Enterprise Architecture Framework Selection Criteria: A Literature Review

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Abstract – **To remain competitive in today's highly competitive global markets, organizations must be able to continually transform themselves, doing so at an ever-increasing pace. To succeed in their digital transformations, more and more organizations are adopting an enterprise architecture practice and related frameworks. Unfortunately, there is a plethora of EA frameworks (EAFs) available to choose from and the limitations of the EAF comparison matrices still make it difficult for organizations to select the right one. As a first step to fill this gap in the literature, this study proposes to review the academic and professional literature on the subject. The results of our scoping literature review show that there are nine criteria commonly used to compare/select EA frameworks (taxonomy, meta-model, accelerators, development process, maintenance and evolution process, principles, governance process, architecture practice and simplicity) and that the operationalization of these criteria remains elementary. We hope that our contribution will help organizations improve the success rate of their information technology-enabled organizational transformation.**

Keywords-Enterprise architecture; framework; selection criteria.

I. INTRODUCTION

In today's global economy, competition between organizations is becoming fiercer. The term 'hypercompetitive' is often used to describe this global economic market in which competition between organizations is rapidly escalating [1]. The growing competition in this landscape is mainly fueled by the increasing pace of technological innovations along with the adoption of a liberal economy by more and more developing countries [1]-[3].

To remain competitive in today's highly competitive global markets, organizations must be able to continually transform themselves and rethink every aspect of their operations, doing so at an ever-increasing pace [1][4]. An organizational transformation (OT) is an organization-wide program that aims to substantially change an organization's structure and/or practices [5] in order to enhance performance and boost organizational health [6]. A digital transformation, in addition, is an organizational transformation that changes how value is created and delivered to customers by integrating digital technologies into all areas of the organization [7].

Orchestrating an organizational transformation is extremely difficult. Indeed, the numerous challenges organizations face while transforming themselves are so important that most transformation endeavors are failures. According to a recent Mckinsey Global Survey, which garnered responses from 1,946 executives representing the full range of regions, industries, company sizes, functional specialties and tenures, only 26 percent of respondents mentioned that the transformations they're most familiar with have been very or completely successful at both improving performance and equipping the organization to sustain improvements over time [8].

Practitioners and researchers have proposed a number of initiatives and best practices that organizations can use to alleviate the challenges they face and increase the success rate of their (digital) transformation endeavors (e.g., top down direction setting; broad-based, bottom up performance improvement; cross-functional core process redesign; change management; and an integrated management system that links strategy formulation and planning with operational execution) [9]-[11].

An enterprise architecture practice is one of the best practices organizations can use to transform themselves. Indeed, recent research has demonstrated that an enterprise architecture practice can facilitate (digital) organizational transformations by managing technological complexity and setting a course for the development of their companies' IT landscape [12].

EA presents an integral view of the enterprise and greatly facilitates the alignment of various components of the organization [13][14]. An EA practice is defined as a set of coherent services, roles and people with predefined responsibilities who participate in the creation, maintenance and evolution of the EA. The resources responsible for this practice participate in organizational decisions, their implementation and their post-implementation evaluation [15].

An EA practice can support an organizational transformation in several ways. Amongst the most important, we note: (1) engage top executives in key decisions; (2) emphasize strategic planning; (3) focus on business outcomes; (4) use capabilities to connect business and IT; (5) develop and retain high-caliber talent; and (6) reduce IT operating costs through standardization and reutilization; (7) increase flexibility and agility; (8) increase innovation; and (9) reduce the complexity of the organization [12][16]-[18].

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Over the years, a great amount of progress was made in the field of EA. Indeed, many frameworks were developed to help organizations start their EA practice. An EA framework is defined as a coherent set of principles, methods and models used by practitioners to design, implement and maintain an enterprise's organizational structure, business processes, information systems and infrastructure [16]. EA frameworks can provide organizations with (1) one or more meta-models to describe the EA; (2) one or more methods used to design and maintain the EA; and (3) a common vocabulary and optional reference models used as templates or blueprints [14]. EA frameworks can also be used as tools to access, organize and communicate various architectures that describe key components of the enterprise [19][20].

