Towards the Adoption of International Standards in Enterprise Architecture Measurement

Ammar Abdallah
Software and IT Engineering
École de Technologie Supérieure
University of Québec
Montréal, Canada
ammar.abdallah.1@ens.etsmtl.ca

Alain Abran
Software and IT Engineering
École de Technologie Supérieure
University of Québec
Montréal, Canada
alain.abran@etsmtl.ca

Bashar Abdallah
Software and IT Engineering
École de Technologie Supérieure
University of Québec
Montréal, Canada
bashar.abdallah.1@ens.etsmtl.ca

ABSTRACT
Literature on Enterprise Architecture (EA) report that EA is an emerging discipline with an increasing attention from both academia and industry. However, the literature report on some challenges in EA research. For instance, EA modelling and EA measurement. In this paper, we aim to assist the EA community to overcome the challenges found in EA measurement, and enhance the adoption of knowledge from mature disciplines. Therefore, and to our knowledge, this paper is the first attempt to adopt two (2) international standards: ArchiMate as a standard language for EA modelling, and Common Software Measurement International Consortium (COSMIC) as a measurement method standard. The paper outlines the adoption (referred to as mapping process), and propose accordingly a novel EA measurement approach based on these two (2) international standards. Since the proposed approach is based on recognized international standards, it is expected that the approach can be handy for EA practitioners, and easy to adopt by organizations. The paper describes a demonstrative example from the insurance industry using the novel measurement approach, and concludes with future research avenues.

CCS Concepts
• General and reference → Measurement; • Software and its engineering → Architecture description languages; • Information systems → Enterprise applications

Keywords
Enterprise Architecture; Measurement; Archimate; Cosmic; Modelling language

1. INTRODUCTION
Since the 1980s, the concept of Enterprise Architecture (EA) has emerged as a discipline to manage the architectures of organizations and support the transition from a current (as-is) to a future (to-be) state [5]. EA can be defined as a set of management system components and their structure, interrelationships and interdependencies [8]. Furthermore, multiple EA definitions can be found in EA literature, such as [12] who defines EA as "a coherent whole of principles, methods, and models that are used in the design and realisation of an enterprise's organisational structure, business processes, information systems, and infrastructure."

EA has become a growing interest in both academia and industry and created the expectation that EA would help improve decision-making, reduce IT costs, improve business processes and enhance the re-use of resources [4, 8, 11, 17, 19].

However, EA comes at a price [20,21] and organizations planning to invest in it must be able to identify and quantify the expected benefits. Measuring EA is therefore necessary to ensure that organizations are harvesting the expected EA benefits.

EA measurement has received some research attention by academics and researchers. For example [13] proposed an EA measurement solution in an attempt to measure the expected EA value, while[17, 22] proposed an EA measurement solution based on the balanced scorecard providing a multi-perspective framework (financial, customer, internal, learning perspectives) in an attempt to justify investments in EA. Other researchers proposed EA measurement solutions to quantify EA complexity [7, 23].

Reference [11] proposed a solution in an attempt to investigate the factors that influence the EA implementation process, [3], who proposed a solution in an attempt to quantify EA value on IT projects. Other attempts can be found in [15, 16, 24, 25].

While some publications propose different EA measurement solutions, researchers report that there is a little guidance on EA measurement [4, 7, 10] and, insufficient practices that consider all EA functions and processes for evaluation and measurement [16], the existence of several drawbacks in EA evaluation [16] and that organizations are facing a challenge on how to measure the value of EA [13].

Not limited to this, [1] reports that the current research on EA measurement lacks the rigorous terminology found in science and engineering, and shows limited adoption of knowledge and best practices from other disciplines in the proposals of EA measurement solutions.

Therefore, the research objective of this paper is to assist the EA community to overcome the challenges found in EA measurement, and enhance the adoption of knowledge from mature disciplines. Therefore, this paper adopts by combining two (2) international standards: ArchiMate as a standard language for EA modelling, and Common Software Measurement International Consortium (COSMIC) as a measurement method standard. Accordingly, we propose a novel EA measurement approach based on these two (2) international standards.

The remaining of this paper is structured as follows: section 2 presents a background of ArchiMate and COSMIC. Section 3

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presents the research method. Section 4 presents the novel EA measurement approach. Finally, conclusions and future works are presented in section 6.

