Original Paper

Another Look at Enterprise Architecture Framework

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Abstract

Although there were many comparison literatures of EA frameworks, these literature use qualitative criteria based on intuitive practitioner's experience. The paper first defines 36 concrete features of EA frameworks using six categories and six interrogatives. Then we concretely compare typical EA frameworks based on the key features. The result shows the easiness and concreteness of the proposed EA comparison framework.

Keywords

enterprise architecture, enterprise architecture framework, comparison framework, case study

1. Introduction

As spreading the Enterprise Architecture (EA), many EA frameworks are proposed to implement EA. In the same time comparative studies of EA frameworks also are increased. However, there was a problem that previous EA framework comparison literatures use qualitative criteria. Some papers claim contradictory claims for the same criteria. This paper proposes a concrete evaluation framework to compare EA frameworks. Then six EA frameworks are compared by using the proposed comparison framework.

The rest of the papers are organized as follows. Section 2 explains related work. The comparison framework is proposed in section 3. Section 4 shows a comparison of EA frameworks using the proposed approach. The effectiveness, novelty and limitations are discussed in section 5. Finally, section 6 concludes the paper.

2. Related Work

2.1 Enterprise Architecture Model

Schelp and Winter (2009) investigated seven academic EA language researches from meta-model for EA descriptions, procedure model for EA management, architecture levels, methodology, explication rules, and design research guidelines. The ArchiMate they mentioned is currently standardized as the EA modeling language of TOGAF.

Blevins et al. (2010) showed to define DoDAF by using TOGAF as the meta-model. Farwick et al. (2011) analyzed for automating to maintain enterprise architecture models based on EA repository. Kotusev et al. (2015) described the following EA documentation problems: hard to develop, unusable, and isolation from EA practice.

Feodoroff (2016) also described TOGAF seems apt as an example of a meta-model for Enterprise

Architecture.

2.2 Features of Enterprise Architecture Framework

Buckl et al. (2010) defined a conceptual framework for EA design consists of EA vision, EA principles, EA strategy, and conformance to EA vison.

Luke et al. (2010) identified two EA problem categories that are understanding and management of EA, and modeling of complex systems. Lagerström et al. (2011) analyzed the relationship between EA management and IT project success. The tested EA activities consist of existence, work load, and maturity. They conclude that maturity of EA management was necessary to succeed IT project.

Farwick et al. (2011) identified architectural requirements, organizational requirements, integration requirements and data quality requirements to automate EA model maintenance by using EA repository.

Haki et al. (2012) proposed three dimensions of EA management to adopt EA in enterprise. Three dimensions are EA phases, EA model and documentations, and EA governance. They also showed the importance of environmental elements as drivers, situational factors, and reference models.

Roth et al. (2013) found major EA problems came from EA documentation, quality of EA models, and EA documentation process maturity. Mueller et al. (2013) clarified six categories on EAM framework challenges as Governance, Infrastructure and Application Integration, Process and Data Integration, organization of the network, Social Issues, Strategy. They also argued that TOGAF only supports for inter-organization and social issues restricted on a meta-level.

Korhonen and Molnar (2014) proposed a concept of Enterprise Architecture as capability (EAAS) to govern enterprise transformation. The EAAS constituents are Ecosystemic, Socio-Technical, and Technical architecture. They discussed strategic, segment and capability architecture of TOGAF support to construct Socio-Technical architecture.

Petrikina et al. (2014) proposed an integration model of business models and EA by defining a map between potential components of Business models and EA. EA Potentials they identified are business-IT alignment, provision of Business architecture, external perspectives, and target architecture.

Lo¨he and Legner (2014) clarified the necessity to consolidate IT management and EAM perspectives. They used design theory to compare EAM approaches by EAM elements which are Standard and principle, stakeholder involvement, organization structure, roles, and EAM process. They also identified EA management elements such as life cycle processes, application patterns, usage scenarios, and governance.

Alwadain and Alqahtani (2015) developed a research model by identifying potential factors that influence Enterprise Architecture evolution. The identified factors are view of SOA, SOA scope, SOA perceived benefits, SOA governance, SOA design and business/IT collaboration. They also reported that TOGAF is the most adopted EA framework. Bogner and Zimmermann (2016) proposed mechanisms for integrating Microservice Architectures by extending original enterprise architecture reference models with elements for more flexible architectural meta models and EA-mini-descriptions. The mechanism used ArchiMate as the representation language to model the adaptable enterprise architecture meta-models.

