible by a highly-developed capital market system. In order for businesses to raise the money needed to build and expand, they must have access to investors willing to purchase equity ownership in the form of stocks and to lend money in exchange for debt in the form of bonds. Conversely, investors seeking to accumulate and preserve their wealth can use stocks and bonds (known as securities) for these purposes. The ability of investors to buy and sell these securities to one another adds even greater strength and resiliency to the capital markets. This system benefits not only businesses, but also federal, state, and municipalities seeking to borrow money in order to provide services to the public(3).

All of this is performed in what is known as the capital markets.

The capital markets can be broken down into two basic types: primary and secondary markets. The primary market pertains to the sale of securities by issuers, an example being an Initial Public Offering (commonly referred to as an IPO). An IPO represents a corporation's first public attempt to attract capital from financial institutions and the general public. In a primary offering the corporation (or the issuer) seeks to sell its securities directly to investors. An example of a primary offering with regards to debt instruments is the weekly auction of Treasury Bills by the US government to the public(3).

The secondary market provides a system for the trading of financial instruments between investors. An example is the sale of stock from one party to another on the floor of the New York Stock Exchange (NYSE). Although this sale has no direct effect upon the stock's issuing corporation, the ability to sell (or liquefy) increases an investor's willingness to invest money in securities in the first place(3). This willingness to invest indirectly benefits corporations seeking to raise capital in the future.

With the flow and understanding of capital market structure in mind, the next logical question begs: "What are the equity and debt instruments that are being exchanged on the secondary market?"

Equity securities represent an ownership interest in a business. The nature of the equity varies with the form of the business that is involved. The most common equity security owned by investors is common stock, which represents an ownership interest in a corporation. A corporation is owned by its shareholders, but since a corporation is a separate "person" in the eyes of the law, an individual shareholder generally may not be personally responsible (or liable) for the corporation's debts. If the business fails, the most a shareholder can lose is his or her investment(3). This concept is known as the investor possessing a limited liability interest. At some point, the corporation may need to raise additional capital to fund its operations.

Brokerages

A brokerage acts as an intermediary between buyers and sellers of the aforementioned equities by facilitating these securities transactions. These firms bridge the gap between investors and organizations. They are responsible for managing trade executions and at times, providing investment advice to consumers.

Investment Banks

Investment Banks operate differently than their commercial bank counterparts. An investment bank is a financial intermediary that performs a variety of services for businesses and some governments including underwriting debt and equity offerings, acting as an intermediary between an issuer of securities and the investing public, making markets, facilitating mergers and other corporate reorganizations, and acting as a broker for institutional clients(1). These organizations act similarly to a brokerage firm in that they also provide research and financial counseling amenities to their client organizations. As a general rule, investment banks focus on IPOs and large public and private share offerings(1).

Insurance Companies

The purpose of insurance companies is to assist individuals and organizations in preserving their wealth in case of an accident. Insurance companies pool risk by collecting premiums from a large group of people who want to protect themselves and/or their loved ones against a particular loss, such as a fire, car accident, illness, lawsuit, disability, or death(1). Insurance companies cover a large number of clients, allowing them to earn revenue based off customer payments while compensating any claims happening against other clients. Insurance companies use statistical analysis to project what their actual losses will be within a given class(1). This is how they become profitable, by balancing classes of clients.

Trade Finance

Trade Finance is the commercial backbone of international trade. Trade finance organizations provide their global clients with many of the financial activities similar to which banks and insurance companies provide. Trade finance is of vital importance to the global economy, with the World Trade Organization estimating that 80 to 90% of global trade is reliant on this method of financing(4).

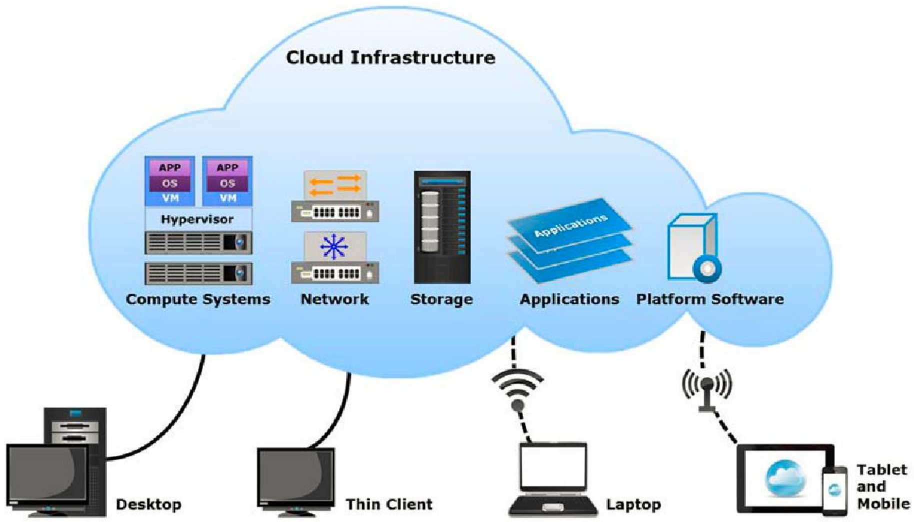
Disruptive Technologies and Finance

Now we will begin to dig into the nitty gritty of disruptive technologies and how they impact finance and financial institutions. We will begin with a brief look into what Cloud is, and how it is influencing financial institutions internally and externally. Next we will explore Big Data and how it is changing the financial markets before concluding with a detailed look at how cryptocurrencies operate and change the dynamics of trade.

Finance in the Cloud

What is Cloud?

According to the U.S. National Institute of Standards and Technology (NIST), Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources, (e.g. servers, storage, networks, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction[5]. In short, Cloud computing refers to the provisioning of on-demand computational resources (i.e. a collection of servers, client computers, storage units, and applications) through a virtualized network.



Cloud Infrastructure Model (Adapted from EMC Corporation)[6]

In order to be considered a Cloud implementation, it is essential for an infrastructure to have these five characteristics as adapted by *Singapore Management University's Information Technology Wiki* [7]:

- **Broad Network Access** – Access from Anywhere
- **Resource Pooling** – Sharing/Maximize resources
- **On-demand Self Services** – It's there when you need it
- **Rapid Elasticity** – You get what you need
- **Measured Services** – You get what you pay for

In summary, a Cloud infrastructure needs to be accessible from anywhere (Broad Network Access) in the globe when a user needs it (On-Demand Self Service). A Cloud infrastructure should be flexible, making it easy for a user to share resources across their infrastructure (Resource Pooling) while also be given the opportunity to expand or minimize said resources as they see fit (Rapid Elasticity). In the Cloud, the consumer pays for only what they need – nothing more, nothing less (Measured Service).

When an organization looks to implement a Cloud infrastructure, they do so by purchasing the technology from a Cloud vendor/Cloud service provider, who then has the responsibility of owning and operating these technological assets in various data centers – a facility that houses and maintains centralized IT systems and components including computer systems, storage systems, and network equipment[8].

These Cloud services fall under three Service models, explained as:

1) *Infrastructure as a Service (IaaS):* The end user is purchasing the ability to provision processing, storage, networks, and other essential computing resources in order to deploy their software, operating systems (OS), some networking capabilities, and applications of which they have full control.
2) *Platform as a Service (PaaS):* The end user is obtaining the space to deploy their created or procured applications utilizing the programming languages, libraries, services, and tools that are supported by the Cloud provider only. The end user has no management insight or control to the underlying cloud infrastructure yet has free reign over the deployed applications.
3) *Software as a Service (SaaS):* The end user has no line of sight into any of the Cloud infrastructure (including network, servers, operating systems, storage) and has limited access to the application capabilities itself. In this service model, the end user is given the right to run the Cloud provider's application(s) on the Cloud infrastructure. The application(s) are easily accessible from multiple end user devices (i.e. laptop/tablet, thin client interfaces, etc.).

Finally, Cloud services can be deployed for an organization in four separate models, as illustrated by VMware vCloud® documentation:

Cloud Deployment Models[9]

Each model offers its end users a different level of service, Below is a more detailed look into each Cloud deployment as defined by NIST[5]:

- *Public cloud:* The cloud infrastructure is provisioned for open use by the general public. It may be owned, managed, and operated by a business, academic, or government organization, or some combination of them. It exists on the premises of the Cloud provider.
- *Private cloud:* The cloud infrastructure is provisioned for exclusive use by a single organization comprising multiple consumers (e.g. business units). It may be owned,

managed, and operated by the organization, a third party, or some combination of them, and it may exist on or off premises.

- *Community cloud:* The cloud infrastructure is provisioned for exclusive use by a specific community of consumers from organizations that have shared concerns (e.g. mission, security requirements, policy, and compliance considerations). It may be owned, managed, and operated by one or more of the organizations in the community, a third party, or some combination of them, and it may exist on or off premises.
- *Hybrid cloud:* The cloud infrastructure is a composition of two or more distinct cloud infrastructures (private, community, or public) that remain unique entities, but are bound together by standardized or proprietary technology that enables data and application portability.

Bernie Baker, Senior Director for the Executive Briefing Program at EMC Corporation said it best when it comes to why an organization would leverage Cloud computing: "At a high level, Cloud is really about leveraging the server storage and networking components and delivering those in a completely new way [10]". For this technology to be effective as Baker points out, Financial institutions that may look to begin leveraging Cloud computing technologies and solutions must first understand the benefits and drawbacks to their organization and the financial industry as a whole.

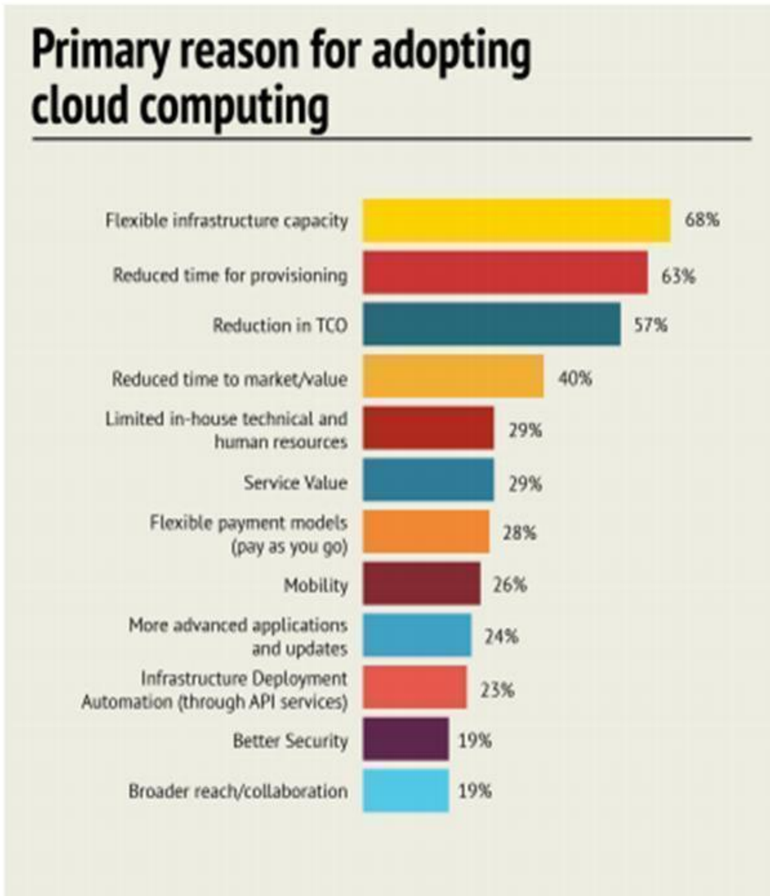
Why Cloud in Financial Services?

Cloud computing is shifting how customers and corporations interact with data. This exchange of information between corporations and customers will ultimately impact how the financial industry does business[11]. Since financial institutions rely on the use of individuals, it's important that they meet those individuals and do business according to the preferences of their consumer, i.e. in a way that is convenient to how people interact with technology. Cloud computing is a disruptive technology which complements financial services technological readiness.
Before Cloud computing can be adopted within a financial institution, however, the organization must be ready to align business operations with the new technology. According to Bernardo Nicoletti in his book *Cloud Computing in Financial Services*, the following summarized objectives are those in which a financial institution would consider as positives when considering adoption of Cloud computing solutions[12]:

- Promise of business agility, with the ability to scale and respond to business variations as needed rather than building redundant capacity;
- Initial success of virtualization and on-demand solutions in the infrastructure space. Most financial institutions today are focusing on consolidating their servers and data centers. They are implementing organization-grade virtualization solutions, with excellent Return on Investment (ROI) benefits;
- Success of outsourcing at all levels pushes to entrusting significant parts of the business and technology operations to multiple service vendors; and
- Standards are always shifting, being adopted by the market at different speeds; hence it is crucial for a technology to be able to handle the shift of the changing standardization and service-based model of the business functions, products, and services.

