Chapter 17
A Method for Emerging Technology Evaluation. Application to Blockchain and Smart Data Discovery

Jacky Akoka and Isabelle Comyn-Wattiau

Abstract Emerging technologies represent a major innovation that offers significant advances to both private and public organizations. Examples of these technologies are the "Blockchain technology" which combines cryptographic mechanisms and peer-to-peer (P2P) architecture and "Smart Data Discovery" combining artificial intelligence and analytics. The importance of these emerging technologies requires the use of evalua-tion methods in order to understand their contribution and the associat-ed risks. The objective of this article is to propose a method supporting the evaluation of emerging technologies. A guidance approach is pro-posed. It is based on the recognition that emerging technologies are complex systems. Our approach combines three conceptual frame-works: the underlying theory of complex information systems, systems theory, and the ISO 25001 standard devoted to software quality. We propose a multi-criteria hierarchy which serves as the basis for the eval-uation. To illustrate this approach, we apply it to the particular cases of "Blockchain" technology and "Smart Data Discovery".

17.1 Introduction

According to [4], emerging technologies (ET) represent an innovation that has the potential to transform an existing industry and / or create new ones. [14] summarize different definitions into five main characteristics: (i) radical innovation, (ii) rapid growth, (iii) coherence, (iv) significant impact, and (v) uncertainty and ambigui-ty. [18] define four stages in the evolution of ET: techno-logical change, implantation of technologies, application of innovation, and innovation through the integration of technologies.

Jacky Akoka
CEDRIC-CNAM & IMT-TEM, e-mail: jacky.akoka@cnam.fr

Isabelle Comyn-Wattiau
ESSEC Business School

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There are many examples of ET notably: (i) nanotechnologies that have creative potential in many domains [9]; (ii) fire-fighting information systems including digital maps, dedicated drones, land ro-bots, emergency information systems and intelligent protective clothing [15]; (iii) technologies implemented in the cloud and more particularly Cloud Mobile Learning [1]; (iv) energy storage technologies including "smart grids" [20]. One of the main characteristics of these ET is complexity [8]. Beyond being complex systems, they are more gener-ally complex information systems (IS).

An important issue is the ability of organizations to assess the contribu-tion of these ET and the associated risks. The main objective of this arti-cle is precisely to propose an approach to the evaluation of emerging technologies taking into account the complexity that characterizes them. We illustrate this approach by evaluating the Blockchain and the Smart Data Discovery technologies, which are today among the most important disruptive innovations. We propose a guidance approach to evaluate emerging technologies. This approach is based on a multi-criteria hierar-chy capitalizing on knowledge. The rest of the article is organized as follows. The second paragraph is devoted to a brief state of the art on complexity, complex systems, and methods of evaluating emerging technologies as complex systems. Our approach is presented in Section 3. The following section is devoted to the application of this approach to the emerging technologies of block-chain and smart data discovery. We conclude in the last section and pre-sent some future avenues of research.

17.2 State of the Art

There are several definitions of complexity that reflect the different sys-tems involved and their contexts. [10] presents some thirty definitions of complexity as well as the associated measures. [2] considers that complexity has two dimensions: organizational and technological. [6] characterize complexity by three dimen-sions: trust, fact and interaction. The theory of complex systems consid-ers these systems to be characterized by their degree of self-organization, by their emergence property, their innovative character, and their ability to learn and by their adaptability [17]. Research in this field focuses on notions such as the emergence of collective properties, chaotic behavior, self-organization, redundancy, recursion, etc. [7]. Some authors consider that interde-pendence and size have a significant effect on complexity. Others place greater emphasis on uncertainty [13].

We consider emerging technologies to be complex systems because they have all the characteristics and attributes described above. More generally, we classify them as complex information systems that must respond rapidly to changes in sociotechnical dimensions and to non-functional requirements. They must also take into account changes in user requirements, organizational needs (business processes and man-agement rules), and increased interdependence between individuals, organizations and technologies. They must also incorporate changes in the environment of these systems such as those of markets, regulators, competition, threats and opportunities. Finally, they must be able to cope with the changes generated by proprietary solutions, open source software and the emergence of new applications and protocols. More generally, they must solve the problems arising from rapid changes in information technology, which are an important dimension of complex in-formation systems.