To implement digital transformation, Hafsi and Assar (2016) suggested the importance of the four focus area which are unified view, architecture vison, architecture repository, and stakeholder management. The focus areas were chosen from TOGAF.

Niemi and Pekkola (2016) clarified Inter-relationship among constructs such as EA process quality, EA

product quality, EA service quality, and EA results use in the EA benefit realization process. They also identified dimensions of constructs. For example, dimensions of EA service quality are activeness, availability, competence and usefulness. Moreover, they identified twenty two dimensions of EA benefits, such as reduction of IT cost, increased interoperability, and improved alignment.

Saint-Louis et al. (2017) surveyed systematically literatures to clarify common understanding in EA definition. Although the significant divergence of different EA definitions, they found the five categories of generic EA elements are: 1) deliverable, 2) process, 3) tool, 4) people, and 5) principle and practice.

Dang and Pekkola (2017) surveyed 71 EA research articles in the public sector. They suggested that future GEA needs to focus interoperability and integration, and alignment and strategy to reduce the number of fragmented business services.

2.3 Implementation Evaluation of Enterprise Architecture

Nikpay et al. (2015) found requirements of EAF implementation evaluation method including artefacts quality assurance, scientific foundation, and holistic evaluation view.

Nikpay et al. (2016) conducted a systematic review on post implementation evaluation models of EA artefacts. They categorized EA practices into initiation, controlling and sustainability. They also showed that current EA evaluation approaches were not covered all aspects, lacked of structured models, difficult to understand, and lack of evaluation method.

Proenca and Borbinha (2017) extracted eleven Critical Success Factors to develop a maturity model of EA in organizations using TOGAF ADM. The CSF are Communication and Common Language, Business-driven Approach, Commitment, Development Methodology and Tool Support, EA Models and Artifacts, EA Governance, Project and Program Management, Assessment and evaluation, IT Investment and Acquisition Strategies, Skilled Team, Training and Education, and Organizational Culture.

2.4 Adaptive Enterprise Architecture

Gill et al. (2015) showed that an adaptive enterprise service system meta-framework has been used to develop an agile or Adaptive Service Resilience Architecture (ASRA) capability.

Purnawan and Surendro (2016) showed their own EA process model was able to define mainly based on TOGAF ADM for the Indonesian hospital information system. Santikarama and Arman (2016) derived an enterprise architecture framework for migrating to cloud using TOGAF. They chose TOGAF by comparing with other EA frameworks using the criteria such as Process Completeness, Reference Model Guide, Implementation Guide, Business Focus, Governance Catalogue, Vendor Neutrality, and Information Availability.

Korhonen et al. (2016) proposed three levels of EA by comparing EA schools of Enterprise IT Architecting (EITA), Enterprise Integrating (EI), and Enterprise Ecological Adaptation (EEA). The EA schools have been proposed by Lapalme (2012). The EA levels are Ecosystemic, Socio-Technical, and Technical Architecture. At the Ecosistemic Architecture level, EEA collaboratively evolves with business eco-system, industry, markets, and the large society. The collaboration derives structural embeddedness among external environments, partners, and open ended interrelationship with others. Korhonen and Halen (2017) compared the aspects of digital capability for digital transformation with two levels of the enterprise-strategic and the ecosystem-adaptive EA. The aspect of digital capability consists of business digitalization, work digitalization, collaboration and connectivity, customer engagement, information and technology management, and resource use.

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2.5 Comparison of EA Frameworks

Leist and Zellner (2006) compared EA frameworks by using the five constitutive elements that are Meta model, Procedure model, Techniques, Role, and Specification document. The evaluation result did not reflect the latest version of TOGAF, because the paper was written in 2006.

Rouhani et al. (2013) compares EA implementation methodologies using three major aspects, i.e., Concepts, Modeling, and Process. For example, modeling aspects elements are easy to use, easy to learn, traceability, consistency, different views, complexity, and dynamic. As these elements are difficult to concretely evaluate, the comparison was subjective.

