Generic data models for Semantic e-Government interoperability: Literature Review

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Abstract. Interoperability of e-government systems is suggested to increase transparency, efficiency, effectiveness, and customer service in the public sector. Generic data models are often seen as a way for achieving especially semantic interoperability. To assess how the contemporary data models support semantic e-government interoperability, we reviewed literature on data models suggested for the public sector in light of four features: standard modelling language, entity-relationship modelling, vocabulary for data exchange and methodology. The review contributes previous research by introducing a four-feature framework for assessing capability of e-government data models to enhance interoperability and by providing an up-to-date review of the generic data models for this purpose.

Keywords. Data Model, Information Model, Interoperability, Public Administration

Introduction

E-government and electronic governmental services require good information system interoperability, which increases government transparency, efficiency, effectiveness, co-operation and information exchange among governmental organizations [8, 10]. Also, positive effects on service quality for citizens and other stakeholders are mentioned [29, 30]. European Interoperability Framework (EIF) defines the concept of interoperability as the ability of disparate and diverse organizations to interact towards mutually beneficial common goals, including the sharing of information and knowledge between the organizations, through the business processes they support, by exchanging data between their respective ICT systems [8].

Moreover, in the context of public administration, EIF describes four interoperability levels: legal interoperability, organizational interoperability, semantic interoperability and technical interoperability [8]. However, two recent studies [10, 30]

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reviewed public administration interoperability initiatives and denoted the lack of common conceptual frameworks and interoperability success factors.

In this paper, we aim for shedding more light on the issue of semantic interoperability. In semantic level, interoperability is pursued by the meaning of data elements and the relationships between them [8]. One way to ensure semantic interoperability is to create a common information model which defines the central concepts, their attributes and relations [15]. In this paper, information model is seen as a representation of entities, attributes and relationships among entities. It is independent from physical implementation, and it should be developed using a formal modelling language [18].

When analyzing how data models can enhance semantic interoperability, it is important to further determine the types of data models. In [25], Peristeras et al. reviewed the model-driven initiatives for public administration interoperability. They have divided the model-driven initiatives into three categories: Data initiatives (focusing on object/entity modeling), process/service initiatives (focusing on process and service modeling) and organizational modelling (modeling organizational issues). However, we need to update this information in part of the data initiatives, searching for the latest generic data models and assessing how they support the semantic interoperability of public administration.

In this paper, the focus is on generic data models, because of their wide utilization possibilities. According to Peristeras et al. [25], a generic data model is an abstract model that covers the overall public administration domain. They can also serve as a basis for conducting lower level or domain specific models, such as Geographic Information Systems (GIS) [1] in the technical domain and Health Level Seven (HL7) [6] in the health care domain. However, these domain specific models are not included in this review, because of their more limited generalization possibilities in organizational level.

According to Peristeras et al. [25], data models can also be defined with regard to their application scopes, and can act as a the basis for either a single information system, a number of domain information systems, or as a basis for whole organizations' information systems. Accordingly, the authors have defined three scopes for data model scalability: 1) Global, 2) National and 3) Sub-domain level (e.g. ministry or local authority). The global level means that data models can be applicable and reusable across different countries, the national level refers to applicability within one country. Sub-domain level means that a data model is applicable inside one organization.

Based on the knowledge presented above, our review addresses the following research question:

1. How do the generic data models found support the interoperability of public administration in sub-domain, national and in global level?

The article is structured as follows. Review scope and process is presented in section 2 and section 3 establishes four success factors to analyze how existing generic data models can enhance semantic interoperability. The results of this review are presented in section 4 and finally, section 5 discusses the research contributions and outlines possible avenues for further research.

1. Review Scope and Process

This literature review focused on generic data models for public administration, encompassing both government and municipality organizations. These data models could be developed for the use of one organization or multiple organizations, nationally or globally. Actual use experiences were not required. We followed the review in following:

Identifying the purpose of the literature review: The topic and the purpose of this review address the area of interoperability in public administration. The interest is especially in semantic interoperability – How the current generic data models are able to support this interoperability area. For evaluating this, we generated four-feature framework to assess the specific features which are assumed to have a positive effect on semantic interoperability.