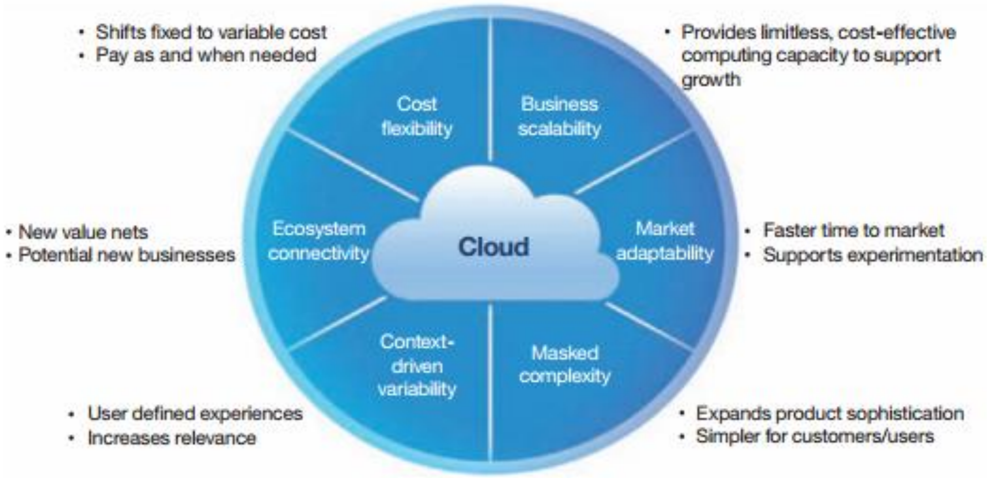
- Finally, yet importantly, reduction of operational risks. Cloud computing involves a radical restructuring, avoiding many of the execution risks (such as a limited number of available skilled resources).

Studying the advantages of adopting Cloud a little further, a *2015 Cloud Alliance Survey Report* provides a snapshot of the top cloud services/applications that are being adopted in the financial sector:



Adapted from 2015 Cloud Security Alliance Financial Sector Survey[11]

As seen above, the top three reasons why a financial institution would adopt Cloud services correlate to Bernardo Nicoletti's reasoning as to why financial institutions should consider adopting Cloud in their businesses.



Cloud computing can enable new business models that can fundamentally shift competitive landscapes[13]

Cloud-based solutions offer the next stage in the evolution of the business paradigm for financial institutions, as they begin to consider next-generation technology solutions. These benefits, however, also come with some interesting considerations that a financial organization must be aware of before moving to the Cloud.

Addressing the Concerns with Cloud

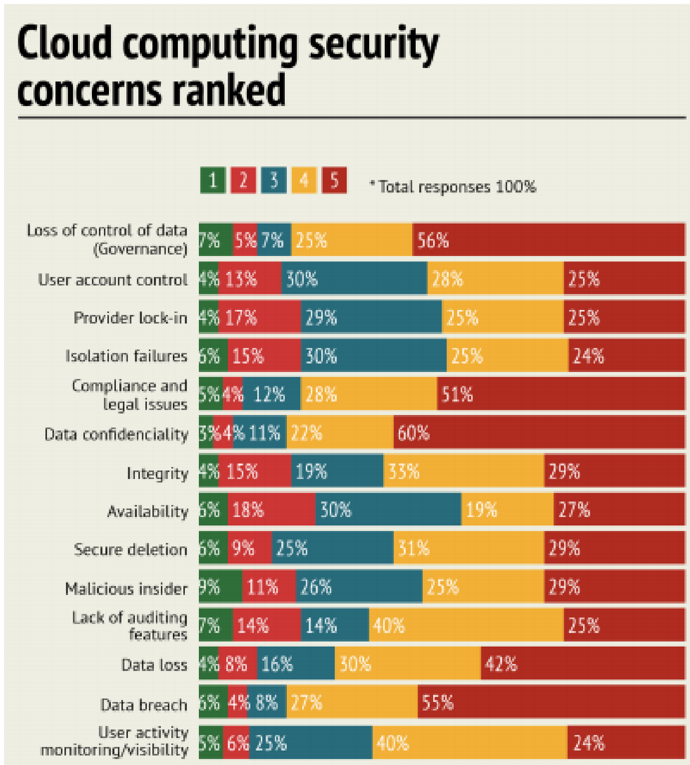
It can be argued that financial institutions should not consider Cloud computing solutions as an answer to a business problem; rather, as a drastic reformation of its current business processes and infrastructure. As such, when a financial institution is considering adopting Cloud computing technologies, they first must weigh the possible bearings caused by the complex laws and regulatory policies, standardization, and industrialization of systems and processes within financial institutions. Bernardo Nicoletti in his book *Cloud Computing in Financial Services* summarizes these significant challenges in adopting Cloud services into the following points[12]:

- Issues around security and performance
- Legal concerns
- Reliability
- Complexity of processing
- Operational control
- Governance
- Evidence of the economic benefits promised

Referring back to the *2015 Cloud Alliance Survey Report*, when it comes to **not** adopting cloud, the top reasons reported by our respondents were[11]:

- Security concerns (100%)
- Regulatory restrictions (71%)
- Concerns over public breach notification (43%)

The primary concern of financial institution respondents is **Security** in the Cloud. The article goes on to state that in particular, data security was the most commonly cited area of concern for the reported incidents: Data availability and leakage was reported in 50 percent of the cloud incidents with 33 percent unauthorized access, 25 percent experienced malware and other vulnerabilities in their breaches, and 17 percent reported service abuse(11).



Adapted from 2015 Cloud Security Alliance Financial Sector Survey(11)

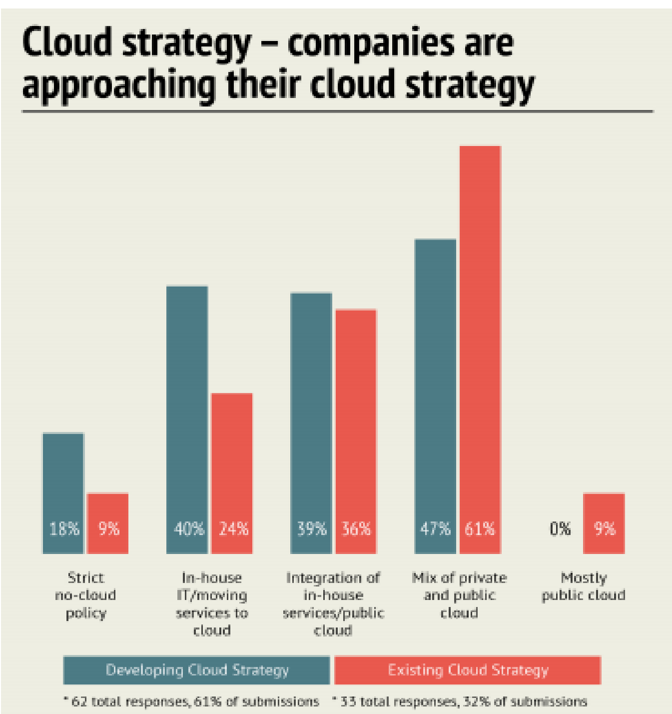
The report delves further into the security concerns by asking the respondents to rank a list of common security concerns. The report states: "The respondents ranked each item of concern on a scale of one to five with five being the greatest concern. Once again, concerns over the confidentiality of data and the control of data took the top positions: **60 percent of financial institutions ranked data confidentiality as their highest security concern**, followed by loss of control of data (57 percent), and data breach (55 percent). Of the top five highest ranked concerns, the only one that wasn't data-related was legal and compliance issues (51 percent). **Each of the issues represents an opportunity for cloud and technology providers to strengthen their offerings to enable financial services firms to better leverage the power of cloud computing(11)".**

These security concerns are valid for those financial institutions that have already implemented Cloud services as well. Quoting an article by the website *Cloud Tech*, "15.5% of financial services have at least one compromised credential, more than any other industry…the number across all industries which have one compromised credential or more is at 11.2%...while the report also found 94.3% of financial services companies have exposure to compromised credentials – again higher than the overall average of 91.7% from all industries[14]".

Which Cloud is the Best Cloud?

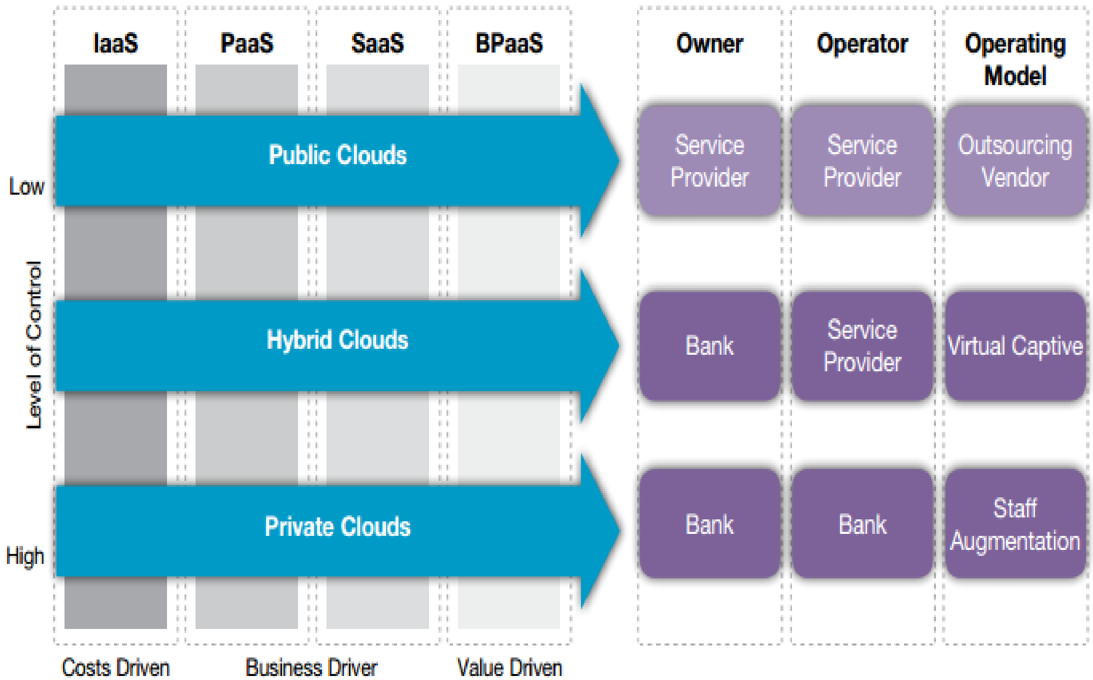
Since security is a top concern, an inference can be drawn that some financial institutions are still hesitant to adopt Cloud technologies for their core business services. However, as mentioned in the section *What is Cloud?* there are many different deployments of Cloud, which can be utilized differently to mitigate any security issues that may be present. While the public cloud environment provides the ability to deliver services to a vast number of users, its functionalities are offered in an openly pooled method which causes serious concerns within financial institutions as they would be placing sensitive internal and client information in a virtualized public domain. Characterized by the high compliance requirements that come with the critical business data and by the complexity of infrastructure, the level of adoption of the public cloud could therefore remain low in the financial services sector over the short and medium term[12]. To that end, 71 percent of financial companies consider compliance as a reason to keep controls in-house and not migrate data to public cloud services[11]. A Community cloud may be used instead, as Cloud providers could work together to better combat any security/compliance issues for financial institutions who share the same information. An example of this will be found later in this section, for now, it is crucial to understand that there is one deployment model witch better fits the security needs of the financial institutions. The most reasonable deployment to avoid security breaches, as described by Bernardo Nicoletti, is a private cloud implementation and should be considered the only implementation as an internal information-sharing environment…above all has the security to maintain the information within its own structure….its applications in the financial services sector, private clouds must anyway meet specific industry regulations and requirements related to security and reliability[12].

What is most interesting, however, is that financial institutions are not moving towards a specific Cloud deployment; rather they are blending many deployments for their specific needs. "As the mix of in-house IT, private, and public clouds were the most common approach to cloud, it's interesting to note that 70 percent of the companies with existing cloud strategies have moved from hybrid clouds to either a mix of private and public cloud[11]".



Adapted from 2015 Cloud Security Alliance Financial Sector Survey[11]

In his whitepaper *Cloud Computing in Banking,* Sudhir Sriram, Senior Consultant in the Strategic Analysis Group for Capgemini Financial Services writes this in regards to how financial institutions (specifically banks) should proceed with adopting Cloud services for their organizations: "Financial institutions must select the right service, deployment, and operating models to address security and compliance concerns. In the initial phases of cloud computing adoption, it is expected that banks will own and operate the cloud themselves with service providers taking increasing ownership and control of the cloud infrastructure as cloud computing matures and more rigorous controls become available(15)".

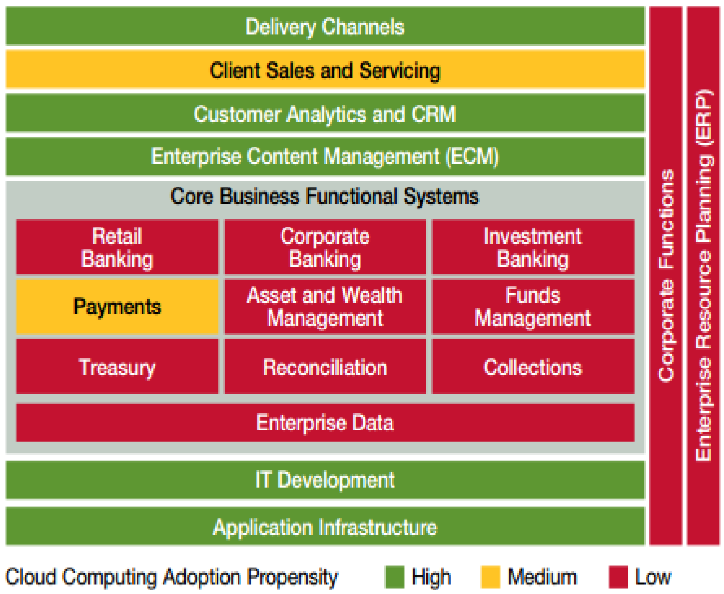


Adapted from Capgemini Analysis 2011(15)

Recognizing that no single cloud computing services model can be expected to meet all the technology requirements for every financial institution is an important first step when a financial institution is considering the adoption of Cloud services. Confidence in adopting Cloud services and infrastructures is growing for financial institutions as they are relying less on in-house IT. Although security is an issue, the benefits of Cloud such as having a flexible infrastructure, reduced TCO, and time reduction in provisioning are greatly offsetting the cost.

