

Public Service Models: a systematic literature review and synthesis

Alexandros Gerontas, Vassilios Peristeras, Efthimios Tambouris, Eleni Kaliva, Ioannis Magnisalis, and Konstaninos Tarabanis

Abstract—During the last decades, public authorities worldwide have invested heavily in electronic public services (PSs). This includes efforts for publishing information about PSs and for providing online PSs. Each of these efforts is based on an underlying PS Model, i.e. a data model developed for describing and/or developing PSs. Although many PS models exist, none has been universally accepted. This resulted in a fragmented landscape where resources are wasted, economies of scale cannot be achieved, and interoperability is hampered. Recently, the European Union (EU) launched the Core Public Service Vocabulary-Application Profile (CPSV-AP) as a reference PS model. However, CPSV-AP has not been thoroughly evaluated yet for comprehensiveness and compliance with EU policies. The aim of this work is to identify and analyze in a systematic way existing PS models and compare them with CPSV-AP. We conclude that CPSV-AP is comprehensive but can be further enriched with concepts from other PS models. We also provide evidence that the proposed enriched CPSV-AP better supports EU policies. Finally, we present a proof-of-concept pilot of the enriched model using linked data to demonstrate its technical feasibility and value added. Researchers, policy makers and practitioners could use the enriched model for conceptualizing and implementing electronic PSs.

Index Terms—H.2.1.a Data models, I.5.4.e Government, M.4.1.b Metadata of Services Interfaces, M.1.0.b Services Models

1 INTRODUCTION

During the last twenty years, electronic government (eGov) is high in the political agenda of most countries worldwide, e.g. Strategy 2020 in the European Union (EU) and the Recovery Act in the USA. The overall financial investment in eGov is immense.

The electronic provision of public services (PSs) is a core component of eGov. PSs link the government operations with society, directly affecting citizens and businesses [1]. In EU, the online sophistication of twenty important PSs was systematically monitored for many years to benchmark national eGov progress.

To cope with the increased demand, public authorities have developed online PS catalogues where information about PSs is available. They have also developed systems for online PS provision and one-stop portals for integrated PS provision. All these PS catalogues, systems and portals, either implicitly or explicitly, are based on PS data models. These models are sometimes based on national standards or interoperability frameworks. However, in most cases *ad hoc* PS models are used.

We note here that, in this paper, the term *Public Service*

(*PS*) model is used to denote a data model that has been developed for describing and/or developing public services. A PS model contains concepts and may also include relationships between these concepts. For example, title, description, cost etc. are concepts that are often included in PS models.

For many years, academics and practitioners recognize the development of a universally-accepted PS model as both a top priority and major challenge (e.g., see [2], [3], [4]). The relevant benefits include, among many others, more efficient development of eGov systems, better quality public services, reduced development costs, improved software quality, increased users' experience, and improved interoperability [5].

Embracing the need for a standard PS model, standardization bodies such as CEN and W3C have become active in the area without however proposing a concrete PS model. Recently, the EU has introduced the Core Public Service Vocabulary (CPSV) as a modular and extensible PS model. In addition, an application profile (namely CPSV-AP) has been proposed to be used by EU Member States in the implementation of relevant policy (namely, the Service Directive).

CPSV-AP is a promising model; however, it has not been thoroughly evaluated yet. As a result, it is unclear whether it includes all major concepts suggested in the relevant literature. In addition, it is unclear whether, and to what extent, CPSV-AP can adequately support relevant recent EU eGov policies.

The research objectives of our work are: (a) to collect, analyze and present in a structured way the *superset of all concepts of PS models* proposed in the academic literature and applied by national public authorities in real-life set-

- A. Gerontas is with the Applied Informatics Department, University of Macedonia, Thessaloniki, 54636, Greece. E-mail: agerontas@uom.edu.gr.
- V. Peristeras is with the School of Science and Technology, International Hellenic University, Themi, 57001, Greece. E-mail: v.peristeras@ihu.edu.gr.
- E. Tambouris is with the Applied Informatics Department, University of Macedonia, Thessaloniki, 54636, Greece. E-mail: tambouris@uom.edu.gr.
- E. Kaliva is with the Applied Informatics Department, University of Macedonia, Thessaloniki, 54636, Greece. E-mail: eleni.kaliva@gmail.com.
- I. Magnisalis is with the School of Science and Technology, International Hellenic University, Themi, 57001, Greece. E-mail: i.magnisalis@ihu.edu.gr.
- K. Tarabanis is with the Business Administration Department, University of Macedonia, Thessaloniki, 54636, Greece. E-mail: kat@uom.edu.gr.

tings, (b) to examine the *comprehensiveness of CPSV-AP* and further *enrich* it with selected concepts from that superset, and (c) to *implement* the enriched CPSV-AP model using *linked data technologies* and demonstrate its added value.

The concepts' superset presented in this article is aspired to be the main reference and an important tool for any researcher or practitioner working on the field of PS models.

This paper continues in section 2 with background information on PS model standards. In section 3 the research approach employed and the research results are presented. The results include the identified PS models and concepts, an analysis of these concepts, and a proposed enrichment of the CPSV-AP model. In section 4, the implications of our work to eGov research and practice are articulated. Potential usage scenarios, suggesting how the enriched CPSV-AP model supports current EU eGov policies are described in section 5. In section 6, a pilot implementation of the enriched CPSV-AP model is presented. Finally, in section 7 the conclusions are provided.

2 BACKGROUND ON PS MODEL STANDARDS

The development of a standard PS model has attracted attention by standardization bodies, including CEN and W3C. CEN recommends the development of commonly agreed standards for implementing eGov services as a means of achieving interoperability. W3C established the W3C EGOV Interest Group for advancing eGov through W3C technologies. Interestingly, the development and use of a common PS model is among the cases of great interest for this group [6]. So far, however, neither CEN nor W3C has proposed a concrete PS model.

Recently, the European Commission has developed such a PS model, termed Core Public Service Vocabulary (CPSV) [7], as part of the core vocabularies family. A Core Vocabulary is defined as a simplified, reusable and extensible data model that captures the fundamental characteristics of a data entity in a context and syntax-neutral fashion [8]. CPSV initiative's goal is to develop the core vocabulary of a service offered by public administrations. The first CPSV version was released in 2013.

Based on CPSV, an Application Profile was developed in 2014 (henceforth referred to as CPSV-AP). An Application Profile is a specification that reuses terms from other standards, adding more specificity by identifying mandatory, recommended and optional elements, as well as by defining controlled vocabularies to be employed. CPSV-AP was developed by a working group with members that include representatives from 17 EU Member States (Austria, Belgium, Estonia, Finland, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Poland, Slovakia, Spain, Sweden, the Netherlands, and the UK). In this paper we use CPSV-AP version 2.0, which was released at the end of 2016 [9].