Forming clear research protocol: This phase documents the research stages in detailed level, and provides instructions for searching, screening, extraction and synthesis. As a part of this phase and also for identifying the data models which are genuinely applicable for more than one operational area in public sector organization, we formed content criteria for analyzing the content of the papers: 1) Data model is a generic data model, 2) Data model is developed for public administration, 3) Data model is developed to support either one organization or multiple organizations nationally or globally.

We used the key concepts and their combinations as search terms. Moreover, we limited our search to academically reported material and chose academic databases for literature searches based on the topic of the database (information technology) and also for the commonness of database. The chosen databases were IEEE Xplore, SCOPUS (Elsevier) and ACM Digital Library. In addition, Google Scholar was used for complementing the search results.

Searching for the literature: The search terms used were "interoperability" AND ("information model" OR "data model") AND ("public sector" or "government" or "e-government" or "eGovernment" or "municipality" or "public administration"). The publication year range was limited to 1980-2013 and the searches were conducted for all contents, both metadata and content. Document type was restricted to peer-reviewed conference publications and journal articles, paper length at least 6 pages. Moreover, language of the papers was limited to English. Because of the large number of database hits in several search terms, we had to limit the practical screening to concern no more than hundred articles per search. Results of the queries are presented in Table 1.

Table 1. Search Results Overview

Academic databases and search engine	Hits in total	Relevant based on practical screening	Relevant based on quality appraisal
IEEE Xplore – IEEE/IEE Electronic Library	1	1	0
Scopus (Elsevier)	208	16	4
ACM Digital Library	290	9	2
Google Scholar	42	8	1
Hits in total	**541**	**34**	**7**

In *Practical screening* we reviewed the suitability of title and abstract against the content criteria. If the paper met each criterion, it was selected for quality appraisal. During this phase, the notable decrease in the number of papers was mainly due to first point of content criteria; the data model had to be general and thus not domain-specific. Consequently, data models generated for example for health care or geographic information purposes were not taken into a further observation.

During the *quality appraisal*, we observed the quality of the articles which passed the previous phase. At first, we ensured that articles certainly met the content criteria. This was already observed in practical screening, but also verified here. Secondly, we ensured that the preconditions described in Searching for literature phase (e.g. requirement for paper peer-reviewing, minimum page amount) were met. Hence, separate scoring of the methodological quality was not conducted [22]. While examining the papers which passed the quality appraisal, we also discovered original sources and in this way enriched and complemented our selection of literature.

Data extraction phase was conducted by analyzing each article. During the data extraction, we assessed how the data models found supported the interoperability aims of public administration organization. In the *synthesis phase*, we conducted the conclusions, assessed how the research question could be answered and finally deduced some possible implications for future research. The review was written in parallel with each of the previous stages.

2. Four-feature Framework for Assessing Semantic Interoperability

Based on the literature review, we assessed the features of found data models, which are reported to have positive influence on interoperability, standardization and utilization of existing standards are highlighted in several studies [2, 3, 8, 11, 27, 29, 30]. Furthermore, the importance of organizational issues over technical ones is proposed in [16, 29]. In opposite to these advancing factors, also some constraints for interoperability have been reported in research by Scholl & Klischewski [29].

Scholl & Klischewski [29] created a research framework for e-government integration and interoperation. In this framework, they stressed the importance of success factors in integration and interoperation, especially as implications for future research. In their later study [30], the authors utilized the framework by studying several interoperability initiatives in their research project. As a result, they discovered that the lack of interoperability success factors and metrics was still prominent. Also Flak & Solli-Saether stated in [10], that interoperability as a research area lacks a common conceptual framework and thus the understanding of the factors that constitute interoperability is still vague. Altogether, we seem to have a clear gap in current research concerning the interoperability success factors. In this review, we try to address this research gap especially in part of semantic interoperability. For this purpose, we analyzed the existing literature and conducted four features of generic data models, which are based on the literature stated to have positive effect on public administration interoperability, especially on semantic interoperability. These features are:

1. *Using standard modeling language or notation*, enhancing interoperability through common understanding of processes and related information [3, 8, 11, 17, 27, 30, 31]

2. *Modeling and describing relationships between entities*, enhancing interoperability by describing entities and their structures [8, 25]
3. *A separate vocabulary to describe data exchanges*, influencing interoperability by ensuring agreed values or terms are used and they follow a specific format or pattern [5, 8]
4. *Agreed procedures and methodologies for developing generic data models or other interoperability assets*, influencing interoperability by ensuring the correct understanding and utilization of data models through specific instructions [8].

