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An Enterprise Modeling Perspective On Quantum Computing

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Short Paper

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Abstract

In recent years substantial advances have been made in engineering and scaling up quantum computing resources such that there is a growing awareness of this technology in non-technical fields. However, due to the complexity of the subject, it is not readily accessible to organizations that have not already made a commitment. Numerous uncertainties remain on the ways in which quantum computing will shape the technological, organizational, and economic environment. While research has focused on addressing the many engineering and technical challenges, research on non-technical aspects remains rather sparse. Organizations require means of reasoning about quantum computing and how it affects them, which is suitable to inform their market positioning and long-term strategic decisions. In this research-in-progress paper, we present a novel high-level perspective on quantum computing through the lens of enterprise modeling. Based on a structured literature review of business and societal concerns regarding quantum technology, an enterprise architecture was constructed condensing the manifold findings into tangible models expressed in the ArchiMate language.

Keywords: Quantum Computing, Enterprise Modeling, Enterprise Architecture, Strategic Management, ArchiMate

1 Introduction

Quantum computing (QC) promises a significant economic shift due to its potential to greatly improve the efficiency with which existing and currently intractable problems are solved, as well as the prospect of new business opportunities. Despite the numerous unresolved technical challenges, rapid progress has not gone unnoticed by industry and government bodies, as evidenced by investments (Boerkamp, 2022) and government initiatives (Räsänen et al., 2021). However, QC technology is complex, raising many technical, societal, and economic concerns and uncertainties. This makes the technology hard to grasp from a business perspective and difficult to reason for strategic decision-making in organizations. Organizations need to understand how QC affects their business models and how to integrate it into their information systems. (Nofer et al., 2023; Rietsche et al., 2022; Ukpabi et al., 2023). Enterprise modeling enables an organization to be represented at various levels of abstraction for documentation, exploration, and reasoning in a structured way (Fill, 2020). Specifically, holistic enterprise architecture considers an organization from high-level strategic and business concerns to technical infrastructure, allowing concepts from different levels of abstraction to be related. This paper explores existing academic and magazine publications through a structured literature review to identify business concerns regarding QC, such as strategic aspects, adoption practices, and research on integrating QC. The findings were analyzed and condensed into an enterprise architecture using the ArchiMate modeling language, resulting in a novel strategic perspective on QC. Although prior studies have examined quantum computing from a business standpoint, construction of an enterprise model was not attempted.

The remainder of this paper is structured as follows: In Chapter 2, the research methodology is outlined. Chapter 3 presents the results of the SLR and the illustrative enterprise architecture. Finally, in Chapter 4, promising avenues for future research are presented.

2 Research Methodology

The research presented here was conducted in two phases. First, we collected relevant documents through a structured literature review. In the second phase, the documents were analyzed, and the findings were summarized using enterprise modeling techniques.

In the first phase, we were interested in reports discussing quantum technology from the perspective of organizations. In particular, this included mostly high-level topics, such as business models, adoption challenges and drivers, approaches to strategic management, regulatory and governance frameworks, etc. Pre-studies suggested that research on individual topics is rather sparse, necessitating a broader scope to be able to derive a framework. The literature review followed the PRISMA guidelines (Page et al., 2021). Figure 1 shows the data collection and screening process. In the first step, two literature databases, DBLP and Web of Science, were queried. In DBLP, the search was conducted based on an assembled list of outlets commonly publishing topics related to information systems, e-commerce, enterprise modeling, and adjacent topics. This list encompassed a total of 259 outlets in the form of conferences, forums, workshops, and journals. The only inclusion criterion for this first database search was that a document's title must include the word "quantum." In Web of Science, the search criteria were that (i) the title of a document must include the word "quantum," and (ii) the word "business" must be found in the title, abstract, or list of keywords. This combined search approach was chosen since many of the outlets in the initial list are not indexed in Web of Science, and DBLP only includes academic literature from the fields of computer science, information systems, etc. A series of term combinations were evaluated in preliminary studies by sampling the search results. The chosen keyword combination was found to yield the most promising results in terms of inclusivity and the rate of false positives. A subsequent search of these two databases yielded 278 documents, the titles of which were then screened. Instead of formulating strict inclusion criteria, broad exclusion criteria were applied. Documents whose titles suggested a technical focus, specifically those regarding the development of quantum algorithms and circuits, applications of quantum technology for specific use cases, performance evaluations, mathematical modeling, or quantum cryptography, etc., were excluded from consideration. During this screening process, documents did not have to specifically relate to quantum computing. It was sufficient if quantum technology in general was addressed.

