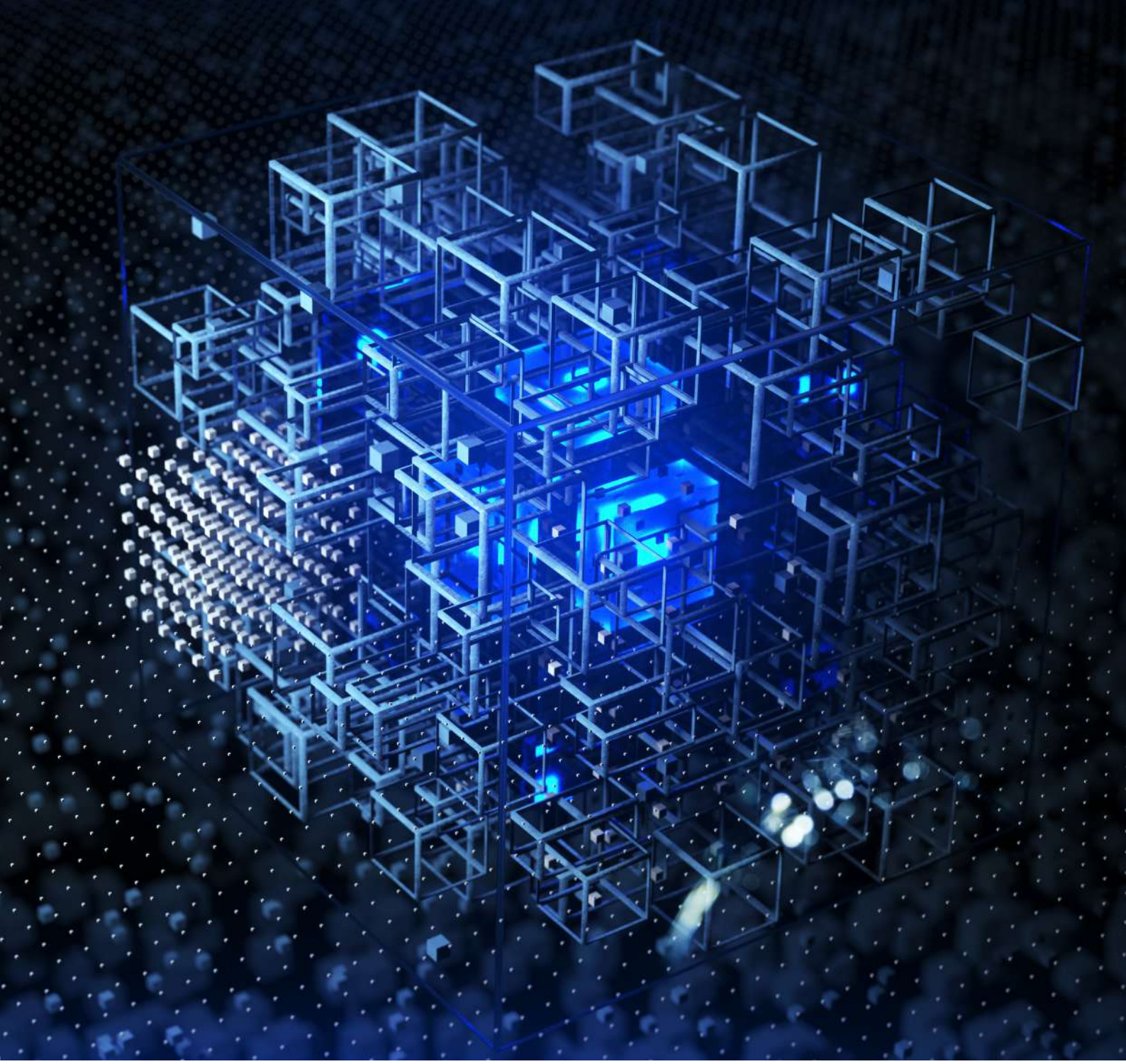

White Paper

Semantic interoperability: challenges in the digital transformation age

Executive summary

Expansion of the digital transformation age is generating entirely new businesses and markets. Urbanization, increased life expectancy, climate change, the expanding reach of the global supply chain and the "digitalization of almost everything" have become central to business models and capabilities across all industries.

Pressure is growing on companies and market participants to use data from this digital revolution to make the right decisions concerning investment, research, market assessments and adaptions. Furthermore, with the explosion of available data and the resulting demand for increasingly interactive systems, it is becoming more and more difficult to build applications that can function conjointly in such a complex environment. Semantic interoperability can help resolve some of the challenges involved as a choice element of the digital transformation age.