In addition, the importance of organizational issues was brought up in several studies [10, 16, 30], but we did not found enough evidence or exact definitions from the literature for including this factor in our framework. In this review, we analyzed the generic data models found in light of the above criteria (four-feature framework).

3. Results

The results of this review are divided into 1) an overview of the generic data models found, 2) analysis in light of the four features as defined above and 3) a summary of the findings.

3.1. Generic Data Models

To aid the examining of the data models found, we divided the models in to two main groups. First group is national and sub-domain data models, which are developed for the purposes of one country or one organization. Although they are often developed from the viewpoint of a single interest group, they are often based on some other general data or information model or an interoperability framework [8, 23]. Moreover, some of the models intended mainly national, are used as a backbone of some other national models. The second group is global data models, which are developed for the use of multiple governmental organizations world-wide.

Under these two categories, we further divided the data models into three categories, based on their properties and representation style. First sub-category is ER-based initiatives, which are often represented for example using UML notation. The second sub-category is metadata initiatives, which are mostly based on Dublin Core metadata model [25]. According to Shukair et al. [31], several countries have their own standard for metadata descriptions, often based on Dublin Core. The third identified group is ontologies which are intended to support interoperability aims by assuring semantic compatibility [26]. Ontologies are often represented in a standard machine understandable language, like OWL (Ontology Web Language) which is a standard and recommendable language developed by W3C [33]. OWL has also a set of sublanguages intended for other levels of complexity [27].

The next table (Table 2) presents the found data models in general level, providing further references for more detailed information:

Table 2. *Summary of the found data models*

Data model	Description
ER-based initiatives:	
UK Government Common Information Model (GCIM) [21, 25]	ER-based high level data model for all public administration's activities. It is a part of the UK e-Service Development Framework. The model emphasizes the concept of interaction [21, 25].
Federal Enterprise Architecture (FEA) [32]	FEA is a framework for federal government, developed in United States by the Office of Management and Budget's, Office of E-Government and Information Technology. FEA is strongly a business-driven model [32].
The Governance Enterprise Architecture (GEA) [24]	GEA is a technology neutral model which describes the business context and the business relationships of public administration domain. It is a top-down model consisting of two mega-processes: Public Policy Formulation and Service Provision [25].
Fidis [9]	FIDIS (Future of Identity in an Information Society) is an excellence group funded by the European Union's 6th framework programme. They concentrate mainly on identity management and from this point of view; they have also formed a development method and a framework for interoperability of information systems. Among the other deliverables, FIDIS provides best practice guidelines to incorporate the development method and framework into practice. The method and its framework are divided into four domains, like the business modelling domain, described in ER modelling language [9].
Metadata initiatives:	
Dublin Core metadata model and Dublin Core-based metadata models [5]	Dublin Core is one of the most influential and domain independent metadata standard managed by the Dublin Core Metadata Initiative (DFMI) [3]. Dublin Core-based e-GMS standard for metadata management (e-Government Unit, 2006) and it is developed as a part of e-GIF Framework. E-GMS describe several metadata elements and their level of obligation, aiming to support information resource discovery, management and digital preservation [7].
ISO 11179-based metadata models [14]	ISO 11179 is a standard for metadata registries. Metadata registries address the issues like the semantics of data, representations of data and the registrations of the data descriptions. According to Shukair et al. [31], two notable examples of ISO-based metadata models are DESIRE [12] and CORES [13].
Ontologies:	
Knowledge management system [28]	A web-based knowledge management system which aids the service provision. The main component of their system is a knowledge portal, which consist of two components: public administration ontology and RDF metadata repository [28].
The Dip eGovernment Ontology [4]	A domain ontology for public administration, using Operational Conceptual Modelling Language (OCML). The ontology models a wide range of information and services, although, its deficiency is that it is stated to be only a taxonomy, not a thoroughbred ontology [4, 25].
WebDG Ontologies [20, 25]	WebDG Ontologies have been developed in Computer Department of Virginia Tech, as part of Web Digital Government project. The ontology is centered on two main features: composing e-government services and ensuring privacy of the services [20, 25].
A semantic framework for Public Administration services	In this framework, Life Event (LE) is a central concept, in orchestrating one-stop government services [27].