The main objective of CPSV-AP is the description of public services and business events for the Points of Single Contact which each Member State had to implement in the context of the EU Services Directive

(2006/123/EC).

The use of CPSV-AP enables European public administrations to:

1. Provide information on public services in a user-centric way, grouped logically into life and business events.
2. Map different data models used in the EU Member States to describe life and business events and PSs to a common model. This enables the portals on which these events and services are published to federate and share information.
3. Improve the Points of Single Contact and enable government portals publishing descriptions of life and business events and PSs in an easy, efficient and interoperable manner through a standard data model.

CPSV-AP can be also used besides the implementation of the Points of Single Contact prescribed by the Services Directive. For example, recently, the European Commission introduced the Single Digital Gateway to reduce the transaction costs incurred by businesses and citizens resulting from searches for information and fulfilling administrative procedures when engaging in cross-border activities. The implementation of the Single Digital Gateway could benefit from the use of a reference PS model across Europe, such as CPSV-AP.

3 APPROACH AND RESULTS

The overall approach and the results of our research are illustrated in figure 1 and presented below.

Step 1. Identification of all concepts used in existing PS models. In this step we first identified PS models proposed in the academic literature (henceforth referred to as *academic PS models*) and national PS models applied in real-life settings (henceforth referred to as *applied PS models*).

The identification of applied PS models was easy, as these are reported in a study published by the European Commission [10]. The identification of academic PS models was more challenging, as no comprehensive review of academic PS models exists. It was therefore decided to employ the systematic literature review methodology proposed by Webster and Watson [11].

In this respect, we first searched Scopus (the last search was conducted in early September 2018) using the following expression:

("public service" OR "online service" OR "electronic service" OR "e-service" OR "one-stop government" OR "joined-up government" OR eGovernment) AND (model OR modeling OR ontology OR vocabulary), in Article title, AND ("public sector" OR "public administration" OR government), in Article title, Abstract, Keywords.

As a result, 179 articles were identified. We then studied their titles and abstracts to evaluate their relevance. This resulted in 35 relevant articles. We performed the "go backward" and "go forward" process to enrich the set of articles. Subsequently, we searched Google scholar using the same search expression. The result of this search was filtered to exclude out-of-scope references.

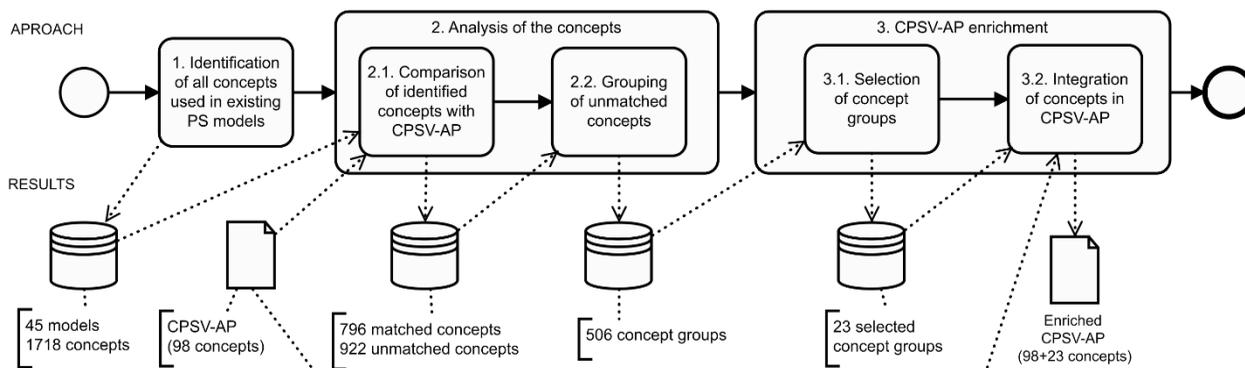


Fig. 1. The steps and results presented using Business Process Model and Notation (BPMN)

In addition, we searched for relevant EU-funded research project deliverables and the ISA/ISA² programmes portal using similar search expressions and exploiting the experience of our research team. From the results, we excluded general purpose service models not specific to the area of public service provision, e.g., Reference Model for Service Oriented Architecture and reference service model for the Web of Services.

It is worth mentioning that our extensive research revealed limited information regarding the influence or the relation between academic and applied PS models. This may be due to the fact that, usually, applied PS models are designed and implemented by IT vendors without disclosing any documentation or details about the underlying PS model or how this was designed. It is possible that, sometimes, there is a reflection of academic research on real-life PS catalogues and PS provision systems. However, this is not explicitly documented.

The final number of relevant documents was 55 comprising of CPSV and CPSV-AP documentation, the EC study presenting applied PS models, two relevant literature review articles ([12], [13]) and 50 articles and project deliverables presenting academic PS models. Due to space limitations, we selected 22 documents to be included in the references list ([14]-[35]). The selection criteria were: (a) the related PS model should be adequately presented in the document, (b) the quality characteristics of the document, e.g., a journal article was preferred over a conference proceedings paper or a project deliverable.

In total, our search revealed 45 PS models besides CPSV-AP. From these, 14 were academic PS models and 31 were applied PS models used in the 28 EU Member States (three Member States have implemented two PS models each). The academic models are shown in Table 1.

All PS models were studied to identify and record their concepts in order to include them in the *concepts superset*. The concepts were extracted manually by the authors, i.e. no automation tool was used. If a model was presented using classes and properties, all classes and properties were considered as concepts. If a model was presented as a set of terms, all terms were considered as concepts.

As a result, 1,816 concepts were identified in total, comprised 98 concepts of CPSV-AP, 294 concepts that appeared in academic PS models and 1,424 concepts that appeared in applied PS models. Thus, 1,718 concepts were identified additionally to CPSV-AP concepts. These concepts are in-

cluded in a spreadsheet file that is used as supporting material to this article and is available on Github [36].

Step 2. Analysis of the concepts. This step contains two sub-steps.

Sub-step 2.1. Comparison of identified concepts with CPSV-AP. Here, the concepts of all PS models were comparatively analyzed using CPSV-AP as a reference model. For this purpose, the authors manually compared all identified concepts to CPSV-AP concepts. This comparison was based on the concept’s name and definition, whenever one was available. A concept was considered as matched with a concept of CPSV-AP if they were semantically close. The comparison of the identified concepts with the concepts of CPSV-AP was a cumbersome and labor-intensive task due to the high volume of identified concepts. In some cases, the team members had to brainstorm to reach a conclusion regarding potential concepts matching.