2. BACKGROUND

This section provides a background about the two (2) international standards (ArchiMate and COSMIC) used in the design of the novel EA measurement approach

2.1 ArchiMate

EA literature posits that EA provides a coherent overview for organizations. Such overview includes insights about the communications and alignments between business and IT architectures. In addition, it is expected that this overview will enable organizations to understand better the consequences of complex change decisions. These changes can include decisions that change the structure of the business process, IT infrastructure, data management, etc. Therefore, EA is expected to deliver a coherent overview about the consequences that might affect the organization.

There are different EA frameworks that can guide organizations to design and benefit from EA, such as The Open Group Architecture Framework (TOGAF), Zachman's framework, and The Department of Defense Architecture Framework (DoDAF). According to [18], TOGAF is rated higher compared to other frameworks. The advantages of TOGAF include the interconnection and integration between different architectural layers, and alignment with industry standards [18].

According to [12], designing EA in organizations is not a trivial task. EA design is complex: it includes various steps that are not standardized and TOGAF was introduced as a framework that attempts to standardize the steps of EA design in organizations.

In most organizations, separate architectural layers are distinguished. For instance, business, information and application layers are not the same. Each EA architectural layer has its own concepts, modelling techniques, tool support, and visualisation. Unfortunately the disadvantage of the distinct EA architectural layers is the difficulty to obtain a coherent overview of the organization [9]. To this end, and in order for EA practitioners to express and describe the architectural layers, most organizations define their own notations and conventions: these notations are informal and consensus on their meaning is not well defined [12].

Therefore, the Open Group introduced a modelling architecture language: ArchiMate. ArchiMate is a uniform modelling language that supports enterprise architects in describing, analysing and visualising the relationships among layers based on well defined concepts [12]. It (i.e., ArchiMate) is expected to enable organizations to obtain a coherent overview about the architecture.

In contrast to other modelling languages, ArchiMate is capable to deliver a high-level overview about the relationships in the architecture – see Figure 1. ArchiMate is not EA layer specific, while other modelling languages, such as UML, are specific to modelling applications and technology and provide detailed descriptions about them. Moreover, BPMN is specific to business process modelling, and does not support the application and technology layers. Therefore, [6] reports a growing interest in applying ArchiMate for high-level enterprise architecture modelling.

The structure of ArchiMate corresponds to the three (3) architectural layers of TOGAF's Architecture Development Method (ADM). ADM and ArchiMate share the same ground, as both are TOGAF standards – see Figure2.

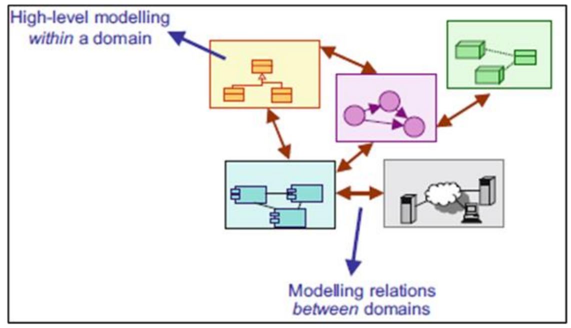

Figure 1. The role of the ArchiMate language [12]

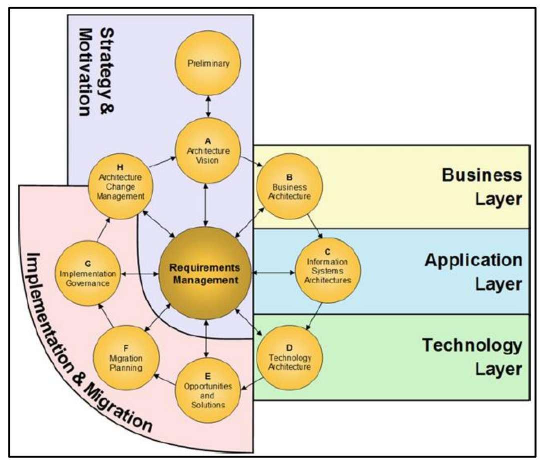

Figure 2. Correspondence between ADM & ArchiMate [12]

2.2 COMMON SOFTWARE MEASUREMENT INTERNATIONAL CONSORTIUM (COSMIC)

COSMIC is a method for measuring the functional size of software. In 2002, it was accepted by ISO/IEC as an international standard, and referred to as ISO/IEC 19761.