Kotusev (2016a) historically categorized EA frameworks into three types, i.e., Business Systems Planning (BSP) until 1980s, early EA from 1980s to 1990s, and modern EA from 1990s through present. Kotusev (2016b) categorized EA frameworks into three types, i.e., Traditional, MIT, and DYA. Then he compared the three EA types from six items, i.e., essentials approach, EA artifacts, key terms, advantages, disadvantages, and applicability.

Purnawan and Surendro (2016) Compares EA frameworks by using criteria consists of Taxonomy completeness, Process completeness, Business focus, Governance guidance, Partitioning guidance, Vendor neutrality, Information availability, Time to value, Readiness assessment, and Business process standardization. They concluded that TOGAF is the most suitable for implementing hospital information systems based on the methodological capabilities.

Nikpay et al. (2017) defined a comparison framework for EA frameworks. The criteria are: 1) Initiative, 2) Management process, 3) maintenance process, 4) Ability to work with other EAF, 5) Requirements management process, 6) Step by step guideline, 7) Easy to understand, 8) Non-functional requirements, 9) Complexity management, 10) Supporting toll, 11) Governance, 12) Type-usage, 13) Repository, and 14) Easy to use. Based on the criteria, they compared EAP, TOGAF, FEAF, and DoDAF. The comparison was basically used the previous review literatures and practitioners' interviews. Moreover, they proposed a five phased EA implementation approach consists of Initiation, As-Is, To-Be, Implementation, and Governance. They also defined checklists for each phase.

3. Method

3.1 Features of Enterprise Architecture Frameworks

A new comparison framework is necessary to concretely evaluate EA Frameworks (EAF). To design concrete comparison framework, we omit subjective evaluation items such as understandability, complexity, and usability. Evaluation values of these items may conflict between different analysts. We identified thirty six feature elements using six dimensions and six Interrogatives as shown in Table 1. Feature categories are Layer, Model, Method, Governance, Capability, and Extensibility.

Table 1. Key Features of EA Frameworks

Dimensions	What	How	Why	When	Where	Who
Layer	Hierarchy	BA/DA/AA/TA	Strategy	Transition	Physical	Stakeholder
Model	Diagram	Language	Meta-model	Reference model	Repository	EA model architect
Method	Process	BLA/TGA	Reuse	Iteration	Tailoring	EA method architect
Governance	EAP	Governance meeting	Compliance	Risk management	Governance log	EA board

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Capability	Maturity	Increment	Skill framework	Capability based Planning	Capability dimension	EA architect
Extensibility	Model Evolution	Method Evolution	Continuum	Forum establishment	Forum Standard	Forum team

The selected features of EAF can concretely be evaluated by checking the existence of the features. Explanations of proposed features are described below.

3.2 Layer

"What" column of Layer shows that EAF has the hierarchy concept of EA. "How" column of Layer shows that EAF has Business, Data, Application, and Technology architectures in the hierarchy of EA. "Why" column of Layer shows the existence of the strategy architecture that defines the reason of EA. "When" column of Layer shows the transition architecture to define EA implementation plan. "Where" column of Layer shows physical architecture to allocate EA components in the physical environment. "Who" column of Layer shows stakeholders who are looking and understanding for EA layers.

3.3 Model

"What" column of Model shows that EAF has diagrams to represent EA artifact. "How" column of Model shows that EAF has Language to describe diagrams of EA artifact. "Why" column of Model shows the existence of the Meta model that defines the EA Language. "When" column of Model shows the Reference model of EA. Reference architecture is necessary to reduce duplication of EA artifacts. "Where" column of Model shows the existence of Repository to store EA models. "Who" column of Model shows EA model architects who are developing EA models.

3.4 Method

"What" column of Method shows that EAF has process definition to implement EA. "How" column of Method shows that EAF clarifies Base Line Architecture (BLA) and Target Architecture (TGA). "Why" column of Method shows EAF has the Reuse method. "When" column of Method shows the Iteration process of EA. Iteration is necessary to revise inappropriate portions of EA. "Where" column of Method shows the existence of tailoring process to adopt EA for individual organizations. "Who" column of Method l shows EA method architects who are developing EA methods.