This comparison revealed that the concepts superset can be divided into two groups: the first set contains all concepts that could be matched to CPSV-AP concepts (termed *matched concepts*) while the second set contains the concepts that could not be matched to CPSV-AP concepts (termed *unmatched concepts*).

The comparison revealed that almost half concepts (796 concepts) were *matched concepts*. These were excluded from further analysis as their semantics are covered by CPSV-AP. For example, the “Public Service” class of CPSV-AP was matched to concepts of academic PS models, such as “Public Service”, “Service”, “Case”, “Administrative Service”, and concepts of applied PS models, such as “Service”, “Service general information”, “Procedure”, “Activity”, “Business activity”, “e-service” etc.

The comparison also revealed 922 *unmatched concepts*. This group of concepts includes 104 concepts that were excluded from further analysis, as insufficient information was provided about them in the relevant documentation. The remaining concepts were retained for further analysis in the next step.

Step 3. CPSV-AP enrichment: This step also contains two sub-steps.

Sub-step 3.1. Selection of concept groups. Here, we formulated a small number of concept groups that met the following inclusion criteria: (1) the group should not be country-specific, (2) it should not be domain-specific, (3) it should be technology-neutral, and (4) it should be present in many PS models.

TABLE 1
THE IDENTIFIED ACADEMIC PS MODELS AND THEIR CONCEPTS

Conceptual PS Model	References	Concepts
Governmental Markup Language (GovML)	[14]	Public Service (identifier, title, language, description, attention, faq-list, eligibility, required-documents, procedure, periodicity, time-to deliver, cost-Info, service-hours, employee-hints, citizen-hints, related-services, audience, public-authority-type, law, result), Life Event
SmartGov model	[15], [16]	Service, Citizen, Business, Organization, Public Authority, Legislation, Cost, Benefit, Quality, Satisfaction, Need, Resource, Strategy, Policy
E-GOV Public Services Ontology (E-GOV PSO)	[17]	Service, Informational Service, Transactional service, Service Consumer, Citizen, Enterprise, Organisation, Municipality, Ministry, Agency, Legislation, Law, Regulation, Life-event, Document, Service Implementation, Informational Service Implementation, Transactional service Implementation, Form
Switzerland Data Model for Public Administration (DMPA)	[18], [19]	Service (Description, Use Type), Informational Service, Communicational Service, Transactional Service, Client, Private, Business, Administrative client, Association, Provider, Support
OntoGov model	[20], [21]	Service Profile (Title, Description, Date, Type, Language, Format, Source, Creator, Contributor, Publisher), Resource, Human Resource, Equipment, Software, Hardware, Law, Amendment, Heading, Topic, Service (Service Name, Service Documentation), Composite Service, Atomic service, Cost, Time Restriction, Security Level, Condition, Precondition, Post Condition, Control Construct, Input, User-defined input, output, parameter, reference, Person, Address, Certificate
FIT Ontology	[22]	Public Service, Process, Backend Process, Front end Process, User, Goal, User Profile, User Behaviour, Log, User Category, User Category Rule, Adaptation, Adaptation Rule, Usability, Backend, FrontEnd, webportal, page, link, text adaptation, graphics adaptation, link adaptation
Governance Enterprise Architecture (GEA)	[23], [24]	Public Service, Social Entity, PA Entity, Service Provider, Consequence Receiver, Evidence Provider, Service Collaborator, Input, Evidence Placeholder, Other Input, Outcome, Consequence, Effect, Output, Law, Precondition, Piece of Evidence, Purpose of Evidence, PA Domain, Administrative Level, Effect Type, Need, Goal
DIP model	[25], [26], [27]	Case, Case Worker, Client, Person, Citizen, Address, Entitlement Provider, Service Provider, Benefit Provider, Agency, Entitlement, Service, Benefit, Entitlement Type, Assessment, Decision, Payment, Eligibility Criteria
OneStopGov model	[28], [29]	Rule, Life Event, Citizen, Citizen Profile, non PA Object Public Service (title, provider, communication channel, authority competence, legal basis, circumstances, time dependencies, initiator, recipient, cost info, delivery time, e-service) PA Document (title, role, issuer, circumstances, refers to)
Access-eGov model	[30],[31]	Service (input, output, precondition, effect, name, description, service provider information, traditional office hours and office location, quality-of-service, security, trust), Life Event, Scenario, Scenario Process, atomic activities, composed activities, abstract activities, activities assigned to human actors, Goal, User Profile, Security Scheme, Fees, Input Form, Output Form, Input Artefact, Output Artefact, Administration (Name, Address, Contact Person, Responsibility, Temporal Responsibility, Spatial Responsibility, Subject-Matter Responsibility, Office hours/Availability, Physical Accessibility Constraints)
Government to Businesses Model (G2BM)	[32]	Service, Process, Business, Organization, Agency, National Agency, Local agency, Type of Agency, Provider, Private Provider, Activity Sector of Business, Industry, Territory, Region, Province, Municipality Precondition, Requirement, Effect
CEN eGovernment Focus Group (CEN eGov) model	[33]	Service, Public Authority, Subject, Location, Standard, Technology
eGovernment Knowledge Interoperability Ontology (eGKI)	[34]	Service, Electronic Service, Web Service, Document, Structured Document, Document Field, Information Public Organization, Public Body, Public Body Department, Information, Information System, Web information system, Civil Servant, Legal Framework, Legal Rule, Legal Element, Event, Action, Transition state
Life Event Ontology (LEO)	[35]	Life Event, Administration, Region, Law, Time, Document, Input document, Output Document, Citizen, Administrative Service (Title, Administrative Description, Deadline, Public Administration, Internal operations)

TABLE 2
THE ADDITIONAL SET OF CONCEPTS

Concept	Freq	Definition/Description
Additional content	44	Includes additional sources of information, notes, FAQs and possible attachments about the PS
Appeal-Complaints	5	Information about the constituents' right to object to a governmental decision relevant to the PS
Availability	11	The time period during which the PS is provided [GovML]
Base Registries	4	The URIs of the base registries that provides necessary data for the execution of the PS
Channel Address	3	The address of the channel where the PS is provided
Channel E-mail	20	E-mail address(es) for contacting the channel personnel responsible for PS provision
Channel Name	11	The name of the channel for PS provision
Channel Phone	22	Telephone address(es) for contacting the channel personnel responsible for PS provision
Comment	2	The text of any feedback provided about the PS
Consequence	1	Information about the executed PS that needs to be forwarded to interested parties [GEA]
Creator	7	Information about the creator of the PS description
Deadline	7	The deadline for submission of an application for obtaining a PS.
Description	10	A description of the Competent Authority of the PS
Feedback	4	Hosts any type of feedback about the PS (e.g., concerning PS description, PS provision, etc.)
Last updated	12	The date of the last update of the PS description
Need	2	The needs of the societal group that the PS is targeting
Potential Consumer	30	Information about the potential consumer of the PS
Potential Consumer Name	2	The name of the societal group (ideally a value of a taxonomy) that the PS is targeting
Process	28	The steps followed during PS provision [eGKI] (ideally provided in machine-readable format)
Profession	3	The profession that the PS is targeting
Purpose of Evidence	1	The purpose served by a piece of evidence [GEA]
Rating	3	The rating of the quality of the PS description (e.g., 5-scale rating)
Service URL	15	The URL related to the execution of the PS