According to [2], COSMIC is not technology dependent. It includes a set of principles and rules applied to the functional user requirements (FUR) of a given piece of software. FUR are descriptions of what the software does or should do to the functional users. The functional users might be human or any application software that communicates through data.

According to [2], the interaction between the functional users and software applications is through a functional component referred to "data movement". COSMIC defines four (4) types of data movements:

- Entry (E): data moved from a functional user to a software.
- Exit (X): data moved from a software to the functional user.
- Write (W): data moved from the software to a persistent storage.
- Read (R): data moved from a persistent storage to the software.

According to [2], the functional size in COSMIC is calculated by adding the data movements. The COSMIC measurement unit is a COSMIC function point (CFP), which represents one data movement of one data group.

The concepts in COSMIC can be applied to various functional domains such as: business application software, real-time software, and combination of the two – see Figure 3.

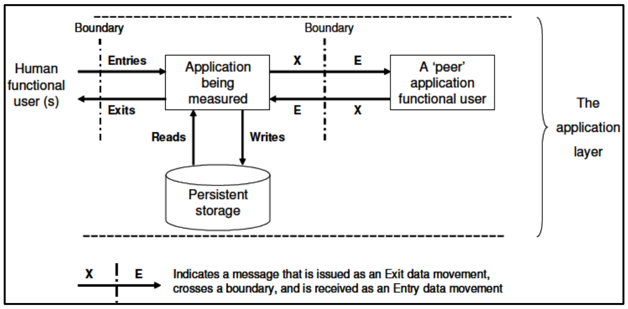

Figure 3. A business application with both humans and another 'peer' application [2]

In each functional process, COSMIC measurement function assigns a value to the data movements. COSMIC defines a standard measurement unit (1 CFP) as an equivalent of one single data movement. The functional sizes of individual data movements shall be aggregated into a single functional size value in units of CFP by arithmetically adding them together – see Equation (1).

$$Functional\ Size = \sum Size_{Entries} + Size_{Exits} + Size_{Reads} + Size_{Writes} \quad (1)$$

3. RESEARCH METHOD

The research method followed in this paper is to map the concepts of ArchiMate and COSMIC based on building on top of previous works related to modelling languages– see Figure 4. The method is divided to three (3) steps as follows:

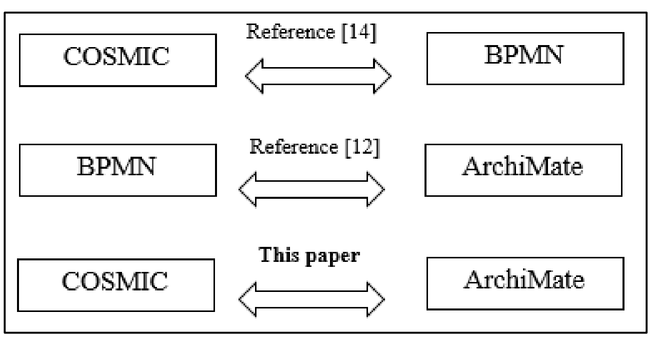

Figure 4. Mapping COSMIC & ArchiMate based on previous works

3.1 Mapping between BPMN and COSMIC

Reference [14] developed a procedure to measure the functional size of a software application based on the business process models representing the software application: Business Process Model and Notation (BPMN), as a standard to model the business process, was used to develop this procedure. In order to measure the functional size of a software application based on the business process models, [14] mapped BPMN to COSMIC: this mapping includes defining a set of mapping rules between the BPMN modeling notations and the COSMIC concepts – see Table 1.

3.2 Mapping between BPMN and ArchiMate

Reference [12] proposed that BPMN and ArchiMate be used in combination:

- ArchiMate to model high-level processes, and
- BPMN to model fine-grained (detailed modelling) for sub-processes.

Their mapping includes defining a set of mapping rules between the BPMN and ArchiMate modeling notations – see Table 2.