3.5 Governance

"What" column of Governance shows that EAF explains EA Principles (EAP). "How" column of Governance shows that EAF explains Governance meeting to achieve EA governance. "Why" column of Governance shows the EAF mentions compliance that governs EA activities. "When" column of Governance shows Risk management to resolve unexpected incidents against EA governance. "Where" column of Governance shows the existence of Governance log to record EA governance activities. "Who" column of Governance shows EA board who are responsible for EA governance.

3.6 Capability

"What" column of Capability shows that EAF has the Maturity model to represent implementation capability of EA. "How" column of Capability shows that EAF denotes the incremental capability of implementing EA. "Why" column of Capability explains the Skill framework of EA architects to achieve necessary levels of maturity. "When" column of Capability shows the Capability based planning necessary to achieve the capability increment of EA. "Where" column of Capability shows the Capability dimensions to evaluate EA capability. "Who" column of Capability shows EA architect who are implementing EA based on their own capability.

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3.7 Extensibility

"What" column of Extensibility shows that EAF describes Model evolution of EA. "How" column of Extensibility shows that EAF provides means of Method evolution of EA. "Why" column of Extensibility shows the concept of EA continuum that describes from generic EA to specific organizational EA through industry EA. "When" column of Extensibility shows Forum establishment to start for extending EA. "Where" column of Extensibility shows the Forum standard to realize EA extension. "Who" column of Extensibility shows Forum team who are developing extended EA standard.

4. Result

This section compares six EA frameworks by using key EA features mentioned above.

4.1 EA Frameworks

4.1.1 EAPM

EAPM (Enterprise Architecture Planning Model) is extended from EAP by Spewak and Tiemann (2006). The original EAP has been proposed by Spewak (1992). EAPM added concepts such as business, principles and value, transition strategy, and project management. The four tiered hierarchy of EAPM consists of: 1) EA principle, 2) Business modeling and Current system technology, 3) DA, AA, TA, 4) Implementation plan and Transition strategy. EA cube contains Goals & initiatives, Products & services, Data & information, Systems & applications, and Networks & Infrastructure.

4.1.2 EA^3

EA^3 has been explained in Bernard (2005). EA^3 provides a generic documentation framework for EA to show multiple vertical levels that are different documentation areas; multiple layers of depth that are distinct activity areas; and multiple sub-cubes at each level that represent EA components. The EA implementation methodology of EA^3 has the following four phases: 1) EA program establishment, EA framework and tool selection, 2) Documentation of EA, and 3) use and maintain the EA. In phase tree, current and future EA components are developed. Phase four maintains EA documentation using repository.

4.1.3 DYA

DYA (Dynamic Enterprise Architecture) has been published in Wagter et al. (2005). DYA consists of theoretical and working models. The theoretical model contains the outer circle to represent the company as a whole and the inner circles for IT. A company develops a vision, strategies, and objectives with interests of stakeholders. The DYA working model defines three processes that are Strategic dialogue, Architectural services, and Development with (or without) Architecture. DYA working model contains Governance, DYA processes, and Dynamic architecture based on Business, Information and technology architecture.

4.1.4 EAAS

EAAS (Enterprise Architecture As Strategy) has been proposed in Ross et al. (2006). The models of EAAS are Operational model, Core diagram, and IT engagement model. Operational model defines requirements of EA from integration and standardization. Core diagram logically defines business process, system and IT infrastructure based on the EA requirements. EAAS also defines EA maturity based on stages of business silo, standardized technology, optimized core, and business modularity.

4.1.5 AECA

AECA (Adaptive Cloud Enterprise Architecture) is published in Gill (2015). AECA defines the Adaptive Enterprise Service System (AESS) Meta-model. The AESS contains three levels of service,

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capability, and enterprise. The AESS lifecycle management capability contains Adopting, Defining, Operating, Managing, and Supporting capabilities. The Gill Framework is a meta-framework defining AESS. ACEA recommends to use ArchiMate as the EA modeling language, because it lacks representation language. The Adaptive Capability Maturity Model (ACMM) consists of six levels, i.e., Infancy, Initial, Transition, Defined, Managed, and Adapting.

