

BLOCKCHAIN :

Reinvent Service Delivery
Technology Trend Analysis
of Blockchain Technology



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Executive Summary

The size of the global blockchain market is estimated to be 2.3 billion US Dollars by 2021 and about 339.5 million US Dollars has already been invested into blockchain companies in 2017 (Statista, 2018). It is no surprise then that the blockchain market is being hailed as a revolutionary technology similar to internet, smartphones etc. that will transform the way companies operate their businesses. Although the applications of blockchain are majorly in the financial industry but there are endless possibilities for blockchain being considered.

This report aims to emphasise how blockchain can revolutionise Thailand major industries based on the study of world-wide patent data. According to Thailand 4.0 economic model, Thailand is unlocking the country from economic challenges by focusing on value-based economy that is driven by innovation, technology and creativity especially on 5 major industries – Robotics industry, Aviation and Logistics industry, Biofuel and Biochemicals industry, Medical industry, and Digital Industry. As patents are an important signal of innovation, the patent filing in the domain of blockchain can represent a growing opportunity in this area where the data can be analysed to see what are the emerging technologies, who are the key players, and where is the potential market. This can give a broad overview of world situation and be a guideline for Thai businesses to before start adopting blockchain technology into their businesses.

Overall, worldwide collection of 3,763 patent families have been found in this domain in the last 10 years with a rapid year-on-year growth in the filings of patent family members from 2014-2017. Majority of the inventions originate from China, followed by USA and South Korea respectively. Among the top priority countries, China reports the highest Compound Annual Growth rate (CAGR) of 430% from 2014-2017. Majority of the top patent filing entities are also dominated by Chinese organizations. It is the American software giant IBM that has emerged as the top filing entity followed by South Korea's Coinplug and China's e-commerce company Alibaba. These top entities are commercial institutions with focus on either technology or finance. Amongst the top filing entities, Coinplug, nChain Holdings and

MasterCard have the broadest geographic filing strategy indicating a wider commercial potential. However, the Chinese organizations are mainly filing in China with Alibaba as the only exception.

Overall, Privacy/Security and Identity/Access Management are the top enabling technologies in blockchain with IBM and Coinplug as the key patent filers in this area. Smart Contract is an emerging enabling technology that witnessed the highest growth rate of 358% between 2014-2017. Cross-chain/Atomic swap is one of the latest & emerging technologies in the blockchain domain with most of the patent filings from 2015 onwards in China, USA, South Korea and Australia. Banking/Finance and Crypto-currency are the largest application areas in blockchain followed by Logistics and Supply Chain Management. Internet of Things is an emerging application area for blockchain with a growth rate of 283% for the period 2014-2017 and organisations such as nChain Holdings and China Unicom Group have patents in this area.

Objectives

This analysis report presents the patent analysis data and the current situation of blockchain technology by reflecting the technologies through the perspective that is shown in patent registrations internationally by depicting the trend of the blockchain technology, the information of the key players (the applicant of the patent) and the trend or the characteristic of the trend that is shown. In which this analysis report includes the presentation of the database relating to the current technology of the blockchain system data collecting, including the supply chain in order to present the overall perspective of the industry from the upstream level to the downstream level as a supporting data for conducting the technology analysis based on the patent data from this analysis report.

In addition to the technology data and the patent perspective this analysis report is aimed to create awareness of the body of knowledge, the understanding and the use of the patent data to reflect the current situation of the industry. In which the patent data could also be adapted for the use in different ways, it also could create awareness of the importance of Intellectual Property and for the industrial relating to the creation and development of new technologies.

Patent as Indicators of research performance

Patent can be used as an index indicator of the research and development (R&D) result (Griliches, 1998). Furthermore, the patent data and the patent reference ratio have a great impact on the market value (Hall, 2005) in which the patent is a certificate which certified that the product, method is novel, having an inventive step and is industrial applicable. Patent also give an exclusive right to the patent applicant to have the exclusive right to produce, use, sell, or import the product or product formed by the procedure in accordance with the patent for a certain time frame.

Patent also contains the useful information which is available for the public such as the International Patent Classification: IPC, applicant information, inventor information, the reference documents that is the foundation of the invention development (Background of the invention).

Therefore, the patent data analysis by using the credible researched data for analyzing the patent data such as the inventor, the technology group, the countries that have filed for patent protection, the countries that have a patent publication through a patent search engine along with the expert advice, these factors could help us have a perspective of the essential patent activity including the scope of the invention, the collaboration between the government sector and the company, and the numbers of the patent filed.

The publicized patent specification needs to be an information concerning innovations that is industrial applicable and is a tangible innovation. As for the intangible innovation, it is hardly founded such as a creative work concerning art and appreciation, computer program or business model (WIPO, 2018).

The patent data analysis is categorized by the group of industries which the vision that is clear and familiar is not usually could be done due to the restriction of the patent information as follows:

1. One innovation is a combination of different technologies, however, the patent data is categorized into group by the technology filed in the other we cannot search the innovation group that is composed of various technologies directly by using the International Patent Classification: IPC code for example in the cloud funding system or the distance learning system because in these innovation comprises of various technologies such as the network technology, the data input technology or the data display technology these depends on the inventors that what have they been developing the innovation in to which filed. For some instance, when the inventor solely develops the display technology for the long-distance medical technology, for this instance, this invention could be categorized in to the same group as the group concerning the broad casting for the gaming technology. For the above example, categorizing the display technologies is quite difficult.

2. The terms used in patent specification is the term that not a layman term that could be understood by most people, but it is a description of the feature or the uses for example when searching for an invention regarding “a chair” by using the search term “chair” all inventions relating to chairs would not show up due to the patent’s descriptions. The patent applicant or the patent agent will use a broad description for that certain patent, such “an instrument for sitting purpose” or “receiving plate” for example, in order to broaden the protection scope and to avoid being found by simple patent searching. For the mentioned reason making patent searching for analyzing purpose by using a search term only would not give sufficient and complete output data.

With this specific characteristic and limitation of patent as mentioned above making patent searching, technology grouping and patent data analyzing resulted in a different data results and different perspectives on the analysis report comparing to other technology analysis report, such as market analysis report and scientific experiments report for example, however this data still helps business entrepreneur or business executive to have some information to help making better decision and to have a better business strategy (T., 2015)

Definition

Blockchain is a public database system in form of ledger storing. This system does not require an intermediary to manage the data due to its distributed data storage. All data will be copied and stored on all computers in the network which is called “node”. The word “blockchain” came from the refereeing of digital data as “block” which is merged with the historical data in the database as they “chain” together.

This blockchain network can store information in the form of transactions such as details of the transaction, date, time, amount, payee name, or money. The transaction is registered in the database only after it has been validated and accepted by most computers. On the blockchain network as shown in Figure 1 Workflow of blockchain network, firstly, one party request a transaction. Then the requested transaction is funnelled in to peer-to-peer network and broadcast to all the node or each individual computer connected to the blockchain network. After each node received the request, they must validate the transaction using an algorithm. The approved transactions are represented as a block and added to the public ledger, and once the block is added to the existing database or chain, it could not be changed.

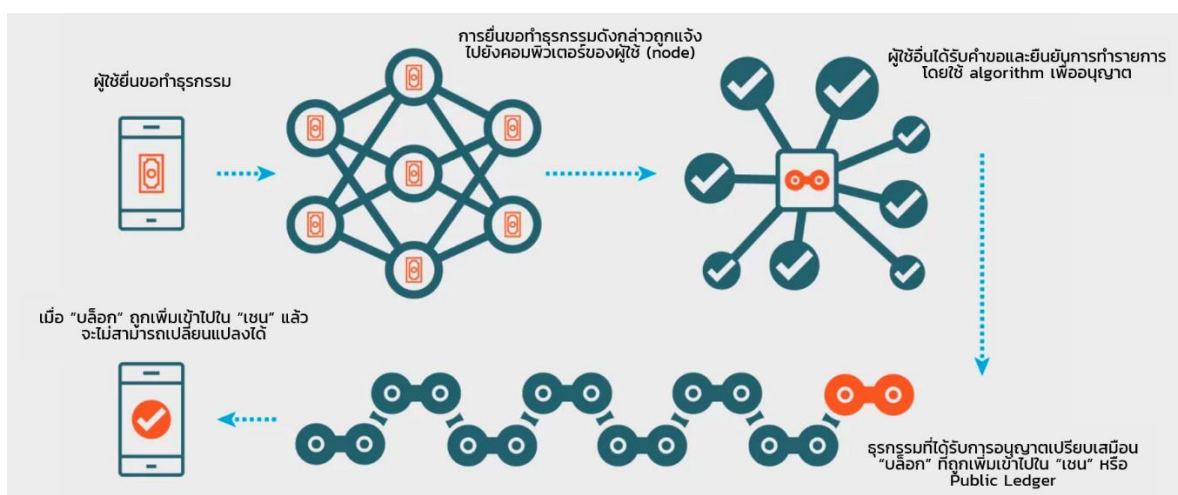


Figure 1 Workflow of blockchain network (G2 Crowd, 2018)

Blockchain in the industries of the future

Currently, Thailand have supporting the investment to drive the expansion of the economy in order to make Thailand transform form the middle-income trap in to a developed country. One of the strategies is the targeted Industrial investment support from the Ministry of Industry which have the total of 10 targeted industries. Most of these are related to Thailand’s capability to drive the growth of the economy, divided into 2 groups which is the 5 potential industries (First S-Curve) and the future industries (New S-Curve). The First S-Curve is a foundation industry of the country that have a ability to further expand to the future industry which includes the Next-Generation Automotive industry; the Smart Electronics industry; the Affluent, Medical and Wellness Tourism industry; the Agriculture and Biotechnology industry; and Food for the Future industries. Whereas, the 5 future industries (New S – Curve) includes the Aviation and Logistics industry; Biofuels and Biochemicals industry; the Medical Hub industry; the Robotics industry; and the Digital Industries as depicted in Figure 2 10 Industries of Thailand 4.0 (Office of Industrial Economics, 2017)

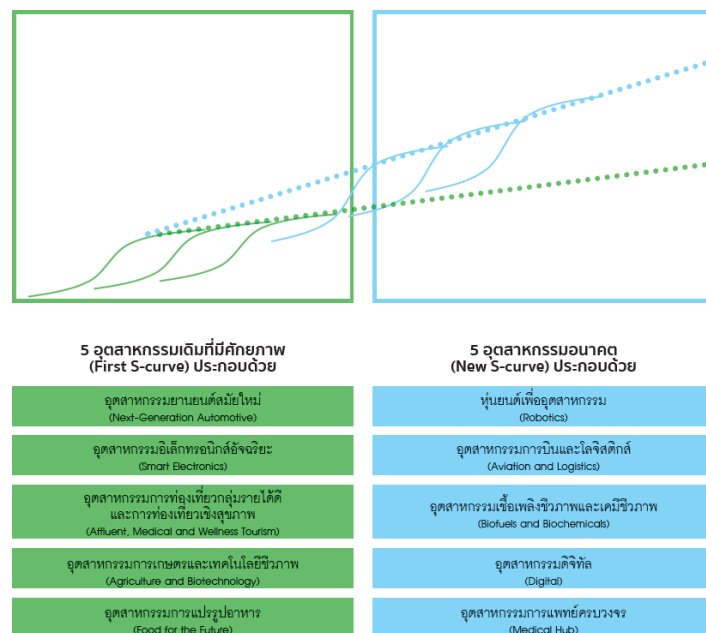


Figure 2 10 Industries of Thailand 4.0 (Office of Industrial Economics, 2017)

In the future industries according to Thailand policies. It has capability to support more growth, both from existing technologies and emerging technologies. This report will demonstrate the capabilities of the blockchain technology to maximise the potential of the industry as follows.

1. Aviation and Logistics Industry

Currently, in the aviation and logistics industry, there are still several limitations, as evidenced by the fact that each process is still used as a documentation system in every stage of transportation and aviation. The preparation and exchange of documents at each stage can cause complexity and delays in the workflow. There is a need for communication between the various parties in the transport process. Nowadays, although there are many shipping companies or airlines, each company or airline still adopt technology at different levels. It can cause complexity when exchanging information between one another. In addition, in international shipping or aviation may required to comply with the rules of the destination country, which differ in each territory. Most of this international transport still requires a document system to communicate through customs. It can be seen that the current transportation system is still complex and delays unnecessary parts.

With the ability of distributed ledger storing in the blockchain network, which is notable that has superior security, transparency, and cannot edit the recorded data or immutable. This can help to address the limitations of the aviation and logistics industry. This will benefit the various industries in terms of transport of the entire supply chain from upstream businesses to consumer such as in transportation in pharmaceutical industry, food industry or in the automotive industry.

An example of the use of block chaining is for the aviation and logistics industry, such as the Road Launch transport management platform, which utilizes a decentralized database to track the goods during transportation (Roadlaunch, 2018). Aeron has started a flight data management platform for pilots, airlines, flight control units. Access to accurate information and reduce the risk of accidents on the basis of the blockchain system (Aeron, 2018).

