Future Agenda of Blockchain Perceived By Three Important Communities: Academia, Enablers, Industry

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Abstract

Blockchain is a decentralized data transaction enabled by evolving technologies since 2008. As it has drawn significant attention from many industries and academics recently and it is claimed to have strong disruptive potential. Especially for the last two years, there has been considerable increase in the number of research papers, use cases generated, pilot implementations and also platforms enabled by the technology providers. According to the industry research, by 2022 blockchain business will be worth $10 billion and the business value-add of blockchain will exceed $3.1 trillion by 2030 when it will be in its mature state. To reach its maturity efficiently and effectively, it is vital to design future agenda that addresses the tasks or expectations of three parties (industry, enablers, research) from a technological perspective. In this paper, comprehensive maturity model based future agenda will be presented.

Keywords: Blockchain, Challenges, Maturity model, Technology agenda, Disruptive technologies.

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Introduction

Blockchain is a distributed database solution that maintains immutable public records of data that are cryptographically protected and secured by a network of peer-to-peer participants. This technology enables trust between two parties without an intermediary and is more transparent than centralized transactions involving a third party. In line with these benefits, industry has been demanding to use it for three years [11]. As a result, technology providers/consultants have also been interested in it with either providing platforms or consultancy services. On the other hand, it is a combination of known technologies and sciences, it is attractive for academia to research with new motivation.

On the other hand, current research has showed that this technology is not mature now [11] [12] [19]. Therefore it is essential to combine them in a comprehensive agenda to reach maturity efficiently and effectively.

However, there were two main challenges about this research area. The first one was identification of the critical points that are of interest to and agreed by the three parties (industry, enablers, research). To overcome this challenge, not only research contributions and but also ideas and experiences from enablers and industry were used. The second challenge was the effective expression of this agenda. To get around with this challenge maturity model based expression was chosen among other alternatives, which will be explained in the next chapter.

Background & Related Work

Today's technological limitations, challenges, outcomes, opportunities are considered to be the best candidates for future research. Previous research showed that there exists a gap in technology performance, scalability, latency, integration [4] [14] [17].On the other hand, the trend analysis by search engines show that this technology has captured everyone's attention and momentum of everyone's attention is greater than research momentum [6]

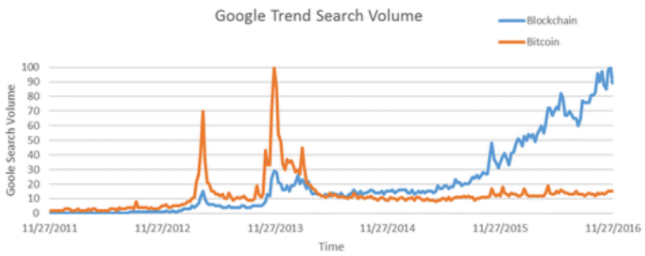

Figure 1. Google Trends search volume [6].

Moreover, since some practical works were done, evaluation of results is vital to understand the technological limitations and effective continuity of industrial needs. Since industry is demanding in this field because of the opportunities, enablers also invest in and do R&D on that topic. Also, there are industry reports that show the direction of the work to be done.

To structure the agenda in a holistic and rigorous way, the following options were considered:

- task owners
- contributions to the industry that is business driven approach
- underlying computer sciences (for example: cryptography, database related etc.)
- time based approach
- maturity based approach

Since research is primarily based on an emerging technology and the ultimate aim is to reach its mature state, maturity model based approach was chosen. Such an approach is practically enabled by called Blockchain Maturity Model (BCMM) [12] (see Figure 2) and we adopt it for our own research purpose.

	Initial (stage 1)	Repeatable (stage 2)	Defined (stage 3)	Managed (stage 4)	Optimizing (stage 5)
Networks		Network load	Reliability		
Information Systems	Architecture Upgrading Integration	Maintenance Storage Scalability		Business efficiency	
Computing Methodologies	Standardization	Computational complexity			
Security and Privacy			Privacy	Data security Transaction security	

Figure 2. Blockchain maturity levels in technology perspective [12].

Method for Structuring Future Agenda

Following steps were applied:

STEP 0: Design the criteria for searches and categorize the information

Sources of this research will be detailed through STEP1 and STEP5. Also in each step, consolidation method will be introduced. Each step's output will be classified as [12]

- Networks
- Information Systems
- Computing Methodologies
- Security & Privacy

STEP 1: Searching Electronic Databases for Papers

While searching electronic information, both industry papers and academic research were taken into consideration. Despite the first use in 2008, academic papers have existed since 2014. The survey was based on articles in journals and mostly conference proceeding papers. Master theses, doctoral dissertations, textbooks, unpublished working papers were excluded. The literature search was based on "blockchain" descriptor. After review papers were examined, "limitations, challenges, opportunities, future work, trend" filters were used. It was conducted using the following databases:

- IEEE
- Association For Computing Machinery
- Science Direct
- Springer Link
- Computer and Applied Science Complete
- Plos One

Following industry research organizations' reports were also taken into consideration:

- Gartner
- Forrester
- Accenture
- Deloitte
- KPMG

Several rounds of data (articles, reports etc) examination have been done. When gap was identified, iterative process was applied since new research could address the current gap.