The selection revealed 23 concept groups. For each group, a representative name was selected. As a result, the analysis revealed a set of 23 *additional concepts* not currently included in CPSV-AP. We should note here that concept *Consequence* was selected although it can be considered as a case of the relationship *related* in the existing CPSV-AP model. Nevertheless, it is included as a separate concept due to its importance.

The list of additional concepts including a definition and/or description is presented in Table 2 in alphabetical order. This table further indicates the frequency of appearance of each additional concept in academic and applied PS models.

Sub-step 3.2. Integration of selected concept groups in CPSV-AP. Here, we integrated the concepts identified in the previous sub-step in the CPSV-AP model. The output of this step was the *enriched CPSV-AP model*.

More specifically, we first decided whether the additional concepts selected in the previous sub-step could be integrated as properties in an existing class or should constitute a new class. As a result, ten concepts were included as properties of class *Public Service*, one as property of class *Public Organization*, two as properties of class *Evidence* and five as properties of class *Channel*. In addition, two concepts were selected as new classes namely, *Potential Customer* and *Feedback*. Furthermore, three concepts were included as properties of the new class *Potential Customer* and two concepts as properties of the new class *Feedback*. Finally, for completeness, two new properties (namely *ID* and *Description*) were added to the class

Potential Customer and two more properties (namely *ID* and *Date*) were added the new class *Feedback*. All new classes and properties are optional, extending without modifying the CPSV-AP schema.

The enriched CPSV-AP model is depicted in figure 2 as a UML class diagram. In this figure, new classes and new properties are surrounded by shadowed rectangles.

4 IMPLICATIONS FOR RESEARCH AND PRACTICE

This article provides researchers and practitioners with a systematic review of academic and applied PS models that can serve as a conceptual basis for any relevant academic work or application development.

The identification and analysis of all concepts proposed in academic and applied PS models, provides a better understanding of the domain's focus by clearly demonstrating the most influential concepts in PS modeling.

The proposed superset of concepts can be highly reusable for a variety of purposes.

First, it could be used as the starting point for any relevant academic research.

Second, it could be used by public authorities intending to develop or enrich an online PS catalogue.

Third, it could be used as the basis for any PS provision application or eGov information system. For example, it can be used as a blueprint by public agencies at all administrative levels intending to develop a PS provision system. This is particularly true as the published concepts superset can be customized to cover virtually any specific

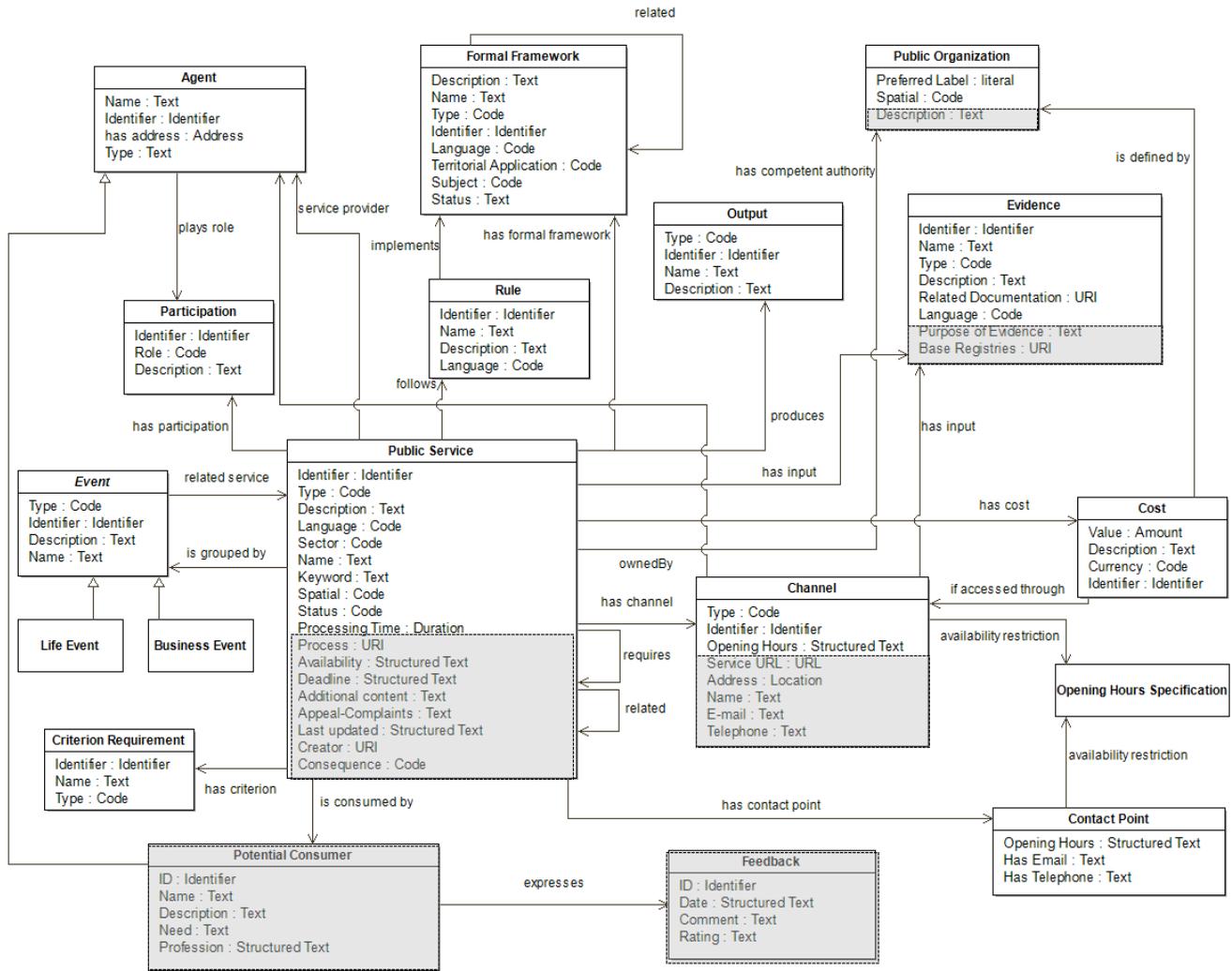


Fig. 2. The enriched CPSV-AP model

need.