4.1.6 TOGAF

TOGAF 9.1 has published by The Open Group (2011). TOGAF is the most popular EAF. TOGAF provides various EA knowledge such as Architecture Development Method (ADM), Capability framework, Building block for reuse, Meta model, Reference model, Tailoring and Extensibility using Forum. ADM includes preliminary phase that prepares organization centric EA process and models by tailoring basic ADM. Most literature to compare EAF omitted this important EA adoption phase of TOGAF. Examples of Forum are Architecture, ArchiMate, IT4IT, Platform, and Real-time & Embedded System Forums. These Forums continuously standardize EA for specific industry domains and technical concerns.

4.2 Using Comparison Framework to Compare EA Frameworks

Above mentioned EA frameworks are compared below using the comparison framework in section three.

Features of EA framework A is defined as follows.

Features (A)=(Layer=>{x is a Layer feature of A},

Model=>{x is a Model feature of A},

Method=>{x is a Method feature of A},

Governance=>{x is a Governance feature of A},

Capability=>{x is a Capability feature of A},

Extensibility=>{x is an Extensibility feature of A})

Features for EAPM, EA3, DYA, EAAS, ACEA, and TOGAF are as follows using the above definition.

Features (EAPM)=(Layer=>{Hierarchy, BA/DA/AA/TA, Transition}, Model=>{Diagram}, Method=>{Process, BLA/TGA}, Governance=>{EAP}, Capability=>empty, Extensibility=> empty)

Features (EA^3)=(Layer=>{Hierarchy, BA/DA/AA/TA, Transition, Strategy}, Model=>{Diagram, Repository}, Method=>{Process, BLA/TGA}, Governance=>{EAP, Governance meeting, Compliance, Risk management}, Capability=>empty, Extensibility=> empty)

Features (DYA)=(Layer=>{Hierarchy, BA/DA/AA/TA, Transition, Strategy}, Model=>{Diagram}, Method=>{Process, BLA/TGA, Tailoring}, Governance=>{EAP, Governance meeting, Compliance, Risk management}, Capability=>{Maturity, Planning}, Extensibility=> empty)

Features (EAAS)=(Layer=>{Hierarchy, BA/DA/AA/TA}, Model=>{Diagram}, Method=>{Process, BLA/TGA}, Governance=>{EAP, Governance meeting}, Capability=>{Maturity, Planning, Dimension}, Extensibility=> empty)

Features (ACEA)=(Layer=>{Hierarchy, BA/DA/AA/TA, Transition}, Model=>{Diagram, Repository, Meta model}, Method=>{Process, BLA/TGA, Iteration, Reuse}, Governance=>{EAP, Governance meeting, Compliance}, Capability=>{Maturity, Planning, Dimension, EA architect}, Extensibility=>{Method evolution, Model evolution})

Features (TOGAF)=(Layer=>{Hierarchy, BA/DA/AA/TA, Transition, Strategy, Physical, Stakeholder}, Model=>{Diagram, Repository, Meta model, Language, Reference model}, Method=>{Process, BLA/TGA, Iteration, Tailoring, Reuse}, Governance=>{EAP, Governance meeting, Compliance, Risk management, Governance log, EA board}, Capability=>{Maturity, Planning, Dimension, Skill

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framework, Increment, EA architect}, Extensibility=>{Method evolution, Model evolution, Evolution})
Table 2 shows the result of comparison using the comparison framework in Table 2. The values in Table 2 are the number of feature elements for the corresponding feature categories. For example, Layer features of EAPM are {Hierarchy, BA/DA/AA/TA, Transition}, then the value of Layer row for EAPM column is three in the Table 2.

The result shows that TOGAF is the most powerful EA framework in the comparison. The complexity and difficult to understand issues on TOGAF may be come from the misuse of TOGAF as explained before. Many literatures did not consider the preliminary phase to appropriately tailor TOGAF ADM for organizations. The adopted TOGAF ADM will be suitable for organizations. The failure to implement EA mainly comes from inappropriate use of TOGAF without tailoring. For the model and method features, TOGAF lacks clear description on model and method architects who conduct tailoring of model and method for organizations, although tailoring tasks are explained.