STEP 2: Gain Industry Leaders/Enablers (Practioners) Insight

Since this technology is in its experimental stage (between POC and pilot), it is essential to understand the experiment results. Since, there is a highly competitive environment, collection of this information was very difficult. Moreover it requires addition of the information to Table 1 anonymously.

While constructing this chart, sector leaders (top 5 of that sector) were included in the table.

Datasource column represents the position of the people that expressed corresponding challenges. Either leader (having the title of director and above), account manager (representative of technology provider) or experts (implementers of project) were considered.

Enabler/Industry column represents the industry and domain of the business area

Challenges Expressed column represents the ideas, opinions and challenges that were mentioned by them. From the meeting result, they are the answers to the following questions:

For Industry:

1. What do you think about the maturity of the blockchain?
2. What are the mostbiggest challenges about blockchain?
3. Why do you choose that use case? What are the challenges? What is your current state?
4. What is the critical problem of current technology?

For Enablers:

1. What is your current strategy around blockchain?
2. Which problems will be solved by you?
3. What is the critical problem of current technology?

STEP 4: Searching search engines to understand trends and current state

In order to understand the research trend Web of Science and SSRN databases were used. Current state is very dynamic while creating this research there was a lot of work done in industry and research. That's why iterative work was needed for double check of what was obtained.

STEP5: Consolidate information to obtain the agenda

All of the findings were categorized according to the below table and agenda were constructed according to the BCMM [12].These domains and capabilities were consolidated according to this BCMM targets.

According to the Table 1, ID and Challenges Expressed column, Enablers, Industry columns were constructed. Concatenation of numbers shows matching of expressions with capability model. s

According to the information that was given by Enablers, Industry and collected from Research were categorized by the following rules:

1. If the party addresses the current issue with enhancement suggestion directly, matching enhancement area is added to below chart. ID of the Reference is put in the table. [1.5] is an example for this.

2. If the party addresses the current issue indirectly that is through non technological expression, implied technology elements are added to the table.. For example, 8th enabler told that regulation was an important issue. In this speech context, technology

implications of regulation are changing the architecture so that it contains also auditability, thinking business cases according to the regulations (for example do not think about public blockchain in banking sector), consider privacy and data security.

ID	Data Source	Enabler/Industry	Challenges Expressed	Technology Used/Offered
1	Technical Leader/Account Manager	Enabler (Global Technology Vendor)	1. Support for complex platforms 2. Awareness 3. 5 years to maturity 4. Performance 5. Integration with chain-of platforms 6. Regulations barrier 7. Consider Apps 8. POC s rather than mature projects 9. Disruptive	• Hyper Ledger • Etherum • Coco FrameWork
2	Financial Sales Manager	Enabler (Global Technology Vendor)	1. 5 years to maturity 2. Will be basis for B2B 3. Turkey is demanding especially banks and other institutions 4. Usage of the technology extensively takes time 5. Payments, loan usage, digital identity verification, investments etc will be moved to blockchain technology 6. One of the three important technologies Disruptive	• Hyper Ledger
3	Account Manager	Enabler (Global TechnologyVendor)	1. Partnership with other big enabler 2. Integration with API technology 3. Inevitable for future	• Hyper Ledger
4	Leader	Enabler (Local Regulator)	1. Auditability is inevitable for financial institutions	N/A
5	Leader	Enabler (Local Solution Provider)	1. Power and storage saving 2. Mobile wallet	• Public blockchain
6	Leader	Enabler (Industry Research)	1. Now immature state 2. Selection of business case critical, new cases that fit for this technology should be chosen Not only efficiency cases also others are important	N/A
7	CEO	Enabler (Start Up)	1. Digital Identity 2. in very early phase 3. Protocol that defined as a set of protocols and data formats, which enable smart contracts owned and controlled by organizations	• High performance • Increase speed and transaction synchronization time • Customized public blockchain platform
8	Leader	Enabler (Big Four)	1. Regulation 2. Selection of use cases 3. Awareness	N/A
9	Leader	Industry (Finance)	1. Digital identity, 2. As of 2018, not mature	• Designing of own protocol • Protocol that defined as a set of protocols and data formats, which enable smart contracts owned and controlled by organizations • Performance, increase transaction speed and synchronization time are ensured by this protocol
10	Manager of Digital Services	Industry (Finance)	1. Discovery of technology 2. Use case design 3. Getting inspired from the owner company since USA and Europe is much mature than Turkey 4. FX, domestic, foreign trade, money transfer ,investment are the candidates for implementation	• Hyper Ledger
11	Experts	Industry (Telecom)	1. Roaming 2. Elimination of central authority 3. To prevent fraud with offline to online	• Hyper Ledger Fabric, Go language • First phase development completed, not replacement with current technology • Consideration of user interfaces
12	Leader	Industry (Finance)	1. Pilot project 2. Loans, seeking standards 3. Eliminate time intensive iterations and review	• Hyper Ledger • Ethereum
13	Leader	Industry (Tourism)	1. Loyalty business case 2. Users reward process accelerated replacing daily settlements with online processing	• Hyper Ledger
14	Leader	Industry (Finance)	1. Loyality programs for employees, nonfinancial 2. Discovery, training cases 3. Pilot case 4. Upgrade the platform 0.6 version to 1. This is new. 5. Other blockchain platforms taken into consideration	• Hyper Ledger • Ethereum will be taken into consideration