Further Benefits of Adopting Cloud Internally

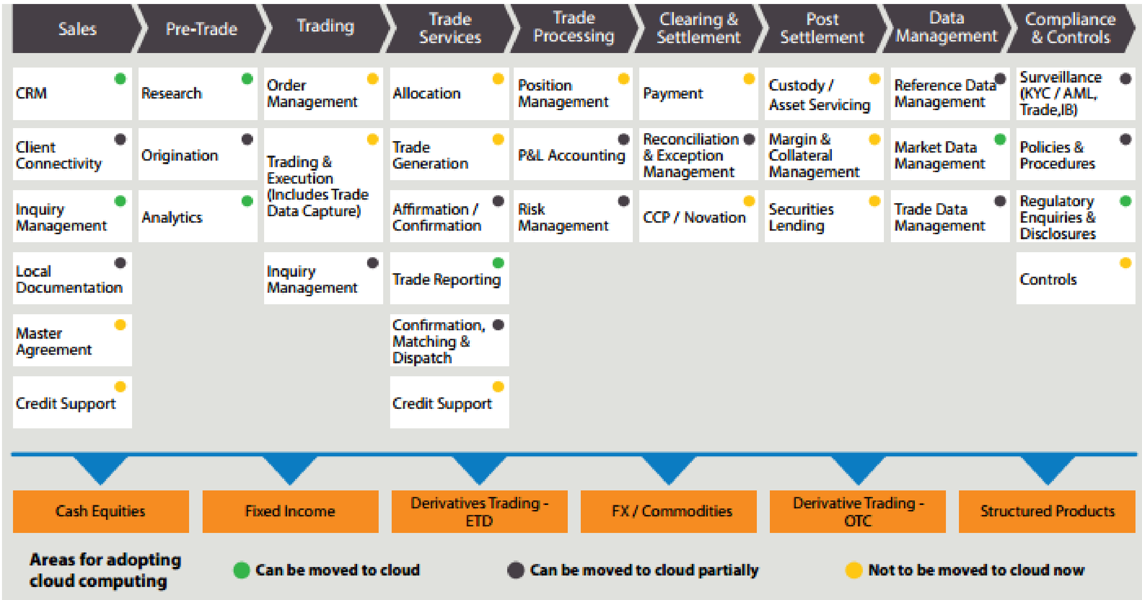
The financial industry is in the early stages of Cloud adoption; however, this technology is rapidly being embraced. A majority (61 percent) of financial institutions have already begun to develop a cloud strategy within their organization(11). Within financial institutions, the early implementations will likely begin with a move of non-core business applications to the Cloud(15). Below is an outline of some such business applications/systems which would be simple for a financial institution to move to the Cloud as diagramed in the whitepaper *Cloud Computing in Banking:*



Which Areas are Best Suited for Cloud? (Adapted from Capgemini Analysis 2011(15))

Analyzing this Figure further alongside applying the known benefits of Cloud to a financial organization, one could conclude that, at a high-level, adopting Cloud computing will be more cost-effective when implementing and testing non-core business as well as new applications on the Cloud versus the organization's current traditional infrastructures. According to an article of the cost benefits of Cloud computing by Forbes, the average cost reduction is 23% due to cloud computing savings on infrastructure, based on the combined results of UK and US-based respondent analysis(16). While investments in legacy systems are expected to continue, Cloud-based services are ideal for newer business applications. Cloud-based services are expected to provide the advantage of both lower investments in implementing business strategies and faster turnaround time for product and service offerings(15).

Taking this analysis a level further, implementing Cloud computing technologies within a capital investment firm (in which it is estimated that 70 percent of firms are either seeking to adopt new cloud services or replace their existing legacy systems with cloud[17]) holds similar benefits to such non-core business systems and applications:



Adapted from Infosys Whitepaper: The Cloud Advantage in Capital Markets[17]

Reporting applications, Customer Relationship Management (CRM) systems, and Data Management systems are prevalent in each Figure. Financial institutions should first leverage Cloud-based technologies and services driving down the use of cumbersome legacy systems and increasing overall organizational capacity to improve or become flexible on other, more business critical, applications.

Now that we've analyzed what Cloud computing can do internally for a financial institution, let's explore how it can, and is, evolving financial services and industries.

Leveraging Cloud in Trade Finance

The globally established industry of Trade Finance has a rich number of members whose facilitating capabilities are impacted directly or indirectly by the use of disruptive technologies rampant in the trade market. As described earlier, Trade Finance covers a vast realm of activities (i.e. lending, issuing letters of credit, factoring, export credit, and insurance) and typically involves many key players in the trade transactions such as importers and exporters, banks and financiers, insurers and export credit agencies, as well as other service providers[4].

Overview of Trade Finance Processing Systems

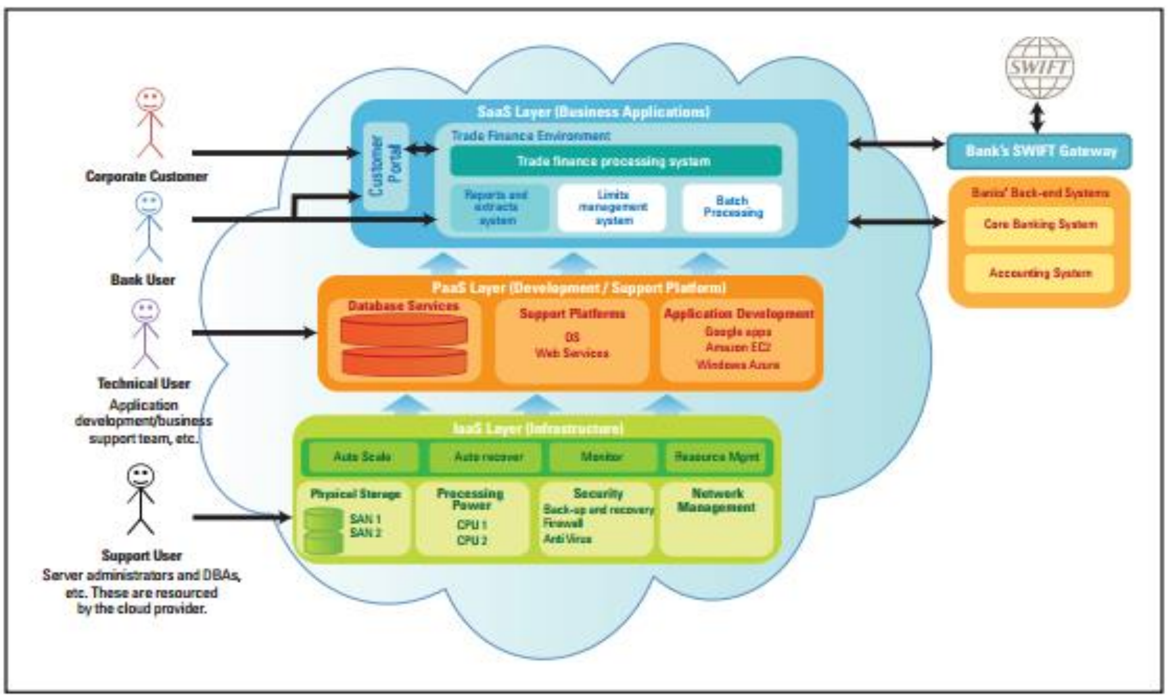
In his whitepaper *How Cloud Computing Impacts Trade Finance*, Tushar Rastogi, an Associate Consultant at Cognizant Business Consulting, summarizes: "the trade finance processing system encompasses a customer interfacing trade portal, back-office transactional trade processing system, Society for Worldwide Interbank Financial Telecommunications (SWIFT) transmission system, transactional data transformation and communication system and reporting system. In a combined manner, trade finance systems form a crucial part of corporate banking services for banks or financial institutions. Such a trade finance system must be extremely robust, scalable, secure, automated and compliant with ICC regulations and Basel II norms... bank-supplied Trade Finance solutions and services are hosted on infrastructure consisting of data centers that are monitored and maintained by financial institutions themselves around the clock and incur immense investment of time and money[18]".

How Cloud Can Help

The development and implementation of Cloud technology being investigated within Trade Finance enables members (such as banks) to construct a resilient architecture in order to provide services that are more affordable and accessible to customers, maintaining their current technological infrastructures, staying within legal compliance, while at the same time, looking to maximize their profitability. Cloud computing's open and shared framework provides an interesting prospect for Trade Finance banks to reduce or even eliminate associated costs of the current in-house infrastructure.

As shown above, if a Trade Finance Processing System is to be based on a Cloud computing platform, the management of such responsibilities is now, in part, the Cloud service providers. The Cloud provider must have expertise in handling such multifaceted technological platforms and total ownership when attending to business-critical issues as their impacts affect global trade. These Cloud services offer dedicated solutions with rigorous security controls, freeing both banks and customers from expensive IT investments[18].

Adopting the solution from his whitepaper, Rastogi provides a clear picture of how Cloud computing is the answer to growing issues Trade Finance organizations face. While employing each Service model, Rastogi illustrates how a Cloud-based Finance Ecosystem would appear to be set up:



Components of a Cloud-based Trade Finance Ecosystem[18]

In this ecosystem, Rastogi believes that the Cloud service provider would be responsible for providing a bank with application hosting, data center management, virtual databases, virtual server processing capabilities, and storage and business support[18].

On the bank's side, it will include trade finance applications, such as[18]:

- Customer portals.
- Back-office trade processing system.
- Limits and liabilities management system.
- Reporting and extracts system.
- Interface to SWIFT gateway.
- Interface between customer portal and back-office trade system.

Notice here that the Cloud service provider only provides a PaaS, leaving the banks still responsible for their applications. The power of the Cloud in this scenario, however, is its implementation of all levels of the Cloud. While each player in the Trade Finance chain can benefit from different Service levels of the Cloud, the shift to Cloud must be industry-wide in order to fully optimize the system.

Cloud computing has great potential to deliver massive cost savings to the slowly recovering trade finance industry. The benefits can be apportioned to increase affordability by reducing costs and increasing accessibility to trade finance solutions for both banks and corporate customers[18]. Studies have shown that a full-fledged cloud migration can help reduce processing costs by 80% to 90%[18].This cost reduction would then filter down to reduce the cost of trade finance transactional charges and fees levied by the banks, thus increasing affordability and yielding increased usage and growth for corporate customers[18].

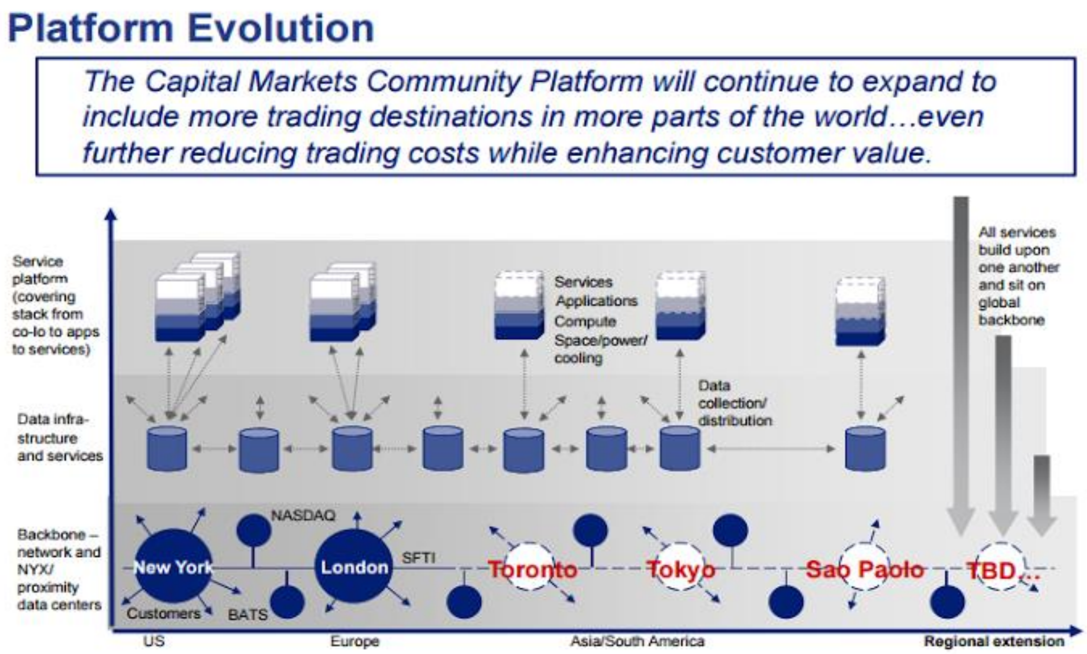
Leveraging Cloud in Capital Markets

NYSE EuroNext

In a changing and highly-regulated industry, NYSE Euronext—owning and managing the systems for over 19 markets worldwide[19]—wanted continued success as an industry leader while fostering growth. Increasing competition from other stock exchanges and broker-owned dark pools is driving down trade volumes and associated revenues and NYSE Euronext is looking to other investment areas for the future[19]. The Exchange had an emergent data problem as well. During that time, in the U.S. alone, the daily scale of transactions executed by the Exchange reached upwards of $70.8 billion in financial transactions and needed to process more than 22.4 billion messages per day[20].

The answer to their dilemma came in the form of an industry-specific, PaaS Community Cloud offering from the commercial technology division of NYSE Euronext. NYSE Technologies, in partnership with EMC Corporation and VMware, was the first capital markets industry-specific cloud platform, christened the *Capital Markets Community Platform*. Launched in 2011, the enterprise-level platform was developed to address the unique performance and security requirements of financial services firms, as well as to provide rapid provisioning of processing power, access to historical market data, and temporary compute capacity for real-time testing[21].