There are over 25 EA frameworks in the current literature, and their number is growing [16][17][21]. The ever-increasing number of frameworks makes the selection process more and more difficult for organizations [22]. To help businesses select the right framework, several comparison matrices have been proposed in the literature [19][20][22]-[27]. For example, [19][26][27] compare many popular frameworks. Franke *et al.* [24] compare mainly frameworks targeted for governmental use. And, [20] use the Zachman framework as a basis to compare other frameworks that are mostly used by governments.

Despite their relevance, the EAF comparison matrices currently available have several limits. Most importantly, they rely on somewhat different criteria making it difficult for organizations to identify the right set of criteria to guide their EAF selection process. These limits still make it difficult for organizations to choose the right framework to support their EA practice.

As a first step to fill this gap in the literature, this study proposes to review the academic and professional literature on the subject to identify the key criteria used by academics and practitioners to compare/select EA frameworks. The results of our scoping literature review show that there are nine criteria commonly used to compare/select EAFs and that the operationalization of these criteria remains elementary. We hope that our contribution will help organizations improve the success rate of their information technology-enabled organizational transformation.

The rest of this article is organized as follows. First, in Section 2, we describe the research methodology used to conduct our literature review. Second, in Section 3, we expose the findings of our scoping literature review. Lastly, Section 4 concludes the article by exposing the next step of our research program.

II. METHODOLOGY

Researchers can adopt several types of literature reviews to attain their research objectives [28]. In the particular case of this study, we relied on a scoping review. We relied on this type of review as the objective of this research is to examine the extent, range and nature of research activities on the subject [29] while focusing more on the breadth of coverage of the literature than the depth of the coverage [30] and being as comprehensible as possible [31].

As such, and as a first step, we focused our research efforts on articles published in the IT seniors scholars' basket of eight journals (European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of AIS, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems and MIS Quarterly), as well as three important professional journals in management - Harvard Business Review, Sloan Management Review, and McKinsey Quarterly. To carry out our research, we selected the ABI / INFORM Global (Proquest), as well as the Business Source Complete databases, since, when taken together, they gave us access to the previously identified journals. We also determined the search criteria to identify the articles to be included in our analysis. Specifically, the terms "enterprise architecture", "selection criteria" and "comparison matrices" were retained as search criteria. Both conceptual and empirical articles identified using these criteria were retained.

Then, as a second step, we also used Google Scholar and the ABI/INFORM Global (Proquest) database to search for other relevant articles in order to expand our research beyond the original set of articles identified. Both of these tools allowed us to conduct several searches using the same search terms identified previously and to identify articles from a wide range of scientific journals, international conferences and professional publications. Again, both conceptual and empirical articles were retained.

Then, as a final step, we read the abstracts of the articles found in steps 1 and 2. This allowed us to identify a subset of articles that merited to be scrutinized in more detail. Anchored on this subset of articles, we then used a backward approach to identify and examine the references works cited in the articles we found [32] and a forward approach to identify and examine other articles that cited all the previously found articles [32]. This last step allowed us to ensure that no important publications were forgotten and therefore that we had the widest possible coverage of the literature on EAF selection criteria.

Although our findings exposed in the following section stem from a fairly small set of articles, our scoping review allowed us to review more than 120 articles in the field.

III. RESEARCH FINDINGS

This section, which presents the findings of our scoping literature review, is subdivided into two subsections. The first presents the EAF selection criteria identified in the literature while the second presents how these EAF selection criteria have been operationalized as of today.

A. EAF Selection Criteria in the Literature

Our scoping literature review allowed us to identify eighteen articles that identified EAF selection criteria and/or proposed EAF comparison matrices (cited in order of appearance in the following nine Tables). These articles enabled us to identify nine criteria: *taxonomy, meta-model, accelerators, development process, maintenance and evolution process, principles, governance process, architecture practice and simplicity*.