Table 1. Insight from Industry & Enablers.

Results & Discussion

Although more than hundred blockchain platforms are in development, industry and enabler use a few of them. Redundant works do exist because every organization start from scratch generally on top of their current business cases. Appropriateness of business cases, selecting accurate platform architecture, success of the work and integration (with chain off platforms and interoperability) are all in question. However, generally because of reputation reasons industry present their work as if there are not any problems and they move their business to the blockchain, enablers also present their work as if they can solve all the problems of industry and when the distribution of research were taken into consideration it was seen that blockchain was threatened as if underlying technology of bitcoin. However this research ensured integration of issues and categorization of them in an unbiased manner. Moreover, future agenda differs from the others in that:

1. It is based on both theory and practice. Reviews showed that 80% related with bitcoin, most of the remaining was related with security [16] [18]. But according to Table 2, business efficiency, network load, architecture also pain points and should be in agenda.
2. It combined future expectations with current facts about blockchain. Because of that it was more realistic. There are SWOT, opportunities analysis in literature [14] [17]. But, it examined only that technology as an item. In that case alignment of future cannot be ensured. For example AI was the inevitable fact of future. That is because opportunities of that technology with AI also should be also taken into consideration.

Domain	Capability	Enablers	Industry	Research
Networks	Network Load	[1.4], [1.8], [2.5], [5.2], [7.2], [1.3], [2.1]	[10.4], [11.1]	[14]
	Reliability	[2.5], [7.1]	[9.1]	[14], [13]
Information Systems	Architecture	[1.1], [1.6], [4.1], [8.1], [2.5], [7.3]		[14]
	Upgrading	[2.6]	[14.4]	
	Integration	[1.5],[3.2]	[11.1]	[14], [4]
	Maintenance	[2.5],[2.6]		
	Storage	[5.1]		
	Scalability	[1.3], [2.1], [2.4], [2.5], [5.2], [7.2], [1.8]	[10.4], [11.1]	[4]
	Business Efficiency	[1.2], [2.5], [1.3], [2.1], [1.8], [2.2], [6.2], [2.3], [3.3], [5.2], [6.3], [7.1], [7.3], [8.1], [8.2], [1.6], [1.9], [4.1], [1.7], [6.1], [7.2], [8.3]	[9.1], [9.2], [10.1], [10.2], [10.3], [10,4], [11.1], [12.1], [13.1], [14.1]	[14], [4], [13], [6]
Computing Methodologies	Standardization	[3.2],[7.3]	[12.2]	
	Computational Complexity	[2.5], [1.1]		[14]
Security Privacy	Privacy	[2.5], [1.6], [4.1], [5.2], [7.1], [8.1]	[9.1], [10.4]	[14]
	Data Security	[2.5], [1.6], [4.1], [8.1], [5.2]		[14]
	Transaction Security	[2.5], [5.2]	[11.3]	[14]

Table 2. Future Agenda Structure based on BCMM.

Table 2 categorization were used to structure below agenda:

Networks

Network load/Scalability:

- Since the technology is immature now, the number of transactions is relatively small. However, volume of the transactions will dramatically increase. Hence, latency, size and bandwidth and wasted resources need to be conducted to ensure scalability. However, there exists major research gap on latency, throughput, size and bandwidth, versioning, hard forks, and multiple forks related research. This requires more research in the future [4].
- Enablers should provide environments for load and performance tests to be done.
- Industry should consider this limitations by designing their use cases of today.