The platform's infrastructure was built to evolve, utilizing industry leading storage and virtualization tools including VMware's vSphere, VMware vCloud Director and VMware vShield security solutions and EMC VNX® series of unified storage platforms leveraging EMC FAST VP® and FAST Cache[21].



Adapted from NYSE Cloud Deck for Press Release[20]

This innovative financial service Community Cloud not only helped the Exchange achieve its business goals, but also assisted in improving the Exchange's customer base. Built for the financial services industry, the *Capital Markets Community Platform* kept brokers, dealers, and other market makers in mind when designed in order to tackle some of their crucial business challenges:

Additional Use Cases

The Community Platform offers customers of all kinds a solution for accessing markets, data and other services quickly and easily

Firm Characteristics	Business Challenge	Community Platform Solution	How It Will This Benefit the Firm?
Agency Broker	Rapid provisioning of services for hedge-fund traders	Compute-on-Demand; Low-latency Market Data, Risk Managed Market Access	*Higher customer satisfaction; less 'non-trading' time; lower cost*
Investment Bank	Processing large volumes of market data for regulatory reports	Virtualized Computing Power; Historical Market Data; Hosted DB	*Reduced WAN bandwidth utilization; more rapid reporting; less infrastructure required*
Low-latency Hedge Fund	Temporary requirement for large compute farm to test and validate strategies	Virtualized, Elastic Computing Power; Historical Market Data	*Improved strategy testing; significantly lower cost*
All size of Financial Services firms	Testing custom developed applications requires large server farm	Virtualized Computing Power; Real-time Market Data	*Exact replicas of production servers can be started and stopped, on-demand*

Adapted from NYSE Cloud Deck for Press Release[20]

Summarizing VMware's *Your Cloud in Finance: Industry Brief White Paper*, the platform created a varied and more rapidly delivered financial services support growth of the Exchange. By providing a cloud environment for the financial services community, NYSE Euronext can extend its technology services to a broader audience. Previously, the Exchange would allow firms to co-locate their own servers in the NYSE Technologies data center to get faster access to the market, but only the medium to large sized firms could afford to make this investment to capitalize on the low latency provided by this geographic advantage.

The *Capital Markets Community Platform*, provided IaaS to the Exchange's customers of all sizes, giving them the ability to host capital market proprietary applications by focusing on the development of their applications instead of worrying about the underlying infrastructure[19]. Firms can also rapidly and easily scale resources when the service applications demand it, using cloud's highly elastic and automated infrastructure[19].

The implementation of the platform provided NYSE Technologies with a competitive differentiator, allowing the Exchange to vastly improve the delivery of its data services. NYSE Technologies provides data – such as who sold what, when, and for how much – to financial researchers for market analysis[19]. Prior to Cloud computing, when companies wanted to use historical market data to run risk models they would have to download historical data around midnight to their respective data centers then run the analysis in an overnight "batch" process and return the results the next morning. This 12-hour delay meant the analysis was no longer fresh[19]. This was resolved with the implementation of the *Capital Markets Community Platform* as the NYSE Technologies now provides the firms the ability to run their analysis against the historical data in minutes.

The *Capital Markets Community Platform* streamlined business processes and improved risk responsiveness by aggregating services in the Cloud. NYSE Technologies has a centralized mechanism for providing access to market and historical data, network services, third-party applications, as well as compute on-demand. In turn, the Exchange's consumers are given the ability to scale resources with just a click, and enjoy the costs savings from cloud computing's reduced bandwidth usage and infrastructure needs[19]. NYSE Technologies can quickly adapt to governmental mandates utilizing its secure financial transaction infrastructure network (SFTI – pronounced "Safety") as needed[19], another important benefit provided by the *Capital Markets Community Platform*. In this trusted and secure community Cloud environment, information is tightly controlled and completely isolated in a network that all major financial firms pay to access, analyze, and use secure financial data[19].

The *Capital Markets Community Platform* is a perfect example of how Cloud is changing the dynamics of Finance. Whether through data processing, staying relevant in regard to government and industry compliances, or just growing a financial institution, Cloud is the "all-in-one" technology that brings the best out of each organization it provides service.

The Future of Cloud Inside Financial Institutions

There are endless opportunities for financial institutions to leverage the benefits of Cloud computing, getting to reap those benefits, however, is a slow process.

The first step in this process is to migrate a variety of applications to the Cloud. Non-core applications and such business processes as recruiting, billing, and organization-wide travel management can—and should—easily move to the Cloud[22]. Next is to move a number of infrastructure operations, such as data center management, data storage, and disaster recovery to a Cloud after a thorough evaluation of different vendors offerings and based on the flexibility of Cloud vendors in documenting contracts[22].

Finally, is the move very few financial institutions are currently comfortable with; utilizing Cloud computing for their core applications. It is important for a financial institution to consider many hosting architectures provided by IaaS Cloud providers and to stay up to date with any emerging avenues in the Community and Hybrid cloud deployment spaces.

In his article *Cloud Computing for the Financial Services Industry*, Abhinav Garg describes four possible areas in which financial institutions could benefit in the future from Cloud. These items summarized are:

- **Risk analytics calculation**: Creating applications in the Cloud to calculate analytics such as cost of trade, current value, yields, and other financial indicators will advance the portfolio diversity of service solutions for financial institutions. A Cloud-based service can handle large volumes that are associated with analyzing real-time financial indicators. Current versions of such applications can only operate at specific times during the trading day. Generally, these applications require dedicated hardware which then leads to unutilized CPU cycles, a problem which can be addressed by a Cloud-based solution. As Abhinav Garg suggests, the whole solution can be implemented on a private cloud where existing computing power can be virtualized and made available as an on- demand service[22].
- **Performance attribution**: Performance attribution provides a methodology that quantifies the additional worth of an investment strategy against its benchmarks. Attribution allows investment managers to identify the factors of the investment process that contributed (positively or negatively) to the performance levels highlighted by

performance measurement[22]. Applications that track benchmarking performance of investments update, in real time, metric calculations. These processes are tremendously data-intensive and just as risk analytics, run at specific times of a day. A Cloud-based solution for such applications would provide scalability while optimizing compute resources availability.

- **Trade matching and reconciliation**: A trade matching process gets trade data from multiple brokers and counterparties and then reconciles it[22]. During peak trading hours, high volumes of transaction data from multiple brokers and counterparties clog the network. A Hybrid cloud-based solution would be most appropriate as the reconciliation portion of the process would be viable enough to implement on a Public cloud for scalability while the committed database servers in a Private cloud would require an enhanced level of security.
- **Reference data virtualization**: Various types of reference data, such as security master data, positions data, holdings and book data, and broker /counterparty data reside and are fed into financial applications from in-house databases or external feeds. When an application needs to access data from many sources, it can be a challenge to devise strategies that connect those data sources and consolidate and aggregate the data within the application for specific needs[22]. The recommended Cloud-based solution would be to develop a centralized data location which could seamlessly join various data sources in a single virtual data source. The solution should be flexible and utilize the efficiency of Cloud technologies to concatenate diverse streams of data accordingly to meet a particular application's criteria.

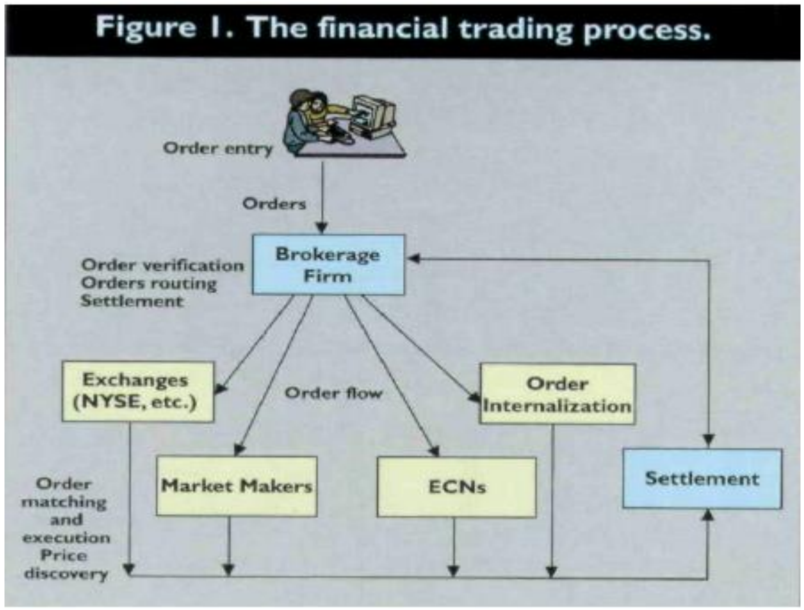
Cloud Computing is changing the paradigm for financial institutions services. Cloud is in a league of its own when it comes to disruptive technologies and is revolutionizing the game of Finance by providing institutions with flexibility they so desperately need in the market. The technology's use of provisioning of on-demand computational resources through a virtualized network makes it the perfect tool for financial institutions to develop, deploy, and deliver game-changing applications to their consumers. Many financial institutions have already recognized the payback of Cloud computing, which include scalability, cost savings, and time to market.

External Applications: Cloud in Trading

To better understand the commercial impact of Cloud, we will explore High Frequency Trading (HFT) and how a capital market trading platform is already capitalizing on Cloud technologies.

What is High Frequency Trading

In recent decades, there have been rapid advances in computing and telecommunication technologies leading to widespread high speed internet connectivity and thus resulting in a dynamic shift within the operation of the financial markets. The popularity of online trading has surpassed full-service brokerage firms with the lure of offering investors the ability to trade traditional financial instruments such as stocks, bonds, and mutual funds in addition to more sophisticated derivative devices such as option contracts and commodity futures. Personal investors also have access to real time market data as well as sophisticated investment research tools that were once reserved for professional investment brokers. Despite these advances, however, the methodology pertaining to order processing (defined as trade order entry, verification, and routing by the brokerage firm and finally trade execution and settlement) has remained largely unchanged and seems to have simply replaced traditional telephonic communication with that of the internet[23].



Adapted from The Internet and The Future of the Financial Markets[23]

In addition to the widespread acceptance and usage of online trading, the US financial markets have also experienced a profound change in the way they function operationally. Chief among these changes has been the rapid growth of Electronic Communication Networks or ECNs, electronic trading systems that can automatically match buy and sell orders without the intermediation of a human agent[24]. As a result of the increased usage of ECNs there have arisen unique competitive challenges among financial networks as a result of there being multiple venues in which a financial instrument can be traded. These market centers can be identified as Financial Exchanges (with the most well-known being the New York Stock Exchange), the market makers and lastly ECNs[24]. Each of these networks are all in competition for order flows, while each utilize different trading mechanisms to match buy and sell orders that can result in diverse market outcomes in terms of the speed and price at trade execution. The brokerage firm has essentially four routes in which to route the trade order: directly to the floor of the exchange, to a NASDAQ market maker, a third party market makers, or lastly to an internal market maker that is an affiliate of the brokerage firm.

As a result of these competing networks, it is ultimately the brokerage firms that play the vital role of determining the order-routing of each trade as the individual investor will rarely decide which market their trade will be executed upon. Due to this role as the "gatekeeper" of order routing, brokerage firms will receive payments or "kickbacks" from market makers or exchanges to prioritize orders in their favor[23]. Consequently, this prioritizing of orders can adversely affect investors' interests, undermine the competition, and reduce the incentive for market centers to innovate toward more efficient trade operations. These circumstances of prioritizing orders in exchange for compensation bring to light issues that destabilize the credibility of brokerage firms as well as the market exchanges and invite potentially immoral practices to occur such as prioritizing firms which employ algorithmic and high frequency trading practices.

In a broad sense, trading algorithms or “algos” can be defined as computer software that is designed with the intent to trade financial instruments in ways that would simulate or surpass the timing, judgement, and skill of a human. Due to the nature of algorithmic trading, there are many types of software utilized toward a myriad of different functions. The commonality that many algorithmic programs and more specifically, high frequency trading programs share is the application of high-speed order processing[(25)]. The use of algorithmic programs for financial trading in conjunction with the absence of human intervention brings to light several unique concerns. These include concern for the impact of high frequency trading upon the overarching financial system, the impact on the personal investor competing against algorithmic models, and lastly the potential use of high frequency programs towards market manipulation.