For example, in the retail market in the United States, Walmart has partnered with IBM to develop a tracking system for food ingredients to be sold in supermarkets (Techcrunch, 2018) especially fruits and vegetables which has high chance of contamination of raw materials during transportation by bacteria (CNBC, 2018). This is called the IBM Food Trust, a system that transforms from digital document storage and sharing to accessible by all parties to trace raw materials from farms, food processors, carriers, distributors until come to the supermarket for consumers to buy. This system brings the ability of a blockchain system to record data during all shipments to increase security guaranteed fresh interpretation of raw materials, lengthen shelf life, reduces the number of defective products and waste (IBM, 2018). Carrefour, a French supermarket. Walmart has announced that it will be using a blockchain system to track honey, eggs, cheese, milk, orange, tomato, salmon and hamburgers by the end of 2018 (BE 2561). Previously, organic chicken meat products were able to track their products. Carrefour developed a tracking system in which customers can scan QR codes on products by the mobile application to access production data of the product. (Carrefour, 2018)

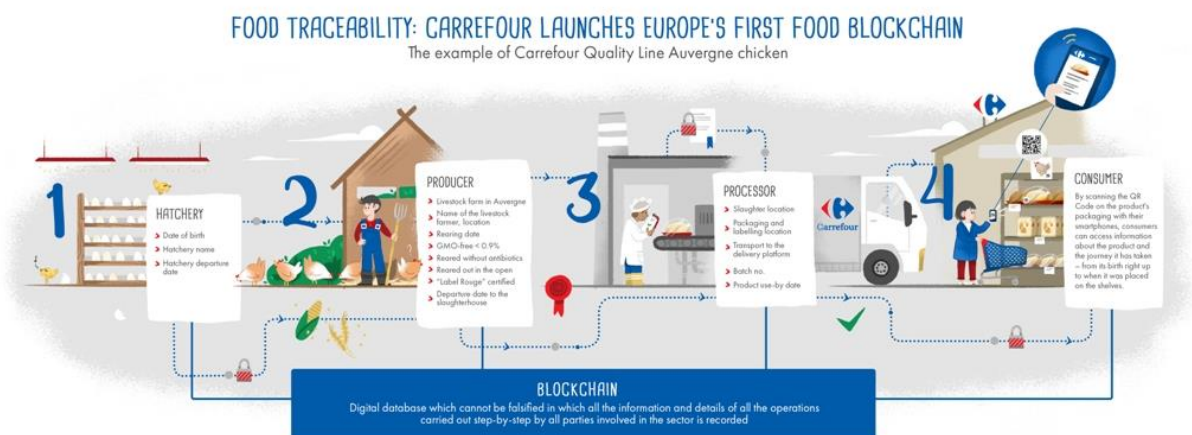


Figure 3 Food blockchain system by Carrefour (Carrefour, 2018)

In terms of transportation in the automotive industry. CarBlock is a leader of the blockchain platform used to store automotive information from the Internet to track the price of car parts, equipment and services. It also can be transferred through CAR Token to provide consumers with the best price and quality products. (CarBlock, 2018)

2. Biofuels and Biochemicals Industry

Limitations of the current biofuel and biotech industries that the blockchain technology can be addressed is related to fuel transportation and bio-chemical transportation systems. Currently, the transportation of biochemical and biofuel product is done in a large volume which may cause mistakes. Moreover, the value of the product is relatively high, there may be an illegal trading during the transportation.

As mentioned above in the topic of aviation industry and logistics. Data collection on the blockchain system helps make the system flow faster and easier. With digital storage that safe and transparent, all participants can access and track the transportation and processing of each step from raw material sources, warehouse resources to consumer.

3. Medical Hub Industry

Currently, patient records of each hospital are kept confidential and cannot disclose to other people. Each hospital has its own procedures to keep patient data confidential by using different database management systems. In most cases, the patient database will be updated only if there is any action on the patient, such as a medical examination, treatment process, or side effects from medications and treatments addressed. These data are still kept secret in the hospital and not disclose other than referral for patients between medical facilities. Another issue is the still present illegal drugs. The drug has not been registered still present in the market. Most of these drugs are traded online where the seller did not receive a license from the Food and Drug Administration (FDA). In 2015, more than 100 drugs, supplements, and dangerous drugs were arrested, worth more than 185 million baht. (FDA, 2015) In addition, each year, the registration of both traditional and traditional medicines is canceled. Whether it is produced in the country. Importing, packaging and direct sales. More than 6,000 entries during the year. 2012 - 2016 (2012 - 2016) (FDA, 2016). These problems are caused by the distribution of information is not thorough. Consumers cannot access the information as it should. The effect is broader, such as the death toll from drug abuse.

Information technology on the blockchain system can help solve the problems in many ways, divided into two main areas: 1.) use of blockchain in drug, medical devices record registration and 2.) use of blockchain in patient record storage.

Bringing blockchain technology to the pharmaceutical industry can be done just like the aviation industry and logistics. The blockchain can be used to store data during the manufacturing and transportation phases, from the upstream business to the consumer. The information collected on the blockchain system must come from qualified contributors. This can help reduce the number of illegal drugs, and non-standard drugs in the market by letting consumers access updated drug information.

Then, in terms of bringing blockchain to help keep patient information and manage access to such information safely. For example, the introduction of a data-logging system on the network has been used to manage patient information, such as MedRec, an electronic patient information management system that collects smart contracts and data codes that help patients access data safe and manage the exchange of patient information between medical institutions. Usually, the patient may not be fully transferred when patients want to move to another hospital. This system helps patients to choose to change, keep, or exchange information with preferred medical institution. Examples of system functions are shown in Figure 4 Workflow of MedRec Patient can access to the information by the identity confirmation. In addition, external agencies, such as government agencies, research institute can access to this system for the benefit of using the information to place appropriate regulations, research development through an application programming interface (API). The prototype system based on MIT Media Lab and Beth Israel Deaconess Medical Center now can be used to track patient dispensing in the database. (MedRec, 2018)

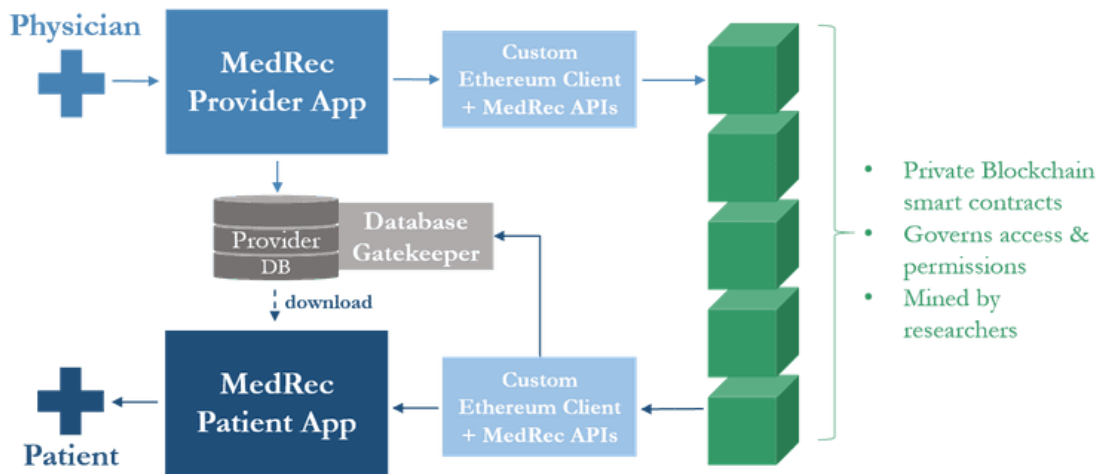


Figure 4 Workflow of MedRec (Viral Communications, 2016)

The mobile applications such as AFIA are built on the Blockchain system that uses to store health information and control access to such information in accordance with the US Health Insurance Portability and Accountability Act. It allows users to manage confidential information that they want to keep confidential or share with a medical institution. (Coindesk, 2018)

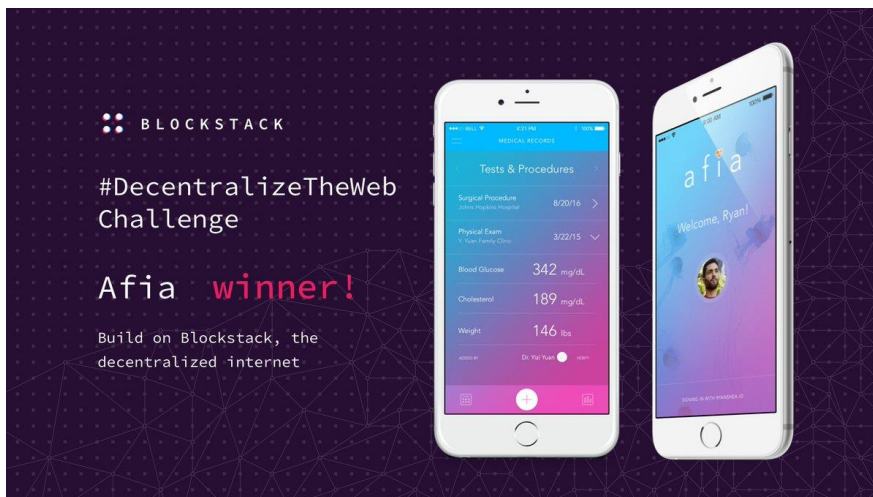


Figure 5 Example of AFIA mobile application interface (Twitter, 2017)

4. Industrial Robotics Industry

Nowadays, there is an interest in bringing together a complex robot group called Swarm Robotics. The robotic system is inspired by the work of ants group to work together to get a lot of productivity. Swarm Robotics uses robots of a low complexity but highly resistant

to changeability and easy to produce. But with the need to communicate between each robot to work seamlessly with other members. This communication needs to be a secure and hard to be disturbed to prevent malfunction.

The security of the storage system on the blockchain is so useful to help communicate between the robots. With a double key security system, a public key and a private key can reduce interference from external signals. By communicating between robots, the the public key can be used to identify which target robot need to receive the message and that robot can decrypt the message sent by the use of private key to authenticate. In addition, robotic control through the blockchain network can also improve the robot's performance by linking multiple blockchain network corresponding to multiple tasks, also known as Pegged Sidechain. So, the robots can perform multiple functions simultaneously. Each step of the robot' task is stored on the blockchain network. So, the robots will be able to access the work of each member. And when one member loses, it can be replaced by the new robot immediately and accessing information stored on the network to continue the workflow. (Ferrer, 2017)

Patent landscape of blockchain technology

Patent landscape is a graphical model created from patent data that covers the technology or industry that needs to be studied. To illustrate the current situation of technology or industry at national, continental or global level, which can be used to analyse the patent information for strategic advantage including technology trend analysis, competitor analysis, whitespace analysis, research collaboration analysis, licensing. IP licensing opportunity analysis, IP acquisition/investment analysis, reverse engineering and design-around analysis.

This analysis report aims to study the trend of blockchain technology especially in the capacity of the blockchain system that can be applied in the future industry in accordance with the policy of the Ministry of Industry, namely the aviation and logistics industry, biofuel and biochemical industry, medical hub industry, and industrial robot industry. This can be a guide for Thai inventors, researchers and creators to create works that can be used to obtain patent protection and commercial use and meet the needs of business and industry. To be consistent with this purpose, this report collects patents related to blockchain technology from international patent database with the keyword in conjunction with the International Patent Classification (IPC) and the Derwent Patent Classification (DWPI Manual codes) relating to the blockchain technology that can be used in the future industry. (keyword, International Patent Classification, IPC and DWPI Manual codes shown in the appendix). The patent landscape of blockchain technology that can be applied in the future industry is shown in Figure 6 Patent landscape of blockchain technology.



Figure 6 Patent landscape of blockchain technology

Figure 6 Patent landscape of blockchain technology shows the keywords from the technology that used to develop the blockchain technology according to patent documents. The colour of each area represents the same height as the geographic map. White represents high space or a large number of patents and decreasing to the dark grey, light grey and green respectively. Blue colour represents water areas or very few patents fall under that area. Overall, the patent map is divided into two major categories: the upper area (1) contains patents related to the development of the blockchain system which related to keywords such as Bulletin, Giver, Electronic Document, Hash Value, Private Key, Blockchain, Compute, Virtual Currency, Distributed Ledger, Gift Card, Digital Asset, Digital Currency, Medical, Patient , And the Intelligent Module, and the bottom area (2) which contains patents related to the implementation of the blockchain technology related to keywords such as Ledger Event, Contract, Party, Database, Personal, Smart, Limit, Assistant, Mobile, Resource, Request, Phone Database, Energy, Vehicle, Vehicle, View, Guide as shown in Figure 7 Patent landscape of blockchain technology.