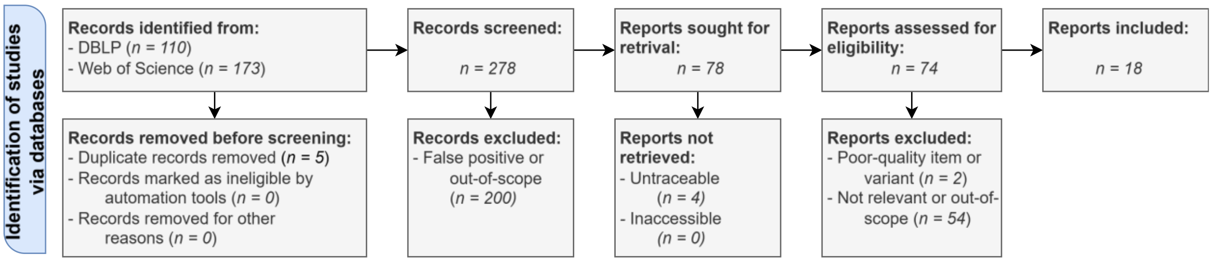


Figure 1. Data collection and screening steps in accordance with the PRISMA guidelines (Page et al., 2021).

The screening process was iterative in nature. First, a researcher performed pre-selection and characterization of records based on the aforementioned inclusion criteria. Then, the researchers discussed relevant characteristics for forming inclusion criteria. This process was repeated until the selection was stable. This screening step reduced the number of documents to 78. This iterative process accounts for emerging dimensions and topics that were not initially captured in pre-studies.

The second phase encompassed the selection and analysis of the final document corpus and subsequent illustration of the findings through the construction of a framework using enterprise modeling. For this, we revert to ArchiMate (The Open Group, 2019), a holistic enterprise architecture modeling method. In ArchiMate, an enterprise is represented in multiple layers, encompassing concerns ranging from an enterprise's strategy, business model, application architecture, and IT infrastructure. For our purposes, we revert to the motivational layer (in purple), which represents the reasons for implementing a particular enterprise architecture, and the strategy layer for modeling the strategic direction of an enterprise (in orange).

First, each retrievable document was assessed for relevance. This assessment was guided by the three ArchiMate concepts, *Driver*, *Constraint*, and *Course of Action*. If a document's full text contained findings or statements that could be formulated into a modeling element that fits one of the concepts, the element was recorded, and the document was mapped to that concept. This yielded a final corpus of 18 documents. Finally, similar elements were summarized and compiled into an enterprise model. A summary of the three modeling concepts, their meaning, and the mapping of the identified literature to these concepts is given in Table 1.

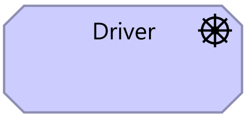
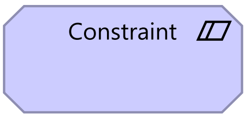
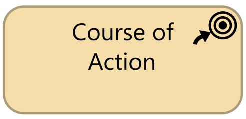
ArchiMate concept		**Mapped references**
 Driver	Condition motivating the definition of goals and the striving to achieve them.	Aljaafari, 2023; Aljaafari and Alotaibi, 2023; Greinert et al., 2024; Hughes et al., 2022; Jenkins, Berente, and Angst, 2022; Khan and La Torre, 2021; Kwon et al., 2026; Räsänen et al., 2021; Stein et al., 2024; Suter et al., 2025; Ukpabi et al., 2023
 Constraint	Represents a factor that limits the realization of goals.	Aljaafari, 2023; Aljaafari and Alotaibi, 2023; Boerkamp, 2022; Greinert et al., 2024; Hughes et al., 2022; Khan and La Torre, 2021; Krishnamurthy, 2022; Kwon et al., 2026; Nofer et al., 2023; Räsänen et al., 2021; Ruane, McAfee, and Oliver, 2022; Suter et al., 2025
 Course of Action	Represents an approach or plan undertaken to achieve a goal	Bova, Goldfarb, and Melko, 2023; Godoy-Descazeaux, Avital, and Gleasure, 2023; Jenkins, Berente, and Angst, 2022; Ruane, McAfee, and Oliver, 2022

Table 1. Summary of utilized ArchiMate concepts and the mapped references that informed the definition of individual instance elements. We refer readers to the specifications (The Open Group, 2019) for further details.