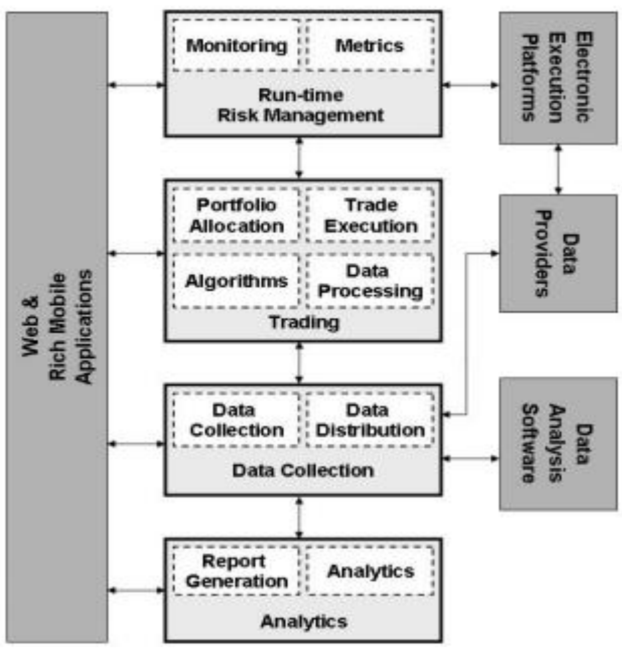
Algorithms are defined as a finite set of logic-based rules that specify the operations and actions to be taken to solve a given problem. Algorithms in themselves are not a new concept in traditional logics based disciplines, but rather their application and execution with computer software is a relatively new field. Algorithmic trading can fall into one of two categories: recessive, or non-executing programs, and executing programs. Non-executing algorithms are passive tools typically utilized to scan, process, and spot complex patterns that would otherwise be very difficult and time-consuming for a human to complete manually. The final decision and execution once the data is compiled, however, is still performed by a human. Executing (or automated) programs, conversely, are defined as those software programs that are directly linked to trading platforms so that the trading is automated based upon the parameters set by the algorithmic model[(25)]. To exemplify this, a non-executing program would scan market data to predict patterns and potentially alert the user as to when a potential “buy” or “sell” signal has occurred. The user then has the final decision as to whether or not to execute the trade. In this same scenario, an automated program would execute the trade once the set parameters have been met regardless of user interaction. The user is in a supervisory role with interaction limited to making sure the program is adhering to the algorithmic model as intended.

The advantage of executing algorithms versus non-executing is that automated programs take advantage of faster information processing. This processing and timing advantage is the key basis of high frequency trading algorithms. In a broad sense, high frequency trading is defined as utilizing automated programs to place, cancel, and modify trade orders at a higher frequency than a human trader would be able to otherwise[(26)]. As is typical for all executing algorithms, high frequency programs use processing power and high speed internet connections to gain a competitive advantage over other traders. The clearest example is the use of automated programs to conduct market arbitrage. Market arbitrage is the exploitation of miniscule price disparities of different securities that theoretically correlate in value but are temporarily uncorrelated in price. High frequency algorithmic trading makes it possible to detect and exploit these miniscule price disparities that typically occur within a matter of microseconds[(26)]. There also exist more complex forms of market arbitrage. This would entail the identification of disparities in price correlations between different assets by use of algorithmic processing to perform complex calculations in addition to the ability to identify trends within vast amounts of historical market data.

Executing programs, and more specifically high frequency trading algorithms, are able to be applied to a number of trading strategies other than the identification and exploitation of market arbitrage. One example is the use of automated programs to monitor and respond to a change in valuation of an asset between multiple exchanges[25]. This is made possible by programs that monitor trade activity of a particular asset on each exchange and will exploit any possible discrepancies across exchanges. This is performed by the programs' ability to identify and place orders in the exchange systems within milliseconds or microseconds ahead of other market traders. For example, the algorithm will identify that a particular stock is being sold for $25.00 on the NASDAQ and is being purchased on the NYSE for $25.05 and will capitalize on this momentary discrepancy within the milliseconds before the prices are properly adjusted.

As adapted from *Financial Business Cloud for High-Frequency Trading*, contemporary high frequency trading platforms incorporate trading, data collection, analytics, and run-time risk management modules. They may also be accessed via web and rich mobile applications to provide user control and enhanced management capabilities[27].

Explained in further detail below, the modules of a high frequency trading platform can be established by a financial institution either in-house or through the purchase of proprietary software sold by major software vendors. Generally, these high frequency trading platform modules are deployed on premises following high investments in expensive data centers including hardware, software, and network connectivity[27]. These modules are independent of one another, and utilize diverse communication protocols and data types. Development, deployment, operation, and maintenance of these systems require experienced IT labor which is expensive and drives costs upwards.



Reference component architecture of a contemporary on premises high frequency trading platform[27]

- **Trading Module** – incorporates optimal execution algorithms to achieve the best execution within a given time interval, and sizing of orders into optimal lots while simultaneously scanning multiple public and private marketplaces [27]. This module is responsible for handling data imports via the Data Collection Module as well as the real-time data imported from the Exchanges. While automating trading operations, the Trading Module produces the criteria for portfolio allocation and trade signals and recording the user's' profit/loss profile.

- **Data Collection Module –** accountable for the collection of both real-time and historical financial data from data providers (or aggregators) who generally provide 24-hour financial news and information including this high-frequency real-time and historical price data, financial data, trading news and analyst coverage, as well as general news[27]. High frequency financial data is mainly comprised of transaction observations on financial variables taken daily, or at a more granular level. The collected data based on the financial news is written in a machine readable format that is then dispersed to both the Trading and Analytics Modules in an effort to optimize trading algorithms, generate ad hoc reporting, and maintain decision making processes.
- **Analytics Module –** responsible for automated report generation from historical financial data as well as providing multidimensional analytics[27].
- **Run-time Risk Management Module –** ensures that the system stays within pre-specified behavioral and profit and loss bounds using predefined metrics[27]. Such applications may also be known as system-monitoring and fault-tolerance software.
- **Electronic Execution Platform –** A coalition of electronic execution platforms that utilize different coding languages. The goal of the Electronic Execution Platform is to optimize the exchange of financial trading data, aiding financial institutions in routing their trade executions from one executing platform to another, or to various platforms concurrently.
- **Web and Rich Mobile Applications –** the channels which enhance the management capabilities of the platform while increasing the promptness of user interactivity to produce a single point of control.

For a high frequency trading platform to be continuously efficient, it must rely upon two factors: processing speed and reducing latency. Reducing latency is crucial for algorithmic trading because it can result in the program receiving information without delay, being ahead of the market, and thus putting the user in a situation to exploit market opportunities before other traders. As previously mentioned, reducing latency correlates to being milliseconds or microseconds ahead of the competition. This has resulted not only in an innovation for hardware and software, but has closed the geographical gap between computational resources and the exchanges. It has become a standard practice for the world's security exchanges to rent space adjacent to and even in the same building or room in which the exchange servers are physically located so as to eliminate latency.

How Cloud is Optimizing High Frequency Trading

High frequency trading requires rapid execution of trading decisions and strategies in order to recognize a financial benefit. Therefore, high availability and scalability are crucial requirements of a high frequency trading platform. This makes high-frequency trading operations IT dependent, which generates two drawbacks from a cost perspective[27]:

1) **Profitability:** Trading itself already entails a transaction cost, and high-frequency trading generates a large number of transactions, leading to exorbitant trading costs. As high-

frequency traders look for tiny gains, the combination of trading and IT infrastructure costs reduces profitability[(27)].

2) **Lead time to deploy trading algorithms and strategies:** Implementing high-frequency trading platforms to deploy algorithms and strategies created by quants and traders requires experienced IT labor and this adds another layer to the operation, costing time and money[(27)].

Cloud Computing can alleviate the dependence of IT for high-frequency trading platforms by shifting the responsibility of the platform infrastructure to Cloud service providers. This removes the costly investment of building and maintaining of a multifaceted IT infrastructure with usage-based pricing service models and allows for a much more flexible utilization of compute resources.

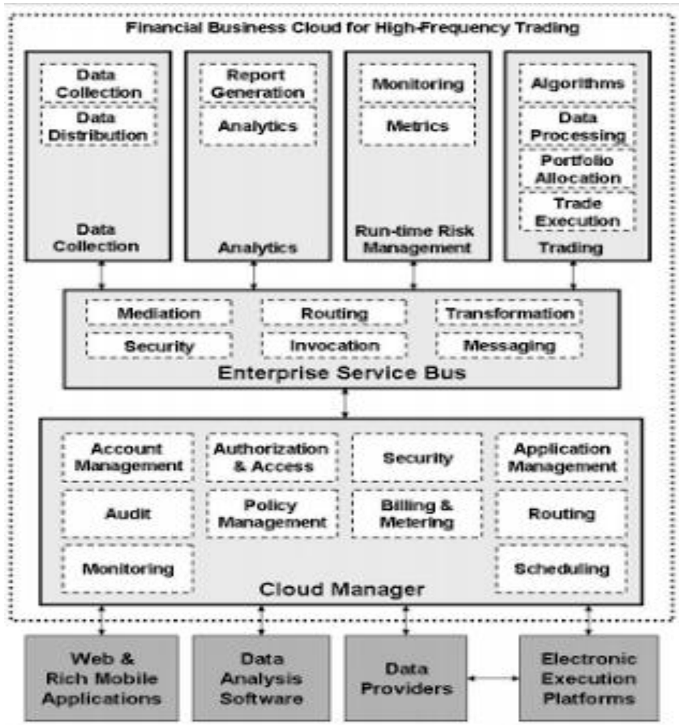
Cloud computing provides the availability, speed, and computing power required for automated algorithms and can computationally handle the batch processing and analytics jobs which high-frequency trading operations endure.

Implementing a Cloud infrastructure in high frequency trading organizations also decreases their total cost of ownership. Buyers can move from a capital expenditure (CAPEX) model to an operational expenditure (OPEX) model by purchasing the use of the service, rather than having to own and manage the assets of that service[(27)]. Cloud computing gives financial institutions the opportunity to outsource their IT infrastructure and operations, and concentrate on business rather than IT[(27)].

A Cloud-based HFT Platform

Adapting the idea further from *Financial Business Cloud for High-Frequency Tradin*g, this section presents the *Financial Business Cloud for High-Frequency Trading (FBC-HFT)* **–** an efficient trading platform and IT infrastructure for financial institutions using Cloud computing architecture[(27)].

Similar to the contemporary high frequency platform, in the Cloud based architecture, much of the original modules such as Trading, Data Collection, Analytics, and Run-time Risk Management Modules still maintain the same functionality, the only benefit now is that they are deployed into a Cloud environment. However, integration of these modules, routing, and data, and protocol conversions between them are now handled with an Enterprise Service Bus (ESB) [(27)], a standards-based integration platform combining messaging, web services, data transformation, and intelligent routing in a highly distributed, event driven Service Oriented Architecture[(27)]. In regard to the Cloud-based high frequency trading platform, the ESB can facilitate the development of data transformation and the integration of different systems. Modules provide standardized interfaces to be accessed and managed in the Cloud[(27)].



Reference component architecture of Financial Business Cloud for High Frequency Trading(27).

Directly connected to the Electronic Execution Platforms and the market data providers, the last piece in a Cloud-based high frequency trading platform is the Cloud Manager (CM). The CM is the common management system which manages request and response flows in the Cloud. Modules which need interaction with Electronic Execution Platforms and data providers use CM to access outside the Cloud(27). The ESB provides all routing, data and protocol transformations, mediations, and messaging between the CM and the modules, both providing elasticity and standardized integration to the system components. CM provides Web and Rich Mobile Application channels as single points of control for the cloud, boosting the speed of user interactivity and control(27).

As we've seen, the Financial Business Cloud for High Frequency Trading is an optimal model flexible enough to be adopted as IT for infrastructure financial institutions running high frequency processes. However, is it enough to stay competitive in the changing landscape that is capital market trading?

The Future of High Frequency Trading

As high frequency traders push the speed of trade executions to the boundaries, other financial institutions, such as asset management firms, are looking to add an extra layer of complexity to their trading and gain a competitive advantage. An available option for such institutions is to make operative use of data management strategies to amass and assimilate data of various types. Information flowing from social media networks, financial news websites, and other unstructured data formats can potentially be a source of revenue for capital market firms. The goal is to use Big Data to view the market state holistically and extract usable trading signals, specifically in the realm of investor sentiment, an aspect which HFT lacks(28).

Next, this article will explore what Big Data is, how it impacts finance at a higher-level, and then explore the notion of sentiment and how it can change the very strategy of trading.

Big Data

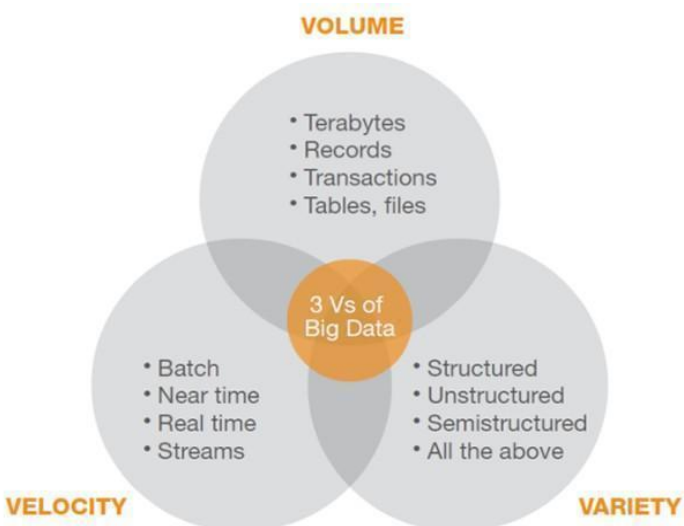
What is Big Data?

Before one can begin to understand what Big Data is, one first must conceptualize what data is. Data is a collection of raw and unprocessed bits and pieces of information in any sequence whose meaning is derived by analysis.