1. System development

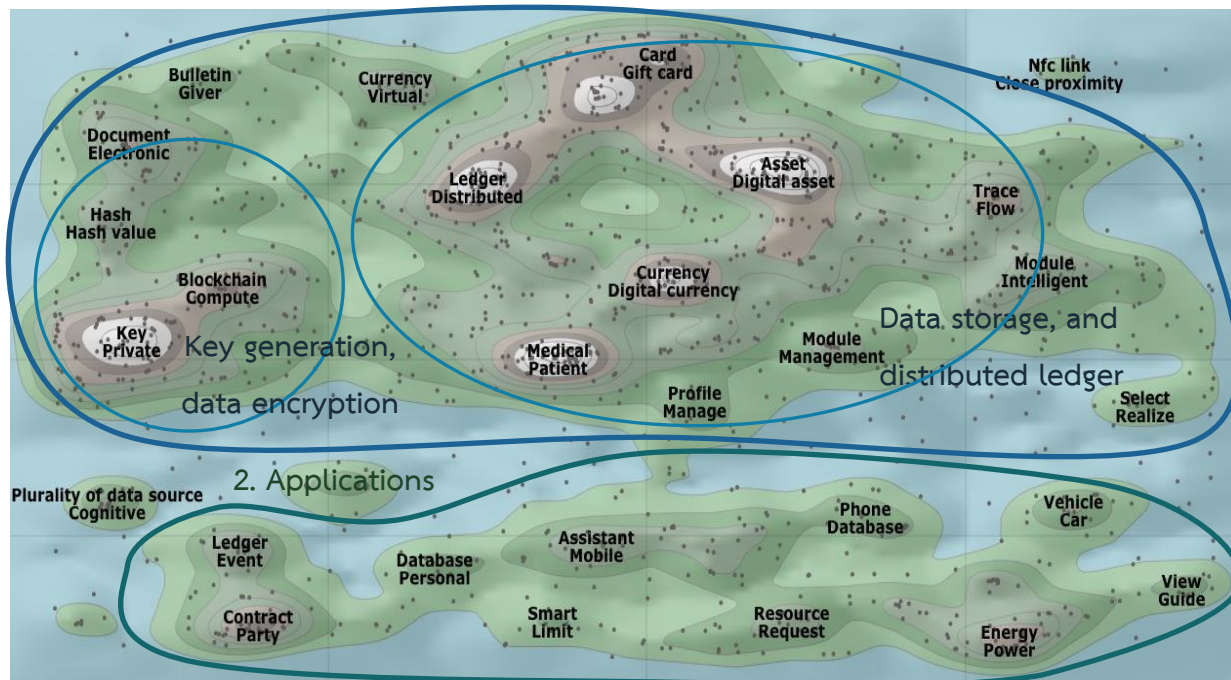


Figure 7 Patent landscape of blockchain technology

The Big Island (1) is divided into two main sections, which are the area related to key system development and data encryption of the blockchain network and the area of data storage and the update and exchange of data on each node. The key development includes Public Key Infrastructure (PKI) technology, or public key cryptography, or asymmetric key cryptography. On the blockchain network, the key system is used to secure the data stored on the network by using a private key and a public key to authenticate the user. Examples of patents in this technology include patent publication number US20170093830A1 "The network authorization system" invented by the Bank of America.

potential to increase the efficiency of the aviation industry and logistics. And it comes from many different parts including the development of a key system, data encryption, electronic document storage etc. In addition, the number of red dots or patents that can be applied to the medical industry is subjected to 115 patents. The blue dots represent patents that can be applied in the industry biotech and biochemicals is subjected to 21 patents and the green dots represent patents that can be applied to industrial robots is 19 patents.

Examples of patents for applications in the aviation and logistics industry, such as the United States patent publication number US20180268491A1 The "Cognitive Regulatory Compliance Automation of Blockchain Transactions" from an IBM who claims rights in the transactional management and regulatory compliance process in the blockchain system. This is useful for monitoring transactions and enforcing regulatory compliance that may be different in each area of transportation. This example of a patent is linked to IBM services such as the Road Launch Platform as discussed in earlier topic, and the TradeLens platform from IBM and Maersk.

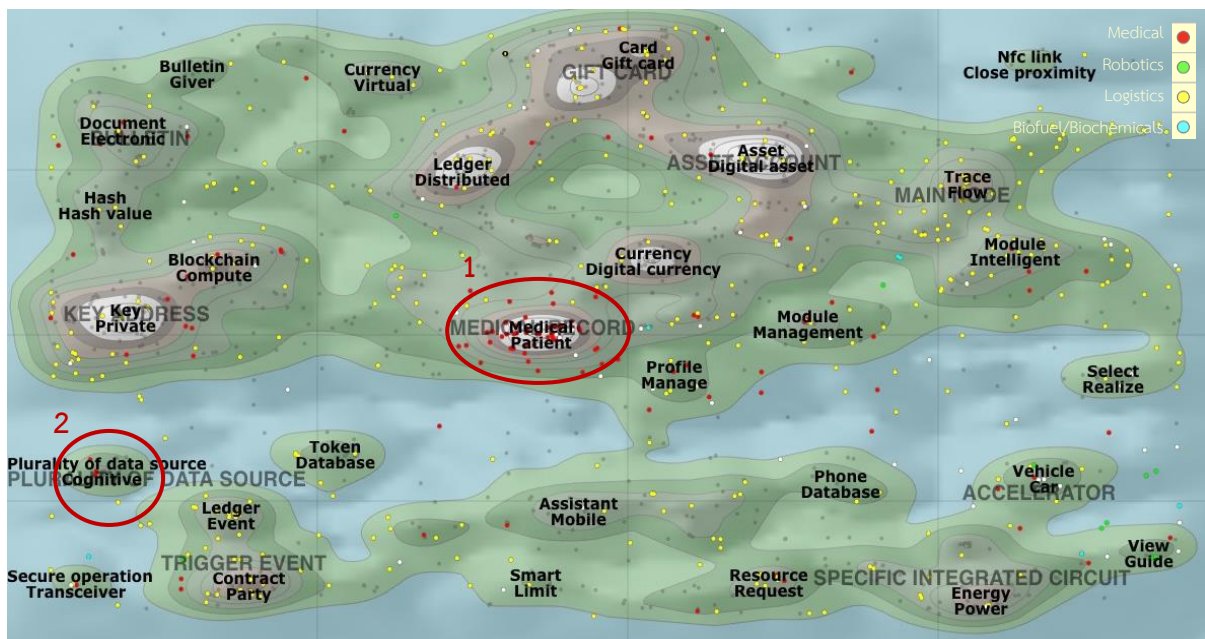


Figure 9 Patent landscape of blockchain technology indicating the patents that can be used in the medical hub industry

Considering the patent portfolio that can be applied in the medical industry, as shown in Figure 9 Patent landscape of blockchain technology indicating the patents that can be used in the medical hub industry, there are two major areas where the red dots are located. 1.) the area related to Medical Patient Keywords and 2.) the small island related to keyword Plurality of Data Source Cognitive. This first area related to implementation of blockchain technology that used to store and manage access to patient information. For example, patent publication number US20170177898A1, title “Personal ledger blockchain” Filing date December 16, 2015, from an IBM who claims rights of the personal information encryption process on the personal ledger of the blockchain network with database access from the computer on the network. Not limited to patient information, electronic documents, financial Information, or software The second area is the Cognitive Blockchain patent group, which uses artificial intelligence in combination with cognitive information processing system which is mainly patented by Cognitive Scale Inc., which develops augmented Intelligence technology.

Supply chain of blockchain technology

The supply chain of blockchain technology consists of upstream businesses which are software companies. Mid-stream businesses are software companies or programmers who develop the platform for blockchain database. And downstream business includes any business or organization that wants to bring the network chain to use in business, such as government agencies, businesses in the medical industry, logistics and other industries.

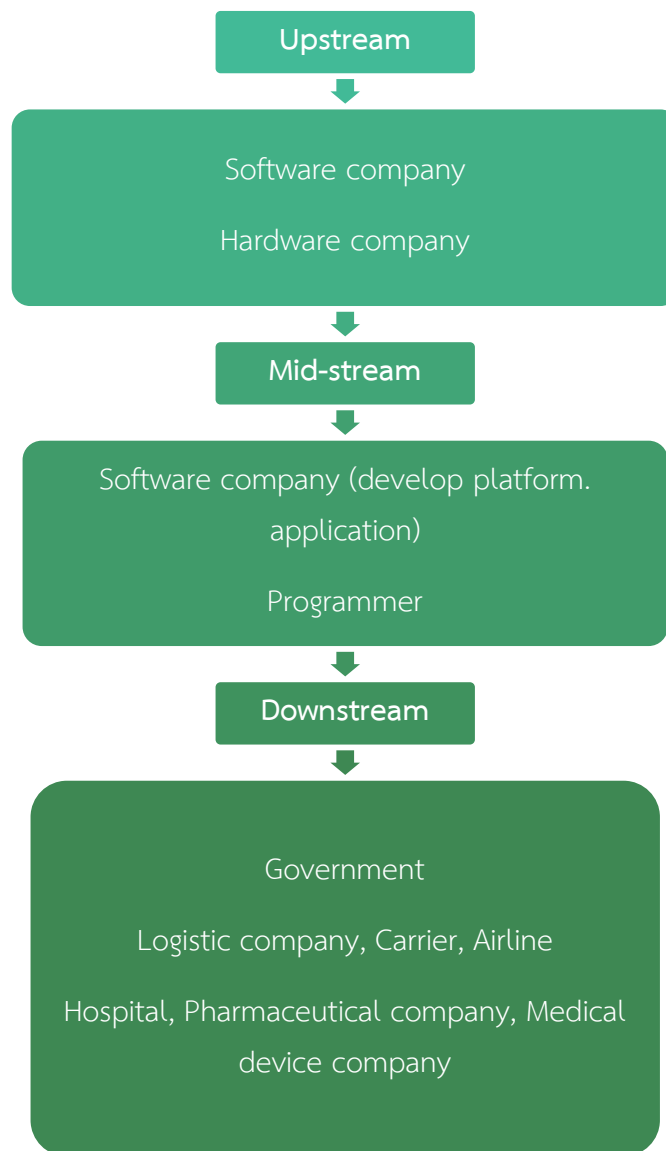


Figure 10 Supply chain of blockchain technology

Upstream business of blockchain technology includes from the development of software to run the blockchain system, coupled with hardware development or computer to support this network to allow each computer on the network to fully and securely store data. The development of this software includes the development of a data collection process, data access control, and security of data stored on the network chain, etc. This can be adapted to a wide range of applications. The mid-level business or maybe a downstream business that's going to develop in the platform or application phase. To enable the proper functioning of the blockchain system, such as the development of a user interface, for digital registration on the blockchain system or digital currency exchange applications, to suit the downstream business. This blockchain can be applied to a wide range of industries and businesses that need a secure and unchangeable data storage system. So, the application of downstream business is very diverse.

Overview of patent related to blockchain technology

1. Overview of international patent related to blockchain technology

1.1 Technology trend of blockchain technology

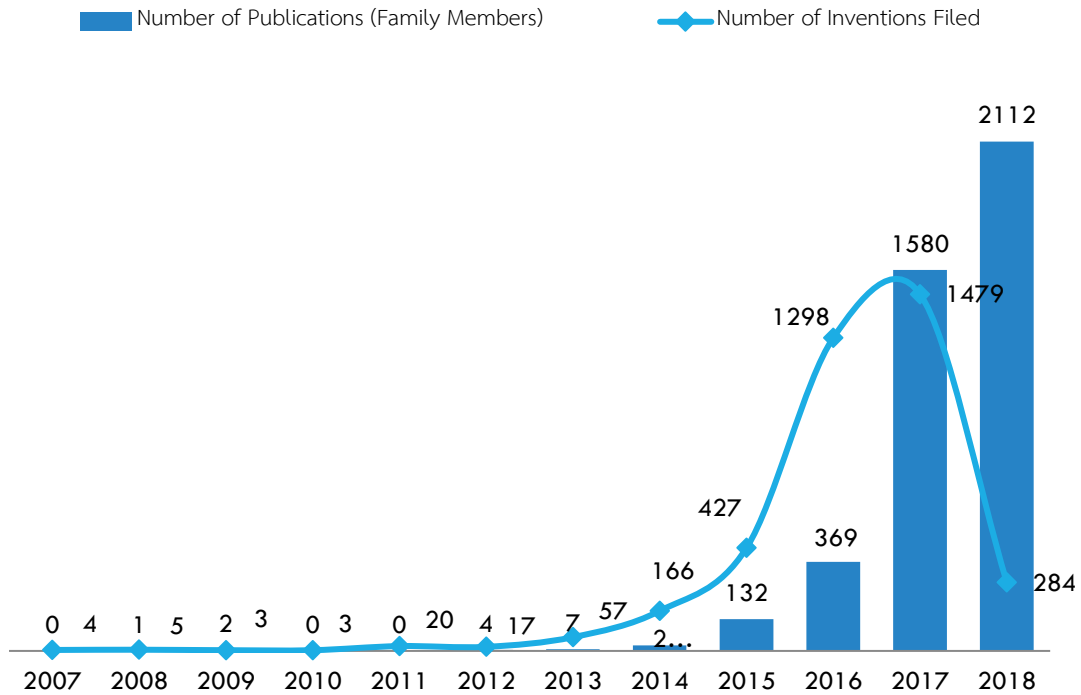


Figure 11 Number of publications and number of inventions filed related to blockchain technology between 2007 - 2018

As shown in Figure 11 Number of publications and number of inventions filed related to blockchain technology between 2007 - 2018 which is the comparison of the number of inventions filed for patent applications that is count by the patent family number or in other words one invention is count as one no matter the said inventions has been filed in any other country or state, this would show the actual invention that has been create in that certain duration, and not including the invention which has been amended and re-filed in another country. Whereas the number of published patents is counted by the number of patents that is published after it has been filed to the intellectual property department of each country, this would depict whether the invention of each patent family have a how much potential to expand into the market, from the number of the patent family members. However, the

number of published patent could be the amount that have been accumulated from the previous year due to the fact that the examination time frame is at least 12 months starting from the filing process up until the publication process, these therefore, making the data information of year 2017-2018 (B.E.2560-2561) is not completed based on the fact that the incomplete published information.

Figure 11 Number of publications and number of inventions filed related to blockchain technology between 2007 - 2018 shows the increasing number of the patent relating to Blockchain technology in the past 10 years period wherein the number of patents in this group have a steady increasing number, from less than 10 patent per year in 2007-2010 (B.E. 2550-2553) increasing to 3,763 patents in year 2018 (B.E.2561) (data is updated until August 2018) especially from year 2015 (B.E.2558) further that the number of patents have drastically increases. Theses growth shows that the blockchain development and the adaption to uses in various industries is still relatively new and it is still in the beginning of the Technology Life Cycle which have a tendency to be steady developed and used in a wider range.

