Business context-based quality measures for data exchange standards usage specification

Elena Jelisic[1,4], Nenad Ivezic[2], Boonserm Kulvatunyou[2], Scott Nieman[3], Zoran Marjanovic[4]

[1] Associate, Systems Integration Division, National Institute of Standards and Technology, Gaithersburg, MD, 20899, USA
[2] Systems Integration Division, National Institute of Standards and Technology, Gaithersburg, MD, 20899, USA
{elena.jelisic, nenad.ivezic, boonserm.kulvatunyou}@nist.gov
[3] Land O'Lakes, Arden Hills, MN, USA
stnieman@landolakes.com
[4] University of Belgrade, Faculty of Organizational Sciences, Belgrade, 11000, Serbia
zoran.marjanovic@fon.bg.ac.rs

Abstract. Standards-based methods for data exchange are key for Business-to-Business (B2B) integration. However, in the case of Small Businesses, there are significant barriers to utilizing these methods. One of the reasons is that the standards are large, making their use very difficult. The most recent attempt to resolve this issue was the first OAGIS Express Pack version that is defined as Minimal Viable Product (MVP) of the OAGIS standard. Yet, there is no existing approach to assess the quality of the OAGIS Express Pack usage specification. This is important because such quality measurement would give an actionable feedback whether the standard (or its portion) meets the integration requirements. These measurements could help reduce standards-development time, standards-adoption time, and integration-testing time, while increasing the overall integration process effectiveness. This paper introduces two quality measures, illustrates their measurement, and shows how to interpret the results.

Keywords: Data exchange standard, Quality measures, Usage specification, Implementation guideline, Digitalization, Small and Medium Enterprise.

1 Introduction

The Small Business Administration (SBA) Office of Advocacy cites that small businesses account for roughly 40 percent or more of the Gross Domestic Product of the United States, extensively contributing to job growth and innovation [1]. Furthermore, small businesses comprise 99.9 percent of all U.S. businesses. Key, digital, Supply-Chain-related sectors of interest include Manufacturing jobs (44%), Food Services (60%), Agricultural (85%), and Technical/Scientific (57%) [1].

Despite the large numbers and perceived impact, there are significant barriers for Small Businesses to get connected. Their most common challenges include (1) the lack of

skilled, technical resources, especially in rural areas; (2) salary and consulting cost of these resources; (3) large, standards-making integrations more difficult; (4) lack of software application with usable application programming interfaces (APIs) enabling data exchange; (5) vendors of software applications with more interests in customer 'lock-in' their products and reliance on professional services; (6) the high cost of integration tools that enable these capabilities; and, (7) the lack of broadband Internet in rural areas.

In order for small businesses to leverage data exchange standards (DES) for integration, in many cases a consensus on how to use those standards is still needed. Such a consensus is usually included in an implementation guideline [2], which is the refinement of DESs. In addition, tools to support the management of these usage specifications have historically been lacking. Consequently, users often resort to heterogeneous spreadsheets. Interpretation of certain DESs, due to their flexibilities and coverages, required highly skilled professionals with substantial standards maintenance and implementation experience.

The **Score** tool, developed by the Open Applications Group Inc. (OAGi) [3] and the National Institute of Standards and Technology (NIST) [4], was designed to speed up the development of DESs and their usage specifications [5, 6]. **Score** is the first and only open-source tool based on the ISO Core Components meta-model (CCTS). CCTS provides both the required research and the operational support for enterprise-integration architects, business analysts, integration developers, and standards architects. The tool was used to advance research on life-cycle management [6, 7] and quality improvement of DESs [8]. Additionally, it has been used to develop new releases of the Open Applications Group Integration Specification (OAGIS) standard [9].