The *taxonomy* criterion evaluates how an EAF defines, describes and classifies all the models that compose the enterprise architecture [19][24]. The *meta-model* criterion evaluates how an EAF defines design rules and all components of an EAF along with their relationships [24][26][34]. The *accelerator* criterion evaluates if the EAF comprises specialized software tools, procedures, generic models, templates, patterns or blueprints to accelerate the development of the EA (adapted from) [24][33][35]. The *development process* criterion evaluates if the EAF includes a step by step method to design an enterprise architecture that is aligned with the strategy of the organization. The *maintenance and evolution process* criterion evaluates if the EAF comprises processes for maintaining and evolving the enterprise architecture and to keep it updated with the recent changes in the IT/business landscape of the organization [23][24][36]. The *principles* criterion evaluates if the EAF expresses the philosophy and rules of an organization that guide the design and evolution of the enterprise architecture [37]. The *governance process* criterion evaluates if the EAF includes processes to carry out the review of various architecture and maintenance projects to ascertain their compliance with architecture principles and business-IT alignment [24][34][36][38]. The *architecture practice* criterion evaluates of the EAF promote the creation of a coherent set of services, processes, roles as well as bodies with responsibilities assigned to them and who participate in the creation, maintenance, modification and evaluation of the EA [39]. The *simple* criterion evaluates if the EAF is useable by internal resources with limited EA and IT knowledge without needing the help of external experts (adapted from) [13]. The following nine tables list the terms used in the articles identified in the literature review referencing the nine criteria we identified. In cases where the article didn't present a clear definition for a term, our comprehension of this term is listed instead and noted by (*).

TABLE I. TAXONOMY EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Taxonomy Completeness	Evaluates how well the practitioner can use the methodology to classify architectural artifacts.	[19][22]
Planner View	Classifies models based on the 'Planner' perspective of the Zachman framework.	[20]
Owner View	Classifies models based on the 'Owner' perspective of the Zachman framework.	[20]
Designer View	Classifies models based on the 'Designer' perspective of the Zachman framework.	[20]
Builder View	Classifies models based on the 'Builder' perspective of the Zachman framework.	[20]
Subcontractor View	Classifies models based on the 'Subcontractor' perspective of the Zachman framework.	[20]
User View	Classifies models based on the 'User' perspective of the Zachman framework.	[20]
What? Abstraction	Classifies models based on the 'What?' abstraction of the Zachman framework.	[20]
How? Abstraction	Classifies models based on the 'How?' abstraction of the Zachman framework.	[20]
Where? Abstraction	Classifies models based on the 'Where?' abstraction of the Zachman framework.	[20]
Who? Abstraction	Classifies models based on the 'Who?' abstraction of the Zachman framework.	[20]
When? Abstraction	Classifies models based on the 'When?' abstraction of the Zachman framework.	[20]
Why? Abstraction	Classifies models based on the 'Why?' abstraction of the Zachman framework.	[20]
Best of Breed / Best Fit	Evaluates if the framework can be identified as the best for a certain need/context/domain. (*)	[22]
Concept: Artifacts	The framework describes various components of an organization. (*)	[23]
Modeling: Different Views	The framework classifies models in different views. (*)	[23]
Modeling: Consistency	The definition, description and classification of the models is consistent. (*)	[23]
Modeling: Dynamic	Models describe the dynamic nature of an organization. (*)	[23]
Model Taxonomy	Defines, describes and classifies all models that compose the enterprise architecture.	[24]
From Biz to Technology	Evaluates how well the framework describes and classifies various components of the enterprise based on the 'User' perspective of the Zachman framework.	[25]
Integration in Function	Evaluates how well the framework describes and classifies various components of the enterprise based on viewpoints related to interoperability, flexibility, reusability, scalability, portability, standardization, communication and complexity reduction.	[25]
Layer Decoupling (Clear description)	Evaluates how well the framework classifies models based on the Zachman framework perspectives 'Planer', 'Owner', 'Designer', 'Builder' and 'Sub-contractor'.	[25]
From Business Driver to Model	Evaluates how well the framework describes and defines information related to business drivers.	[25]
Architecture Analysis	Describes a set of viewpoints to guide the collection and analysis of information for making architecture choices.	[27]
System Model	Describes major components of the system.	[27]
Information Model	Describes data models, data transformation and data interfaces.	[27]
Computational Model	Describes the functional aspects of the system, system process flow as well as system operations, software components and interactions.	[27]
Software Configuration Model	Describes how software is packaged, stored, configured, managed and shared.	[27]