Data can be organized into four main data structure types:

1) *Structured Data* – data with a definite format, structure, and type, typically compiled into rows and columns (ex. Transaction data in an Excel template)
2) *Semi-structured Data* – data that has not been organized into a specialized repository (schema), such as a database, but that nevertheless has associated information, such as metadata, that makes it more amenable to processing than raw data[29] (ex. A website's HTML/CSS code)
3) *Quasi-structured Data* – Textual data with erratic data formats; can be formatted with effort, tools, and time (ex. Web clickstream data that may contain some inconsistencies in data values and formats) [30]
4) *Unstructured Data* – data with an undefined structure and can be stored as many different formats and structures (ex. text files, videos, images, and PDFs)

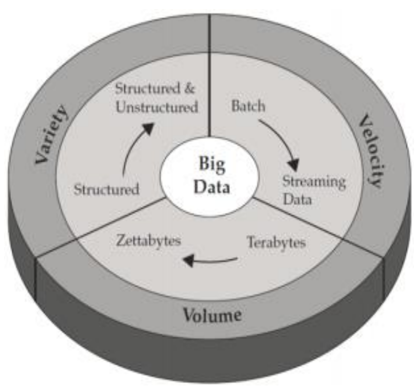
Big Data is a term for a collection of "large", structurally diverse, and "denormalized" (meaning there are instances of redundancies) data sets which are difficult to process using traditional data processing applications. This vast compilation of data sets follow three attributes as defined in 2001 by industry analyst Doug Laney, as he conceptualized the now conventional definition of Big Data with the inception of the three V's – Volume, Velocity, and Variety[31]:



The Three V's of Big Data[32]

- ***Volume*** – refers to the exponential growth in data quantity. The unseen digital universe being created by this data will continue to expand as both users and their devices continue to engage online. The digital universe is doubling in size every two years, and by 2020 the digital universe – the data we create and copy annually – will reach 44 zettabytes, or 44 trillion gigabytes[33]. The challenge for organizations now is to determine the significance of the data within enormous data volumes and how to utilize analytics to create value.
- ***Velocity*** – refers to the extensive rate at which data is being uploaded, downloaded, and streamed across multiple sources (i.e. social media sites, networks, business processes, etc.). According to Cisco's annual Visual Networking Index Forecast, in 2016, annual global Internet Protocol (IP) traffic is forecasted to be 1.3 zettabytes[34]. The pressure is on for organizations to capture and manage data in order recognize its worth. In order to do so, this large stream of data must be processed in a timely manner or risk becoming quickly outdated – a general challenge for many organizations.
- ***Variety*** – refers to the previously described structure of the data. The exchange of information has vastly changed from the traditional methodology of only being able to capture and organize data into structured datasets. The adoption of technology into every aspect of life, sure as sharing videos and photos instantly to transferring funds amongst bank accounts via smartphone has changed the format and presentation of data. Organizations are struggling to store, mine, and analyze each type of data when attempting to derive its value and meaning.

Considering the implementation of the three V's into the definition of Big Data, one could deduce a more refined definition of what Big Data is. Gartner provides such a definition as "high-volume, high-velocity and high-variety information assets that demand cost-effective, innovative forms of information processing for enhanced insight and decision making[35]".



Characterization of Big Data[36]

Reading further into this definition, it is clear that organizations must leverage Big Data and analytics to obtain valuable comprehension to inform better business results. So how do financial institutions do so? And what can Big Data do in the future for them?

The Impact of Big Data on Finance

The world of Finance comes face to face with Big Data issues each day. For example, the New York Stock Exchange (NYSE) captures one terabyte of information daily[37]. This constant increase in volume of market data poses various challenges for Wall Street firms that are trying to manage and analyze all this data. The problems span further as financial institutions face progressively fierce opposition, a demand for unique services from customers, and pressure from regulatory constraints. In an effort to attain dexterity over these burdens, these institutions are seeking new ways to leverage Big Data technology.

Alongside solving operational issues, financial institutions can leverage their ability to collect copious amounts of data with relative ease to develop meaningful information and customer services. Utilizing Big Data analytics, financial services have been provided the opportunity to optimize their investment decisions and provide their clients with consistent returns.

	Asset management	Banking	Capital markets	Insurance
Customer data	• Sentiment analysis-enabled sales forecasting • Sentiment analysis-enabled lead/referral management • Quality of leads analytics • Closed loop marketing campaigns • Investment product distribution channel effectiveness • Micro-segmentation • Sentiment analysis-enabled brand strategy management • Cross-asset class product impact analytics • Fund price discovery analytics	• Client experience closed feedback loop • Customer life event analytics • Next best offer • Real-time location based offerings • Sentiment analysis-enabled sales forecasting • Sentiment analysis-enabled lead/ referral management • Micro-segmentation • Customer gamification • Sentiment analysis-enabled brand strategy management	• Sentiment analysis-enabled sales forecasting • Sentiment analysis-enabled lead/ referral management • Closed loop marketing campaigns • Sentiment analysis-enabled brand strategy management	• Micro-segmentation • Closed loop marketing campaigns • Sentiment analysis-enabled brand strategy management • Client experience closed feedback loop • Customer life event analytics • Next best offer • Real-time location based offerings • Sentiment analysis-enabled sales forecasting • Sentiment analysis-enabled lead/ referral management • Customer needs sentiment analysis
Transactions	• Best trade templates • Log analytics • Real-time capital calculation • Operational data store (ODS) consolidation • Trading sentiment analysis • Time series data management	• IVR analysis • Business-to-business (B2B) merchant insight • Real time capital calculation • Log analytics • ODS consolidation	• Time series trade data management • Real-time margin calculation • Log analytics • Over-the-counter (OTC) contract optimization • ODS consolidation • Trading sentiment analysis	• Customer experience analytics • Log analytics • ODS consolidation • Claim leakage/increased payout analytics
Risk management	• Centralized risk data management • Counterparty risk management • Reputational risk management • Anti-money laundering	• Management information systems (MIS)/regulatory reporting • Disclosure reporting • Real-time conversation keyword tracking • Anti-money laundering • Indirect risk exposure analytics • Reputational risk management	• Centralized risk data management • Counterparty risk management • Insider trading analytics • MIS/regulatory reporting • Disclosure reporting • Reputational risk management	• Social media customer behavior fraud analytics • Reputational risk management

Adapted from PwC: How can the Financial Services Industry use Big Data? [38]

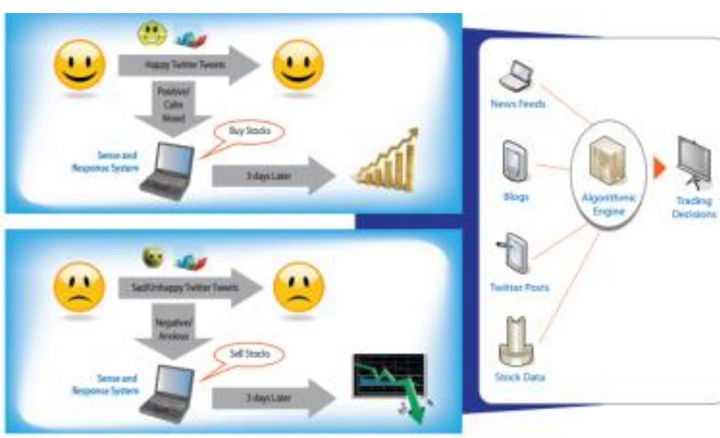
Inevitably, the continual adoption of Big Data will beneficially transform the landscape of financial services, while at the same time, presenting the same institutions with problems when capturing the necessary insights and value from the rising volume of market data. Big data projects may be frequently implemented in a sporadic manner across capital markets firms, but they can be categorized into three main types of implementation—those focused on revenue generation, those aimed at meeting compliance or risk requirements, and those focused on cost reduction and operational efficiency.

We can see that Big Data makes a big difference in financial institutions, but how can it change the way we look at trading? Can Cloud play a role in this?

Incorporating Sentiment into Equity Trades

As discussed, High Frequency trading has been able to capitalize on Cloud-based technologies to gain a competitive advantage. However, as Cloud-based solutions become widely adopted throughout capital markets and utilized for HFT, innovative financial institutions are moving towards the benefits of unstructured data that are changing the very dynamics of trading. Financial institutions are now able to more easily compile unstructured data consisting of daily stock feeds, social media conversations about certain ticker symbols, and blog posts about the current market trends, opening the door for algorithmic traders to yield substantial returns based on market news.

Capitalizing on this new wave of unstructured data, financial institutions are utilizing sentiment analysis, a Big Data strategy used to gather and process information surrounding specific markets to create a clear understanding of market sentiment in order to drive front office trading strategies, as well as to determine the valuation of individual securities(39). Traders are able to leverage this information to determine whether various market participants and commentators, including those on social media networks have positive (bullish) or negative (bearish) outlooks for the market and frame investment strategies accordingly. At the organizational level, incorporating a sentiment analysis utilizing the news surrounding an organization into the valuation methodologies of its current stock price can yield a different picture of the company's stock price. By comparing this to the market value, investors can more effectively gauge whether an equity is undervalued or overvalued, thereby highlighting potential opportunities for arbitrage(39).



Adapted from Infosys: Use of Big Data Technologies in Capital Markets(40)

Behavioral analysis is an increasingly important input for modeling and predicting the movement of financial assets. Market sentiment is commonly measured using a range of statistical tools focusing on stock market highs and lows to produce a relative comparison between the numbers of advancing and declining stocks. More recently, firms have focused on increasing their capabilities to perform news analytics, thus entailing the use of Big Data strategies.

Adding this extra layer of analytics to a high frequency trading algorithm opens the door for traders to capitalize on the sentiment of the market. Big Data and Cloud technologies optimize not only the way we trade, but how we view the meaning of trading.

There is another disruptive technology that goes beyond Cloud and Big Data technologies by fundamentally changing the dynamics of trade. Utilizing high-powered compute and network resources, this revolutionary concept of technology will completely change the way we trade. It is the development of cryptocurrency.

Cryptocurrency

Cryptocurrency is a form of digital currency in which encryption techniques are used to regulate the generation of units of currency and verify the transfer of funds, operating independently of a central bank(41). As is the case with many forms of currency worldwide (such as the US dollar), cryptocurrency has no intrinsic value in that it is not redeemable nor is it backed by another commodity, such as gold. The only apparent value created is the one in which individuals are willing to trade real goods and services, and believe that others will do the same. It is not legal tender, and is not currently backed by any government or permissible entity. Unlike fiat currency (the paper money in our wallets), however, cryptocurrency has no physical form. Since the supply of cryptocurrency is not determined by a central bank and the network is completely decentralized, all transactions are performed by the users of its system (utilizing a peer-to-peer architecture). Users decide for themselves what each unit of a certain cryptocurrency represents – whether it is a portion of a US Dollar or a kilowatt of electricity. They also decide the cryptocurrencies properties, as they have the ability to divide it into 100 million units, all of which are both independently classifiable and programmable. The term cryptocurrency is used because the technology is based on public-key cryptography, meaning that the communication and transactions are removed from the view of “Trusted Third Parties”. These third-parties are entities whom would usually facilitate, regulate, and approve financial transactions, such as governments, banks, accountants, and/or notaries(42).

Bitcoin is often thought to be the only virtual money that follows the cryptocurrency system, but that notion is untrue. Even though Bitcoin is the largest cryptocurrency by market capitalization volume, acceptance, and notoriety, it is not considered the most valuable coin(43). Other cryptocurrencies have matched the power of the Bitcoin back in 2014, where at one point, NEMstake, while only having a market cap of $1,116,720, traded at $1,117 a coin(43).

Bitcoin, the first cryptocurrency, appeared in January 2009 and was the creation of a computer programmer using the pseudonym Satoshi Nakamoto[44].

Cryptocurrency may be considered nothing more than “electricity converted into lines of code with monetary value[43]” but it is a monetary value that is growing. There are 615 currencies which are traded daily on 1902 cryptocurrency markets. The current cryptocurrency market capitalization is around $7 billion, with daily volumes trading as high as $32 million[45].

As previously noted, unlike fiat currencies, cryptocurrencies are decentralized, meaning they are limited to or have no government control in regard to regulations or compliances. This leaves the designers of a cryptocurrency to develop properties into their creations in order to better regulate the currency’s volume and market capitalization. For example, Bitcoin is designed to decrease in production over time, creating a market cap. This differs vastly from cryptocurrency’s fiat counterpart in which financial institutions can always create more, hence inflation. Bitcoin will never have more than 21 million coins in circulation[43].

How Cryptocurrency Trade Works

As defined by *Investopedia*: “Trade is a basic economic concept that involves multiple parties participating in the voluntary negotiation and then the exchange of one's goods and services for desired goods and services that someone else possesses. The advent of money as a medium of exchange has allowed trade to be conducted in a manner that is much simpler and effective compared to earlier forms of trade, such as bartering. In financial markets, trading also can mean performing a transaction that involves the selling and purchasing of a security[46]”.

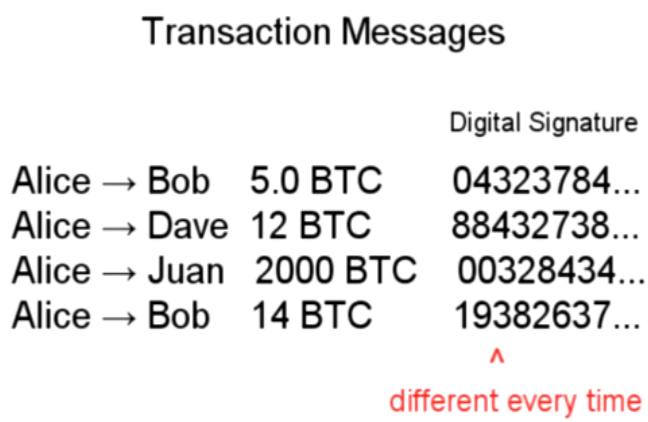
Cryptocurrency trading, at its core, still employs an identical denotative meaning. The difference, however, is in how the trading of cryptocurrency actually works behind the scenes compared to its traditional counterpart.

In cryptocurrency trading, a transaction is a digital declaration by one party of its intent to transfer a certain number of cryptocurrency to another party. Trading a cryptocurrency signifies the trading of the collective transaction entries in a ledger of that coin. These ledgers are ordered in what is known as the “Blockchain”, which plays a key role in the integrity and security of each transaction.