Most recently, **Score** was employed to define Minimal Viable Product (MVP) of the OAGIS DES for use by Small and Medium Enterprises [10]. The first OAGIS Express Pack version is released in March 2021. The OAGIS Express Pack reflects "*the requirements gathered from SMEs over many years in an 80–20 principle (i.e., 80% of the users need only 20% of the product) approach*" [7]. Currently, however, the **Score** platform does not measure whether a candidate DES usage specification meets implementation requirements. Failures at the enterprise level, caused by DES usage failures, can be very costly and time-consuming to fix. Data-exchange errors at the production level can result in scrapping entire product batches. Without such a measurement mechanism, candidate DESes must undergo a lengthy testing and validation process. This testing could be greatly reduced with effective initial measurements. Usage specifications and quality measurements would help reduce DES usage-development time, standards-adoption time, and integration-testing time while increasing the overall effectiveness of DESs. The main contribution of this paper is to introduce usage-specification-quality measures, propose their measurements, and discuss their interpretations.

The structure of the paper is as follows. Section 2 provides the necessary background. Section 3 introduces the proposed quality measures and gives instructions for their measurements. Section 4 uses the OAGIS Express Pack to illustrate the quality measures. Section 5 discusses the results of the quality measures and proposes future research directions. Finally, Section 6 concludes the paper.

2 Background

The Core Components Technical Specification (CCTS) is an ISO-approved, implementation-neutral, meta-model standard that improves the practice of developing and using DESs [11]. CCTS introduces two types of data modeling components - Core Components (CCs), as DES building blocks, and Business Information Entities (BIEs), as DES usage specifications. CCs are conceptual, data-model components, while BIEs are logical components that restrict the underlying CCs to a specific Business Context [8]. Business Context is a novel concept described by CCTS to describe integration use case(s) the BIE captures using a directed acyclic graph. Each Business Context is described by a set of Business Context categories that have an assigned list of values. UN/CEFACT proposed eight Business Context categories, but one can choose their own list of Business Context categories beyond those proposed and most often these unique categories relate to business processes. Besides OAGIS [12], the CCs part of CCTS has been adopted by several DESs such as UBL [13], and NIEM [14].

Effective business context is another important concept [2]. Keeping in mind that each BIE has its associated Business Context, *Effective business context* for a BIE is calculated to determine whether the BIE is relevant for a requested integration use case. It is calculated as an intersection between the BIE's assigned Business Context and the Business Context of the requested integration use case (i.e., requested Business Context). The intersection is determined for each employed Business Context category. If the intersection for any category is an empty set, the *Effective business context* is resolved as null, thus the component will be treated as not relevant for the requested integration use case. Otherwise, if the *Effective business context* is not null, the component will be treated as relevant (details can be found in [15]).

3 DES usage specification quality measures

During the DES usage-specification-development process, only a limited list of integration use cases can be accounted for. Otherwise, this process would become inefficient, and the usage specification would become difficult to use by developers. Each integration use case is specified by a combination of values that are valid for each employed Business Context category. This paper proposes a measurement methodology to predict the performance of candidate DES usage specifications. The main technical idea is to develop a CCTS Business Context-based, measurement method that advances the notion of standards performance given a set of requirements. Contextual information is important for successful DES-based integration. Contextual information indicates meta-data about the integration. Examples of contextual information include the overall objective of the integration workflow, the data objects associated with a workflow task, and the specific industry and country in which the task will be performed. Contextual information narrows the semantics and value domains of the DES components. Similarly, it explicates the semantics of the integration and exchange requirements (e.g., message structure, value domains). Two quality measures are suggested to support the assessment of a DES usage specification.

- *Completeness of coverage* - measures how completely the standard covers the data exchange requirements.
- *Effectiveness* - measures how focused and compact the standard is in meeting the requirements.

3.1 Completeness of coverage

The *Completeness of coverage* measure indicates the difference between the Business Contexts for projected and targeted integration use cases. Targeted integration use cases are those that are originally accounted for, while projected are the ones for which we hope that DES usage specification will be able to cover. If there is an identified difference between these two Business Contexts (e.g., Business Context for projected integration use cases is wider), it would indicate that the scope for the projected, integration, use case is not covered entirely. For example, there might be some required DES components missing from the usage specification, or the value domains are too restricted. This situation would result in a conclusion that the content of the DES usage specification should be revised and analyzed to identify the potentially missing components. Another scenario would be that projected use cases are narrower. This situation would result in a conclusion that components from the DES usage specification are too general and need to be refined. However, this scenario will be neglected and left for future work since it requires more detailed analysis. The numerical result of *Completeness of coverage* will inform us about the portion of projected integration use cases that are likely to be covered entirely by existing DES usage specification. This measure may be interpreted to assess the ***quality of the structure*** of the DES usage specification. To measure the *Completeness of coverage* of a DES usage specification, two scopes have to be identified. The first one, *Targeted scope* (TS), is a union of N integration use cases that were accounted for when the DES usage was specified.