Table 1. Mapping between COSMIC and BPMN [14]

COSMIC FSM Method V.3.0.1	BPMN 1.2	Comments
Functional User	Lane and pool	Those who interact with the lane of the software to be measured
Boundary	The lane that represents the software to be measured	
Functional Process	Pool	Those that contain the lane that represents the software to be measured
Triggering Event	Start Event	
Data Group	Name of a message	Between pools
	Data Object	When a persistent storage must be accessed
Entry	An incoming message or sequence flow	
Exit	An outgoing message or sequence flow	
Read	An upstream association with a data object	
Write	A downstream association with a data object	

Table 2. Mapping between BPMN and ArchiMate [12]

BPMN	*ArchiMate*
Participant/Pool, Lane	Business Actor, Role, Application Component
Collaboration	Business/Application Collaboration
Process	Business/Application Process
Sequence flow	Triggering
Data association	Access
Inclusive and parallel gateways	Junction
Exclusive and event-based gateways	Or-junction

3.3 Mapping between ArchiMate & COSMIC

Based on the mappings of (BPMN & COSMIC) and (BPMN & ArchiMate) in Tables 1 and 2, the first attempt to map COSMIC concepts to ArchiMate modeling notations emerges in this paper. The mapping rules (e.g., rule 1 to rule 12) are shown in Table 3. This mapping will facilitate the utilization of COSMIC and ArchiMate, and is the basis of the proposal of the novel EA measurement approach.

4. A NOVEL EA MEASUREMENT APPROACH

To our knowledge, this novel EA measurement approach – see Figure 5, is the first attempt that utilizes COSMIC concepts to measure EA. The objective of this mapping is to improve measurement in EA, and to strengthen EA measurement from a metrology perspective. The approach is summarized as follows and refers to the three (3) EA layers of TOGAF:

- Each EA layer should be modelled using ArchiMate modelling language.

- Each modelled EA layer should be mapped to COSMIC.
- Apply COSMIC measurement function in each EA layer.
- The resulting mapping of ArchiMate and COSMIC (ArchiMate COSMIC V1) should produce functional sizes for each distinct EA layer with a measurement unit called COSMIC function point (CFP).

Table 3. Mapping COSMIC to ArchiMate V1

Mapping Rules	COSMIC	ArchiMate
Rule 1	Functional User	Business Actor, Role, Application Component, Business service, Business process
Rule 2	Functional Process	Business/Application Process
Rule 3	Entry	Incoming message (flow) or Triggering relation
Rule 4	Exit	Outgoing message (flow) or Triggering relation
Rule 5	Read	Access
Rule 6	Write	Access
Rule 7	Boundary	Unspecified
Rule 8	Unspecified	Collaboration
Rule 9	Unspecified	Junction
Rule 10	Unspecified	Or-Junction
Rule 11	Triggering Event	Triggering Event
Rule 12	Data Group	Data Object (Business object, Application object,) Name of service Or messages between functional users

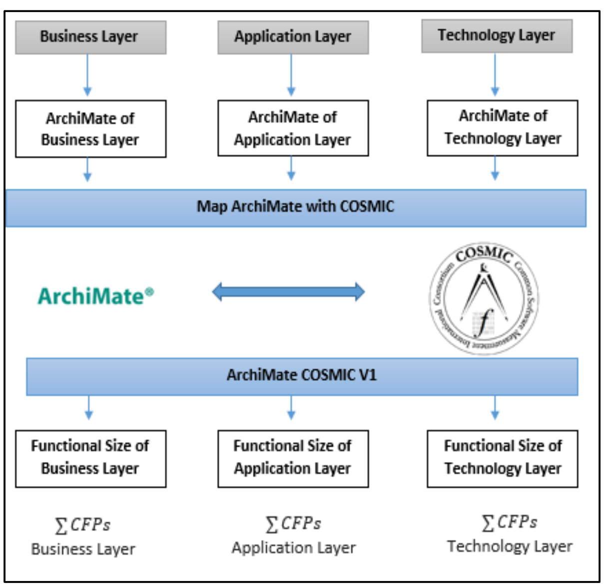

Figure 5. The novel EA measurement approach

Next is an example that demonstrates the application of the novel EA measurement approach.

5. DEMONSTRATIVE EXAMPLE

This section provides a demonstrative example from the insurance industry adopted from [12]. The objective of this example is to illustrate the how EA layers can be measured using the novel EA measurement approach.

Example: In an insurance company, a claim is received about a damage, causing an insurant to enter the claim data, and causing other functional processes and data movements to occur in the EA business and application layers.

Figures 6 and 7 are the representation of EA business and application layers respectively. These figures use the notations of ArchiMate to model each EA layer.