In order to develop a deeper technical understanding of the technology, an example provided by Scott Driscoll, in his blog post “How Bitcoin Works Under the Hood” will be utilized to showcase how a cryptocurrency technology functions (in this case, the cryptocurrency is Bitcoin).

Transaction Chains

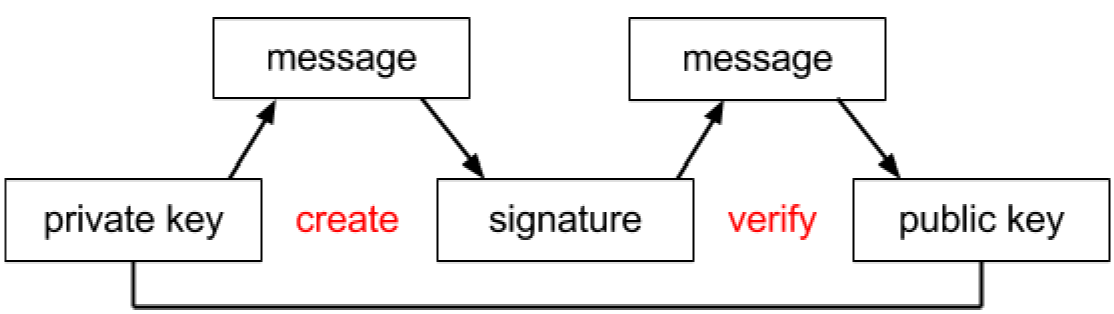
At an elementary level, Driscoll explains a Bitcoin transaction between two parties, Alice and Bob. In this scenario, Alice wishes to send Bitcoin to Bob, and does so by simply broadcasting a message with the accounts and the amount [47].



Adapted from "How Bitcoin Works Under the Hood[47]"

Once Alice has done so, every node in the Bitcoin ecosystem receives the message and begins to update their copy of the ledger, and then pass along the transaction message. The authenticity of this transaction is validated by a password which unlocks the funds to be transacted using what is called a "Digital Signature." Like a real handwritten signature, it proves the authenticity of a message, but it does so through a mathematical algorithm that prevents copying or forgery in the digital realm[47]. For each transaction occurring between two parties, an entirely different Digital Signature is required.

A Digital Signature works by utilizing two different (but connected) keys, a "private key" to create a signature, and a "public key" that others can use to check it[47].



Adapted from "How Bitcoin Works Under the Hood[47]"

- **Private key** – A password which identifies an individual's signature and is used as a midway transaction point that proves an individual has the correct password without requiring them to reveal it. This key should **not** be shared.

- **Public key** – the "send to" addresses in Bitcoin. Each individual in the Bitcoin ecosystem has a specific public key that identifies them. This key can be shared.

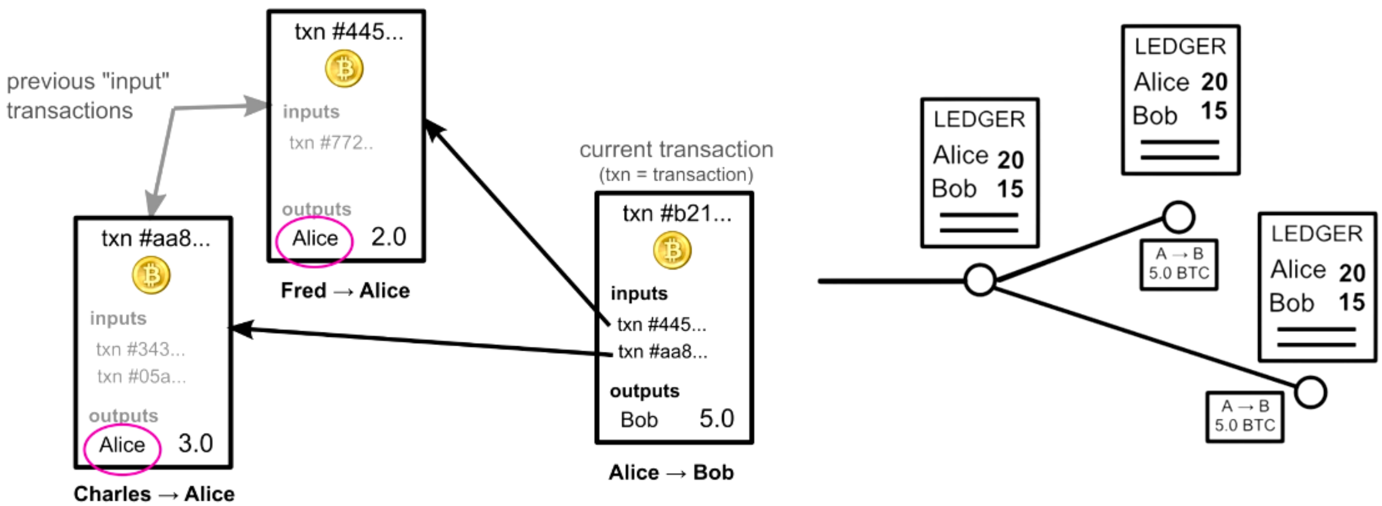
In order for the transaction to occur, an individual must prove that they are the true owner of their assigned public key address where the Bitcoin was sent, which is done by generating a Digital Signature from a transaction message and their private key.

signature = f(message, private key)(47)

Other nodes in the Bitcoin network can use the Digital Signature to verify that it corresponds to an individual's public key.

1 =? v(message, public key, signature) (47)

The nodes in the Bitcoin network are able to verify that the sender owned a private key without requiring a validation of the key.



Adapted from "How Bitcoin Works Under the Hood(47)

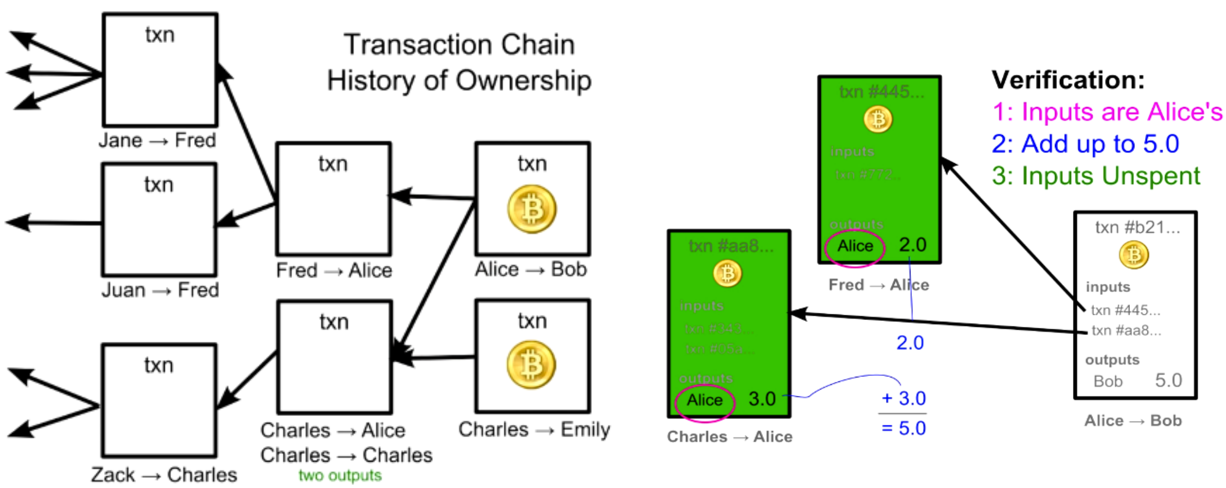
It is important to recognize that the Digital Signature depends on and is different for each transaction message; therefore, it can't be reprocessed by another individual in another transaction. This dependence on the transaction message signifies the message cannot be modified while in transit across the network, as any alterations to the message would invalidate the signature.

The transaction record is created and information logs include the date, time, participants ,and quantity of every transaction. For this reason, transactions are considered pseudonymous, not anonymous.

Reverting back to the example provided by Scott Driscoll, let's continue to look at the transaction between Alice and Bob.

For Alice to send five Bitcoin to Bob, Alice must reference other transactions where she received 5 or more Bitcoins(47). These referenced transactions are denoted as "inputs" which are then verified by other nodes to ensure Alice was in fact the recipient, and the inputs add up to 5 or more Bitcoins.

The resulting outputs of a transaction are two-fold. The first output would be identified as the trade made from one individual to the next. As an example, in the Figure below, we can see that Charles has sent Bitcoin to Alice (identified as Charles → Alice). The second output would be the remaining delta of the transactions sent back to oneself. A simplifying rule states that each input must be used up completely in a transaction, so if you're trying to send an amount that doesn't exactly match one of your inputs, you need to send any remaining amount back to yourself(47). As an example, reverting back to the Figure below, we can see that after Charles sent a share of Bitcoins to Alice, he then sent however many Bitcoins he still owned back to himself (identified as Charles → Charles).



Adapted from "How Bitcoin Works Under the Hood(47)

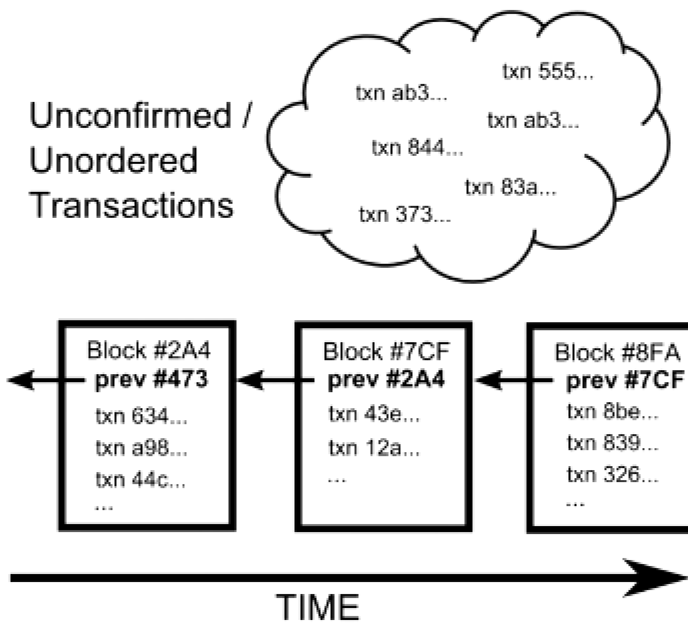
Upon completion of a transaction, any Bitcoin transferred from one individual to the other is considered as expended and is not eligible to be utilized in another transaction. Otherwise, someone could double-spend an input by referencing it in multiple transactions(47).

During the validation of a transaction, nodes also ensure that the currently utilized inputs haven't already been spent by checking every other transaction in the Bitcoin network. This means for every transaction, there is a public notification and thousands of nodes must unanimously agree that said transaction has occurred on that specific time on that specific date. In this implementation, each node has access to a collective single source of truth. While this may seem time consuming, as there are now over 20 million transactions, it's made fast with an index of unspent transactions(47).

Unlike traditional financial transaction tracking, such as balances in a bank statement, ownership of funds is verified through the links to previous transactions. These lists of transactions are ordered in what is called the "Blockchain".

Blockchain

The Blockchain is a public ledger, or list, of all of a cryptocurrency's transactions. These transactions are permanently recorded in the ledger files and are deemed as "blocks". It is continuously increasing as 'completed' blocks are added to it with new sets of recordings. This decentralized public ledger keeps a record of all transactions taking place across the peer-to-peer network. Identifying information is encrypted, and personal information is not shared.



Adapted from "How Bitcoin Works Under the Hood(47)"

Every block in the chain has a reference to its previous block, and spans all the beginning group of transactions ever made. Transactions in the same block are considered to have happened at the same time, and transactions not yet in a block are called "unconfirmed," or "unordered"(47).

There is no specific node assignment to unconfirmed transactions when moved into a block, so to remediate the issue of multiple transactions creating numerous blocks at the same time, a rule is implemented so that in order to create a new, valid block, the solution to very distinctive mathematical question must be solved. A computer runs the entire text of a block plus an additional random guess through something called a **cryptographic hash** until the output is below a certain threshold(47).