Fourth, it could be used as a basis for domain engineering or for developing Governmental enterprise architectures particularly for the PS provision domain. Here, our results can be used in every phase of the domain engineering process, such as when developing a reference architecture for the PS provision domain, and when developing reusable software components for that domain.

5 EUROPEAN UNION POLICY SUPPORT

The new European Interoperability Framework (EIF version 3) [37] and the EU eGovernment Action Plan 2016-2020 [1] are fundamental policy documents where EU eGov priorities are presented. In this section, the relationship between some of the proposed additional concepts and the EU eGov priorities is explored based on a number of potential **usage scenarios**. The notation that is used for the names of the concepts is *class: property*.

First, the *underlying principle 6: user-centricity* of the new EIF puts emphasis on user needs (see EIF recommendation 12). Additionally, the coordination function, which is a basic component of the conceptual model of

EIF for integrated PS provision, comprises the following phases: need identification, planning, execution and evaluation. Furthermore, the eGovernment Action Plan emphasizes that efficiency and effectiveness of public administrations should be improved by making digital public services needs-based and user-friendly. The aforementioned policy priorities are supported by the following usage scenario.

Usage Scenario 1: Systematically organize PS consumer needs. In line with the above principle and policy priority, the concept “*Potential Consumer: Need*” collects information about user needs. The use of this concept is two-fold. Citizens could declare their needs and public administration could collect and organize them, for example in a taxonomy or a controlled vocabulary. This information could be exploited from online dialogue platforms, including chatbots, for better understanding which PS is relevant to specific needs. Thus, it could improve PS bundling and increase PS findability.

Second, in the EU eGovernment Action Plan 2016-2020, it is mentioned that the European Commission will transform its websites into a *thematic, user-centred* web presence. Additionally, the European Commission will en-

hance EURES European Job Mobility portal with more services for job seekers and employers, *facilitating the mobility of job seekers in the EU*. Moreover, the Action Plan prompts for *personalized provision of public services*. These policy priorities are supported by the following two usage scenarios.

Usage Scenario 2: PS discovery according to potential service consumer's profession. In view of this priority, the concept "*Potential Consumer: Profession*" could be used for the categorization and bundling of public services according to a specific profession. This can be exploited independently or as an additional categorization criterion thus improving PSs findability. Moreover, a pan-European taxonomy or a controlled vocabulary of professions could be adopted facilitating cross-border provision of public services. Towards this direction CPSV-AP can offer a liaison with relevant standards.

Usage Scenario 3: Personalized PS provision. Similarly to "*Potential Consumer: Profession*" concept, the concept "*Potential Consumer: Name*" offers a potential categorization of PS target groups facilitating public services findability. Some examples of such categories of constituents include elderly, disabled, immigrants, etc. Furthermore, the systematic profiling of *Potential Consumer* could enable personalized and proactive PS provision that can support the vision of *no-stop government*. In our view, the *Potential Consumer* concept has the potential to attract more attention in future PS provision.

Third, the *underlying principle 6: user-centricity* of EIF puts emphasis on *citizens' participation* to analysis, design, assessment and further development of PSs (recommendation 12). The aforementioned policy priority is supported by the following usage scenario.

Usage Scenario 4: Promoting public services co-design aiming to constant improvement. The concept "*Feedback: Comment*" facilitates the co-design of PSs. It gives the opportunity to stakeholders to participate by providing comments and proposals regarding both PS description and execution. Furthermore, the concept "*Feedback: Rating*" facilitates feedback provision from PS consumers thus promoting constant PSs' improvement. Feedback regarding PS quality could be an important ingredient of the Total Quality Management action plan of every Public Organization.

Fourth, in the framework of the *underlying principle 6: user-centricity* of EIF, recommendation 13 highlights that *citizens should be asked once-only and relevant-only information*. The *once-only principle* is also highlighted as a top priority at the EU eGovernment Action Plan 2016-2020. Additionally, EIF recommendation 39 advises to match *base registries* with appropriate metadata. The aforementioned policy priorities are supported by the following two usage scenarios.

Usage Scenario 5: Promote Once-Only Principle in PS provision. The concept "*Evidence: Base Registries*" facilitates base registries governance as it potentially associates a PS with one or more base registries. A part or all input (aka *evidence* in CPSV-AP terminology) needed for the execution of a PS could be fetched from one or more base registries. This can result in the reduction or even elimination

of documents required as input for the execution of a PS. Efficient base registries management and interoperability could facilitate the automatic acquisition of required evidence (e.g., data or information) for the execution of a PS, promoting the *Once-Only Principle*. Thus, "*Evidence: Base Registries*" concept is also related with the simplification and the reengineering of PSs execution.

Use Case 6: Promote Relevant-Only Principle in PS provision. The concept "*Evidence: Purpose of Evidence*" is inline with the principle that citizens should be asked related-only information. *Purpose of Evidence* is defined as "*the purpose served by a piece of evidence*" in GEA PS model. A document (*evidence placeholder*, according to GEA), might include a number of pieces of evidence, for example name, birth date, nationality, etc. Thus, the utility of a document equals the utility of all pieces of evidence included in that document. If a piece of evidence is not necessary for the execution of a PS, it should be removed from the list of required input data. Thus, we argue that this concept could be also exploited for the simplification and reengineering of PS provision in line with the *Relevant-Only principle*.

Fifth, another important dimension of the *user-centricity* principle, appearing in most policy documents, is the *proactive public service provision*. This policy priority is supported by the following use case.

Usage Scenario 7: Proactive public service provision. The "*Public Service: Consequence*" concept provides "*Information about the executed public service that needs to be forwarded to interested parties*" as defined in GEA PS model. We argue that this concept could enable proactive provision of public services, as it may function as the trigger for the execution of another public service. For, example the public service "register of a birth" could trigger the execution of a PS related to the payment of child benefit. Additionally, it provides a connection between public services facilitating the visualization of public services as a graph. Consequently, it facilitates integrated PS governance, as the PSs constituting a life or business event could be organized as a PS directed graph. Thus, it could be utilized for PS reengineering enabling no-stop (proactive) PS provision.

Finally, *EIF Recommendation 28* advises that *public administrations should document their business processes using commonly accepted modelling techniques*. This will facilitate the *Organizational Interoperability* between public administrations. This policy priority is supported by the following usage scenario.