$$\text{TS} = \cup\, IUC_i, i \in N \tag{1}$$

The second one, *Projected scope* (PS), identifies M projected integration use cases for which we hope that developed DES usage specification will be applicable.

$$\text{PS} = \cup\ IUC_j, j \in M \tag{2}$$

The ratio between those two scopes gives us information about the *Completeness of coverage*. The *Number of intersecting integration use cases* represents the number of integration use cases that can be found both in the TS and PS.

$$Completeness\ of\ coverage = \frac{Number\ of\ intersecting\ integration\ use\ cases}{M} \tag{3}$$

3.2 Effectiveness

The *Effectiveness* measure involves two, classical parts – precision and recall [16]. To assess the *Effectiveness* of the DES usage specification, we will have to go through the following steps. First, we must select a list of arbitrary test integration use cases from

the TS. Second, for each test integration use case, we must calculate *Effective business context* (see Section 2). Third, we must calculate the precision and recall, as follows:

$$Precision = \frac{Number\ of\ true\ relevant\ components}{Number\ of\ true\ relevant + False\ relevant\ components} \quad (4)$$

$$Recall = \frac{Number\ of\ true\ relevant\ components}{Total\ number\ of\ components\ needed\ for\ targeted\ use\ case} \quad (5)$$

The precision rate denotes the capability of a DES usage specification to identify **only** components that are relevant for the targeted integration use cases. On the other hand, the recall rate denotes the capability of the DES usage specification to identify **all** components that are needed for the same use cases. Low precision and recall rates indicate that the DES usage specification is not informative enough to support recognition of all relevant components. This situation would indicate that the contextualization should be revised and improved. This measure may be interpreted to assess the ***quality of the contextualization*** of the DES usage specification.

4 OAGIS Express Pack – use case

Starting with a B2B process definition, which communicates the scope of a use case, one selects a schema to support a specific, information exchange in the process. Let's assume that a PurchaseOrder Schema from OAGIS Express Pack [17] has been identified. Fig. 1 outlines the schema that will be used for illustration of the proposed measures.

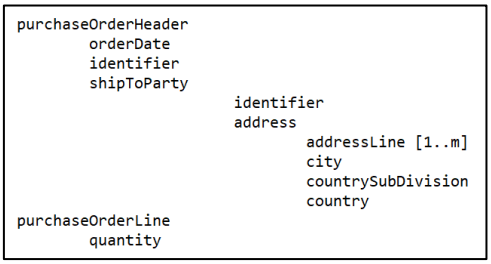

Fig. 1. An example OAGIS Express Pack PurchaseOrder schema

4.1 Business Context knowledge base

For this paper, we will employ five Business Context categories (see Table 1).

Table 1. Business Context definition.

Business Context category	Business Context schemes
Size of Organization	Size list
Item Type	Products and services
Industry	ISIC [18]
Geo-political Location	Countries
Business Process	Order-to-Cash

Fig. 2 shows a portion of the Business Context knowledge base for the OAGIS Express Pack comprised of the identified categories and schemes.