[27]

Public Service Ontology [19]	Public Service Ontology was developed with the primary goal of providing a standardized, formal, unambiguous, reusable and extendable way of presenting public services [19].

3.2. Data Model Support for Interoperability

We analyzed the data models against the four features to see how each model supports semantic interoperability. In addition, we evaluated the differences between the national and global data models in supporting these interoperability features.

Support for using standard modelling language or notation: To enable interoperability, use of standard language or notation is often seen important [3, 8, 11, 27, 29, 30]. According to Benguria and Larrucea [2], the proliferation of different standards and formats is the main barrier for interoperability between organizations. When observing the found data models against this feature, only GCIM and GEA models have considered this aspect. Both of the models are ER-based, however GCIM's ER orientation is much stronger. GCIM is an object based model, with the strong idea of reusing general elements and patters, avoiding reinventing the wheel [20]. GCIM provides a wide variety of ready-made diagrams to employ, like use cases, activity diagrams and class diagrams. The notations are explained in detailed level which aids the utilization of ready elements and patterns even more.

The viewpoint in GEA is more on processes, and it doesn't provide as wide support for modelling initiatives than GCIM. GEA also utilizes GCIM and broadens it by including the knowledge aspect into the public administration domain model. Authors have also made some adjustments to presented objects [24]. In ER-based models, FEA also includes a data model in UML notation, but it is considered more as an abstract data model, without any concrete examples of public administration domain. This is why FEA model is considered not to possess support for using standard modelling language or notation.

Support for modelling and describing relationships between entities: All the observed data models described the relationships between different entities, although in different manners. ER-based models described the relationships by using both graphic and textual illustrations, whereas metadata models and ontologies described the relationships by textual means. In metadata models, relationships were often modelled also in related XML or RDF schemas [13]. In addition, the following two ontologies modelled the relationships with the help of the OWL (Ontology Web Language): Knowledge management system [28] and semantic framework for public administration services [27]. Although, this article criticized OWL for some shortcomings in modelling relations [27].

The DIP eGovernment Ontology presents the relationships by describing the classes, subclasses and inheritance of properties. Because The DIP eGovernment Ontology is mainly a taxonomy, the relationships are described only in a superficial manner. In this review, we do not evaluate which way of describing the relationships is the most descriptive and useful, they are considered as equal.

Support for separate vocabulary to describe data exchanges: For supporting the semantic interoperability, the existence of separate vocabularies or data dictionaries

to describe data exchanges is seen as an important attribute [8]. GCIM includes a specific vocabulary in which the key terms of the model are described. Also in the viewpoint of technical implementation, GCIM has code sets and related vocabularies as reusable resources. GEA and FEA models recognize also a vocabulary and in GEA, the viewpoint is mostly technical implementation. In ER-based models, FIDIS is the only model which does not include a separate vocabulary.

In metadata models, vocabularies are usually expressed in vocabulary encoding schemes, where values for the data elements are from controlled vocabularies (e.g. ADLS, e-GMS, Desire, Cores, Canadian metadata model). A data element can be for example a class, a property, a vocabulary encoding scheme or a syntax encoding scheme [5]. In addition to permitted values, encoding schemes ensure that the values conform to a specific format or pattern. An RDF schema can be used to describe a vocabulary, using an RDF Vocabulary Description Language which is the case in DESIRE and CORES models. Dublin Core metadata model has defined a DCMI Type Vocabulary to categorize the nature or genre of the resource. This is done with the help of the set of classes specified in the DCMI Type Vocabulary.

Although both ER-based and metadata models are using vocabularies to obtain semantic interoperability, they are pursuing it by using different approaches. Whereas in ER-based models vocabularies are often in appendixes or in other list-based files describing the exact meaning of a specific term, metadata models are using vocabularies to ensure that the right values are given to the elements.

Ontologies are considered essential in the area of e-government, as they state an agreement to adapt a specific vocabulary in a coherent and consistent manner. Ontology can also be understood as a vocabulary itself [4].