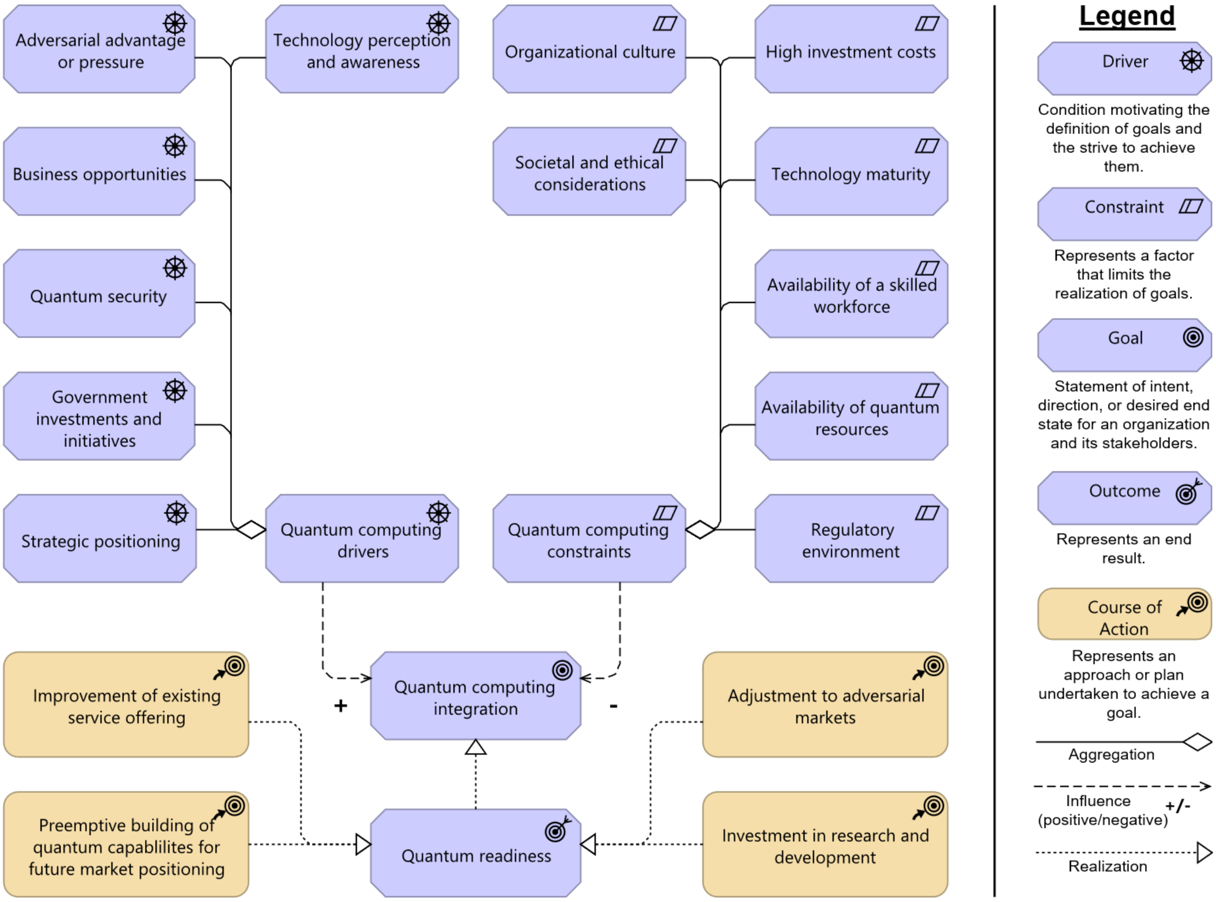


Figure 2. ArchiMate model depicting motivational drivers, inhibitors, and potential strategies for quantum technology integration in enterprises. Hint: Read from bottom to top.

3 Illustrative Enterprise Model for Quantum Computing

The proposed enterprise model, illustrated in Figure 2, places an emphasis on the drivers, inhibitors, and goals expressed with the motivation layer of ArchiMate. This vertical layer encapsulates motivational factors for changing or implementing a particular enterprise architecture. We present a view, focusing on the strategic perspective with *quantum computing drivers, constraints,* and *adoption strategies*.

3.1 Quantum Computing Drivers

In ArchiMate, drivers represent a motivation for formulating a goal and the strive to achieve it. In the context of QC adoption, drivers are formulated based on technical and economic promises, as well as based on favorable factors imposed by the environment.

Adversarial advantage or pressure is a motivational driver encapsulating advantages of timely adoption of QC in adversarial markets. This includes gaining competitive advantages due to quantum supremacy or quantum advantage (Kwon et al., 2026). The former refers to an increase in efficiency in solving traditional problems, while the latter refers to the potential to solve traditionally incalculable problems. Besides striving to gain such advantages through QC, enterprises might be forced to adopt due to pressure imposed by the adversarial market environment (Stein et al., 2024).