Semantic interoperability influences the entire information life cycle, both horizontally between individual devices and systems and vertically across dissimilar systems. In this white paper, it is assumed that the interoperability considered in this document is among two or more systems whose information models and syntaxes are mutually different. It is defined as "the ability of computer systems to exchange data with unambiguous, shared meaning" and as "a requirement to enable machine computable logic, inferencing, knowledge discovery, and data federation between information systems."[1]

With the digitization of functions at every level, providing systems with the means to handle more of their day-to-day operations without direct human control or brittle programming constitutes a key element of adaption for moving forward, but this requires the existence of information models that are flexible and unambiguous. Standards can form the foundation for domain-based information models, and indeed a number of such standards already are in place. Thus, the issue of standards and their relation to semantic interoperability is essential to assessing how machine understanding works and determining how to connect industry-related standards to effectively address this concern.

Another aspect of this challenge involves understanding why semantic interoperability has moved forward so slowly and why there exists a lack of semantic best practices. To address this challenge adequately, semantic best practices must be developed, embraced, adhered to and enforced in the same way that software development has matured to support object-oriented programming (OOP), software patterns, libraries and application programming interfaces (API). Furthermore, and to a much greater extent, because information models are shared (at least in interoperability scenarios), best practices must be extended to include aspects of model development.

This white paper offers an assessment of current and future challenges involving semantic interoperability in industrial domains and related industry-based standards. The main goal of the paper is to identify conditions in which the application of ontology-based semantic technologies, together with already existing information models, can be used to improve interoperability within and between applications and domains, and to formulate recommendations based on a review of use cases versus existing technology and standards.

1 en.wikipedia.org/wiki/Semantic_interoperability

This white paper addresses its content to a broad audience. As noted above, semantic interoperability influences the entire information life cycle, both horizontally between devices and systems, and vertically across dissimilar systems. Because of the distinct points of view held by these various stakeholders, the white paper provides a variety of viewpoints and levels of detail in the individual sections in order to address the different concerns and interests of these stakeholders. Persons who can benefit from reading this white paper include:

- IEC decision makers
- Managers charged with deciding whether to provide resources for information modelling/ knowledge representation
- Persons responsible for life cycle management of both products and systems engineering
- Ontology developers and semantic technologists
- Engineers involved in developing standards-based semantic interoperability in tools

Section 1 begins by describing what interoperability involves, what semantics and ontologies consist of, and what "understanding" means in the context of knowledge processing. This is followed by a description of the digitalization process.

Section 2 discusses the state of the art of information modelling in the industrial production life cycle. Because this includes findings fundamental to understanding the requirements associated with semantic interoperability, it is recommended that all readers with a technical background read this section carefully. The paragraphs dedicated to the state of the art include references to existing IEC Standards. These aspects are of special interest for engineers who develop semantic interoperability in tools.

Examples of industrial use cases are presented in Section 3. These serve to illustrate semantic interoperability requirements and discuss gaps between the current state of the art and requirements introduced within a projective framework of 5 to 10 years. This presentation also indicates where the emphasis should lie in modelling resource expenditure efforts by the responsible management. Those involved in the life cycle management of product and system engineering can identify appropriate main use cases and derive decisions concerning the strategic use of standard or company-specific solutions.

Section 4 recapitulates experiences from the semantic interoperability scenarios as they relate to the use case information modelling and provides relevant hints to ontology developers and semantic technologists.

This white paper formulates recommendations based on a review of use cases versus existing technology and standards. Section 5 outlines the challenges involved in achieving semantic interoperability and Section 6 offers recommendations to the IEC and its committees as well as to industry and consortia.

As one of the globally recognized *de jure* standards organizations, the IEC is in a unique position to drive semantic interoperability forward and to identify conditions under which the application of ontology-based semantic technologies can be used to improve and achieve interoperability within and between applications.