There are several approaches to complexity management, such as the theory of adaptive complex systems [7], reductionist theory [5], and systems theory [16]. We con-sider that systems theory is the most appropriate for facilitating the management of complexity. Indeed, the complexity of the system is linked to its structure, its behavior and its relation to the environment. These three elements are precisely the main characteristics of systems theory [17].

[12] describe many measures of complexity and their limi-tations. The metrics generally used are based on the size of the system considered, its entropy, the information, the hierarchy of costs and the organization. Other metrics are proposed, including those based on Shannon's contributions. Examples of evaluation of complex systems are presented by [12].

There are many methods for evaluating technologies. [19] propose a taxonomy of these methods. Another family of meth-ods falls under the impact assessment (Delphi and SBAM) [3]. Technology-based risk assessment is an approach that attempts to measure "negative synergies" and has resulted in the de-velopment of the ITRACS methodology [21].

Unlike the approaches described above, our approach to evaluating emerging technologies integrates three conceptual frameworks: com-plex information systems, systems theory, and the ISO 25000 (SQuaRE) standard for software quality.

17.3 Our Approach

Our objective is to define a guiding approach for the evaluation of an in-formation system based on emerging technologies. In the first section, we present the multi-criteria hierarchy that we have defined to organize the evaluation. In the second part, we describe the proposed approach.

Understanding emerging technology as a complex information system requires analysis of the different characteristics of this system. A system obeys a goal. It has a structure, which can be static or dynamic or which can include a static part and a dynamic part. The system interacts with its environment. it evolves over time. Thus, an emerging technology can be evaluated as a system that has a structure, an environment and an evo-lution. We propose to organize our hierarchy according to these three characteristics.

The theory of complex information systems is based on the socio-technical perspective of information systems, which makes it possible to distinguish social factors from technical factors. The social adjective en-compasses both the organizational dimension and the human dimen-sion, as well as the economic and financial dimension. Similarly, the technical factor covers all aspects of emerging technology, both hard-ware and software, for example. Thus our second level of organization of the hierarchy consists in understanding the system, its environment and its evolution, on the one hand on the social level and on the other hand on the technological level.

The ISO standardization organization has developed a standard called SQuaRE (Software QUAlity Requirements and Evaluation) for software evaluation. This standard is based on an eight-dimensional quality model that is mainly technical (six) and functional (two). Based on the McCall model [11], they represent the three types of factors (opera-tion, scalability, maintainability) recommended by this model. In this way, they are also in alignment with the dimensions previously consid-ered for the description of the complex information system.

Thus, considering successively emerging technology as a system, then as a socio-technical system, then as a software, we obtain a hierarchy in three main levels which can then be refined (Figure 17.1). The eight dimen-sions of the SQuaRE standard (functional relevance, usability, reliability, security, portability, maintainability, performance, compatibility) are then subdivided into about thirty sub-characteristics that have been in-tegrated into the hierarchy.

By a mapping and merging process, for the sake of completeness, the hierarchy was then aligned with those proposed in [8]. Without pretending to completeness, we pre-sent the hierarchy (Figure 17.1).

17.3.1 The Guiding Method

Faced with emerging technology, the decision-maker must find the rele-vant information to understand the issues, the components, the oppor-tunities and the associated risks. It must then organize this information in order to understand and, where appropriate, be assisted by experts for evaluation. He/she can then synthesize this information. The pro-posed process thus comprises five steps described below (Figure 17.2).

17.3.1.1 Hierarchy Feeding

The first step is a parsing process. It consists of gathering documentation on emerging technology, whether it is professional press, white papers, technical or organizational research articles. All data and information col-lected from these sources and deemed relevant are transferred to the nodes of the hierarchy. This process is carried out until saturation i.e. as long as there is any untracked documentation and / or new elements are still discovered. The purpose is to gather and structure decision-making information.