Usage Scenario 8: PS Improvement or reengineering exploiting information technology. The concept "*Public Service: Process*" could be used for visualizing as well as reengineering administrative processes and PS execution using BPMN or other process modeling notation. As a result, more sophisticated, citizen-centric and user-friendly public services could be designed. However, we acknowledge that the explicit documentation and modeling of all different PS sub-cases (or versions [38]) can be a cumbersome task. We thus suggest that the integration of full PS execution logic within a PS model is still an open research issue. However, the incorporation of "*Public Service: Pro-*

cess" concept into PS descriptions could be exploited as a first step toward this direction. We suggest that the information included in this property should be both human-readable and machine-readable adhering with the *Digital by Default* principle of the EU eGovernment Action Plan.

6 TECHNICAL IMPEMENTATION & DEMONSTRATION

To demonstrate the technical feasibility and value of the enriched CPSV-AP model, a proof-of-concept pilot was implemented. In this pilot, we focus on two concepts and their corresponding usage scenarios. The pilot capitalizes on linked open data technologies to facilitate semantic interoperability.

6.1 RDF SCHEMA OF ENRICHED CPSV-AP MODEL

In this section, we present the steps followed to develop an RDF schema of the enriched CPSV-AP model. The starting point was the published RDF schema of CPSV-AP 2.0. This was imported into Protégé tool. Subsequently, we had to integrate in this schema the RDF representation of the additional concepts that we introduced in the enriched CPSV-AP model.

Following the relevant good practices of linked open data research community, we searched in popular linked data vocabularies for existing classes and properties that have identical semantics with our additional concepts. In the cases where an identical concept was found, this was reused. Table 3 presents the additional concepts in our model (left column) along with the URI of the reused concepts (right column).

Concept	URI
cpsv:PublicService class	
Availability	http://purl.org/dc/terms/available
Additional content	rdfs:seeAlso
Last updated	http://purl.org/dc/terms/modified
Creator	http://purl.org/dc/terms/creator
Public Organization	
Description	http://purl.org/dc/terms/description
Channel	
Service URL	http://schema.org/serviceUrl
Address	http://schema.org/serviceLocation
Name	http://purl.org/dc/terms/title
E-mail	https://schema.org/email
Phone	https://schema.org/telephone
cpsvext:PotentialConsumer class	
ID	http://purl.org/dc/terms/identifier
Name	http://purl.org/dc/terms/title
Description	http://purl.org/dc/terms/description
Profession	http://schema.org/jobTitle
cpsvext:Feedback class	
ID	http://purl.org/dc/terms/identifier
Date	http://purl.org/dc/terms/created
Comment	http://purl.org/dc/terms/description
Rating	https://schema.org/ratingValue

Table 3. The properties that were reused for the definition of additional concepts

Despite our efforts to reuse concepts already published in linked data vocabularies, there were still a small number of additional concepts where identical published concepts could not be found. In order to define those additional concepts, we first introduced a new namespace, specifically for the purposes of this pilot implementation. The name of the namespace is *cpsvext* and its URI is <http://data.dai.uom.gr:8890/PublicServices/cpsvap-extension/>.

Consequently, the additional concepts were defined in RDF. Table 4 presents these concepts. In the case of properties, the relevant range and cardinality is also provided.

URI	Range	Cardinality
cpsv:PublicService class		
cpsvext:process	foaf:Document	1..1
cpsvext:hasPotentialConsumer	cpsvext:PotentialConsumer	n..n
cpsvext:deadline	DateTime	0..1
cpsvext:appeal	foaf:Document	0..1
cpsvext:consequence	cpsv:PublicService	0..n
cpsvext:baseRegistry	URI	0..n
cpsvext:purposeOfEvidence	Text	1..1
cpsvext:PotentialConsumer		
cpsvext:need	Text	0..n
cpsv:expresses	cpsvext:Feedback	0..n
cpsvext:Feedback class		

Table 4. The newly defined additional concepts

A part of the RDF schema, which includes the definitions of one class and one property, is depicted in figure 3.

```

@prefix cpsv: <http://purl.org/vocab/cpsv#> .
@prefix cpsvext:
<http://data.dai.uom.gr:8890/PublicServices/cpsvap-extension/>

cpsvext:PotentialConsumer a rdfs:Class ;
  rdfs:label "PotentialConsumer"@en ;
  vann:usageNote "Optional class. This class provides information about the potential consumer of the PS."@en .

cpsvext:hasPotentialConsumer a rdf:Property ;
  rdfs:label "hasPotentialConsumer"@en ;
  vann:usageNote "Cardinality [n..n]. Links the PublicService with the PotentialConsumer."@en ;
  rdfs:domain cpsv:PublicService;
  rdfs:range cpsvext:PotentialConsumer.
    
```

Fig. 3. A part of the RDF schema including some of the additional concepts

The complete RDF schema of the enriched CPSV-AP is available on Github [36].

6.2 ENRICHED CPSV-AP DEMONSTRATION

We now demonstrate *usage scenario 2*, involving the con-

cept “Potential Consumer”, and usage scenario 7, involving the concept “Public Service: Consequence”. The usage scenarios are presented in detail in the previous section.

The pilot implementation utilizes two sets of PS descriptions from two real-life PS catalogues.

For usage scenario 2 we utilized 45 PSs already published in an RDF store as CPSV-AP compliant linked data, as part of previous research. Here, we added RDF data for the additional concepts that are present in the enriched CPSV-AP model.

To demonstrate the added-value of Potential Consumer concept we use linked data technologies to answer the following questions:

- i) What is the cost and processing time of all PSs concerning a particular societal group, e.g. plumbers;
- ii) what is the population and geographical area covered by these PSs?