Reliability:

- Blockchain and trust managements are also subject to examinations. There is not holistic research on that topic.

Information Systems

Architecture:

- Blockchain reference architectures especially smart contract based reference architectures are subject to be researched and evolve for both researchers and enablers
- Outlining the key characteristics and differences of blockchain platforms and the providers is important for the industry. This task should be handled in a rigorous and holistic way.

Upgrading:

- Platforms are also evolving while applications are developed. Seamless upgrades should be taken into consideration not to burden extra development costs to industry

Integration:

- Integration with legacy systems as well as interoperability are issues that are addressed by the practitioners and should be in the future agenda. Industry should strategize the replacements or coexistence of the current situation.

Storage:

- Data analytics and data management technologies should be subject to be researched.

Standardization:

- Few of the blockchain platforms is being used actively and learning languages, understanding API's are difficult to handle.

Business Efficiency:

- Efficiency is not just ensured by replacing the current technology with the efficient one;it, is also ensured by building new business models on top of it. Correct understanding of technology required for proper use. [15]. Moreover, as seen by industry leaders interviews, understanding and discovery are the common phases. Do you need blockchain is the first question [13] and there is a research on this. However, current and potential blockchain applications should be examined with design science and matching technologies of blockchain identified.

According to lead industry researchers while blockchain investigation is broadening, 80% of current projects will not go live by 2018[16] [18]. That's why evaluating the effectiveness of the proposed solutions with an objective evaluation criteria is very important. Although several solutions to challenges and limitations have been presented, many of them are just brief idea suggestions and lack concrete evaluation on their effectiveness [4] [14]. Evaluation framework should be designed by enablers. It can also serve the compliancy perspective if it is used as audit framework. Hence, it can accelerate the regulative works.

Operational risk management aspects should be examined in order to prevent loses of businesses.

Computing Methodologies

Computational Complexity:

Computational complexity of blockchain (consensus mechanisms etc) brings other challenges like resource efficieny. Energy-efficient resource management for distributed systems should be in the agenda.

For the sake of the trust mechanisms when a transaction is being processed, a blockchain has to do all the same things just like a regular database does, but it carries additional burdens as well[14], optimizing mechanisms can be discovered.

Exploring the relationship and interaction of blockchain technology with other emerging technologies, such as IoT and AI are also challenges of future [17]

Security & Privacy

Security & Privacy:

While technology is evolving new ways of disturbing and attacking that technology also developing. Therefore, aspects of the blockchain security should be examined. Blockchain attacks could be accomplished-through [14]:

- User identify theft
- Fraudulent sender and receiver
- Asset/node theft or impersonation
- Targeting of Bitcoin miners
- Injection of malicious code into a distributed ledger
- Target reconnaissance
- Bypassing the onboarding and off boarding of nodes
- Fictitious blockchain applications will appear to steal transaction details/personal information/behavior from nodes/individuals.

Research should be done and enablers can prepare themselves new attack technology. Cybersecurity concerns and improvements should be in the agenda if the personal data moved to public blockchain platform

Conclusion & Future Work

Blockchain is claimed to be a disruptive technology in next 5 years. Although everybody demanding to use for that technology it is not mature enough.

This paper contributes to agenda maturity by presenting a future agenda in technology perspective. However, although out of scope of this work, regulation and auditibility issues that were addressed as requirements should be also taken into consideration. Also, cost management should be investigated that is because while it offers huge savings in transaction costs and time the high initial capital cost could be limit. Financial model can be constructed for different company sizes.

While underlying technologies (distributed ledgers, consensus cryptography and cryptocurrency tokens, wallets, and smart contracts) of blockchain are evolving, designing of effective architecture on top of it is crucial for success but it is not sufficient. Industry should embark on blockchain initiatives, considering the balance provided by these technologies with their appropriateness for their business use cases.

More than hundred blockchain platforms are in development. Despite this none has proven it in scale, and their long term viability is in question.

Organizations appear to gain experience with blockchain with a trial and error mechanism for not only, to setup the environment, but also thinking of organization, interoperability considerations and building applications around it. Performing these with the trial and error mechanism is very expensive way. Because of that, while industry is generating appropriate use cases, enablers should provide sandbox environments to enable the industry to attain their best fit architecture on time and within their budget. Standardization of platforms and designing assessment frameworks, protocols are tasks of enablers as well as academic researchers.

In the academic area, not only research on underling technology capabilities enhancements (scalability, performance, security etc) but also reference architectures are needed. Moreover, integration of blockchain with other emerging technologies IoT and AI seem to be of interest to academia, enablers as well as industry..

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