The system	Social	Functional relevance	Functional completeness
			Accuracy
			Functional adequacy
	Technical	Reliability	Maturity
			Availability
			Fault tolerance
			Recoverability
		Security	Confidentiality
			Integrity
			Non-repudiation
			Accountability
			Authenticity
		Performance	Temporal efficiency
			Resource utilization
			Capacity
Its environment	Social	Human *Usability*	User adequacy
			Recognizability
			Learnability
			Operability
			Error protection
			Interface aesthetics
			Accessibility
		Organizational	Mastery of technical skills
		Economic	Financial risk
			Profitability
			Total cost ownership
			Added value
			Market share
		Societal	Ethical acceptance
			Environmental acceptance
		Regulatory	Privacy
			Intellectual property law
			Conformity with industry regulations
			Compliance with certifications
	Technical *Compatibility*	Coexistence	
		Interoperability	
Its evolution	Social	Organizational adaptability	
		Functional adaptability	
		Regulatory adaptability	
		Societal adaptability	
	Technical	Portability	Adaptability
			Installability
			Replaceability
		Maintainability	Modularity
			Reusability
			Analyzability
			Modifiability
			Testability
		Scalability	

Fig. 17.1 The evaluation hierarchy.

Fig. 17.2 The evaluation process.

17.3.1.2 Hierarchy-based Evaluation

Depending on its level of expertise, the user can use the hierarchy to evaluate the emerging technology considered. Using the information provided on each aspect the technology, he/she can thus evaluate it. He/she can perform a more detailed analysis enabling the enrichment of the hierarchy for all the aspects considered to be more relevant.

17.3.1.3 Search for Additional Information

In the absence of information, some leaves or even branches of the hierarchy may not be fed, making it difficult to evaluate the technology concerned. These leaves or branches are highlighted for a search for additional information. The expert characterizes the information needed and searches it. This process, for the time being manual, can be automated by using an automatic information search using generalist or specialized search engines. He/she e can then complete the missing elements, performing if necessary experts' inquiries.

17.3.1.4 Editing the Evaluation Report

After the pruning and refinement of the tree structure, a structured re-port can be edited.

17.3.1.5 Knowledge Capitalization

The hierarchy itself can be enriched with the new branches obtained during its use, thus enabling a capitalization of the new evaluation fac-tors proposed by the experts.

The hierarchical model and the guidance method were used to evaluate the blockchain and the smart data discovery technologies, in order to show the feasibility and the usefulness of the approach. For space rea-sons, we describe very briefly each technology and present only a partial result of its application (step 2 of the method). Some conclusions are drawn by comparing the two case studies.

17.4 Application to Blockchain and Smart Data Discovery

17.4.1 The case of Blockchain (BC)

We present below a summary of different sources describing the BC technology.

The concept and the technology of BC is the result of the combination of cryptographic mechanisms and peer-to-peer (P2P) architecture. BC is seen as a disruptive innovation that has the potential to redefine many sectors of the economy. BC functions as a public database or open ledg-er where the details of each bitcoins exchange are recorded. The princi-ple of the BC lies in the fact that each operation is inscribed in thousands of large account books, each subject to the scrutiny of a different ob-server. This system is reliable because it is based on cryptography. It is also resilient thanks to the P2P architecture. The concept of BC is ex-tended to sectors requiring the recording of transactions or contracts. The US Federal Securities and Exchange Commission has approved the use of the BC as a share ownership registry. There are also smart con-tracts applications based on the Internet of objects. The BC generates data using distributed algorithms. It stores these data using encrypted chained blocks. The architecture of the BC model is composed of seven layers (similar to ISO layers). Three major players can be impacted by the BC:

trusted third parties, state institutions and all organizations seeking new forms of financing to manage their capital shares. The main risk is that of security and especially the existence of vulnerabilities that could be exploited by hackers. Another risk is related to the use of different technological approaches. It is the social, legal and financial challenges that this technology will bring to light that could prove to be the most difficult problems to solve.

Applying our guiding method and the multi-criteria hierarchy, we obtain the following results (Figure 17.3). Five types of judgments can be issued: 1) the node does not contain information: this situation may reflect a lack of information on this criterion or the irrelevance of the criterion for this technology, 2) the node contains factual information (gray) with descrip-tive value), 3) the node reflects a positive judgment, an opportunity provided by the technology (green), 4) the node represents an alert (or-ange), informing the decision-maker about an aspect requiring special monitoring, 5) the node represents a risk), which calls for a strength-ened evaluation.