To answer the first questions, the following SPARQL query was applied to the SPARQL endpoint (URL: <http://data.dai.uom.gr:8890/sparql>):

```

prefix cv: <http://data.europa.eu/m8g/>
prefix cpsv: <http://purl.org/vocab/cpsv#>
prefix dct: <http://purl.org/dc/terms/>
prefix schema: <http://schema.org/>
prefix profession:
<http://data.dai.uom.gr:8890/PublicServices/id/profession/>
prefix cpsvext:
<http://data.dai.uom.gr:8890/PublicServices/cpsvap-extension/>

select distinct ?ps_name ?cost ?currency ?process_time
from <http://data.dai.uom.gr:8890/CPSV-AP-enriched>
where {
  ?ps a cpsv:PublicService .
  ?ps dct:title ?ps_name .
  ?ps cv:hasCost ?cost_id .
  ?cost_id cv:value ?cost .
  ?cost_id cv:currency ?currency .
  ?ps cv:processingTime ?processing_time .
  ?ps cpsvext:hasPotentialConsumer profession:Plumber .
}
ORDER BY (?ps_name)
    
```

The result is:

ps_name	cost	currency	process time
Announcement of the commencement of a plumber professional activities	15.0	Euro	P1M
Matching the old license of a plumber with a new type of license	400.0	Euro	P15D

Similarly, the relevant SPARQL query and result for the second question follow.

```

prefix cpsv: <http://purl.org/vocab/cpsv#>
prefix dct: <http://purl.org/dc/terms/>
prefix owl: <http://www.w3.org/2002/07/owl#>
prefix schema: <http://schema.org/>
prefix profession:
<http://data.dai.uom.gr:8890/PublicServices/id/profession/>
prefix cpsvext:
<http://data.dai.uom.gr:8890/PublicServices/cpsvap-extension/>
    
```

```

-extension/>

select distinct ?population ?area
where {
  ?ps a cpsv:PublicService .
  ?ps cpsvext:hasPotentialConsumer profession:ElectricalEngineer .
  ?ps cv:hasCompetentAuthority ?auth .
  ?auth owl:sameAs ?dbauth .
  service <http://dbpedia.org/sparql>{
    ?dbauth
    <http://dbpedia.org/ontology/populationTotal>
    ?population .
    ?dbauth
    <http://dbpedia.org/ontology/PopulatedPlace/areaTotal> ?area .
  }
}
    
```

population	area
336856	"9203.22"^^<http://dbpedia.org/datatype/squareKilometre>

The first query demonstrates the added value of the concept “Potential Consumer” as described in usage scenario 2 of the previous section. Additionally, the second query exemplify the interlinking of our semantic repository with other semantic repositories, such as DBpedia. We suggest that the union of semantic repositories containing PS descriptions could form the national or even global semantic graph of PS descriptions, enabling PS management in an easier and more efficient way.

For usage scenario 7 we selected four PSs that constitute the life event “Having a baby” as presented in the Greek official portal of public administration in html format. In this case, we had to transform the PS descriptions to linked data and to publish them in the RDF store.

To demonstrate the added-value of the Public Service: Consequence concept, we will use linked data to answer the following questions:

- i) Which PSs are included in the life event “Having a baby”, where the output of one PS is a needed input of another PS?
- ii) Which input documents are required for each PS of this life event?

The SPARQL queries and their results are depicted below.

```

prefix cv: <http://data.europa.eu/m8g/>
prefix cpsv: <http://purl.org/vocab/cpsv#>
prefix dct: <http://purl.org/dc/terms/>

select distinct ?ps_name ?cost ?currency
from <http://data.dai.uom.gr:8890/ERMIS-consequence>
where {
  ?ps a cpsv:PublicService .
  ?ps_consequence a cpsv:PublicService .
  ?ps
  <http://data.dai.uom.gr:8890/PublicServices/cpsvap-extension/consequence> ?ps_consequence .
  ?ps_consequence dct:title ?ps_name .
  ?ps cv:hasCost ?cost_id .
  ?cost_id cv:value ?cost .
  ?cost_id cv:currency ?currency .
}
    
```

ps_name	cost	currency
Granting of childbirth benefit (financial aid)	0.0	Euro
Granting of pregnancy and childbed allowance by Social Insurance Institute (IKA)	0.0	Euro
Supplementary maternity allowances by OAED for women insured at IKA	0.0	Euro

```

prefix cv: <http://data.europa.eu/m8g/>
prefix cpsv: <http://purl.org/vocab/cpsv#>
prefix dct: <http://purl.org/dc/terms/>

select distinct ?ps_name ?required_documents
from <http://data.dai.uom.gr:8890/ERMIS-
consequence>
where {
?ps a cpsv:PublicService .
?ps_consequence a cpsv:PublicService .
?ps
<http://data.dai.uom.gr:8890/PublicServices/cpsvap
-extension/consequence> ?ps_consequence.
?ps_consequence dct:title ?ps_name .
?ps_consequence cpsv:hasInput ?req_doc .
?req_doc a cv:Evidence .
?req_doc dct:title ?required_documents
}
    
```

ps_name	required documents
Granting of childbirth benefit (financial aid)	Application for childbirth benefit
Granting of childbirth benefit (financial aid)	Account excerpt
Granting of childbirth benefit (financial aid)	Insurance Booklet
Granting of childbirth benefit (financial aid)	Birth certificate
Granting of pregnancy and childbed allowance by Social Insurance Institute (IKA)	Application for childbed allowance
Granting of pregnancy and childbed allowance by Social Insurance Institute (IKA)	Account excerpt
Granting of pregnancy and childbed allowance by Social Insurance Institute (IKA)	Insurance Booklet
Granting of pregnancy and childbed allowance by Social Insurance Institute (IKA)	Birth certificate
Supplementary maternity allowances by OAED for women insured at IKA	Application for supplementary allowances

The results indicate that the Potential Consumer of the above life event (presumably the parents of a baby) are requested to submit the same documents multiple times for different PSs. This is potentially interesting when implementing integrated PSs systems.

We should note here that this section aims to present a technical proof-of-concept pilot and not an operational system. We acknowledge citizens and policy makers should not be required to formulate SPARQL queries in order to obtain useful information. An operational system will be required to hide linked data complexity under suitable user interfaces.

7 CONCLUSIONS

A large number of eGov initiatives are related to Public Services (PSs). These include publishing online information about PSs, e.g. in the form of online PS catalogues, as well as providing online PSs. In both cases relevant data models, termed PS models, are used. Despite all relevant efforts, only recently, the European Union has launched a relevant standardization initiative, namely CPSV and published a relevant application profile, namely CPSV-AP. This, however, has not been thoroughly evaluated.

In our work, we started by performing a systematic review of the relevant literature, in order to identify and review both academic and applied existing PS models and record and study their concepts. The review identified 1,816 concepts supporting the claim that the field is both complex and highly fragmented. These constitute a PS concepts' superset, which is a valuable resource for every researcher and practitioner working on PS modeling and provision.

We then proceeded by matching the identified concepts to CPSV-AP. Our analysis concludes that about half of the identified concepts in the superset have a clear match with CPSV-AP concepts. In addition, most of the unmatched concepts appear in just one PS model, which is an indication that they are too specific. We argue that these are strong indications that CPSV-AP is a comprehensive model, which includes most of the popular concepts found in the literature.

The concepts that could not be matched were further analyzed and grouped. The outcome was a set of the most widely-accepted additional concepts. These concepts were subsequently integrated into CPSV-AP. The enriched CPSV-AP data model was presented in both UML and RDF.