A cryptographic hash function creates a short digest from any arbitrary length of text, in our case; the result is a 32 byte number. The examples below are provided by Scott Driscoll of the specific hash function utilized by Bitcoin which utilizes the Secure Hash Algorithm (SHA) 256:

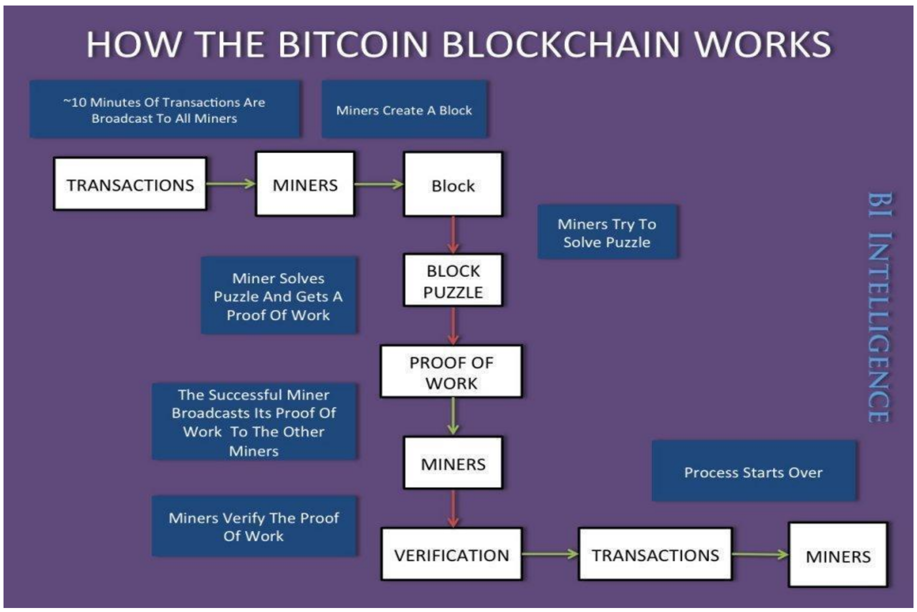
SHA256("short sentence")
0x
0acdf28f4e8b00b399d89ca51f07fef34708e729ae15e85429c5b0f40329
5cc9
SHA256("The quick brown fox jumps over the lazy **dog**")
0x
d7a8fbb307d7809469ca9abcb0082e4f8d5651e46d3cdb762d02d0bf37c
9e592
SHA256("The quick brown fox jumps over the lazy **dog.**") **(extra period added)**
0x
ef537f25c895bfa782526529a9b63d97aa631564d5d789c2b765448c86
35fb6c

Adapted from "How Bitcoin Works Under the Hood[47]"

It is important to understand that any change to the input vastly impacts the outcome of the output. In the above example, the simple addition of a period to the input created a completely different looking output. The output is completely unpredictable, so the only way to find a particular output value is to make random guesses[47]. This process would take a typical computer several years of estimating this output before a block would be considered deciphered. It is up to someone to solve this problem and allow the transactions to be recorded and blocks created. This seemingly impossible problem is solved by "cryptocurrency miners" whose role is explained in greater detail in the following section. The first cryptocurrency miner to solve the convoluted math problem presented will then broadcast their block, which moves their transactions to next in the chain. The randomness in the math problem effectively spreads out when people find a solution, making it unlikely that two cryptocurrency miners will solve it at the same time[47].

Cryptocurrency Mining

In an effort to ensure zero redundancy in every transaction, all cryptocurrency Blockchains are maintained by a community of "cryptocurrency miners". These miners take on the duty of adding transaction records to the Blockchain by solving the complex and specific mathematical problem to create the previously explained cryptographic hashes to create a new block. Miners are members of the general public that have set up their computers or Application-Specific Integrated Circuit (ASIC) machines to participate in the validation and processing of transactions[43].



An illustration of Coin Miner's functionality in the Blockchain[48]

Miners engage in the effort to help with the broader validation of transactions between two parties. Their job is to utilize distinct hardware and software to solve complex mathematical puzzles to, as stated above, participate in the validation and processing of transactions[43]. In return, these miners are compensated a certain number of coins in exchange for their work.

For a miner to prove that they have actually completed a mining task, one of two protocols is utilized to validate their work has been completed: *Proof-of-Work* or *Proof-of-Stake*:

- **Proof-of-Work (POW)** system where the probability of mining a block is dependent on how much work is done by the miner[49].

- **Proof-of-Stake (POS)** system varies in that a person can "mine" depending on how many coins they hold. Simply put, a person owning 5% of a coin based on Proof-of-Stake can mine 5% of the blocks in the same way that a person owning 5% of the bitcoin mining network will theoretically mine 5% of the blocks[49].

The goal of a Cryptocurrency miner is to validate each transaction as quickly as possible. To do so, a miner must have the appropriate energy capabilities (i.e. thousands of kW/h of energy utilized), compute (i.e. kH/s, MH/s, etc.), and network (i.e. high transfer rates in Mbps) resources to solve each block puzzle. A cryptocurrency's mining power is rated on a scale of hashes (i.e. cryptographic hashes) per second, and is generally mined utilizing various hashing functions, the most common being Secure Hash Algorithm 2 (SHA-2) or Scrypt.

Cryptocurrency mining rigs (i.e. hardware and software specifically used for coin mining) vary amongst miners. A rig with a computing power of 1kH/s is mining at a rate of 1,000 hashes a second, 1MH/s is a million hashes per second, and a GH/s is one billion hashes per second.

Some of these rig implementations that cryptocurrency miners are utilizing have started to go beyond what is feasible to attain for an individual looking to start cryptocurrency mining. These complex rigs utilize advanced hashing algorithms such as SHA-2 or Scrypt which consume formidable amounts of compute and processing power to help successfully complete a cryptocurrency transaction. Some examples include an ASIC SHA-256 mining rig running 4 GPU's would get a hash rate of around 3.4 MH/s and consume 3600kW/h, while an ASIC machine can mine 6 TH/s and consume 2200kW/h[43].

Photo of an ASIC Miner [50]

Mimicking the Markets- Cryptocurrency Exchanges

If you aren't technologically savvy, but want to start trading cryptocurrencies, there are exchanges – just like traditional stocks and commodities – which one could begin exploring. Set up as traditional stock and commodity exchanges, cryptocurrency exchanges have been created to help investors build and maintain their digital currency accounts(51). While it is possible to trade cryptocurrencies outside of an exchange (i.e. doing so directly with other cryptocurrency traders), it is not a recommended course of action. Direct trades with other individuals can be cheaper and quicker than going through an exchange in many cases, but you're also working without the built-in "safety net" that the services exchanges provide(51).

Unlike its traditional counterpart, the cryptocurrency market is traded internationally, and there are no rules or regulations as to how or when a trade can take place.

Just as traditional stock exchanges, cryptocurrency exchanges offer many similar statistics such as the number of trades executed in a set time frame (i.e. one hour, a day, a week), the current value against the US dollar, or Euro, or the British pound and the currency value trend over time. Beyond market stats, exchanges will often include information that's specific to the exchange, too, such as membership numbers, trades made on the exchange, and mobile applications(51).

Facilitating Trades

As noted earlier, trading cryptocurrencies is no different than trading for stocks and commodities on traditional exchanges by matching the needs of both buyers and sellers and transacting at an agreed-upon price. As described in Michael Miller's "The Ultimate Guide to Bitcoin", someone wanting to buy Bitcoin puts in a *buy order* (or *bid*) is essentially saying he's committed to purchasing X number of Bitcoin at Y price. Separately, someone wanting to sell Bitcoin puts in a *sell order (or ask*), saying he's committed to selling X number of Bitcoin at Z price(52). These transactions are managed via the exchange and match both parties' orders to perform the trade.

Depending on which exchange is used, the trade itself may or may not be the responsibility of the exchange. With some exchanges, the Bitcoin goes directly from the seller to the buyer, while in others, the seller deposits the Bitcoin with the exchange, and that Bitcoin is transferred to the buyer at the completion of the transaction(52).

Executing Trades

As in traditional investing, when a buyer or seller places an order, they may choose to place either market orders or limit orders. A market order guarantees a trade, but leaves no certainty to price. Mentioned earlier, a market order is an agreement to buy or sell X number of equities at the current market price. Limit orders are trade actions taken when the desired buying or selling price is specified, but the trade itself is not guaranteed. Just like a limit order in the traditional exchange of equities, the buyer or seller will place an explicit limit on the amount they are willing to transact their Bitcoin for; when the market price meets the limit price, the transaction occurs. If the prices never meet that limit, no transaction is made and usually after a certain time, the trade option expires.

Bitcoin exchanges vary in whether or not they offer both market orders and limit orders.

Transaction Fees

Bitcoin exchanges are for-profit enterprises, and like most service-oriented businesses, they charge fees on each transaction[52]. These fees vary between exchanges. There may be fees based on the size of the trades, and/or there may be fees for a particular party involved in the transaction (i.e. fees for sellers but not buyers).

According to Michael Miller in "The Ultimate Guide to Bitcoin", one can expect to pay anywhere from 0.05% to 1.0% per transaction[52].

Conclusion

Trading cryptocurrencies in an exchange has many similarities to the traditional stock and commodity exchanges with the only exception being not having a single broker or exchange representative one could reach out to. Since digital currencies are in effect owned by their investors, exchanges tend to play a hands-off role[52]. Risk is rampant through any form of financial investing and cryptocurrency trading is no different. The exciting part of these exchanges, however, is the countless opportunities that may arise from cryptocurrencies and their technologies that could change the financial industry. If cryptocurrency exchanges can mimic those of its traditional counterparts in such a short amount of time, imagine the potential for disruption it could create in the future.

Future of Cryptocurrency Technology and Investors

In the 2015 report *Money is No Object: Understanding the evolving cryptocurrency market* published by PwC©, it is stated that investors generally appear to be confident regarding opportunities associated with cryptocurrencies and cryptography[53]. This is derived from an analysis of reputable cryptocurrency organizations, which have appealed to the institutional investors. However, the main source of investments for cryptocurrency technologies have been from venture capitalists – many with formidable experience investing in the technology sector – who have been pouring capital into the cryptocurrency market, staking on the technology's future market growth.

Outside the realm of direct investing, enterprises with a focus in cryptocurrency have begun to capitalize on the technology's early market by developing and mining cryptocurrency, and creating cryptocurrency exchanges, transaction processors, and cryptocurrency storage and backup[53]. Here is where cryptocurrency technologies differ vastly from their traditional technology startup counterparts by deviating from customary investment strategies. Traditional technology startups typically involve new ideas that function either outside of existing regulations or safely within their boundaries. Unfortunately, those organizations looking to implement cryptocurrency face a host of complex regulations. For this reason, cryptocurrency will not reach its true market potential unless and until it develops in harmony with applicable regulations[53].

Cryptocurrency Technology utilized by Financial Institutions

Conventionally, it has been the duty of financial institutions – more specifically, banks – to be in the business of money, whether it is loaning capital to a small business or opening up personal savings accounts. However, the rise of Internet banking has augmented consumer use of alternative payment methods alongside the advances of mobile payment applications. These innovative approaches to banking still ultimately depend on traditional financial institutions to process transactions. Cryptocurrency technologies provide an alternative opportunity by enabling a faster, more protected, low-cost solution for consumers to execute and transmit trade over the Internet.

Cryptocurrency transactions are processed using cryptographic code verification that clears and settles transactions within minutes, at zero or nominal cost. Theoretically, this would render traditional banks unnecessary. Traditional clearing and settlement services are required only at the point of exchange for fiat currency. For this reason, the more that cryptocurrency gains acceptance among merchants and consumers, the less need for traditional financial institutions to provide clearing and settlement services(53).

Bank of America

It would be difficult to state with absolute certainty if cryptocurrency will ever replace banks, but the technology has already begun to show potential for transformation. In a recent article by *Coin Desk*, Bank of America has filed a patent, on March 17th, 2014 (still pending), seeking to protect a system by which electronic funds could be sent between customer accounts using the underlying Blockchain of a given cryptocurrency as the rails for payment(54).

The system described, for example, would enable customer funds to be converted at a cryptocurrency exchange and then sent to a second cryptocurrency exchange to be converted into a foreign currency before the value is moved to the recipient(54). The market for cryptocurrency technology in financial institutions is prevalent, as a majority (76%) of current users say cryptocurrencies will redefine banking as we know it, and 59% say their banking experience would improve if they had greater access to cryptocurrencies(53).

NASDAQ LINQ

NASDAQ, the world's second-largest stock exchange, is utilizing cryptocurrency technology. In an article by Joseph Young from *News BTC*, NASDAQ is leveraging a Blockchain implementation titled NASDAQ LINQ Blockchain. Developed by Blockchain software developer and infrastructure provider *Chain.com,* this ledger technology is used for settling private securities transactions(55). The benefit to the NASDAQ falls in the Blockchain network used by the provider *Chain.com* in order to significantly reduce settlement time and cost for paper stock certificates(515). As per the article, the Blockchain provided the stock exchange a deeper level of transparency, enabling both equity issuers and investors an accessible means of tracking and viewing official documents online. NASDAQ plans to test the technology for proxy voting in Estonia late 2016 and is working to develop an enterprise-wide Blockchain-based applications for banks, financial institutions, and government agencies(55).

Cryptocurrency – What's Next?

Private, open source, and decentralized. The benefits to financial investors and institutions are bountiful. Cryptocurrencies are much more than a form of money or payments; they are smarter forms of currency which can automatize cash flows between organizations. Automating financial processes leads to a decrease in bureaucracy, which saves accountants, controllers, and organizations a considerable amount of time. The programmable, open nature of all cryptocurrencies allows for a complete overhaul and innovative take on the financial sector and administrative processes by making them more efficient and transparent, while significantly decreasing bureaucracy. The rules of the trade are programmed into the coins, allowing each unit to be directed in such a way that it will automatically return to the provider if the receiver doesn't use it after a certain amount of time. Cryptocurrency and its technologies open up market opportunities and break the position of middlemen.

The public ledger that is Blockchain technology and the pseudonymous nature of cryptocurrency processes has the potential to disrupt a wide variety of transactions, in addition to the traditional payments system. No longer would the trade of equities, bonds, and other financial assets need a trusted third party to provide verification of the transaction – the security of such transactions are in the hands of Coin Miners who work in the Blockchain.

Cryptocurrencies have caused a paradigm shift in the financial industry. The future of this new technology will constructively open discussions to seemingly infinite potential applications.

The Future of Finance

Technology is altering the way we trade. Financial institutions are becoming aware of this change, and are utilizing disruptive technologies to get ahead of the times and to stay competitive. The implementation of Cloud technologies within financial institutions are optimizing their businesses and trading platforms such as High Frequency Trading. Big Data is shaking up the definition of financial markets by including consumer sentiment in their valuations of an organization, and both the concepts and technologies of cryptocurrencies are shifting the very dynamics of trade.

It is our hope, after reading this article, that you weren't only taught financial fundamentals alongside each technological concept, but now understand how the application of each disruptive technology is changing the financial paradigm. We hope you enjoyed your front-row seat into the future of finance – an exclusive revelation of the countless emerging technologies and how they will foster the novel fortunes of tomorrow.

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