Support for agreed procedures and methodologies: In this review, with support for agreed procedures and methodologies we mean that a data model includes some instructions to guide the utilization of the data model. Instructions can be either textual descriptions, a numerated list of development phases, or formal and reusable models, like various diagrams. GCIM model aids the developers by providing a preferable order for GCIM classes and separate descriptions for each class. There are also a separate checklist to go through, ensuring that all development phases are taken into consideration. Furthermore, common frameworks for each service interaction are provided. Another ER-based data modeling initiative that takes the agreed procedures and methodologies into account is GEA. GEA guides the development of a description of the overall governance system, by introducing the GEA object model for overall governance system. Authors stated that this model covers a path which leads from the conceptualization of administrative action to the realization and process execution in the real world [24].

In ontology-based data models, we consider that WebDG Ontologies includes the issue of providing support for agreed procedures or methodologies. This is due to in-depth descriptions of standards and technologies used in implementation, and a comprehensive WebDG architecture. Moreover, the issue of semantic composability is addressed. In addition to this ontology, Knowledge Management System [28] and Semantic Framework for Public Administration Services [27] also contains detailed implementation descriptions, so we consider also these data models as supportive for this interoperability feature.

Table 3. Generic data models, their sub-categories and support for interoperability

Scope of the data model	Sub-category of the data model	Using standard modeling language or notation	Modeling and describing relationships between entities	Separate vocabulary to describe data exchanges	Agreed procedures and methodologies
National data models:					
GCIM	ER-based initiatives	x	x	x	x
FEA	ER-based initiatives		x	x	
Dublin Core-based national metadata models	metadata initiatives		x	x	
Knowledge management system [28]	ontologies		x		x
Global data models:					
GEA	ER-based initiatives	x	x	x	x
FIDIS	ER-based initiatives		x		
Dublin Core metadata model	metadata initiatives		x	x	
ISO 11179-based global metadata models	metadata initiatives		x	x	
The Dip eGovernment Ontology	ontologies		x	x	
WebDG Ontologies	ontologies		x		x
A semantic framework for Public Administration services [27]	ontologies		x		x
Public Service Ontology	ontologies		x		

3.3. Findings

We aimed for discovering generic data models, which have a positive impact on public administration interoperability. Although we searched academic papers from three well-known databases and from one comprehensive search engine, among the 541 hits

we found only seven papers, which passed the quality appraisal phase (see Table 1). However, these papers led to the secondary sources in which additional generic data models were reported. The found data models are summarized in Table 2.

During the analysis of data models, we observed a total lack of papers describing data models in sub-domain level. This may be caused by the lack of motivation for single organizations to report their internal models and standards in academic resources, even if the organization is global. When combining our presentation categorization and the scope categorization we noticed that the amount of national and global data models is quite similar in ER-based initiatives. Several countries have their own metadata initiatives and thus, these are more popular in national context, although they are often based on a global standard, mostly in Dublin Core. In ontologies instead, there are more global models in use than national ones.

When analyzing the utilization of existing data models to create new ones, we noticed, that in addition to re-using existing models inside one sub-category (e.g. ER-based initiatives), there exist also utilization across these sub-category borders. For example, the origins of the Public Service Ontology are on the GEA model. Interestingly, ER-based models are reused more often than metadata or ontology initiatives. This might be due to their holistic nature, which makes them easier to apply in different contexts. Also, commonness of Dublin Core model as a background for both national metadata models and ISO 11179-based models is notable.

To support the analysis of the data models, this paper devised a four-feature framework for assessing capability of data models to enhance interoperability, based on synthesis of previous research. Table 3 summarizes the research results by mapping the individual data models (rows) against the supported interoperability feature (columns). Several observations can be made from this table. At first, ER-based models provide the highest level support for public administration interoperability. In line with the specific definition of information or data model [18], all the models support modeling and describing entities, while only ER models support standard modeling language or notation. GCIM and GEA models support each interoperability feature, while other data models support usually two of them. GCIM and GEA models are holistic models in their nature, and include several re-usable elements derived from business or process perspective. The GEA model is also partly based on GCIM, which explains their consistencies in some extent.

From the Table 3 we can also observe that metadata initiatives and ontologies supported quite similar interoperability features. This similarity may be due to the diagrammatic nature of these models as well as use of formal and machine understandable language that is not oriented towards support for organizational issues and support for using standard modelling language or notation. Metadata initiatives tend to support separate vocabulary to describe data exchanges, as they often expressed the vocabularies by using vocabulary encoding schemes. Ontologies supported better the agreed procedures and methodologies, due to their more formal nature and support for implementation issues. Especially WebDG ontology addressed this feature by using in-depth descriptions of standards and technologies used in implementation.