Software Processing Model	Describes how software processes, software threads and run-time environment are structured.	[27]
Implementation Model	Describes physical system structures such as operating environments, hardware components and networking components of the system.	[27]
Platforms	Describe platform software such as operating systems, hardware and networking components, protocols and standards.	[27]
Business Model	Describes business models, business requirements, business process, system roles, policy statements.	[27] [33]
Blueprint	Defines the current and future environment of an organization.	[39]
Modeling	Describes the components of an EA to facilitate its understanding by various stakeholders.	[40]

TABLE II. META-MODEL EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Meta-model	Describes the EA artifacts and their relationships. (*)	[14]
Metamodel	Formally defines the allowed contents of the architectural models, providing semantic rigor.	[24]
Metamodel	Describes the design rules and the structure of the system by using a common language for all models.	[26]
Metamodel	Specifies the consistency and the relationships of the various architecture artifacts that are on different layers and different views of the EA.	[34]

TABLE III. ACCELERATORS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Reference Model	Used as templates or blueprints for EA design and evolution.	[14]
Reference Model Guidance	Evaluates how useful the methodology is in helping the practitioner build a relevant set of reference models.	[19][22]
Prescriptive Catalog	Refers to how well the framework guides the practitioner in classifying and setting up a database of reference models.	[19][22]
Interoperability / Flexibility	Framework offers procedures or tools to allow interoperability with other frameworks. (*)	[22]
Concept: Repository	Evaluates how well the framework helps practitioners by supporting a repository of various EA artifacts. (*)	[23]
Reference Model	Evaluates how well the framework supports capturing knowledge from previous modeling tasks.	[24]
Patterns	Evaluates how well the framework supports practitioners by supplying patterns.	[24]
Building Blocks	Evaluates how well the framework provides building blocks to facilitate the task of practitioners.	[24]
Reference Model / Standard	Evaluates how well the framework helps practitioners by supplying a list of reference models and standards to follow. (*)	[25]
Technique	Evaluates if the framework supplies techniques (Techniques are procedures required to accomplish a task during the development of an EA) to aid practitioners.	[26]
Architecture Models	Provide consistent patterns and standards to document architecture specifications for the planning, management, communication and execution of activities related to system development.	[27]
Architecture Knowledge Base	Evaluates how well the framework helps practitioners by providing a consistent representation and a repository of design and architecture design rationale.	[27]
Visualization tool	Evaluates how well the framework is supported by specialized tools helping the practitioners visualize various parts of the EA.	[33]

TABLE IV. DEVELOPMENT PROCESS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Design Method	Step-by-step process describing the development of the EA creation. (*)	[14]
Partitioning Guidance	Evaluates how well the development process will guide the practitioner into effective autonomous partitions of the enterprise.	[19]
Business focus	Evaluates how well the methodology will focus on using technology to drive business value.	[19]
Process Completeness	Evaluates how well the development process guides the practitioner through a step-by-step process for creating an enterprise architecture.	[19][22]
Planning Phase	The steps of the development process have the equivalent of the SDLC Planning phase.	[20]
Analysis Phase	The steps of the development process have the equivalent of the SDLC Analysis phase.	[20]
Design Phase	The steps of the development process have the equivalent of the SDLC Design phase.	[20]
Implementation Phase	The steps of the development process have the equivalent of the SDLC Implementation phase.	[20]