1.2 Technological Profile

Patent collection for this patent analytics has been divided into technical categories as the following groups

- 1) Categorized by the components of Blockchain
 - a) Consensus Algorithm/Mechanism consisting of patents relating to consensus algorithms that is used for blockchain data collection such as “Proof of Work”, “Proof of Stake”, “Byzantine Fault Tolerance” for instance.
 - b) Cross-Chain/Atomic Swap consisting of patents relating to the linkage of the blockchain data collecting from more than one network together which relating to branches chain, side chain, multi-chain or Atomic swap, such as the digital money exchange from two different money currency and not requiring a central terminal in order to make the currency exchange.
 - c) Identity/Access Management consisting patents relating to user identification, authentication and access permission control.
 - d) Privacy/Security consisting patents relating to security of the data collecting on the Blockchain network such as the private information securing method by using the private key or digital signature, encryption techniques and other private information securing method.
 - e) Smart Contract consisting patents relating to contract gathering on the Blockchain system such as smart contract and the automate escrow system.
- 2) Categorized by the uses of Blockchain
 - f) Banking/ finance/ crypto-currency group consisting of patents relating to data collecting on the blockchain network for the purpose of banking, finance or crypto currency.
 - g) Medical/Healthcare group consisting of patents relating to the data collecting on the blockchain network for the purpose of medical and health benefits.

- h) Logistic and Supply chain management group consisting of patents relating to the data collecting on the blockchain network to be used for the purpose of transportation system, logistic and supply chain managing.
- i) Internet of Things group consisting of patents relating to Internet of Things of the electronic appliance which is connected to the internet network and is then connected to the data collecting on the blockchain network.
- j) Artificial Intelligence group consisting of patents relating to the data collecting on the blockchain network.
- k) Block chain- In General consisting of patents relating to the data collecting on the blockchain network which is not categorised above.

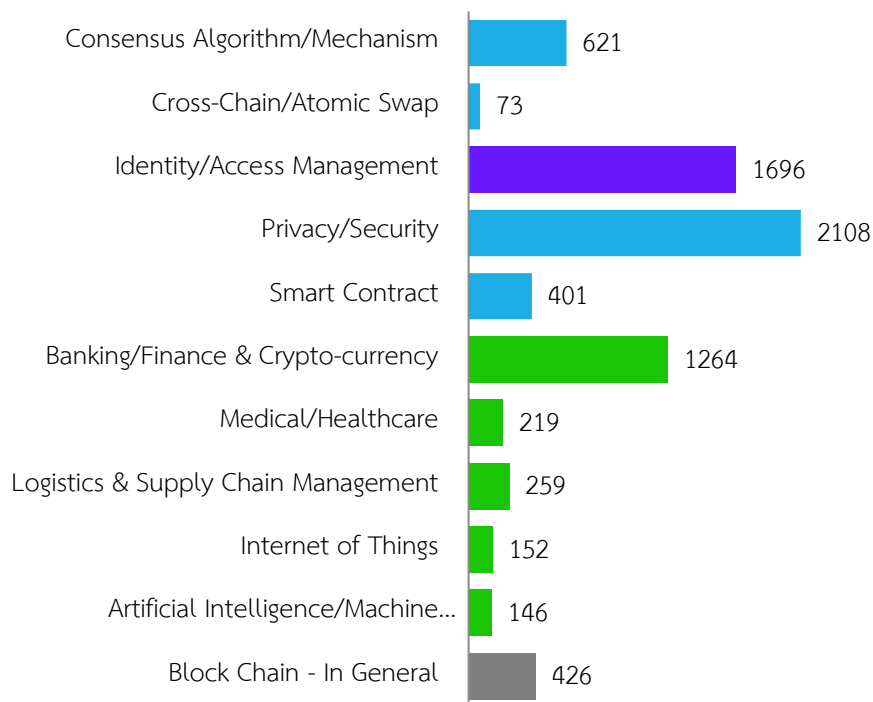


Figure 12 Number of inventions per technical category

Total of 3,763 patents related to blockchain technology have been collected and sorted into technical categories that is accessible by using the key word and the International Patent Classification (IPC) (description of the key word and the IPC class is shown in the index) and restrict the filing year from year 2007-2018 (B.E.2550-2561), then categorize into groups of

technology as above, as shown in Figure 12 Number of inventions per technical category. Whereas, each patent might be re-counted in each group of the technology since one invention could be categorized in more than one group of technology.

When categorized by the components of Blockchain which can be categorized into Consensus Algorithm/Mechanism group, the Cross-Chain/Atomic Swap group, the Identity/Access Management group, the Privacy/Security group and the Smart Contract group. It is shown that the Privacy/Security group has the greatest number of patents at 2,108 patents, the second is the Identity/Access Management at 1,696 patents, whereas, the other groups which are Consensus Algorithm/Mechanism group, Cross-Chain/Atomic Swap group and the Smart Contract group having less than 1,000 patents.

When categorized by the uses of Blockchain which can be categorized into Banking/finance /Crypto- currency group, the Medical/Healthcare group, the Logistic and Supply chain Management group, the Internet of Things group, the Artificial Intelligence group and Blockchain- In general group. It is shown that the Banking/finance/Crypto-currency group is the industry that uses blockchain technology the most, having the most patents at 1,264 patents, whereas the other groups have only the hundred figures of patents as shown in Figure 12 Number of inventions per technical category. Wherein the drastic high number of patents in the Banking/Finance/Crypto-currency group is in accordance with the current situation that blockchain is widely used in the Crypto-Currency genre such as Bitcoin which is the first Crypto-Currency used by the Blockchain system for the purpose of eliminating the middle man or the bank as the central money transaction provider, the crypto-Currency therefore is the start of the use of the blockchain system which helps revolutionize the possibility of using the blockchain system in other industries in the future.

1.3 Technology trend

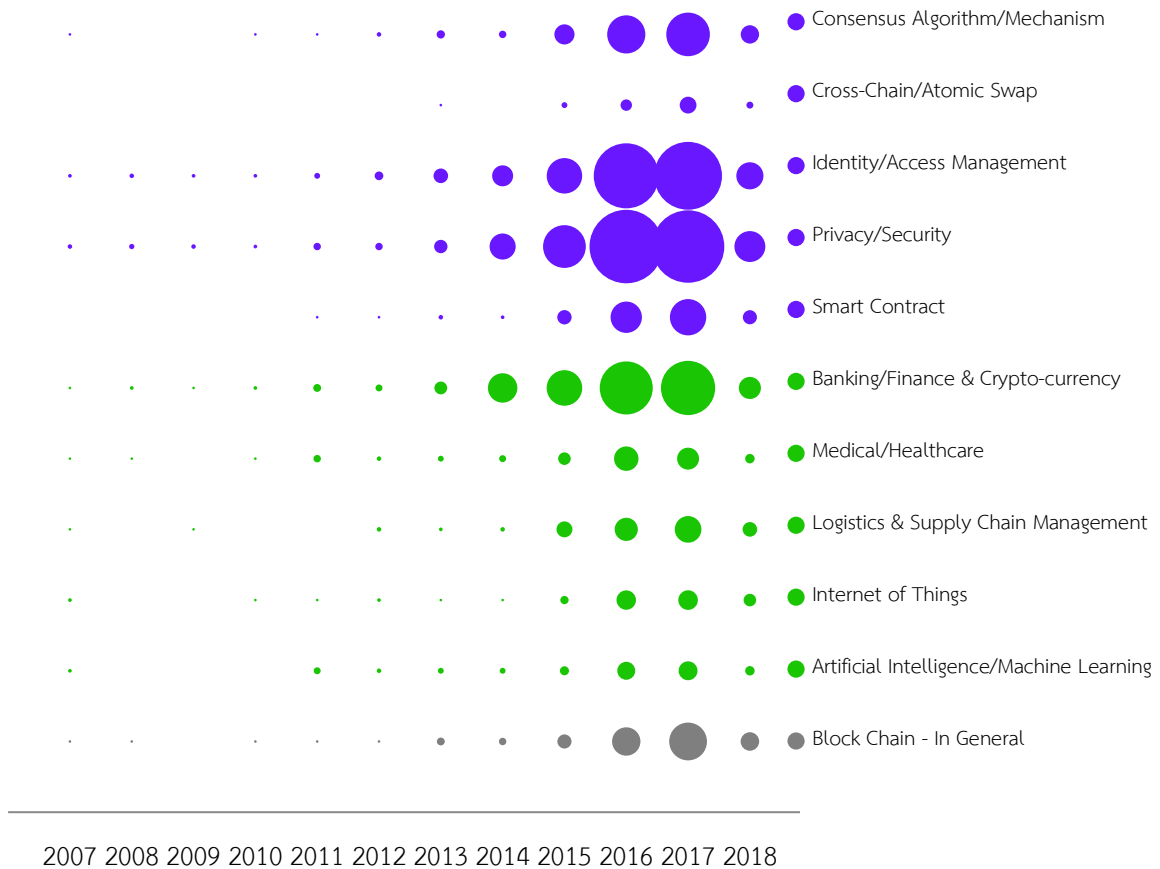


Figure 13 Timeline of activity per technical category between 2007 and 2018

Figure 13 Timeline of activity per technical category between 2007 and 2018 shows the groups of patents categorizing by the component of blockchain which the Consensus Algorithm/Mechanism are, the Cross-Chain/Atomic Swap group, the Identity/Access Management group, the Privacy/Security group and the Smart Contract group. It has shown the Smart Contract group, the Identity/Access Management group and the Privacy/Security group have a drastic increase in year 2015 (B.E. 2558) onward, the said component groups has been developed before other components due to the fact that it is the core or the most crucial part of data collecting on the blockchain system, it must have a user identification/access management and the Privacy/Security in the blockchain system. Later on, the other components are further developed and added on, such as the Smart Contract

group as shown in the graph, it shows that its patents has increased drastically in the year 2016 (B.E. 2559) and the linkage of other blockchain networks together, which this is categorized in to the Cross-Chain/Atomic Swap and having a visibly increase in year 2017 (B.E. 2560).

When categorised by the uses of Blockchain which are the Banking/ finance /Crypto-currency group, the Medical/Healthcare group, the Logistic and Supply chain Management group, the Internet of Things group, the Artificial Intelligence group and the Block Chain- In general group. It shows that the Banking/finance/Crypto-currency group have been developed since 2014 (B.E. 2557) before other industries. While the Medical/Healthcare group, the Logistic and Supply chain management group, the Internet of Things group and the Artificial Intelligence group have been drastically increased in around the year 2016 (B.E. 2559) onward.

Considering the increasing of the patents rate in a compound annual growth rate of patents as shown is Figure 14 Compound Annual Growth Rate, CAGR between 2014 and 2017 of patents related to blockchain technology, it can be seen that Smart Contract group has the highest compound annual growth rate among the groups of technology categorised by the components of Blockchain, by 358% annually between 2014 and 2017. This number is correlated to the situation that smart contract that run based on blockchain technology has been adopted in many industries. Then, the Consensus Algorithm/Mechanism has reached 226% annual growth rate during the same period. It could be considered that inventions relating to consensus algorithms used in the blockchain data collecting system still have the tendency to increase further because it is widely in the development of new processes to be used with the blockchain system, while in the past mostly having the process of the Proof of Work such as the procedure of Bitcoin and other crypto-currency in order to make the computer in the blockchain system solves problem and adding new transactions (Block) into the former database (Chain). Nowadays, there is the development of Proof of Stake and “Byzantine Fault Tolerance” later on.

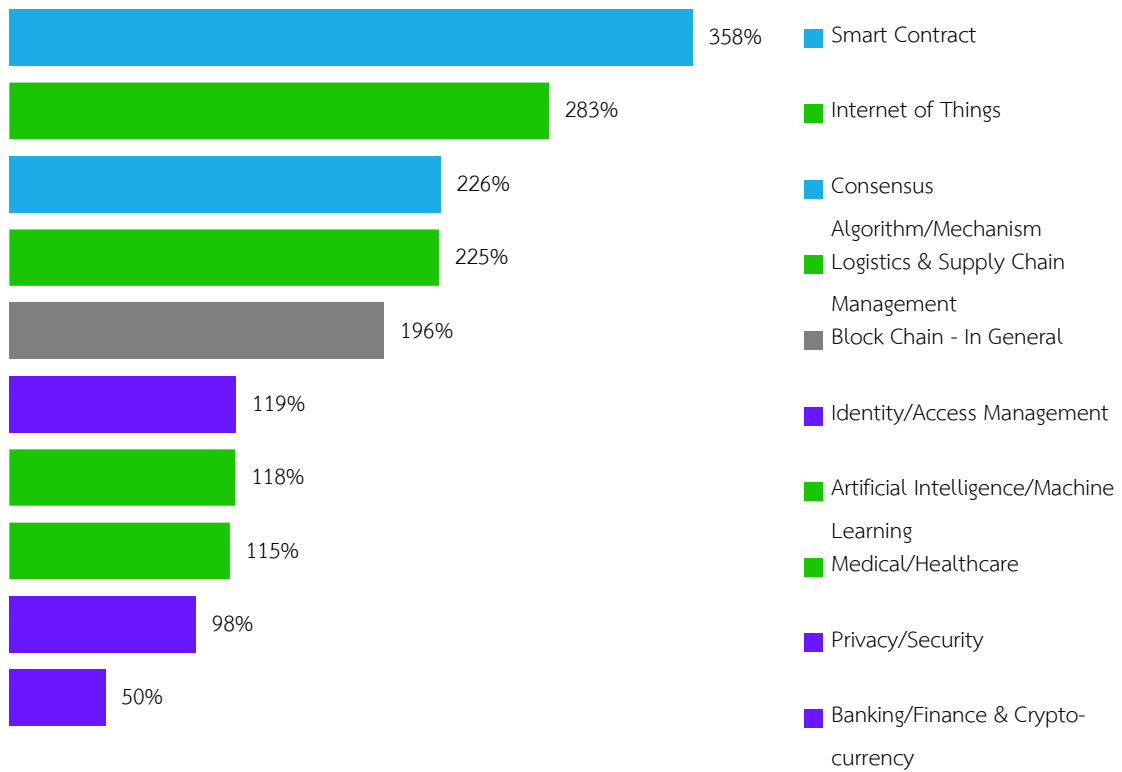


Figure 14 Compound Annual Growth Rate, CAGR between 2014 and 2017 of patents related to blockchain technology

When considering the Compound Annual Growth Rate according the group of technology categorized by the uses of the technology it shows that the Internet of Things group has the highest CAGR among all other blockchain applications, at 283% per year during 2014 and 2017. This evidence relates to the discussion earlier, where we can see the big island of blockchain application where showing the application of this technology in various perspectives including mobile phone and vehicle. Next, the Logistic and Supply Chain Management group has reached 225% CAGR during the same time, correlating to the landscape where we can see the yellow dots the represent patent that can be applied in the logistic and aviation industry spread all over the map.