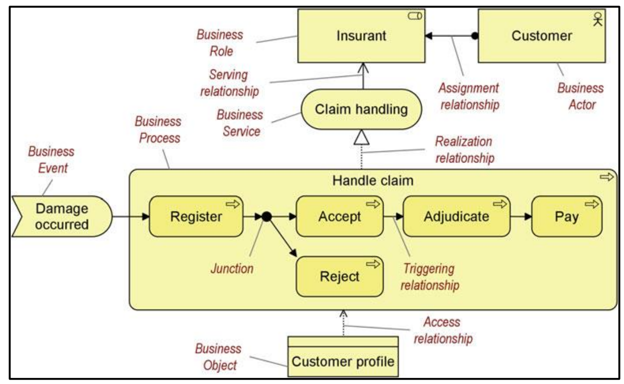

Figure 6. Example of EA business layer in insurance industry [13]

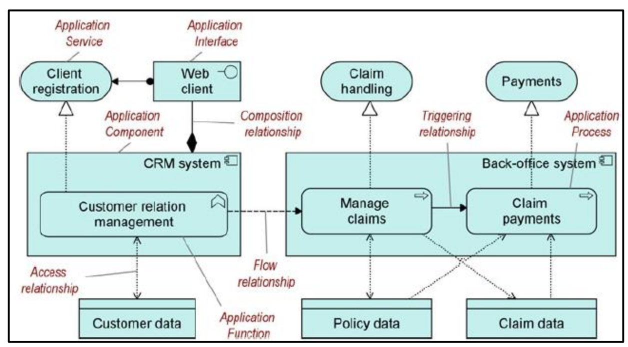

Figure 7. Example of EA application layer in insurance industry [13]

Based on the ArchiMate modelling in Figures 6 and 7, section 5.1 shows a detailed description of the measurement of the EA business layer, and section 5.2 shows a detailed description of the measurement of the EA application layer.

5.1 Measuring the functional size of the EA business layer

The description of the data movements of the "handle claim" business process presented in Figure 6 is reworked in this section to show the data movements. For instance, from Figure 8: a damage has occurred, and the customer is submitting a claim to the insurance organization. In turn, the organization handles the claim

Table 4. Detailed description of "handle claim" business process in EA business layer

Functional User	Sub-processes	Name of Data Group	Data Movement	CFP
Insurant (Business Role)	Register	Registration Data	E,X	2
	Accept	Accept Data	E,X	2
	Adjudicate	Adjudicate Data	E,X	2
	Pay	Pay Data	E, X	2
	Reject	Reject Data	E, X	2
	Access	Customer profile	R	1
Total size for handle claim business process = 11 CFP				

through the "handle claim" business process. This business process triggers data movements, and are described as following:

- Entry (E) and Exit (X) data movements to/from the "Register" sub-process.
- Entry (E) and Exit (X) data movements to/from the "Reject" sub-process.
- Entry (E) and Exit (X) data movements to/from the "Accept" sub-process.
- Entry (E) and Exit (X) data movements to/from the "Adjudicate" sub-process.
- Entry (E) and Exit (X) data movements to/from the "Pay" sub-process.
- Read (R) data movement on the customer profile.

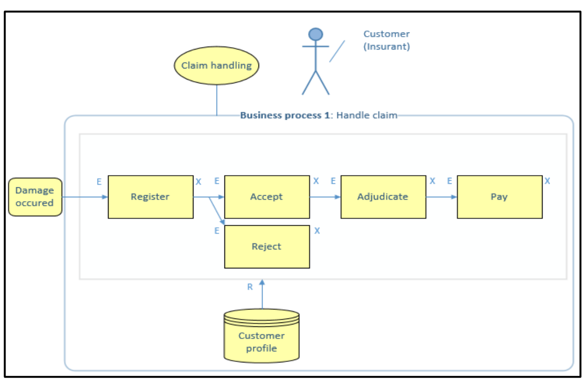

Figure 8. Data movements of the "handle claim" business process in EA business layer, reworked [12]

The detailed description of the data movements visible at the business layer including the corresponding functional sizes are presented in Table 4.

By applying equation (1) on Table 4, the total functional size of the business process in the EA business layer is 11 CFP.