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Business-IT alignment / Business focus	Evaluates if the framework mandates the alignment of business and technology with a focus on business. (*)	[22]
Process: Requirement	Evaluates how well the development process supports stakeholder requirements. (*)	[23]
Process: Step by Step	Evaluates how well the development process is detailed. (*)	[23]
Concept: Alignment	Evaluates if the framework mandates the alignment of business and technology. (*)	[23]
Concept: Strategy	Evaluates how well the framework considers the strategy of an organization as development process inputs. (*)	[23]
Process: Detailed Design	Evaluates how well the development process produces detailed outputs. (*)	[23]
Process: Implementation	Evaluates how well the development process supports the implementation of the EA. (*)	[23]
Architecture Development Process	Step-by-step process describing the development of the EA creation.	[24]
Integration Method	Evaluates how well the development process guides the practitioner in integrating the EA into the organization's structure. (*)	[25]
Enterprise Status and Transitional Plan	Evaluates how well the development process guides the practitioner in creating a transitional plan. (*)	[25]
Linkage Model with SDLC	EA models have to be linked with various SDLC methodology phases.	[25]
From Enterprise to Component	Evaluates if the framework mandates the alignment of business and technology. (*)	[25]
Procedure Model	Describes a set of directives that define the order in which architecture descriptions are derived and transformed.	[26]
Specification Document	Describes the outputs generated during the creation of the EA.	[26]
Business Requirements	Evaluates how well the framework considers users' requirements, functional requirements, data requirements and other business system related requirements as development process inputs.	[27]
Non-functional Requirements	Evaluates how well the framework considers non-functional requirements like availability, reliability, scalability, security, performance, inter-operability, modifiability, maintainability, usability and manageability as development process inputs.	[27]
Information System Environment	Evaluates how well the framework considers budget, schedule, technical constraints, resources and expertise, organisation structure, other constraints and enterprise knowledge base as development process inputs.	[27]
Design Trade-offs	The development process allows for more than one design choice by resolving multidimensional conflicting requirements.	[27]
Design Rationale	The development process documents reasons behind design decisions for future verification.	[27]
Architecture Verifiability	The development process provides sufficient information or explanation in the architecture design for review and verification.	[27]
Architecture Process	Evaluates if the framework has a well-defined process to guide the construction of the EA.	[27][33]
Business Drivers	Evaluates how well the framework considers business goals, direction, principles, strategies and priorities as development process inputs.	[27][33]
Technology Inputs	Evaluates how well the framework considers strategic architecture direction including technology platforms, future architecture, systems interoperability and emerging technology standards as development process inputs.	[27][33]
Development Process	Step-by-step process describing the development of the EA creation. (*)	[39]

TABLE V. MAINTENANCE AND EVOLUTION PROCESS EAF SELECTION CRITERION

Term used within the literature	**Definition of the term used by the authors**	**References**
Evolution Method	Step-by-step process describing the maintenance of the EA. (*)	[14]
Maintenance Phase	Evaluates how well the framework supports the equivalent of the SDLC Maintenance phase. (*)	[20]
Process: Continual	Evaluates if the framework has a well-defined process to guide the continual change of the EA to support the changing landscape of the organization. (*)	[23]
Process: Maintenance	Evaluates if the framework has a well-defined process to guide the maintenance of the EA. (*)	[23]
Architecture Maintenance Process	Step-by-step process describing the maintenance of the EA.	[24]
Architecture Evolution Support	Evaluates if the framework has a well-defined process to guide the evolution of the EA.	[27][33]
Transitional Design	The development process provides designs and plans to support system transition and evolution.	[27][33]
Maintenance Process	Step-by-step process describing the maintenance of the EA. (*)	[39]

TABLE VI. PRINCIPLES EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Standardisation	The organization should prioritize the use of development and architectural standards.	[22][33][37]
Process: Guidelines	Evaluates if the framework defines a list of guidelines and principles to adhere to. (*)	[23]
Architecture Guidelines and Principles	Describes the principles and guidelines to which the EA has to adhere to.	[24]
Scope Integration	The use of the EA has to be efficient and based on the following quality attributes: interoperability, flexibility, reusability, scalability and portability.	[25]
Architecture Definition and Understanding	Mandates the use of standard terms, principles and guidelines for consistent application of the framework.	[27][33]
EA Principles	EA principles give advice on how to design the target architecture by restricting the design freedom of EA transformation projects.	[37][41]