Table 2. Comparison of EA Frameworks

Dimensions	EAPM	EA^3	DYA	EAAS	ACEA	TOGAF
Layer	3	4	5	3	4	6
Model	1	2	1	1	3	5
Method	2	2	3	2	4	5
Governance	1	4	4	2	3	6
Capability	0	0	2	3	4	6
Extensibility	0	0	0	0	2	6

Figure 1 shows the radar chart to compare EA frameworks based on Table 2.
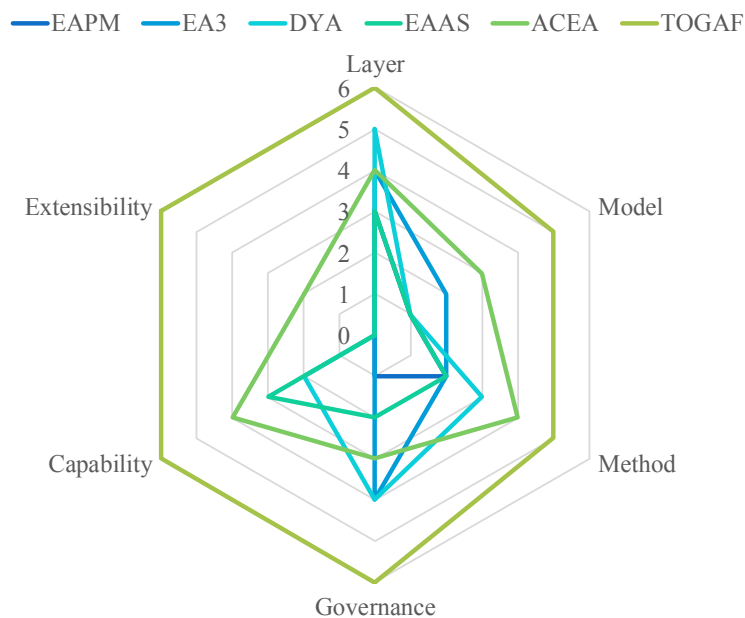
Figure 1. Comparison of EA Frameworks Using Radar Chart

5. Discussion

This paper proposes a comparison framework of EA frameworks based on concrete features. The comparison framework consists of six dimensions and six interrogatives as shown in Table 1. The feature categories are Layer, Model, Method, Governance, Capability, and Extensibility. The characteristic of the comparison framework is able to evaluate concretely. This section discusses the effectiveness, novelty and limitations of the proposed comparison framework.

5.1 Effectiveness

The proposed comparison framework is effectively applied to compare EA frameworks. As the comparison task is achieved by counting feature elements based on six categories, it is easy and concrete. There is no ambiguous decision on the way to select existed features from EA framework text book.

Using the comparison result to integrate different EA frameworks also be able. For example, model features of TOGAF can be integrated to those of EAAS, because the model feature of EAAS is weak.

5.2 Novelty

So far, there is no concrete evaluation framework on comparing EA frameworks. The proposed comparison framework only consists of objective thirty six features in two dimensions that are six categories and six interrogatives. We introduced extensibility features in the proposed EA framework comparison method for the first time. The past and current EA comparison literature did not consider the extensibility features that are significant EA framework evolution mechanism.

5.3 Limitations

The number of compared EA framework is six. It is necessary to compare other EA frameworks, such as DoDAF (DoD Architecture Framework), FEAF (Federal Enterprise Architecture Framework) and Gartner frameworks. We intentionally omitted Zachman framework, because it did not have any other features than hierarchy of Layer.

The comparison framework omits quality criteria such as understandability and complexity. These criteria is difficult to evaluate objectively. Therefore different research might have the conflict for the same criteria. Moreover, as intuitive opinion of practitioners were used to evaluate these qualitative criteria, the result depends on the expertise of practitioners.

The proposed comparison framework consists of six feature categories and interrogatives. The feature categories can be extended to more than six. It also did not evaluate the representation power of features. As shown in Figure 2, the comparison framework can be extended to add the third dimension of representation power of features. For example, the Language feature depends on the representation power of Languages.
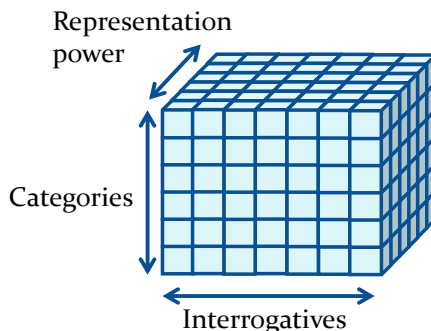
Figure 2. Dimensions of EA Framework Comparison

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