Technology perception and awareness refer to the opinions and level of awareness established by the predominant narratives in media and public discourse. Although the narratives about QC relate mainly to technological aspects (Suter et al., 2025), a rising awareness of this technology may serve as driver for adoption.

New ***Business opportunities*** may drive enterprises to evolve their existing business models or implement new models that take advantage of QC, for example, leveraging quantum advantage (Kwon et al., 2026) or offering services, software, or hardware around QC (Jenkins, Berente, and Angst, 2022).

The driver ***Quantum security*** summarizes concerns regarding QC and security. The potential of QC to render established encryption schemes ineffective is seen as a major security threat (Khan and La Torre, 2021; Ukpabi et al., 2023). Advances in quantum cryptography and post-quantum encryption schemes may alleviate these concerns over time (Ukpabi et al., 2023). Nevertheless, the looming threat and new security schemes leveraging quantum cryptography may drive enterprises to invest in QC.

The market around QC is comparatively underdeveloped but can be fostered by ***Government investments and initiatives*** (Räsänen et al., 2021). Government bodies may support the establishment of a quantum computing ecosystem by investing in education programs to train the workforce required by the quantum industry (Greinert et al., 2024; Hughes et al., 2022), support for start-ups and offering research grants (Räsänen et al., 2021). Moreover, government policies may positively shape the regulatory environment (Kwon et al., 2026), reducing investment risks for enterprises and reducing regulatory uncertainties (Aljaafari, 2023).

An enterprise's ***Strategic positioning*** may also favor integration of QC. In particular, the availability of financial resources and the medium-to long-term allocation of investment budgets favor the adoption of QC (Kwon et al., 2026). Similarly, a clear strategic perspective on QC is beneficial for adoption (Jenkins, Berente, and Angst, 2022), also necessitating a clear commitment by decision-makers (Aljaafari and Alotaibi, 2023). However, rigid adoption strategies may prove detrimental by impeding exploratory activities and innovation (Kwon et al., 2026).

3.2 Quantum Computing Constraints

Multiple challenges have been identified that inhibit or pose a risk for the integration of QC in organizations. These are summarized and represented as *constraints* in the ArchiMate model shown in Figure 2. First, the ***Organizational culture*** influences the rate of adoption. Although this factor is relevant not only for QC, but also for novel technologies in general, the complexity of QC enforces this factor. In particular, the introduction of QC may be impeded by resistance within the organization (Kwon et al., 2026) due to negative sentiments of stakeholders. An organizational culture that encourages innovation can alleviate this risk factor.

A major barrier are the comparatively ***High investment costs*** for acquiring QC capabilities (Aljaafari, 2023; Räsänen et al., 2021). Organizations need to acquire quantum computing resources, but also invest in a specialized and highly educated workforce (Greinert et al., 2024; Hughes et al., 2022), while the financial return remains uncertain.

Societal and ethical considerations regarding QC are expressed in the public discourse, but to a lesser extent in business and governmental discourses (Suter et al., 2025). This constraint comprises a varied range of issues: Quantum computing resources might not be readily accessible to citizens on account of the scarcity and cost of the resources. If accessibility and inclusion are perceived as non-satisfactory, the negative shift in public sentiment may discourage investment in QC (Suter et al., 2025). Further, QC capabilities may be used to disservice citizens by threatening data privacy and online security (Aljaafari and Alotaibi, 2023; Khan and La Torre, 2021; Krishnamurthy, 2022), or putting ethnic groups or citizens of certain social standing at disadvantage (Aljaafari, 2023), e.g., by hampering access to financial services (Krishnamurthy, 2022). Finally, factors that impact the environment, e.g., energy consumption, must also be considered (Aljaafari, 2023).

The constraint ***Technology maturity*** accounts for the novel nature of QC, its ongoing development on a fundamental level, the yet undetermined evolution and adoption, and the lack of standards (Aljaafari, 2023). Regarding business opportunities, it is unclear to what extent the potential of QC will manifest and in what time frame the technology will become commercially viable (Nofer et al., 2023; Ruane, McAfee, and Oliver, 2022).

Organizations must have access to or acquire knowledge of QC to be able to develop and execute their adoption strategy. However, the ***Availability of a skilled workforce*** is limited and may not meet demand

(Aljaafari, 2023). Due to the complexity of QC, the technical and non-technical concepts involved and the resulting business implications, it is first required to promote QC as a topic across fields and levels of education (Greinert et al., 2024; Hughes et al., 2022).