The blockchain technology impacts highly the security of the IS, positive-ly since its mechanism really improves both integrity and non-repudiation levels. However, in terms of confidentiality, there is no basic guarantee. The two main points of vigilance are maturity and compliance with certifications. Many other leaves of the tree could not be feeded, which means that additional information has to be found before con-cluding. For example, there is no information on the performance of the blockchain. Moreover, the adaptability may be questioned.

17.4.2 The case of Smart Data Discovery

Smart Data Discovery (SDD) corresponds to the application of artificial in-telligence to Business Intelligence. Unlike the conventional means used to produce conclusions based on data, SDD provides users with the abil-ity to understand the patterns hidden in the data. It can provide quick insights and advanced data visualization tools offering levels of granulari-ty analysis in a single interface. It enables users to perform self-service analysis including data preparation, native language queries and auto-matic creation of visualizers. It is an encapsulation of predictive analyt-ics, interactive data visualization, pattern matching, and machine learn-ing to assist automated decision support. Using semantic technologies (4), SDD methods improve the effectiveness of BI analytics. Semantic graph databases, which store data as a graph, allow end users to relate to their questions while concentrating on relevance. The architecture of a typical SDD system comprises several modules: data preparation, in-sight generation, data discovery, recommendation engine, and insights delivery. SDD is characterized by an ease of use, a real degree of agility and flexibility, and by an optimal time-to-results. However, it suffers from a limited depth of data exploration and a low complexity of analy-sis. SDD exploits machine learning to automate the analytics workflow. Banks, retailers, and insurance companies are among the main users of SDD. Many tools exist such as DataRPM, run directly on

Social: Blockchain is seen as a disruptive innovation that has the potential to redefine many sectors of the economy, financial markets, public and government activities, as well as high-tech companies. Blockchain functions as a public database or open ledger where the details of each bitcoins exchange	**Functional relevance:** The blockchain records a data set such as a date, and a cryptographic signature associated with the sender. In the case of the bitcoin, it is the number of bitcoins sent, but it could be the digital cryptographic fingerprint, called the hash function, of any electronic document. The blockchain principle lies in the fact that each operation is inscribed in thousands of large account books, each subject to the scrutiny of a different observer. Any blockchain is a register (and therefore a file) existing in a large number of copies. The concept of the blockchain is defined as a system for recording transactions. Beginning in 2014, this concept is extended to sectors requiring the recording of transactions or contracts. For example, the Proof of Existence website allows a user to download any document and record their fingerprint forever in the Bitcoin blockchain. This demonstrates that the person who downloaded the document had this specific document in his or her possession at some point. This can also be used to prove that the document has not been modified since that time.	**Functional adequacy**
Technical: Created by Satoshi Nakamoto in 2008, blockchain (BC) concept and technology result combine cryptography mechanisms and peer to peer (P2P) architecture	**Reliability :** This system is reliable since it is based on cryptography	**Maturity**
	Security	**Confidentiality**
		Integrity: This technology is designed so as to prevent the same bitcoin from being counted in duplicate, without any intermediary, such as a bank. The Stamperya startup has transformed this service into a business enabling other companies to "digitally stamp out" any electronic document or e-mail in order to establish its integrity
		Non-repudiation : It is also resilient thanks to the P2P architecture
		Accountability: The Stamperya startup has transformed this service into a business enterprise that allows other companies to "digitally stamp out" any electronic document or e-mail in order to establish ownership
		Capacity: The two main parameters are the length of the blockchain and the number of copies. For the bitcoin, the length of the blockchain rose from 27 GB in early 2015 to 74 in mid 2016
		Profitability: The attractiveness of this system is that it offers an immediate settlement while traditional stockbrokers offer a 3-day settlement period
	Societal	**Ethical acceptance**
	Regulatory: The US Federal Securities and Exchange Commission has approved the use of the blockchain as a share ownership registry through the Overstock.com web site. The latter intends to use the alternative trading technology system proposed by To.com to allow individuals to buy and sell shares	**Compliance with certifications**

Fig. 17.3 Evaluating blockchain through the hierarchy.

Hadoop/Spark as a data source. They offer a natural-language query interface and interac-tive. They also offer visual-based data discovery. Other SDD tools, such as Ayasdi and DataRPM, exploit graph analysis to identify meaningful re-lationships. Finally, the Smart BI software developed by Yseop write in-telligent reports in-stantly and leverage on the company's best practices to explain what actions to take and why.