1.4 Market demand

Patent data analysis may depict Industrial market demand by analysing the data related to the number of patents in given industries in each legal territory which discloses that whether a given legal territory is the industrial market able to be commercialized under and be worthy to file patent applications to protect the infringement the registered inventions and market shares.

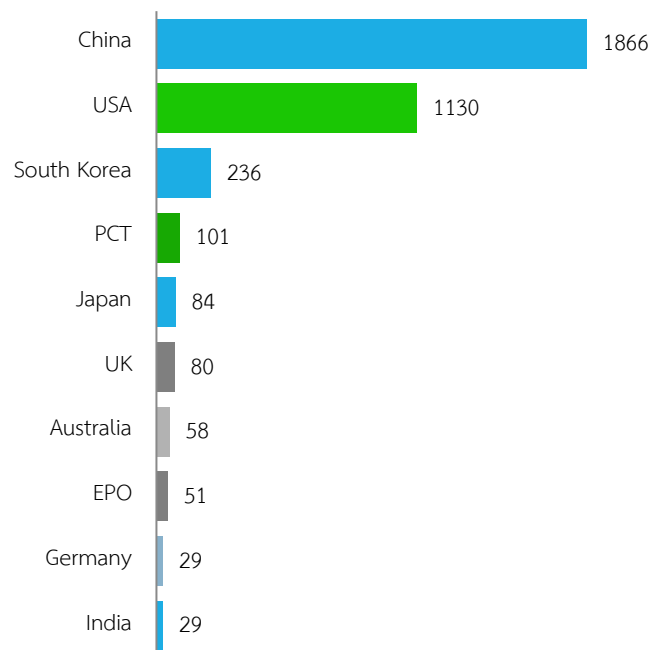


Figure 15 Number of inventions for top 10 first filing locations between 2007 - 2018

As shown in Figure 15 Number of inventions for top 10 first filing locations between 2007 - 2018, It illustrates that database storing technology on blockchain were developed and filed as patent applications in mentioned territories which highlights key markets of that technology. Furthermore, the graph depicts the top 10 countries filed the database storing technology on blockchain namely: China, United States of America, South Korea, Patent Cooperation Treaty (PCT), Japan, the United Kingdom, Australia, European Patent Office (EPO), Germany, and India. It is found that China is in the top first of the with 1,866 applications filed between 2007 – 2018 (B.E. 2550 – 2561). Following by the US as the second with 1,130 applications in the same period. Figure 15 Number of inventions for top 10 first filing locations

between 2007 - 2018 above depicts the interest in this technology and market demand on blockchain technology resulting in the abundant numbers of patent filings filed by applicants so as to develop their inventions serving the industrial market's need. However, other countries have been filed patent applications in only hundreds of applications related to this technology illustrating the blockchain technology is still the novel technology in these countries.

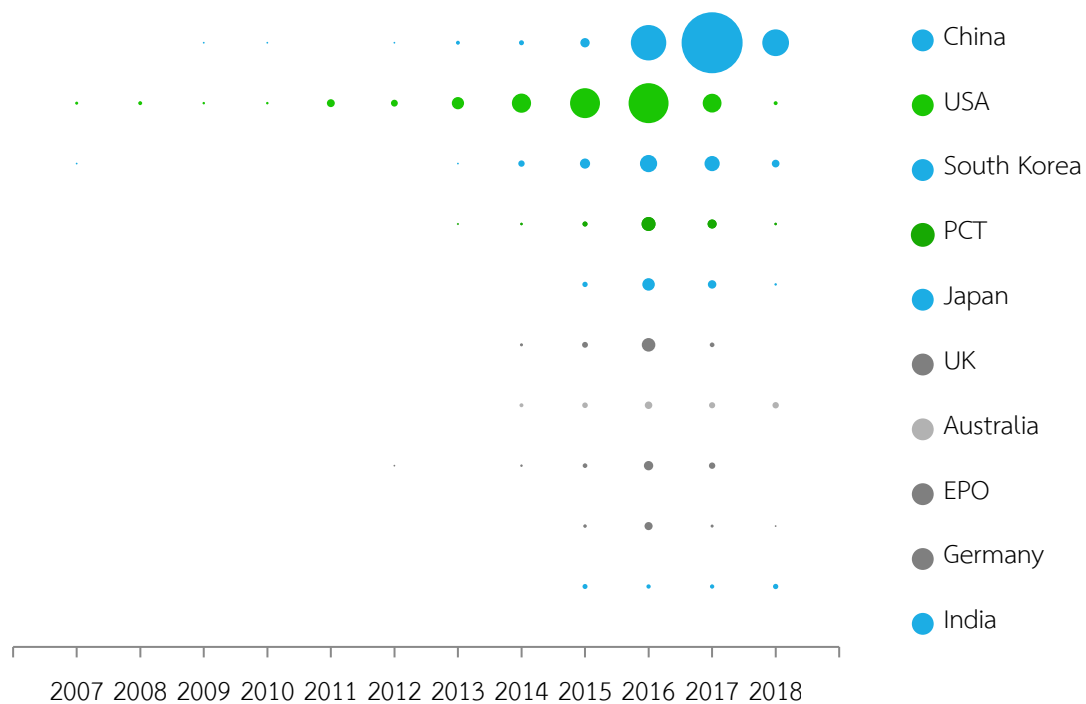


Figure 16 Timeline of activity for top 10 first filing locations, during 2007 to 2018

When we consider patent application numbers divided by the priority countries in each year, China is evidently inclined to file blockchain database storing system-related patent applications in the past 3 years or from 2016 (B.E. 2559) to the present (2018 (B.E. 2561)). While, the US has accumulative patent application numbers in the past 10 years as the second ranking following China. The US began filing the mentioned patent applications in 2007 (B.E. 2550) and its patent application numbers continuously increase from that year. This situation illustrates that blockchain technology has been developed in the US before being spread worldwide and the US was the number one for blockchain system thanks to the huge related patent numbers filed in the US much larger than that in other countries before 2017 (B.E.

2560). However, China have increased the blockchain related patent numbers and become the top first blockchain technology patent filing country since 2017 (B.E. 2560). Furthermore, other countries have been developed blockchain technology and increasingly filed the related patents between 2014 – 2015 (B.E 2557 – 2558).

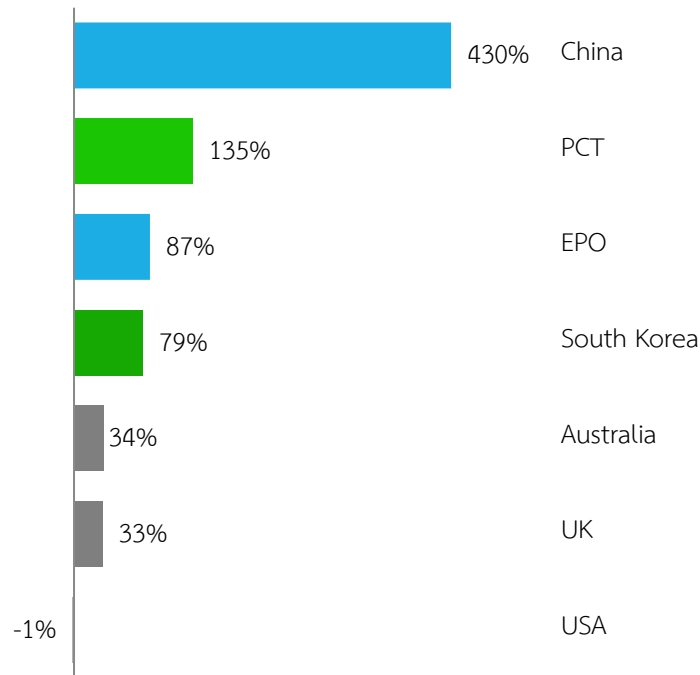


Figure 17 Compound Annual Growth/Decline Rate during 2014 -2017 of number of patents in first filing locations

Considering patent application trend divided by the priority country in forms of Compound Annual Growth Rate: CAGR of patent application numbers as shown in the Figure 17, it is found that China has the CAGR percent rate with 430% per year, from only 1 patent application filed in 2012 (B.E. 2555) to 402 applications in 2016 (B.E. 2559). Additionally, there are patent applications filed via Patent Cooperation Treaty (PCT), European Patent Office (EPO), and South Korean patent office increasing CAGR per year with 135%, 87%, and 79% respectively. From the previous figures, the US has a lot of blockchain technology related patent applications as the second rank following China, but its accumulative growth is decreased with -1% between 2014 – 2017 (B.E. 2557 – 2560).

1.5 Key players

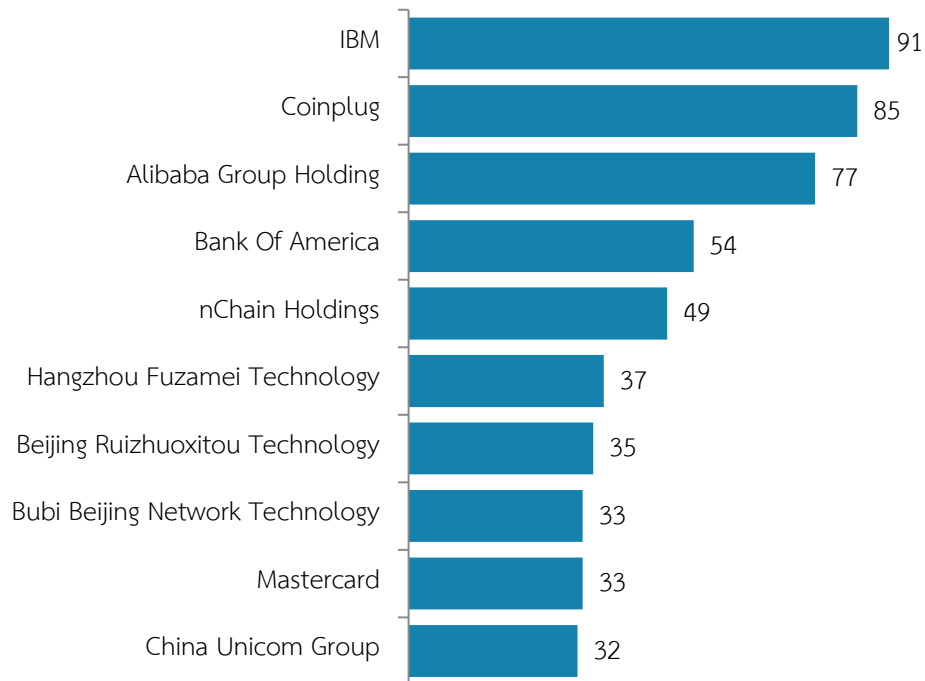


Figure 18 Number of inventions related to robotic technology for elderly people for top applicants

As shown in Figure 18 Number of inventions related to robotic technology for elderly people for top applicants, it is found that the top first rank filing blockchain database storing system patent application is IBM, a gigantic computer and information technology corporation from the US with 91 patent applications. Following by Coinplug, a blockchain company from South Korea filing 85 patent applications, and Alibaba Group Holding, a multinational E-commerce company from China with 77 patent application filings. Moreover, when we consider insight into all top 10 key players, it is found that 5 key players come from China namely: Alibaba Group Holding, Hangzhou Fuzamei Technology, Beijing Ruizhuoxitou Technology, Bubi Beijing Network Technology, and China Unicom Group, 3 players come from the US namely: IBM, Bank of America, and Mastercard, and the rest are Coinplug, and nChain Holdings, being a blockchain companies coming from South Korea and the United Kingdom respectively. Additionally, when we consider types of all 10 key players from the figure above,

there is no key player coming from academic institutes or research institutes, but SMEs, a big multinational company, a bank, and government enterprise instead.