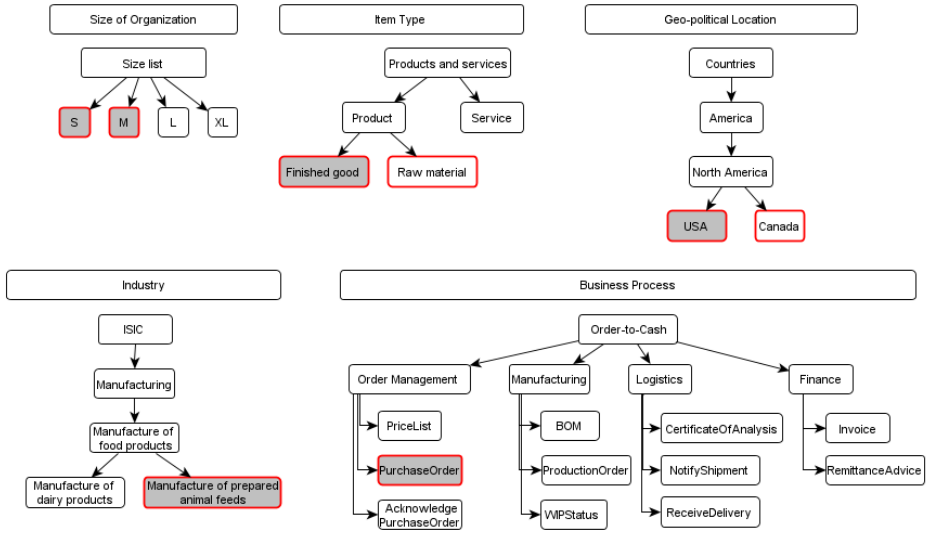

Fig. 2. OAGIS Express Pack - Business Context knowledge base

Gray nodes denote the TS, while red rounded-rectangle nodes denote the PS. As emphasized in Section 3, each integration use case is specified by valid combinations of values for each employed Business Context category. That means that if Canada, hypothetically, does not have organizations of size S, then this combination of values for employed Business Context categories (i.e., integration use case) would not be valid. This does not have to necessarily be a general rule. Instead, it can denote applied domain business rules (e.g., OAGIS Express Pack business rules). For this paper, we do not consider such rules, so all combinations are valid.

4.2 OAGIS Express Pack - quality measures' results

In this section, we will present the measurement and results of the proposed DES usage specification quality measures.

Completeness of coverage.

To measure the *Completeness of coverage*, t we first determine the intersection between TS and PS. The list of targeted integration use cases is presented in Table 2, while the list of projected integration use cases is presented in Table 3.

Table 2. Targeted scope.

Number	Targeted integration use cases
1	S – Finished goods – USA – Animal feeds[1] - PurchaseOrder
2	M – Finished goods – USA – Animal feeds - PurchaseOrder

Table 3. Projected scope.

Number	Projected integration use cases
1	S – Finished goods – USA – Animal feeds - PurchaseOrder
2	M – Finished goods – USA – Animal feeds - PurchaseOrder
3	S – Finished goods – Canada – Animal feeds - PurchaseOrder
4	M – Finished goods – Canada – Animal feeds - PurchaseOrder
5	S – Raw material– USA – Animal feeds - PurchaseOrder
6	M – Raw material – USA – Animal feeds - PurchaseOrder
7	S – Raw material – Canada – Animal feeds - PurchaseOrder
8	M – Raw material – Canada – Animal feeds - PurchaseOrder

The number of intersecting integration use cases is 2, and consequently, the result for the *Completeness of coverage* is as follows.

$$Completeness\ of\ coverage\ = \frac{2}{8} = 0.25$$

To illustrate the intended interpretation of *Completeness of coverage* (i.e., the portion of the projected integration use cases that are likely to be covered entirely by existing DES usage specification, as stated in Section 3.1), we analyze PurchaseOrder requirements for a new use case that is included in the given projected integration use cases, which differs from the targeted integration use cases. For this paper, we hypothesize PurchaseOrder requirements for some Company A which business can be described by the integration use case No 7 from Table 3.

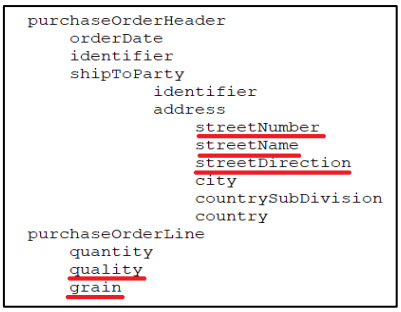

Fig. 3. Projected scope – Company A PurchaseOrder requirements

[1] Abbreviated from Manufacture of prepared animal feeds

Fig. 3 shows PurchaseOrder requirements for Company A. If we compare Company A's requirements with OAGIS Express Pack PurchaseOrder schema, it is obvious that five components are missing. Those components are underlined in Fig. 3. This is possible and likely to occur since this use case was not covered by the targeted integration use cases. Yet, for very homogeneous application domains where new requirements do not result in very different BIEs from the existing BIEs, the measure may be too pessimistic.