5.2 Measuring the functional size of the EA application layer

The description of the data movements of the application processes presented in Figure 7 is reworked in this section to show the data movements. For instance, from Figure 9: a damage has occurred, and the customer is submitting a claim to the insurance organization. The description of the data movements of the three (3) application processes is presented in Figure 9. The application layer serves the business layer through application processes and data movements as follows:

- Entry (E) and Exit (X) , Read (R) and Write (W) data movements in Application process 1,
- Entry (E) and Exit (X) , Read (R) and Write (W) data movements in Application process 2, and
- Entry (E) and Exit (X), Read (R) and Write (W) data movements in Application process 3.

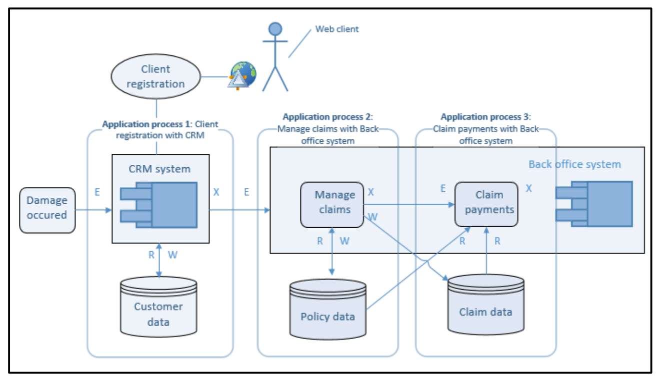

Figure 9. Data movements of three application processes in EA application layer, reworked [12]

Table 5. Manage claims with back office system in EA application layer

Functional User	Sub-processes	Name of Data Group	Data Movement	CFP
Web client	Manage Claims	Manage Claims	E,X	2
	Access Policy data	Policy data	W,R	2
	Access claim data	Claim data	W	1
Total Size for Application Process 2 = 5 CFP				

The detailed description of the data movements visible at the application layer including the corresponding functional sizes are presented in Tables 5 to 7.

Table 7. Claim payments with Back office system in EA application layer

Functional User	Sub-processes	Name of Data Group	Data Movement	CFP
Web client	Claim payments	Claim payments	E, X	2
	Access claim data	Claim data	R	1
	Access policy data	Policy data	R	1
Total Size for Application Process 3 = 4 CFP				

By applying equation (1) on Tables 5 to 7, the total functional size of the application processes in the EA application layer is 13 CFP.

6. CONCLUSION & FUTURE WORK

This paper aimed at helping the EA community improve the adoption of knowledge from other disciplines and overcome the challenges in EA measurement using state-of-art and recognized standards.

To achieve this, a novel approach for EA measurement was presented. The approach is based on adopting TOGAF EA layers, modeling EA layers using ArchiMate, applying COSMIC concepts on the ArchiMate model, and measuring the functional size of EA layers. Applying COSMIC concepts on ArchiMate is possible through the mapping of COSMIC concepts to ArchiMate.

This mapping phase between COSMIC concepts and ArchiMate was achieved by building on top of previous research attempts that mapped COSMIC with conceptual notations such as BPMN, and subsequent map between two conceptual notations, BPMN and ArchiMate.

To our knowledge, mapping COSMIC concepts and ArchiMate is the first attempt toward adopting COSMIC concepts in EA measurement research. Since COSMIC is recognized standard with rules and guidelines in metrology and measurement, this novel approach is expected to improve the maturity of the EA measurement proposals from a metrology perspective. In addition, since the proposed approach is based on recognized international standards, it is expected that the approach can be handy for EA practitioners, and easy to adopt by organizations.

Future work avenues of this paper can focus on standardizing and strengthening the novel approach as follows:

- Conduct case studies to collect data from EA and metrology practitioners about the completeness of the approach.
- Revise the completeness of the mapping COSMIC concepts to ArchiMate. For instance, the relationship between the three (3) architectural layers is service oriented. Therefore, it is required to extend the mapping rules to cover the measurement of the data movements between the distinct EA layers.
- Establish ArchiMate modelling guidelines to handle the levels of abstraction. Different modelling notations might result in different functional sizes.
- Establish a framework based on COSMIC early sizing techniques to handle fine-grained modelling. In-depth modelling will increase the functional size; therefore, COSMIC early sizing techniques can estimate the EA measurements of fine-grained (granular) details.

Table 6. Client registration with CRM in EA application layer

Functional User	Sub-processes	Name of Data Group	Data Movement	CFP
Web client	Customer relation management	Client registration	E,X	2
	Access	Customer data	W,R	2
Total Size for Application Process 1 = 4 CFP				

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