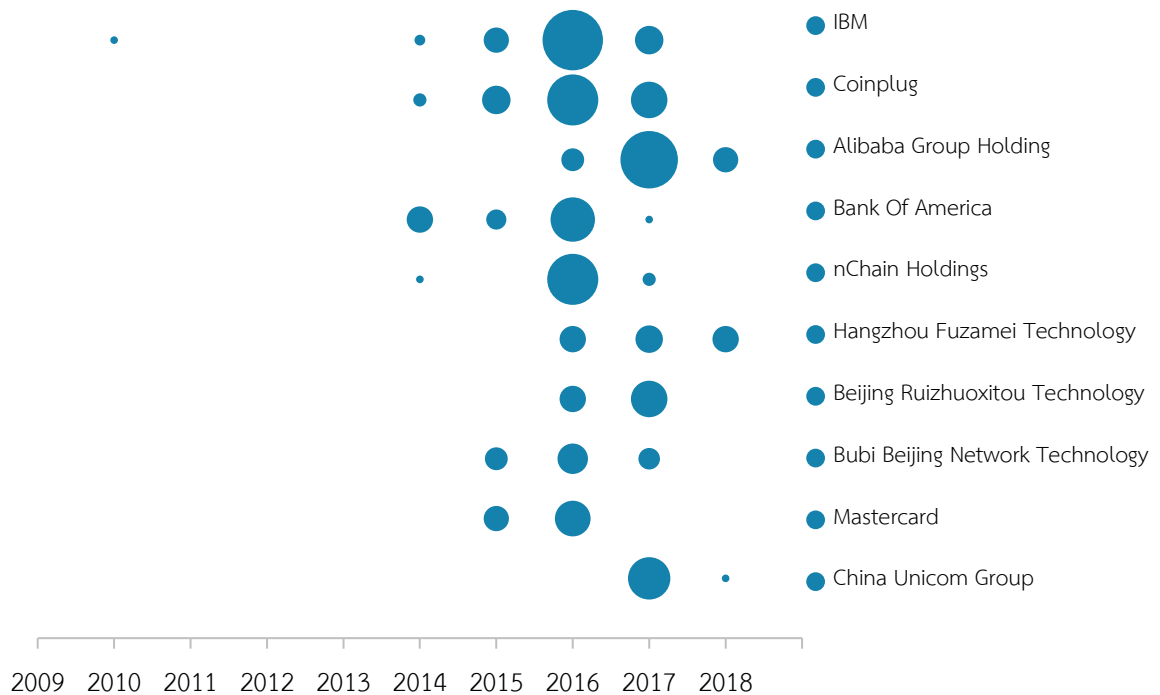


Figure 19 Timeline activity of top applicants during 2007 to 2018

From Figure 19 Timeline activity of top applicants during 2007 to 2018 above, in the aspect of patent application numbers filed a year, there are blockchain technology pioneers beginning filing the related patent application from 2014 (B.E 2557) namely IBM, Coinplug, Bank of America, and nChain Holdings. Additionally, the 4 key players have been focusing on the blockchain database storing technology until the present time and still be the leading organizations in this technology, following by Bubi Beijing Network Technology, and Mastercard filing the blockchain patents in 2015 (B.E. 2558), as well as Alibaba Group Holding, Hangzhou Fuzamei Technology, and Beijing Ruizhuoxitou Technology beginning filing patent applications in 2016 (B.E. 2559), and China Unicom Group beginning filing patent applications in 2017 (B.E. 2560).

1.5.1 Innovation profiles of international companies

Table 1 Original country and type of key player

No.	Key player name	Country	Type
1	IBM	US	Multinational
2	Coinplug	South Korea	Private
3	Alibaba Group Holding	China	Multinational
4	Bank Of America	US	Bank
5	nChain Holdings	UK	Private
6	Hangzhou Fuzamei Technology	China	Private
7	Beijing Ruizhuoxitou Technology	China	Private
8	Bubi Beijing Network Technology	China	Private
9	Mastercard	US	Multinational
10	China Unicom Group	China	Government enterprise

I. IBM

IBM (International Business Machines Corporation) is huge American computer and information technology company which its headquarter is located in New York, the US and there are a lot of branches over 170 countries around the world. IBM produces and distributes computer hardware and software, as well as provides computer consulting service for the organization. Furthermore, IBM have underlined innovation development continuously. The core business of IBM can be categorized into 5 businesses namely: Cognitive Solutions, Global Business Services (GBS), Technology Services & Cloud Platforms, Systems, and, and Global Financing. (Reuters, 2018)

Examples of IBM innovations like: ATM (Automated Teller Machine), Floppy disk, and SQL programming language. At the present, IBM have expanded its business

into various branches such as printing business in the name of its affiliated company, Lexmark International, Inc.

II. Coinplug

Coinplug, Inc., a South Korean blockchain company, was established in 2013 (B.E. 2556). The company experts in using blockchain database storing system for digital currency or the so-called crypto currency such as Bitcoin exchange marketplace, Electronic wallet service, Online Point-Of-Sales service (POS) blockchain system for entrepreneur, or the so-called B2B (Business-to-Business) (Bloomberg, 2018). Coinplug, Inc.'s executives are South Korean persons and additionally Vitalik Buterin, co-founder of Ethereum digital currency, is technical consult (Coinplug, 2018).

III. Alibaba Group Holding

Alibaba Group Holding Limited, a Chinese multinational company, was established in 1999 (B.E. 2542). The Alibaba headquarter locates in Hangzhou, China, known as a global E-commerce company. The Alibaba run various businesses such as retail sales, Electronic payment services, Shopping search engines, and Cloud computing services. The Alibaba affiliated companies like Alibaba (business-to-business), Taobao, and Tmall (consumer-to-consumer) in E-commerce business and retail sales, Alipay in Fintech and Online payment platforms, and Alibaba Cloud in cloud system and artificial intelligence business (Alibabagroup, 2018).

IV. Bank of America

Bank of America Corporation, its head quarter is situated in North Carolina, the US, is an international bank providing financial advice and services around the world.

V. nChain Holdings

nChain Holdings Limited is a private blockchain company, and its headquarter is located in London, the UK (Bloomberg, 2018). The nChain focus upon research and development in blockchain, especially Bitcoin Cash. (nChain, 2018)

1.5.2 Main technologies of the key players

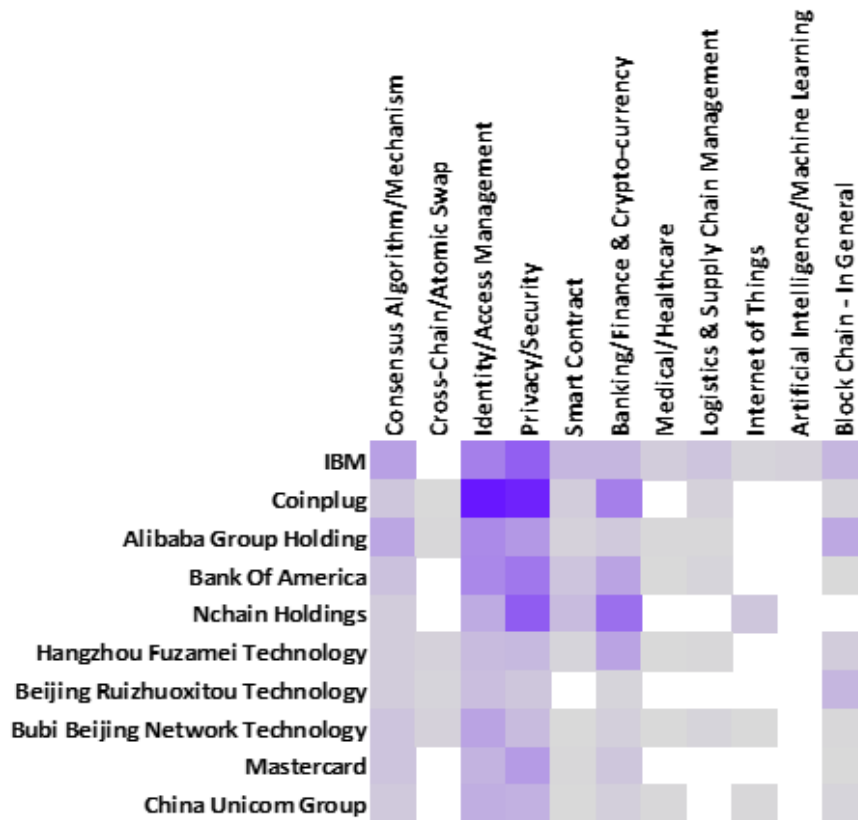


Figure 20 Analysis of top patent applicants broken down by technical sector

All top 10 key players filing blockchain database storing system are experts in different technologies and industrial circles as mentioned above. However, when we solely consider blockchain technology group development as shown in Figure 20 Analysis of top patent applicants broken down by technical sector, where the colour intensity is correlated to the number of patents in the area. It is found that almost all 10 key players primarily focus on developing the invention related to Identity/Access Management, and Privacy/Security. While Cross-Chain/Atomic Swap-related invention has been filed in few numbers by some key players namely Coinplug, Alibaba Group Holding, Hangzhou Fuzamei Technology, Beijing Ruizhuoxitou Technology, and Bubi Beijing Network Technology, which all those companies have filed less than 5 patent applications in the past 10 years.

When we consider application of blockchain database storing system to various fields, it is found that every key player applies the blockchain system to

Banking/Finance/Cryptocurrency conforming to other data analyses. Furthermore, with the era of cryptocurrency, IBM is the only one applying blockchain technology to many industries including Banking/Finance/Cryptocurrency, Medicine, logistics, Internet of Things, and Artificial intelligence. Most importantly, IBM is the only one in all 10 key players to bring blockchain technology to develop with Artificial intelligence and all blockchain-related patent applications of IBM were filed in 2016 (B.E. 2557). After that IBM launched the RoadLaunch platform involved in Logistic management system by artificial intelligence and blockchain, for managing Logistics transactions in order for all stakeholders to collect database with the great security and transparency (IBM, 2018). While, Coinplug has concentrated upon developing blockchain for only Banking/Finance/Cryptocurrency, and logistics, and nChain Holdings has centered on only Banking/Finance/Cryptocurrency, and Internet of Things.

From looking insight into patent applications of key player above, we know that what particular blockchain technology is the technology key players are focusing on and starting to develop. More importantly, it is found there are many Chinese key players beginning developing the blockchain invention related to Cross-Chain/Atomic Swap. Meanwhile, there are a few applying of blockchain to a lot of industries referring that there are a few competitors in those fields, such as applying blockchain to artificial intelligence, or Internet of Things. Additionally, the above analysis report indicates those mentioned technologies are very interesting whitespace area for new comers to run their businesses related to blockchain technology because there are a few patent application numbers and competitors compatible with other technologies

1.5.3 Technology trend

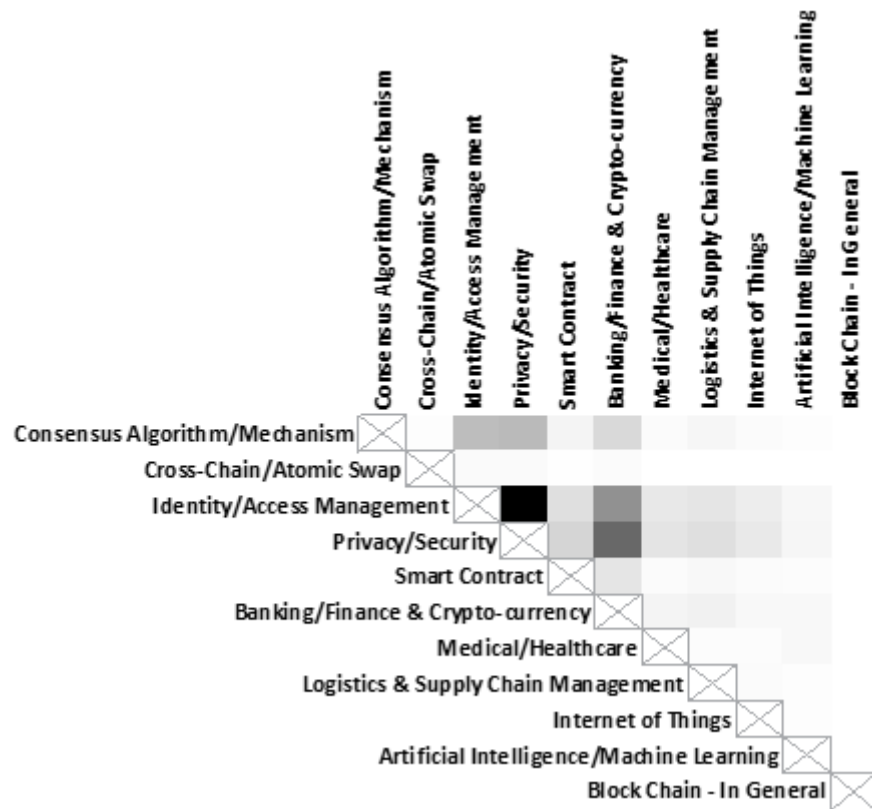


Figure 21 Analysis of overlap between technical sector

As shown in Figure 21 Analysis of overlap between technical sector, the technological crossing patent which colour intensity directly variates patent application numbers in the crossing technology. It is found that Identity/Access Management and Privacy/Security-related technological crossing patents, the patents related to the user identification, or controlling or limiting access to the data in blockchain database storing system together with providing data security in blockchain system, are mostly filed. Moreover, when we consider titles in x-axis, it is found that the Consensus Algorithm/Mechanism, Identity/Access Management, and Privacy/Security technologies have potential to be applied with other technologies.