Effectiveness.

To measure the *Effectiveness*, the first step is to choose a set of test integration use cases from the TS. Let us assume one such example test case is Company B, which declared that its business can be described by the integration use case No 1 from Table 2. Company B's PurchaseOrder requirements are presented in Fig. 4.

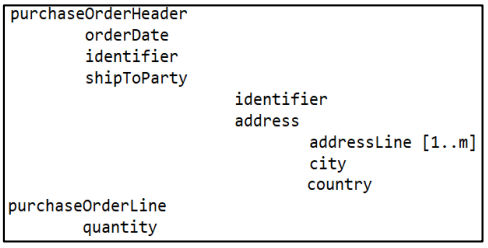

Fig. 4. Targeted scope – Company B PurchaseOrder requirements

The next step is to calculate *Effective business context* for OAGIS Express Pack components from the PurchaseOrder schema. For this example, the required Business Context is Company B (i.e., integration use case No 1 from Table 2). All components from OAGIS Express Pack PurchaseOrder schema have the same assigned Business Context that is defined by the list of identified, integration use cases for the TS (see Table 2). Further, *Effective business context* is calculated as described in Section 2. Since the calculation of *Effective business context* for this example is trivial, details will be omitted.

According to the *Effective business context* calculation, all components from OAGIS Express Pack PurchaseOrder schema are valid for Company B. However, according to the Company B's PurchaseOrder requirements presented in Fig. 4, *countrySubDivision* component is not relevant. In summary, for this simplified test integration use case 11 components are true relevant, and 1 component is false relevant. Consequently, precision and recall rate are as follows.

$$Precision = \frac{11}{12} = 0.92$$

$$Recall = \frac{11}{11} = 1$$

5 Discussion and future work

Proposed quality measures are envisioned to be used as guidelines for more effective DES usage specification development, standards adoption, and integration testing.

If the projected scope is significantly different from the targeted scope, it is not realistic to expect that the *Completeness of Coverage* result would be close to 1. The DES usage specification development team should agree on acceptable results. In the example shown in this paper, that result was notably low. However, this measure only indicates the probability that the DES usage specification would miss the components needed for the projected integration use cases. In practice, this does not have to be the case, especially if targeted and projected scopes are close enough. Having this in mind, it would be useful to introduce an additional, quality measure that would determine the similarity between targeted and projected scopes. We believe that such a measure would give more precise indications about the quality of the structure of the DES usage specification.

In addition, for the measurement of *Completeness of coverage,* only missing BIEs are discussed. In other words, the assumption is that there is no defined usage specification (BIEs) for **existing** DES components (CCs). The separate problem would be if the DES does not contain the needed component at all (i.e., the component is missing on the CC level). This issue should be addressed through future work.

In the example shown in this paper, *Effectiveness* gave notably good results. Such results are surprising since all components from the OAGIS Express Pack PurchaseOrder schema have the same assigned Business Context. In reality, this would not be the case, since not all components are relevant for all targeted, integration, use cases. Although this functionality is not currently supported in **Score**, such variability of components' assigned Business Contexts would indeed require reliable measures about the quality of the contextualization of the DES usage specification. This remains an area of ongoing research.

6 Conclusion

The paper proposes a CCTS Business Context-based, measurement method that advances the notions of standards performance given a set of integration requirements. Two, quality measures were introduced that can be used to assess the quality of the DES usage specification. The paper employs the OAGIS Express Pack PurchaseOrder schema to illustrate the measurement and to give an interpretation of the results. Although these quality measures would be useful, certain caveats are identified. Future research will propose enhancements to tackle those issues.