As a result, some widely-used concepts were identified that are not included in CPSV-AP, for example *Potential Consumer* and *Feedback*. In addition, we provide evidence that the enriched CPSV-AP model is not only inclusive in terms of embracing the relevant literature but also well aligned with contemporary eGov EU policies. Indeed, we were able to provide evidence that the enriched CPSV-AP is well-aligned with the eGovernment action plan 2016-2020 and the European Interoperability Framework (EIF) version 3. Evidence includes a theoretical analysis and a proof-of-concept pilot implementation using linked data technologies.

Potential beneficiaries of our work include all stakeholders involved in PS provision, i.e., citizens and businesses who consume public services, governmental officials who publish and provide public services, policy makers who design public services, and industrial partners who develop information systems to provide such services. For example, governmental officials aiming to develop an online PS catalogue can adopt a template based on our work. In addition, industrial partners can reduce the time needed for systems analysis and at the same time ensure that their systems would exhibit increased interoperability. Researchers working on PS modeling and provision can also use our work as a basis. This includes both the spreadsheet with all PS models and concepts found in the literature and also the enriched CPSV-AP. Finally, we aspire that the additional set of concepts could contribute a useful input to the standardization process and the evolution of CPSV-AP.

However, we acknowledge our research has a number of limitations. First, the literature review has been conducted in English thus, excludes literature written in other languages. Second, the applied PS models represent solely systems developed in EU Member States to adhere to the provisions of the EU Services Directive, thus other applied PS models, particularly from the rest of the world are not included. Third, the pilot implementation is not a real-life implementation; it is rather a technical proof-of-concept pilot. Thus, it cannot be used by citizens or other stakeholders as it lacks a user-friendly interface. Fourth, as the concepts of PS models are sometimes not well-documented in the literature, our understanding of some concepts might not be entirely accurate. Finally, subjectivity is another limitation, as in various stages of the pro-

cess we had to make choices, e.g., when grouping unmatched concepts.

Future work includes the use of the enriched CPSV-AP in domain engineering for developing a reference enterprise architecture for public service provision. Additionally, further enrichment of CPSV-AP, beyond the boundaries of this literature review is another path for future experimentation.

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Alexandros Gerontas holds a Diploma in Electrical Engineering and Computers Technology (5 years curriculum) from University of Patras, Greece, in 1996, an MSc in Communications, Computing & Human Centred Systems from Birmingham University, UK in 2000 and a Master in Business Administration (MBA) from Hellenic Open University, Greece in 2013. From 2016, he is a PhD candidate at the Applied Informatics Department of the University of Macedonia in Thessaloniki, Greece, conducting research in Government Interoperability. He has worked at SONY Europe in UK and at INRACOM in Greece. From 2001, he has been working in the public sector. He is the initiator and the project manager of the “Citizen’s Guide of the Region of Epirus”. This is the first Hellenic regional project to be awarded as best practice at the European Public Sector Award in 2015.



Vassilios Peristeras is Assistant Professor at the International Hellenic University, Thessaloniki, Greece and Associate Research Fellow at the KU Leuven, Belgium. His teaching and research interests focus on the areas of Digital Transformation, Data Science for Business, Business Information Systems and eGovernment. He has worked for the European Commission, Interoperability Solutions for European Public Administration Programme being in charge for semantic interoperability and open data. He has also worked as consultant in the United Nations and as Research Fellow at the National University of Ireland Galway. He has initiated and coordinated several international R&D projects in the area of Electronic Government. He has published over 100 scientific papers and has served as editor, program committee member and reviewer in more than 60 journals, books and conferences. He is Department Editor for AI and Government in the journal

IEEE Intelligent Systems.



Efthimios Tambouris received a Diploma in Electrical Engineering from the National Technical University of Athens, Greece, in 1991 and an MSc and PhD from Brunel University, UK in 1993 and 2001 respectively. In the past, he has worked at the IT industry, at research centre NCSR “Demokritos” and at research centre CERTH/ITI. He is currently Professor of Information Systems and eGovernment at the Applied Informatics Department of the University of Macedonia in Thessaloniki, Greece. During the last twenty years he has initiated, coordinated and participated in several international research projects and service contracts funded by the European Union and the Greek public sector. He has served as an expert in standardization activities at CEN and is an expert for the European Commission. He is associate editor of Government Information Quarterly and co-chair of EGOV/ePart conference. He has more than 150 research publications.



Eleni Kaliva holds a Diploma in Electronic and Computer Engineering with honours from Technical University of Crete (2001), a Master in Information Systems with honours and a Master in Business Administration with honours both from University of Macedonia (2008, 2011). She has over 15 years work experience in managing and monitoring national and European IT projects. She has also served as proposal evaluator for national and European IT projects. Her areas of expertise include information systems, digital economy and e-government.



Ioannis Magnisalis received the BSc degree in mathematics from Aristotle University of Thessaloniki, Greece, and the MSc degree in business systems analysis and design from the CITY University of London. He holds a PHD in the multi-disciplinary field of Information Science and Educational technologies (June 2016, Aristotle University of Thessaloniki, Greece). He is a software engineer working since 1999 and has cooperated with various companies in Greece and Worldwide (e.g. INTRACOM, ERICSSON, SAP). His interests currently focus on applying semantic web technologies, big, open and linked data and web analytics methods for e-government applications.



Konstantinos Tarabanis received an Engineering Diploma in Mechanical Engineering from the National Technical University of Athens (1983), an MSc in both Mechanical Engineering and Computer Science (1984 and 1988, respectively), and a PhD in Computer Science (1991), at Columbia University, New York, NY. He was a Research Staff Member at the IBM T.J. Watson Research Centre, 1991–1994, and was employed by the IBM Corporation as a whole during 1984–1994. He is currently Professor of Information Systems at the Department of Business Administration of the University of Macedonia, Thessaloniki, Greece, where he has taught since 1994, and the Director of the Information Systems Laboratory at the same university conducting research in the fields of electronic government and electronic business. He is also the Head of CERTH/ITI’s eGovernment Research Unit. He received awards from IBM for his work in the field of 3D printing. He was also the recipient of the Best Paper Award at the 1991 IEEE International Conference on Robotics and Automation. In recognition of his work in the field of electronic government, he was the recipient of the Best Paper Award in the eGovernment track at the European Conference on Information Systems in 2000. He served as guest editor of the “Transforming E-Government” issue of the IEEE Intelligent Systems journal in 2009. He has more than 200 research publications in the areas of software modeling and development for the domains of e-government, e-business, e-learning, e-manufacturing.