Application of our guiding method leads to the following result (Figure 17.4).

<table>
<tr><td rowspan="2">Social</td><td rowspan="2">Functional relevance: The latter can provide quick insights. It also provide advanced data visualization tools offering levels of granularity analysis in a single interface. It enables the exploration of data in a less-than-structured way. The smart data discovery process comprises three phases. The first one, related to data preparation, uses algorithms to find schemas and to profile data. It suggests recommendations for data quality improvement and enrichment. It performs data lineage and reuse notably on multi-structured data. The second step is dedicated finding patterns in data. To this end, it uses natural languages query as well as specific algorithms to find all patterns in data. It offers support to users in their context, whether they are business analysts or data scientists. Finally, the last phase aims at sharing and operationalizing the findings obtained in phase two. In general, it uses natural languages to explain the findings to end users. It offers visualization techniques to facilitate the comprehension of the hidden patterns.</td><td>Functional completeness: This is a new trend enabling users to perform self-service analysis including data preparation, native language queries and automatic creation of visualizers. limited depth of data exploration and a low complexity of analysis.</td></tr>
<tr><td>Functional adequacy: The concept of smart technology encompasses all the technologies (physical and logical) that are able to adapt automatically and modify behavior to cope with internal and external changes. It is based on the idea that the smart technology is able to "self-management" and can handle unpredictable events. enhance the contextual offering to the customer.</td></tr>
<tr><td rowspan="7">Technical</td><td rowspan="5">Security</td><td>Confidentiality</td></tr>
<tr><td>Integrity</td></tr>
<tr><td>Non-repudiation</td></tr>
<tr><td>Accountability</td></tr>
<tr><td>Authenticity</td></tr>
<tr><td rowspan="2">Performance</td><td>Temporal efficiency: optimal time-to-results</td></tr>
<tr><td>Resource utilization: optimization</td></tr>
<tr><td rowspan="2">Social</td><td rowspan="2">Human
Usability</td><td>User adequacy: Unlike the conventional means used to produce conclusions based on data, smart data discovery provides users with the ability to understand the patterns hidden in the data. ease of use.</td></tr>
<tr><td>Learnability: It allows users to gain insights using advanced analytics without requiring them to have traditional data scientist expertise</td></tr>
<tr><td>Social</td><td>Functional adaptability: degree of agility and flexibility</td><td></td></tr>
</table>

Fig. 17.4 Evaluation Smart Data Discovery through the hierarchy.

Information on this technology is limited. Is it a niche phenomenon or too emergent technology? Moreover, it appears that no threat or nega-tive impact is mentioned. The assessment comes down to a set of main-ly functional opportunities for easy access to unsophisticated users.

17.4.3 Hierarchies' Comparison

By comparing the two resultant hierarchies, we find that all the dimen-sions are not informed. Moreover, the BC hierarchy is more complete than the SDD one. We argue that the more a hierarchy is complete, the more the underlying technology is disruptive. On the contrary, if the hi-erarchy is incomplete, then the technology can be perceived as a mar-keting phenomenon. In this case, the technology cannot be considered as disruptive. In our case, BC appears to be more disruptive than SDD. in any case, it is important to look for the missing information before de-ciding on the disruptive nature of an emerging technology.

17.5 Conclusions and Future Work

In this chapter, we present an approach to evaluating emerging technol-ogies combining three conceptual frameworks: the theory underlying complex information systems, systems theory and the ISO 25000 stand-ard devoted to software quality. The evaluation process is structured us-ing a multi-criteria hierarchy. We took into account the social and tech-nical dimensions for each component of the system to be assessed, in-cluding the system itself, its environment and its evolution. To illustrate this approach, we have applied it to the cases of âĂIJBlockchainâĂİ and "Smart Data Discovery", which today constitute emerging technologies with many fields of applications. The approach makes it possible to evaluate an emerging technology, to identify the domains where the information is missing and requires complementary expertise, to enrich, and to evolve the hierarchy with each application.