Disclaimer

Any mention of commercial products is for information only; it does not imply recommendation or endorsement by NIST.

References

1. Small Businesses Generate 44 Percent Of U.S. Economic Activity. https://advocacy.sba.gov/2019/01/30/small-businesses-generate-44-percent-of-u-s-economic-activity/
2. Novakovic, D. (n.d.). *Business Context Aware Core Components Modeling.* Retrieved September 28, 2018, from Publikationsdatenbank der Technischen Universität Wien: https://publik.tuwien.ac.at/
3. The Open Applications Group Inc. https://oagi.org
4. The National Institute of Standards and Technology (NIST). https://www.nist.gov
5. Jelisic, E., Ivezic, N., Kulvatunyou, B., Nieman, S., Oh, H., Anicic, N., & Marjanovic, Z. Knowledge representation for hierarchical and interconnected business contexts, Enterprise Interoperability IX, Tarbes, France, 17. - 20. Nov, 2020
6. B. (Serm) Kulvatunyou, H. Oh, N. Ivezic, S.T. Nieman, Standards-based semantic integration of manufacturing information: Past, present, and future, J. Manuf. Syst. 52 (2019) 184–197. https://doi.org/10.1016/j.jmsy.2019.07.003.
7. Ivezic, N., Kulvatunyou, B., Jelisic, E., Oh, H., Frechette, S., & Srinivasan, V. (2021, August). A Novel Data Standards Platform using the ISO Core Components Technical Specification. Proceedings of the ASME 2021. International Design Engineering Technical Conferences and Computers and Information in Engineering Conference IDETC/CIE 2021August 17-20, 2021
8. Jelisic E., Ivezic N., Kulvatunyou B., Anicic N., Marjanovic Z. (2019) A Business-Context-Based Approach for Message Standards Use - A Validation Study. In: Welzer T. et al. (eds) New Trends in Databases and Information Systems. ADBIS 2019. Communications in Computer and Information Science, vol 1064. Springer, Cham
9. OAGi Releases OAGIS 10.7.1 and Score 2.1, (2021). https://oagi.org/NewsEvents/NewsandArticles/OAGISReleases1071andScore21/tabid/323/Default.aspx.
10. Small & Medium Enterprise Working Group, https://oagi.org/OAGISWorkingGroups/WorkingGroups/tabid/149/Default.aspx
11. Core Components Technical Specification CCTS, version 3.0., (2009) 162. https://unece.org/DAM/cefact/codesfortrade/CCTS/CCTS-Version3.pdf (accessed March 10, 2021).
12. OAGIS 9 Naming and Design Rules Standard, (2005). https://oagi.org/Portals/0/Downloads/ResourceDownloads/OAGIS_90_NDR.pdf (accessed April 15, 2021).
13. UBL Conformance to ebXML CCTS ISO/TS 15000-5:2005, (2014). http://docs.oasis-open.org/ubl/UBL-conformance-to-CCTS/v1.0/UBL-conformance-to-CCTS-v1.0.html.
14. National Information Exchange Model Naming and Design Rules, (2020). https://niem.github.io/NIEM-NDR/v5.0/niem-ndr.html (accessed May 19, 2021).
15. Jelisic, E., Ivezic, N., Kulvatunyou, B., Nieman, S., Oh, H., Babarogic, S., & Marjanovic, Z. (2020, August). Towards Inter-Operable Enterprise Systems–Graph-Based Validation of a Context-Driven Approach for Message Profiling. In IFIP International Conference on Advances in Production Management Systems (pp. 197-205). Springer, Cham.
16. Machine Learning Crash Course, https://developers.google.com/machine-learning/crash-course (accessed January 30, 2022).
17. OAGIS - Express Pack Presentation,https://oagi.org/Resources/TrainingVideos/tabid/180/Resources/TrainingVideos/ExpressPacks/tabid/322/Default.aspx (accessed January 11, 2022)
18. International Standard Industrial Classification of All Economic Activities (ISIC) Rev. 4. https://ilostat.ilo.org/resources/concepts-and-definitions/classification-economic-activities/ (accessed October 20, 2021)