An immediate factor constraining the use of QC is the scarce ***Availability of quantum resources*** (Aljaafari, 2023). Quantum hardware is neither readily available nor commercially viable for broader adoption. This scarcity may be alleviated in the future by quantum hardware providers scaling up the computing capacities. However, given the current arms-race and the projected economic potential of quantum technology in general (Boerkamp, 2022; Räsänen et al., 2021), it is probable that the availability of QC resources will remain a limiting factor in the foreseeable future.

The ***Regulatory environment*** may either promote or inhibit QC integration. An ambiguous regulatory environment poses a risk — it is uncertain how challenges such as data privacy, market regulation, dual-use technology, and ethical considerations will be addressed on a regulatory level (Aljaafari, 2023; Krishnamurthy, 2022; Suter et al., 2025). Organizations must be aware of how the regulatory environment with respect to QC changes and align their strategy accordingly.

3.3 Quantum Computing Adoption Strategies

As motivated by the driver on the importance of strategic positioning, organizations should develop an adoption strategy. Given the novel nature of QC, research on strategic management that explicitly deals with QC is sparse. Based on the work of Jenkins, Berente, and Angst (2022), the enterprise architecture includes four *courses of actions* to achieve QC integration. These strategies are not mutually exclusive, and organizations may implement multiple strategies.

First, organizations may seek to ***improve their existing service offering*** rather than shift their business model (Ruane, McAfee, and Oliver, 2022). By leveraging the capabilities of QC to efficiently solve certain problems, the efficiency or quality of existing processes may be improved.

Second, organizations may approach QC by ***preemptively building quantum capabilities for future market positioning***. With this strategy, organizations aim to acquire the necessary capabilities to quickly position themselves in the market once QC becomes commercially viable. This requires investments, e.g., in a skilled workforce for assessing the technology and developing prototypes, before reaching certainty on the viability of the envisioned applications and business models — essentially placing bets (Godoy-Descazeaux, Avital, and Gleasure, 2023). If the bet pays off, the organization gains a first-mover advantage (Bova, Goldfarb, and Melko, 2023).

Third, organizations exposed to adversarial markets may seek to gain advantage through the capabilities of QC, or may be forced to adopt the technology due to competitive pressure. Through ***adjustment to adversarial markets***, organizations follow a strategy aiming to gain an advantage or to level the playing field with respect to algorithmic real-time decision-making capabilities, e.g., in financial markets.

Lastly, through ***investments in research and development***, organizations explore QC in the hope of unraveling novel business opportunities. This approach strongly emphasizes experimentation and research with the aim of exploring new areas of application. However, in order to conduct research and development activities related to QC, organizations require access to quantum capabilities in the form of knowledge and computing resources.

4 Conclusion and Future Work

Research on quantum computing in the context of information systems and organizations is sparse, leaving many open challenges and avenues for future research. In this work-in-progress research paper, we aim to address previous calls for research on the impact of quantum technology, especially quantum computing, on organizations and information systems (Nofer et al., 2023; Rietsche et al., 2022; Ukpabi et al., 2023).

Specifically, this paper aims to offer a strategic perspective on QC adoption by focusing on factors that drive or inhibit adoption, strategic decision-making processes, and integration with classical information systems. To this end, we conducted a systematic literature review, collecting academic and magazine articles on quantum computing, as well as general topics related to businesses and information systems. We analyzed the resulting corpus and modeled the findings using the ArchiMate enterprise modelling language. The results confirm the lack of research on the impact of QC on organizations and its potential integration. In this regard, we see great potential in using conceptual modeling to reason about the QC domain and develop supporting modeling approaches. While some model-driven approaches exist for quantum software engineering, enterprise and business modeling in the context of QC remain largely unexplored — to the best of our knowledge. This lack of research may be attributed to the very early stages of quantum computing, especially regarding real-world applications. Nevertheless, we see opportunities in the short to mid-term future for domain and enterprise modeling to support adoption through knowledge transfer. Conversely, more widespread adoption is required to conduct in-depth, empirical studies on sociotechnical factors in real-world contexts and information systems.

In the future, the SLR may be continued and extended to identify additional factors influencing QC adoption and address current limitations. Research on specific applications or use cases was not considered — there may be specific considerations for each application area. These idiosyncrasies particular to specific industries were disregarded. Additionally, it could be observed that high level perspectives preferably regard quantum technology as a broad spectrum constituting one ecosystem, instead of differentiating between sub-technologies such as QC. It may be advisable to investigate the segregation of ecosystem-level technology-specific factors. The scope of the search could be extended through backward and forward searching and the inclusion of additional databases. At this stage, the selection process was not validated through inter-rater reliability nor were topic modeling techniques employed. Further opportunities lie in the modeling of system architectures for the integration of QC with traditional information systems and its alignment to enterprise architectures.

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