TABLE VII. GOVERNANCE PROCESS EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Governance Guidance	Evaluates how much help the methodology will be in understanding and creating an effective governance model for EA.	[19][22]
Concept: Governance	Evaluates how well the framework supports a step by step governance process. (*)	[23]
Modeling: Traceability	Evaluates if the modeling changes can be traced back to the resources who modified a model.	[23]
Architecture Compliance Guideline and Review Process	Step by step process that is instrumental in keeping the construction of an organization's architecture aligned with stakeholder's requirements and can be seen as a support when making architectural decisions.	[24]
Conformance	Evaluates how well the framework supports the verification of the conformance to the EA of various project implementations.	[33]
Clinger-Cohen act Compliance (CCA)	Evaluates how well the framework complies with the Clinger-Cohen law of the USA.	[33]
Governance	Assures the consistency and timeliness of enterprise architecture process outputs using various control mechanisms.	[36]
EA Governance	Mechanism that (1) defines key architecture roles, (2) involves key stakeholders, (3) monitors the application of EA standards and (4) centralizes IT decision making.	[38]

TABLE VIII. ARCHITECTURE PRACTICE EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Architecture Practice	Coherent set of services, processes, roles and bodies with responsibilities assigned to them who participate in the creation, maintenance, modification and evaluation of the EA.	[15]
Practice guidance	Evaluates how much the methodology helps practitioners assimilate the mindset of EA into an organization and develop a culture in which it is valued.	[19]
Maturity model	Evaluates how much guidance the framework gives the practitioner in evaluating and assessing the effectiveness and maturity of different organizations within your enterprise in using EA.	[19][22][24]
Architecture Roles/Skills	Describes the roles and skills required for the development and maintenance of the EA.	[24]
Roles	Describes the required roles to participate in EA activities.	[26]

TABLE IX. SIMPLICITY EAF SELECTION CRITERION

Term used within the literature	Definition of the term used by the authors	References
Simplicity	To be considered simple, an EAF has to be useable by internal resources with limited EA and IT knowledge without needing the help of external experts.	[13]
Vendor neutrality	Evaluates how likely the organization is to get locked into a specific consulting organization by adopting this methodology.	[19]
Information availability	Evaluates the amount and quality of free or inexpensive information about this methodology.	[19][22]
Modeling: Easy to use	Evaluates if modeling outputs are easy to use. (*)	[23]
Modeling: Easy to learn	Evaluates if modeling tasks are easy to learn. (*)	[23]
Modeling: Complexity	Evaluates if modeling outputs are complex. (*)	[23]

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B. *Operationalization of EAF Selection Criteria in the Literature*

Amongst the eighteen articles that identified EAF selection criteria and/or proposed EAF comparison matrices, only nine of them provided the operationalizations of their criteria [19][20][22]-[27][33]. While these operationalizations represent a step in the right direction, the scales proposed to evaluate each criterion are very simplistic. Indeed, most of the scale proposed (7 articles out of 9) only measured if a specific criterion is supported, partially supported or not supported by the EAF [20][23]-[27][33]. In this list of nine articles, only the ones from [19] and [22] contain scales that properly operationalizes the selection criteria. Indeed, using a range of 1 to 4 (1 being very poor to 4 being excellent), [22] polled managers from various companies about their satisfaction level of the EAF being used in their organization while [19] used a very similar scale to evaluate various EAFs. Yet, the operationalization of the selection criteria in these two articles are based on subjective assessment and not on an objective instantiation or threshold.

In sum, the shortcomings in the operationalization of the EAF selection criteria in articles comparing these frameworks hinders the selection process of organizations [4][22].

IV. CONCLUSION

This research has enabled us to identify the nine criteria commonly used to compare/select EA frameworks: *taxonomy, meta-model, accelerators, development process, maintenance process, principles, governance process, architecture practice* and *simplicity*. This research has also shown that the operationalization of these criteria remains elementary.

Findings of this research will be used as inputs to the following phases of our research program. The next phase of our research program will aim to use the criteria identified in this research to compare the most popular EAF available today in order to validate the pertinence and quality of these criteria. The objective of the following and last phase of our research program will then be to develop and test a complete artifact comprised of the complete set of criteria, as well as their operationalization (metric) to help organizations big and small to choose the EAF that best suits their needs. Ultimately, we hope that findings from our research program will help organizations succeed in their information technology-enabled organizational transformation.

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