1.5.4 Filing locations

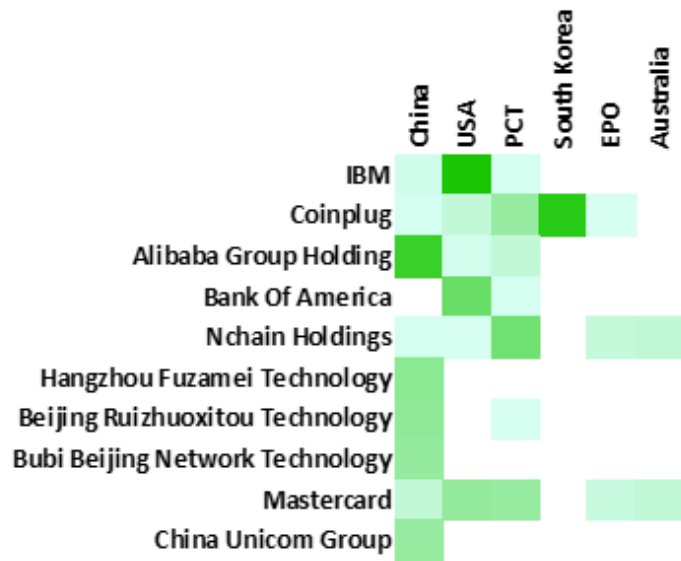


Figure 22 Analysis of top applicants broken down by filing locations

A study of patent priority countries gives benefits to the reader in terms of invention protecting strategies before running business and launching products and services in the real market. More importantly, one of the good filing strategies is to file patent in all countries we need to do marketing so as to protect intellectual property infringement and market share loss.

From Figure 22 Analysis of top applicants broken down by filing locations, where the colour intensity is correlated to the number of patents in the area. It is evident that each of key player has different blockchain technology invention strategies, because each company has his own interested market, or is a pioneer or the leader in different markets. Furthermore, it is found that Coinplug, nChain Holdings, and Mastercard have a strategy to file blockchain-related patents in various countries to protect their intellectual property. While, Chinese key players, namely Hangzhou Fuzamei Technology, Bubi Beijing Network Technology, and China Unicom Group focus on filing patent applications solely in China. On the contrary, Alibaba Group Holding has filed their patents via Patent Cooperation Treaty: PCT system and in the US.

Filing patent via Patent Cooperation Treaty: PCT, the system giving convenience to applicants to file their patent with one language but covering all PCT member countries under

the Patent Cooperation Treaty in the time condition of each member country, is very beneficial to the applicant who want to file their patents in numbers of countries. (Department of Intellectual Property (Thailand), 2016). However, filing patent via PCT system takes time and is quite costly therefore, the applicant ought to be confident that their patent applications being filed via the PCT system are inclined to make worth financial benefits to them before making a decision.

Figure 22 Analysis of top applicants broken down by filing locations illustrates that many key players in top 10 key players have already filed the blockchain technology-related patents, which depicts the filed inventions are the potential patent of each company and have a tendency to breed commercial benefits to the applicant, particularly nChain Holdings, Coinplug, and Mastercard filing their patent applications via the PCT system with 49, 32, and 31 applications respectively.

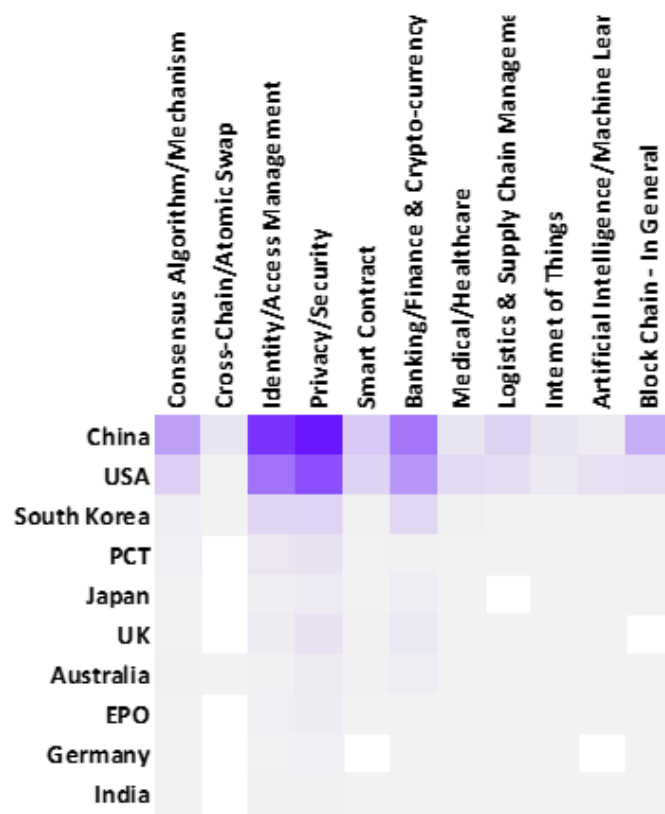


Figure 23 Analysis of first filing locations broken down by technology sector

Figure 23 Analysis of first filing locations broken down by technology sector illustrates that the applicant from China, the US, and South Korea have filed a number of patents in

various groups of blockchain database storing system technologies, especially in Identity/Access Management, and Privacy/Security as well as Banking/Finance/Cryptocurrency applications. Furthermore, Cross-Chain/Atomic Swap technology, gained some interest from the Chinese, American, South Korean and Australian applicants in the past years, is still new for global market.

2. Overview of Thai patent related to blockchain technology

From a study of patent applications filed in Thailand in order to find the blockchain-related patents with using both keywords and IPC classification search methods, there is no the blockchain-related patent application because this technology is quite new in Thailand. From this situation, therefore, it is high possibility that there already have the patents filed in Thailand, but those are still in a pending status or not to be published resulting in the analyst cannot access to the patent application data. Additionally, when we consider characteristics oh blockchain-related patents in foreign countries, it is found that the blockchain technology-related patents can be categorized into two groups namely patent and utility model focusing on developing the foundation of the blockchain technology such as algorithm or system and method of blockchain, the other group focuses on developing and turning the blockchain foundation into its application in a specific field. The blockchain technology existing in Thailand is mostly application of the technology like an application of Open Source – Blockchain Platform, affecting there is no development of new algorithm or system. Furthermore, that computer system and software patent application filing in Thailand are not popular for Thai applicant, and the most Thai entrepreneur lacks the knowledge in this field, are one of the factors results in few blockchain-related patent application numbers and little growth rate of the technology in Thailand.

When we consider patent application numbers of the global key players according to this report, it is found that many companies filing a high number of blockchain-related patent applications are still doing their business in Thailand such as Mastercard, Alibaba Group Holding, and IBM. Besides, there are other companies developing blockchain technology and doing their business in Thailand such as Tencent. When we consider patent family of the patent applications of key players, they have filed patent applications in Thailand which are vary fields. For instance, IBM has filed 8 patent applications in Thailand, in the name of IBM corporation, IBM Japan, Ltd., and IBM Japan business logistics Co., Ltd., filed multilayer printing circuits and the multilayer printing circuits producing method, Packaging for electronic devices, and packaging for parts. Another example is Mastercard, filing patent in the name of Mastercard

international incorporate, Mastercard Asia/Pacific PET., Ltd., has filed patents related to Methods and systems of safety payment transaction, Machine and method for mobile mute prepay, and Method and system for debit card to be an alternative to pay currency by online payment system and payment method, as well as 4 patent applications filed in 2016 (B.E.2559), and 2 patent applications filed in 2017 (B.E. 2560) being not published. Furthermore, the key player, Alibaba Group Holding has filed 52 patent applications in the name of Alibaba Group Holding Ltd. in 2018 (B.E. 2561). Moreover, Tencent has filed patent applications in Thailand but they are not published. From the information above, it is plausible that there is and will be the blockchain-related patent registration filed by foreign applicants in the present time or in the near future in Thailand, or it is possible that there will be key players having their branch in Thailand and filing the blockchain-related patent applications in Thailand in the near future.

Although blockchain-related patent application overall picture in Thailand is not outstanding or illustrating in mega trend, Thai private sectors and Thai government have a focal point on blockchain technology in the past several years by studying and trying to apply blockchain technology as a base technology to raise fund. Furthermore, the blockchain technology increases awareness of cryptocurrency and breeds blockchain information resources and websites providing direct blockchain knowledge and cryptocurrency in Thailand.

The blockchain technology started to be used in various types of business for instance, 14 banks, government enterprise, and private entrepreneur apply blockchain technology to provide electronic bank guarantee on blockchain system to approve the electronic bank guarantee. Moreover, with the strength of the blockchain technology, the banking service provider has a high effective bank guarantee system gaining reliability and being high security system, which the service mentioned above is one of many services the bank to go to 100% electronic bank documents (Techsauce, 2018). From the example mentioned above, it is evident that the blockchain technology heavily affects and thoroughly changes banking business. Furthermore, there are many banks bringing blockchain technology to their other

services, for instance, Siam Commercial Bank: SCB use blockchain technology to transfer currency between Thailand and Japan, Kasikorn bank: KBANK collaborates with IBM provide a service system to collect and send bank guarantee, or Bank of Ayudhya: BAY begins to gather documents and legal contracts via blockchain system as well as to provide loan service application via blockchain system. On the contrary, government tries using blockchain technology to create “eVote system” of Department of Physical Education, Ministry of Tourism and Sports by using the blockchain system in voting system in order to reduce costs, create convenience, top security, and transparency developed by Thammasat University Research and Consultancy Institute: TU-RAC (Bizunbox, 2018)

Furthermore, blockchain technology is used together with cryptocurrency by producing Token or Coin and using those tokens to raise fund or the so-called “ICO (Initial Coin Offering)”, which is fund raising innovation. Additionally, there are Thai private entrepreneurs launching ICO, for instance, SIX NETWORK raises fund via ICO to create a platform for creators including financial services, digital wallet, and decentralized creative work trading (Siam Blockchain, 2018), and Project planning service PCL. (PPS) collaborates with Fintech (Thailand) Ltd. create a platform for investing in construction and real estate industries by ICO (Fintech (Thailand), 2018) . Moreover, with the blockchain and cryptocurrency flow, there is various cryptocurrencies’ exchange, breeding new forms of business like Bitkub.com, a website assisting clients in transferring, exchanging cryptocurrencies rapidly and conveniently.

Furthermore, Blockchain technology has been developed for using in various types of technologies or applications, for example, Digital ventures Ltd. Cooperates with Ministry of Digital Economy and Society, and Higher Education Institutes develop a platform for verifying Educational documents like Degree or Transcript by blockchain technology, which this platform is opened for every institute to access and have a tendency to create Big data with the assistance of artificial intelligence (Brandinside, 2018), or a platform for using blockchain to adapt to own organization as Platooreum which provides Private Blockchain, or a concept to make use of blockchain to trade electrical energy.

In conclusion, although the blockchain patent trend in Thailand is not outstanding in the present time, from the rapid growth of the blockchain technology both in Thailand and around the globe, there are a huge technological impact upon Thai organizations. Therefore, it is highly plausible that blockchain-related patent applications will be increasingly filed in a very near future by Thai private sectors, foreign applicants.

3. Strengths, Weakness, Opportunities and Treats of the technologies

Table 2 Strengths, Weakness, Opportunities and Treats of the technologies

Strength	Weakness
<ul style="list-style-type: none"> • Data security • Transparency • Easy to track • Disintermediary • Reduce cost 	<ul style="list-style-type: none"> • Complex, need a education in order to make massive adoption • Still in early stage of development • Might have some legal conflict in some country
Opportunities	Threats
<ul style="list-style-type: none"> • Easy adoption in digital era • High potential to revolutionise many industries 	<ul style="list-style-type: none"> • Law and policy uncertainty • Need collaboration from many parties

Based on patent analysis related to blockchain technology, it can be seen that most of the patents related to the system development including user verification process, data access control or data encryption. These system development patents aim to improve the efficiency of the blockchain system particullary in security and transparency in data retention without intermediaries needed to manage the data. In addition, when reducing the work of intermediary, It can help reduce the cost as well.

However, the weaknesses of blockchain technology still exist in terms of deployment, which requires a broader understanding of the technology. It is relatively a new technology and still in the early stage of development which may lead to limited use and not accepted in from most people.

When analysing the external impact, it can be seen that blockchain technology has a high chance of being adopted to a wide range of industries, with the potential to keep data secure and transparent. The clear example is digital currency that work based on blockchain system. That can make a change in how people exchange money, make financial transactions. This is the beginning of technology adoption, many of the world's leading companies have already embraced technology in their industry, as shown in this analysis report. For example, IBM has developed a solution platform based on block technology that can be deployed in organisation to track the product status and other information. As present is the digital era, adoption of blockchain technology to replace the old way of how organisation store data is the new way to increase the digital capabilities.

However, the threat of this technology is still come from many parts. The law system may be unfavourable in many countries. This is mainly due to the technology is still emerging. The results of the real use case is still unclear. In addition, the use of blockchain technology is suitable for tracking data, collecting information from multiple parties to gain access to information transparently. The real benefit of using blockchain technology is that it is easy to work with and faster when it comes to working together. But this is still a major threat. All parties have to agree to use the information collected on the same blockchain network. For example, a blockchain system platform from IBM, TradeLens, developed jointly with Maersk, a global shipping company from Denmark, could make a smart contract between its international shipping partners. It requires cooperation from many sectors, whether shipping companies, shipping companies, and the tax authorities. In the period of 12 months for the pilot version, there were two other shipping companies in addition to Maersk: Pacific International Lines (PIL) and Hamburg Süd joined the platform with the Dutch customs, Saudi Arabia, Singapore, Australia, Peru custom (August 2018 data) (Blognone, 2018) For this reason, a great effort has to put into convincing diverse parties to get involved in this emerging technology, in order to make a massive adoption.