Important recommendations include:

- Initiate the elaboration of semantic interoperability standards for both the development of information models as well as their management
- Request the IEC Standardization Management Board (SMB) to consider forming a working group to develop a semantic interoperability best practices guideline including a survey among IEC and ISO standardization groups. The survey should ask which semantically interoperable standards these groups are responsible for, or which they intend to develop soon, and how these standards relate to one another (resource map)

- Glossary/vocabulary: The challenge of semantic interoperability is to ensure that information exchanged is understood not only by the human beings involved on both ends of the ICT communication channel but also by the computer systems and their associated software. Several projects in ISO/IEC JTC 1/ SC 41 and TC 65/WG 23 deal with semantics-related terms, with enough input available to start standardization of these terms

As it is foreseen that semantic interoperability will be of fundamental importance across countless industries and will constitute one of the driving forces of the fourth industrial revolution, the standardization community will play a critical role in shaping its future. Building upon its long track record in ensuring safety and reliability, the IEC can be an instrumental partner in achieving this goal and fulfilling the promise of the digital transformation age.

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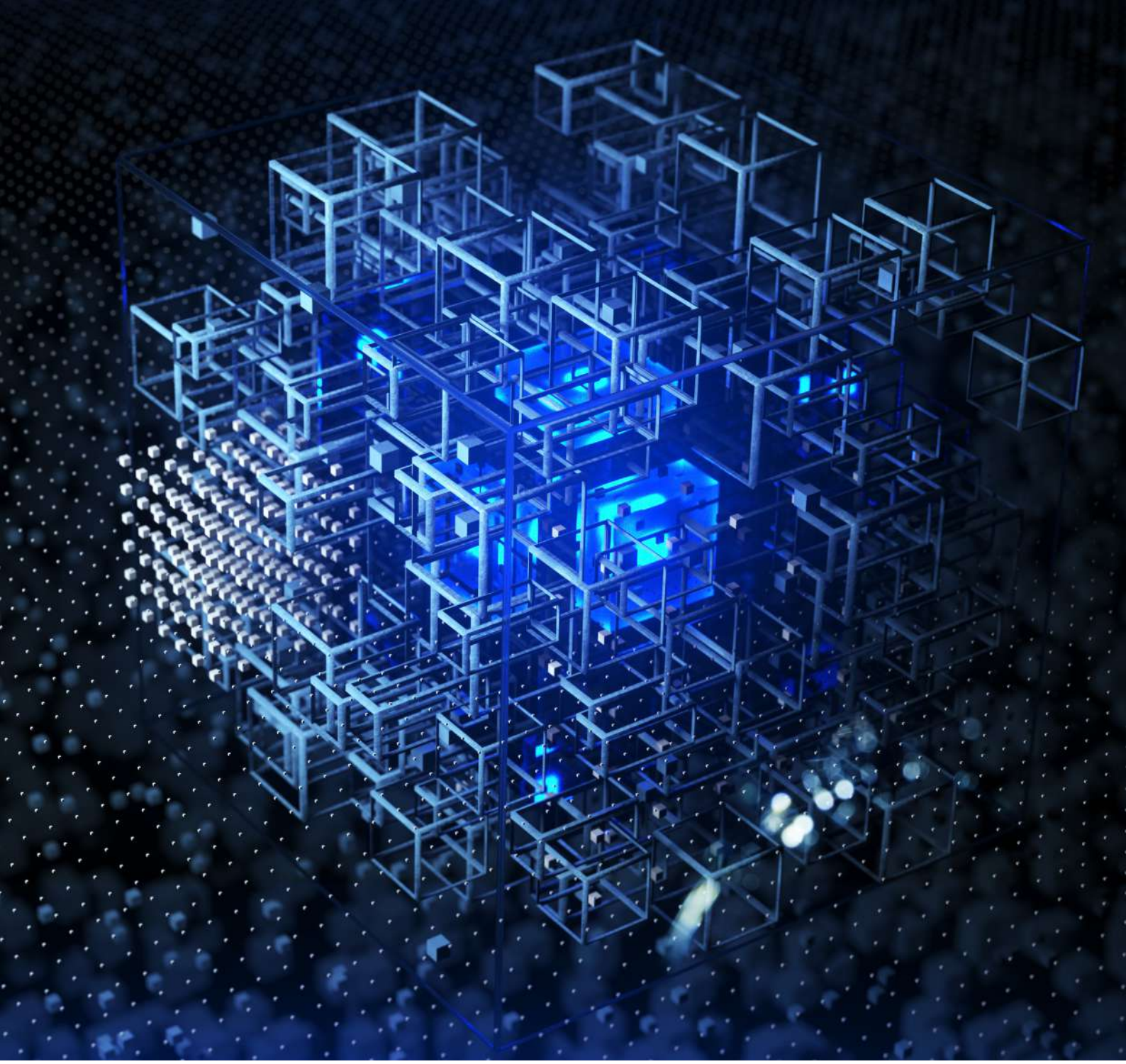

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