We plan, in terms of future research, to extend the evaluation by asso-ciating metrics to the criteria. It should be noted that the weights of the evaluation dimensions and the criteria are not the same according to the sectors of activity or the fields concerned. Thus, in some cases, spatial adaptability (scalability or scale-up) can be significant. In other cases, regulatory compliance is paramount, while depending on the areas con-cerned. Another line of research concerns an approach that would use the same hierarchical model in reverse engineering, as a framework en-abling organizations to determine the most important factors and best suited to their needs when developing emerging technologies. Finally, another avenue of research is to integrate natural language analysis techniques to automate the analysis phase of the documentation.

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References

1. Al-Arabiat, D., Ahmad, W. F. W., Sarlan, A. (2015). Review on critical factors of adopting cloud mobile learning. In: Technology Management and Emerging Technologies (ISTMET), 2015 International Symposium on (pp. 69-73). IEEE.
2. Baccarini, D. The concept of project complexity–a review, International Journal of Project Management, vol. 14, issue 4, pp. 201-204, 1996.
3. Banuls V.A., Salmeron J.L. A Scenario-Based Assessment Model–SBAM, Technological Forecasting and Social Change, Volume 74, Issue 6, July 2007, Pages 750-762
4. Day, G. S., Schoemaker, P. J., Gunther, R. E. (2004). Wharton on managing emerging technologies. John Wiley & Sons.
5. Emmeche, C., Koppe, S. Stjernfelt (1997) F. Explaining Emergence: Towards an Ontology of Levels. Journal for General Philosophy of Science 28: 83.
6. Geraldi, J., Adlbrecht, G. (2008). On faith, fact, and interaction in projects. IEEE Engineering Management Review, 2(36), 35-49.
7. Holland, J. H. (2006). Studying complex adaptive systems. Journal of Systems Science and Complexity, 19(1), 1-8.
8. Huang L., Yuan Y. (2010). Evaluation on the industrialization potential of emerging technologies based on principal component and cluster analysis. In: Computer Modelling and Simulation (UKSim), 2010 12th International Conference on. IEEE, p. 317-322.
9. Letaba, P. T., Pretorius, M. W., Pretorius, L. (2014, June). The use of bibliometrics in the development of technology roadmaps: Planning for industrial impact of emerging technologies. In: Engineering, Technology and Innovation (ICE), 2014 International ICE Conference on (pp. 1-8). IEEE.
10. Lloyd S. Measures of complexity: a nonexhaustive list. Control Systems Magazine, IEEE, 21:7-8, 2001.
11. McCall, J. A. 2002. Quality Factors. Encyclopedia of Software Engineering.
12. Owen, C. L. (2007). Evaluation of complex systems. Design Studies, 28(1), 73-101.
13. Perminova, O., Gustafsson, M., Wikström, K. (2008). Defining uncertainty in projects–a new perspective. International Journal of Project Management, 26(1), 73-79.
14. Rotolo, D., Hicks, D., Martin, B. R. (2015). What is an emerging technology?. Research Policy, 44(10), 1827-1843.
15. Schlauderer S., Overhage S., Weidinger J. (2016). New Vistas for Firefighter Information Systems? Towards a Systematic Evaluation of Emerging Technologies from a Task-Technology Fit Perspective. In: System Sciences (HICSS), 2016 49th Hawaii International Conference on (pp. 178-187). IEEE.
16. Skyttner, L. General Systems Theory: Problems, Perspectives, Practice. 2nd ed. Singapore: World Scientific, 2005.
17. Sommerville I., Cliff D., Calinescu R., Keen J., Kelly T., Kwiatkowska M., Paige R. (2012). Large-scale complex IT systems. Communications of the ACM, 55(7), 71-77.
18. Song Y., Yin L., Research on species traits of emerging technologies and the path of formation, Management, 2007, 4(2), pp. 211-215.
19. Tran T.A, Daim T. A taxonomic review of methods and tools applied in technology assessment, Technological Forecasting & Social Change 75 (2008) 139-1405

20. Wang K., Yu J., Yu Y.,, Qian Y., Zeng D., Guo S., Xiang Y., Wu J., “A survey on energy internet: Architecture, approach, and emerging technologies," IEEE Systems Journal, no. 99, vol. PP, pp. 1-14, 2017.
21. Wilhite, A., Lord, R. (2006). Estimating the risk of technology develop-ment. Engineering Management Journal, 18(3), 3-10.