Analysis on Technologies with adequate potential for further development

By searching and studying patents related to blockchain technology from the Derwent Innovation patent database, researchers can access to potential patent information by analyzing the patent strength index or forward citation to evaluate patent quality. The patent quality can demonstrate the potential of the patent that can be applied to make benefit in various industries. The patent quality index is calculated from the following variables.

- a) Frequency of citation by downstream patent applications: this variable used “a forward citation frequency” instead of counting numbers of citations, helping decrease biases to old-patents having high citation times.
- b) Geographic filing breadth: this variable counts numbers of countries or legal jurisdictions where a patent files, which the numbers show the countries or legal jurisdictions, and value of each patent as well as a strategy to produce and distribute the patent of each applicant.
- c) Technical breadth: this variable is used to measure technology diversity of each patent application by “Derwent World Patents Index™ Classification”, which is a technology classification by technology experts of the Clarivate analytics. The more diverse technical breadth is, the opportunities to apply in various fields of technologies appear, leading to high value of patents.
- d) Age of the patent: this variable measures the remained patent term of each patent, which the longer patent term is, the higher technology utility, leading to high patent value.
- e) Overall strength: this index brings the above indexes to do a statistical calculation in order to calculate overall strength of each patent application.

The top 3 highest strength index patents are

1. Patent publication number EP2634738A1, Name of the invention: Decentralized electronic transfer system, Application date: 2 March 2012 (B.E. 2555), Patent strength index: 140.48 by Derwent Innovation, Assignee: Alcatel-Lucent Enterprise (ALE), a telecommunication company from France, subsidiary of Nokia. This patent claimed decentralized electronic transfer system, which have been cited by 10 patent including patent from IBM, Mastercard, and Coinbase Inc.

2. Patent publication number EP3012771A1, Name of the invention: System and method for protecting electronic money transaction, Application date: 13 August 2015 (B.E. 2558), Patent strength index: 137.73 by Derwent Innovation, Assignee: AO Kaspersky Lab, a cybersecurity and antivirus software company from Russia.
3. Patent publication number US20160269182A1, Name of the invention: Method and apparatus for providing a universal deterministically reproducible cryptographic key-pair representation for all SKUs, shipping carton, and items, Application date: 12 March 2015 (B.E. 2558), Patent strength index: 138.21 by Derwent Innovation, Assignee: SKUChain Inc., a blockchain company from the USA develops blockchain based products for B2B trade and supply chain finance. The company offers BRACKETS, a smart lock with digital keys that moves money when the agreements are met. This patent claimed the method for providing cryptographic key pair that have been cited by patents from Accenture global solutions, Walmart, nChain Holdings, and Blocksettle.

Suggestion for applying the analysis result

This analysis report illustrates the overall trend of international patent data related to blockchain technology. In the study, help to emphasize the important of research and development in the field of blockchain technology of the agency from around the world. This patent information emphasizes the potential of invention especially the ability to create business value. For the research, it can be seen that many of the products or services actually come out, most of them have already received intellectual property protection to protect the invention and reduce the risk of duplication and loss of market share when the invention is released. Patent information studies can also help educators understand the strategies of this technology leaders including the trend of interest in technology or major markets. This can be adapted to the business of the study. Although the blockchain technology is still in a development process, it has started to apply to many industries, such as the logistics industry and the medical industry.

Despite the overall patent data of the blockchain technology in Thailand still has no specific information or special trends have emerged. However, there is interest from many sectors to apply this technology to domestic applications. This shows the good direction of the Thai business sector, with the introduction of emerging technologies.

However, even with no apparent change in the industry, but entrepreneurs should not overlook this emerging technology. That may have the potential to change how we work and increase the productivity of many industries in the future.

Data clean-up and Grouping

Definition of patent data related to blockchain technology

This analysis has selected the patent related to blockchain technology by using the keyword in combination with the International Patent Classification (IPC), Cooperative Patent Classification (CPC), and the Derwent (DWPI class) as a main filter for searching and data grouping.

The Data Grouping is mainly based on the technological perspective, together with the group of technologies which is the country main interest, in the other word, technology grouping can be done based on the core patent information in which this patent information will be divided into each topic. The analyst has divided the industrial group up into a technology groups as follows:

International patent database analysis

The international patent database analysis is performed by gathering patents by using the keyword and the International Patent Classification: IPC class relating to blockchain technology and categorised into groups as follows:

- 1) Categorised by the components of Blockchain
 - a. Consensus Algorithm/Mechanism consisting of patents relating to consensus algorithms that is used for blockchain data collection such as “Proof of Work”, “Proof of Stake”, “Byzantine Fault Tolerance” for instance.
 - b. Cross-Chain/Atomic Swap consisting of patents relating to the linkage of the blockchain data collecting from more than one network together which relating to branches chain, side chain, multi-chain or Atomic swap, such as the digital money exchange from two different money currency and not requiring a central terminal in order to make the currency exchange.
 - c. Identity/Access Management consisting patents relating to user identification, authentication and access permission control.

- d. Privacy/Security consisting patents relating to security of the data collecting on the Blockchain network such as the private information securing method by using the private key or digital signature, encryption techniques and other private information securing method.
- e. Smart Contract consisting patents relating to contract gathering on the Blockchain system such as smart contract and the automate escrow system.

2) Categorised by the uses of Blockchain

- f) Banking/ finance/ crypto-currency group consisting of patents relating to data collecting on the blockchain network for the purpose of banking, finance or crypto currency.
- g) Medical/Healthcare group consisting of patents relating to the data collecting on the blockchain network for the purpose of medical and health benefits.
- h) Logistic and Supply chain management group consisting of patents relating to the data collecting on the blockchain network to be used for the purpose of transportation system, logistic and supply chain managing.
- i) Internet of Things group consisting of patents relating to Internet of Things of the electronic appliance which is connected to the internet network and is then connected to the data collecting on the blockchain network.
- j) Artificial Intelligence group consisting of patents relating to the data collecting on the blockchain network.
- k) Block chain- In General consisting of patents relating to the data collecting on the blockchain network which is not categorised above.

Identification of patent related to blockchain technology

International patent database search

International patent database search by using the keyword in combination with the International Patent Classification (IPC) class and the Derwent (DWPI class) by grouping the IPC class into the technology group that needs to be studied and then search and filter the information.

Timeframe for analysis

International patent database search

Generating the set of information from the international Patent database by limiting the application date from the past 10 years which is the patent application date starting from year 2007 (B.E. 2550) to year 2018 (B.E.2561), however the patent data from year 2017 (B.E. 2560) to year 2018 (B.E.2561) is not fully published, this making the analyse data to be incomplete.

Thailand patent database search

Generating the set of information from the Thailand Patent database is not limited by the application date timeframe due the number of patents in Thailand is not high this making it possible to gather all the related patents up to the application date as of August 2018 (B.E. 2561).

Data extraction and analysis

This analysis has arranged the inventions by analysing the metrics by using the patent database as a foundation base and display the result in the form of a table chart, graph or graphic presentation which incorporate the said patent data.

Data management comprises of 4 steps as follows:

1st Step: Dividing the technology group in accordance with the International Patent Classification (IPC) of the Derwent World Patent Index (DWPI) Class.

2nd Step: Inputting search query by using the relevant description of the IPC or DWPI class.

3rd Step: Filtering and cleaning up the data and then gathering the remaining data.

4th Step: Analysing the data within the scope of the analysis objective.

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Appendix

International patent database search

Keywords

blockchain, block, chain, distribute, share, public, replicate, ledger, decentralize, consensus, smart, contract, ethereum, cryptocurrency, p2p, peer, transaction, payment, currency, bitcoin, trustless virtual, digital, digitize, electronic, money, cash, asset, digiccy, e-cash, namecoin, metacoin, coinjoinm Litecoin, ppcoinm peercoin, peer-coin, coin-join, altcoin, darkcoin, swiftcoin, bytecoin, gridcoin, emergcoin, dogecoin, feathercoin, primecoin, auracoin, mazecoin, potcoin, vertcoin, alternative coin, alternative currency, monero, ripple, zcash, decred, cordano, hashcash, hash, smart property, identity, record management, Internet of thing, IoT, network, game, gaming, theory, transaction, puzzle, hashlock, fault, tolerant, autonomous automate, escrow, genesis, timestamp, mining, forging, cross, relay, branch, multi, side, chain, atomic, swap, algorithm, protocol, network, proof of work, proof of stake

IPC

IPC	Definition
G09C 1/00	Physics -> Educating; cryptography; display; advertising; seals -> Cipherring or deciphering apparatus for cryptographic or other purposes involving the need for secrecy -> Apparatus or methods whereby a given sequence of signs, e.g. an intelligible text, is transformed into an unintelligible sequence of signs by transposing the signs or groups of signs or by replacing them by others according to a predetermined system
G06F 17/30	Physics -> Computing; calculating; counting -> Electric digital data processing -> Digital computing or data processing equipment or methods, specially adapted for specific functions -> Information retrieval; database structures therefor

G06F 21/00	Physics -> Computing; calculating; counting -> Electric digital data processing -> Security arrangements for protecting computers or computer systems against unauthorised activity
G06Q 20/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols
G06Q 20/06	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols -> Payment circuits -> Private payment circuits, e.g. involving electronic currency used only among participants of a common payment scheme
G06Q 30/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols -> characterised by the use of specific devices
G06Q 40/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial,

	<p>supervisory or forecasting purposes, not otherwise provided for -></p> <p>Payment schemes, architectures or protocols -> Payment protocols;</p> <p>Details thereof -> Authorisation, e.g. identification of payer or payee, verification of customer or shop credentials; Review and approval of payers, e.g. check of credit lines or negative lists</p>
H04L 9/00	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements for secret or secure communication</p>
H04L 9/32	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements for secret or secure communication -> Including means for verifying the identity or authority of a user of the system</p>
H04L 29/02	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus, circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing</p>
H04L 29/06	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus, circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing -> Characterised by a protocol</p>
H04L 29/08	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus, circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing -> Characterised by a protocol -> Transmission control procedure, e.g. data link level control procedure</p>

EPO - Cooperative Patent Classification (CPC)

CPC	Definition
H04L63/0442	Electricity -> Electric communication technique -> Transmission of digital information -> Network architectures or network communication protocols for network security -> for providing a confidential data exchange among entities communicating through data packet networks -> wherein the data content is protected e.g. by encrypting or encapsulating the payload -> wherein the sending and receiving network entities apply asymmetric encryption
H04L2209/38	Electricity -> Electric communication technique -> Transmission of digital information -> Arrangements for detecting or preventing errors in the information received -> Additional information or applications relating to cryptographic mechanisms or cryptographic arrangements for secret or secure communication -> Chaining

DWPI Manual Codes

DWPI Manual Codes	Definition
T01-N02A2E	Computing And Control -> Digital computers -> Internet and information transfer -> Communications and control -> Communication -> Network communication -> Peer-to-peer networks
T01-D01	Computing And Control -> Digital computers -> Data conversion -> Data encryption
W01-A05	Communications -> Telephone and data transmission systems -> Digital information transmission -> Secret communication

Thai patent database search

IPC

IPC	Definition
G09C 1/00	Physics -> Educating; cryptography; display; advertising; seals -> Cipherring or deciphering apparatus for cryptographic or other purposes involving the need for secrecy -> Apparatus or methods whereby a given sequence of signs, e.g. an intelligible text, is transformed into an unintelligible sequence of signs by transposing the signs or groups of signs or by replacing them by others according to a predetermined system
G06F 17/30	Physics -> Computing; calculating; counting -> Electric digital data processing -> Digital computing or data processing equipment or methods, specially adapted for specific functions -> Information retrieval; database structures therefor
G06F 21/00	Physics -> Computing; calculating; counting -> Electric digital data processing -> Security arrangements for protecting computers or computer systems against unauthorised activity
G06Q 20/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols
G06Q 20/06	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for ->

	Payment schemes, architectures or protocols -> Payment circuits -> Private payment circuits, e.g. involving electronic currency used only among participants of a common payment scheme
G06Q 30/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols -> characterised by the use of specific devices
G06Q 40/00	Physics -> Computing; calculating; counting -> Data processing systems or methods, specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes; systems or methods specially adapted for administrative, commercial, financial, managerial, supervisory or forecasting purposes, not otherwise provided for -> Payment schemes, architectures or protocols -> Payment protocols; Details thereof -> Authorisation, e.g. identification of payer or payee, verification of customer or shop credentials; Review and approval of payers, e.g. check of credit lines or negative lists
H04L 9/00	Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements for secret or secure communication
H04L 9/32	Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements for secret or secure communication -> Including means for verifying the identity or authority of a user of the system
H04L 29/02	Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus,

	<p>circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing</p>
H04L 29/06	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus, circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing -> Characterised by a protocol</p>
H04L 29/08	<p>Electricity -> Electric communication technique -> Transmission of digital information, e.g. telegraphic communication -> Arrangements, apparatus, circuits or systems, not covered by a single one of groups</p> <p>h04l0001000000-h04l0027000000 -> Communication control; communication processing -> Characterised by a protocol -> Transmission control procedure, e.g. data link level control procedure</p>



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