The technical orientation brings a significant advantage for ontologies, because they are often presented in machine-readable format and are therefore processable at runtime, reducing the chance to misuse or otherwise incorrectly interpret the data model.

In general, the second most supported interoperability feature was a separate vocabulary to support data exchanges. We considered the data model to support this

feature, if it offered a separate vocabulary for describing the semantics of specific terms used in the data model supporting appropriate data exchanges. The third most supported feature is the support for agreed procedures and methodologies. In ER-based data models, the specific modelling guidelines were offered, whereas ontologies included more implementation oriented guidelines. Support for using standard modelling language was rare and mainly taken into account in ER-based data models.

When comparing how the national and global data models support interoperability, we can perceive in Table 3, that there are no significant differences in ER-based models. A comprehensive ER-based model exists in both of these scopes, as GCIM is intended national and GEA as a global model. Also differences in metadata-based models and ontologies between the national and global scopes are minor leading to the conclusion, that there exist no significant differences in ways that national or global data models support interoperability in public administration. The research question is answered as follows:

1. How do the generic data models found support the interoperability of public administration in sub-domain, national and global level?

Unfortunately, not any sub-domain level data models were found in our literature review. Data models in national level supported the interoperability by modelling and describing the relationships between entities, either in UML-based notation (ER-based initiatives), RDF or XML schemas (metadata-initiatives), or in Ontology Web Language (ontologies). Several national data models also supported a separate vocabulary to describe data exchanges, either by textual descriptions or by using vocabulary encoding schemes, which was a common mean in metadata-initiatives. Support for other two features was pursued by the means of textual instructions and UML-diagrams, interrelated reference models and detailed descriptions about the implementation.

In global level, interoperability is mainly supported through modelling relationships between entities and by separate vocabularies to support data exchanges. In this level, there are several ontologies, which contribution to interoperability of public administration is both in implementing semantics and assuring the accuracy of technical issues. Altogether, because of the early stated cross-utilization of the presented data models, the means for supporting interoperability initiatives are quite similar between national and global data models.

In summary, there are no significant differences between national and global data models in the way they support interoperability. Therefore, this categorization of data model scalability [25] didn't provide any additional value in this research context. However, it is noteworthy that there are notable divergences between the different sub-categories of data models and how they support interoperability initiatives.
Based on the results of this review, it can be noted that ER-based data models supported our four features of generic data models in most comprehensive way, regardless of the their scope or application area.

4. Discussion and Implications for Future Research

The purpose of this study was to complement the widely studied interoperability research area by evaluating, how generic data models in different scopes support

interoperability in public administration. In addition to generic data models found in [27], we complement this review by adding other data models introduced in the literature and further enriched the existing analysis by investigating how the evaluated models support interoperability objectives. The first contribution of this paper thus is the up-to-date review of the generic data models.

In addition, we devised a four-feature framework for assessing the capability of data models to enhance interoperability, derived from current interoperability literature. This is a response to the lack of interoperability success factors stated by Scholl et al. in [30]. Moreover, Flak & Solli-Saether noted in their research [10], that the evaluation of interoperability has been given only a little emphasis in previous studies. According to them, this might be due to the complex nature of public administration, which causes difficulties in applying traditional performance metrics. They constructed a conceptual model for interoperability, which included also three evaluation categories for interoperability: Technical quality, organizational performance and regulatory compliance. Compared to our four-feature framework, the categories presented by Flak & Solli-Saether in [10] are applicable for interoperability on a general level. In turn, our features are limited to data models. Hence, our four-feature framework complements the research of Flak & Solli-Saether [10].

Our findings indicate, that there are no significant differences between national and global data models in way they support interoperability. More specifically, the results of this review indicate that ER-based data models support the interoperability in a most comprehensive manner, and in this way they should be widely utilized in interoperability initiatives. To diminish the risk for misusing or interpreting the human-readable ER-based data models, ontologies can be used to complement ER models and aid the implementation stages.

For future research, we propose to further develop the conceptual model of Flak & Solli-Saether [10], by defining the evaluation approach cover also the four interoperability levels stated by European Commission in EIF [10]. This would also enable this model to better consider semantic interoperability. Another interesting area of future work would be sub-domain data models: In which extent they exist, in what data model they are based on, and how they support the interoperability of public administration.

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