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Recent Models for Collaborative E-Government Processes: A Survey

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ABSTRACT Many governments worldwide are engaging into digital transformation initiatives to improve efficiency, effectiveness, cost, and transparency. Collaborative e-government processes offer a way to overcome the typical integration and interoperability issues of existing isolated e-government solutions. A study was conducted to help e-government modelers and architects to know current approaches to modeling collaborative e-government processes that consider integration and interoperability. The research questions are: Which kind of representations (architecture, framework, ontology, meta-model, model or process) are used to model these processes? Which concerns (cost, value, citizen, technology, organization) do they focus on? How do they address collaborative processes concepts (interoperability and collaboration)? This article describes the design, execution and results of a Systematic Literature Review (SLR) that gathered primary studies from well-known scientific literature databases, and organized them with a novel literature classification schema consisting of model type, model focus, collaboration scheme, and interoperability level. The initial search found 326 publications, of which duplicates removal and exclusion criteria application left only 52 for detailed analysis. Key findings are: literature for this topic proposes Frameworks and (general) Models, but not metamodels or ontologies; most addressed focus has shifted from Technology and Organization, towards Citizen; collaboration studies have shifted from Open Participation towards Data Transparency; and most work that addresses interoperability remains focused on Technical aspects with a smattering of Semantics and Organizational aspects. These findings reinforce the need for proposals that address the problem of collaborative e-government processes as something that lives at the junction of e-government, software architecture description, collaborative work, and interoperability.

INDEX TERMS E-Government, collaborative processes, interoperability, software architecture.

I. INTRODUCTION

Many governments make extensive use of Information and Communication Technologies (ICT) to support their internal and external processes to improve efficiency, effectiveness, cost, and transparency [1]; for example, official web portals [2] facilitate interaction among government, businesses, citizens and other institutions. Widely known as digital or electronic government (e-government), this phenomenon has become part of the strategic vision of government at the highest level, offering the public sector a means to operate more efficiently and transparently, and to provide better, cheaper and faster services to citizens.

However, it is also well-documented that many e-government projects are unsuccessful [3], [4]; indeed, some studies put failure rates near 60% [5]. Besides delays and cost overruns, many systems are rejected because they do not fit their defined purpose, with reasons ranging from failure to consider end-user requirements, to lack of vision and strategy [5], [6].

Researchers have proposed several models to conceptualize some or all significant aspects of e-government, to reduce

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the gaps between project design and on-the-ground reality. Thus, there are proposals for e-government adoption [7]; quality evaluation of e-government services [8]; modeling e-government itself with ontologies [9], [10]; meta-models for public services [10], [11]; semantic web service-based architectures for interoperability of e-Government services [12]; and so on.

Collaborative e-government processes can be defined as a set of mutually synchronized actions, by peer and autonomous enterprises or people, in order to jointly provide an input or output for e-government. Several studies present solutions and case studies that combine technical aspects (e.g. architectures, platforms, interoperability, or collaboration) with procedures and regulations for e-government actors (businesses, organizations, citizens [13]–[16]). For example, Beynon-Davies [17] proposes a framework and meta-model of e-government business models, focusing on business processes and information systems, and Helali *et al.* [18] review seven e-government architectures.

This study aims to capture the state of the art in modeling of collaborative e-government processes, and thus identify gaps and research opportunities. Existing literature on the topic are gathered with a systematic mapping, and sorted with a newly developed classification schema, which combines the perspectives of design (about models as artefacts) and research concerns (about the modeled aspects of collaborative e-government).

The remainder of this article is structured as follows: Section II introduces the literature classification schema used for the literature analysis; Section III presents the methodological approach for the literature analysis; Section IV describes the results of this study; Section V presents the main study findings and research challenges; Section VI addresses threats to validity; and Section VII summarizes and concludes.

II. THE LITERATURE CLASSIFICATION SCHEMA

Several researchers have proposed models to conceptualize e-government from different perspectives, such as technology, functionality, components, and quality. For this study's purpose, we adopt the definition of e-government as [19] ''using the internet and the world-wide-web for delivering government information and services to citizens, business and other government agencies.''

The existing literature on modeling of collaborative e-government processes can be studied from two perspectives: (1) *design*, about models themselves, as artefacts product of design activities; and (2) *research concern*, about the domain concerns that these models address and serve (e.g. interoperability, transparency, collaboration, quality of service, etc).

In this study, these perspectives are combined into a single literature classification schema (summarized in Figure-1): from the *design* perspective, we take categories (i) model type, and (ii) model focus; and from the *research concern* perspective, we take (iii) collaboration category, and (iv) interoperability level.

Each scheme category is internally organized using category-specific refinements:

- *Model types* are [20] architecture, framework, ontology, metamodel, and conceptual model.
- *Model focus* are the primary drivers of e-government, as proposed by Kubicek [21].
- *Collaboration categories* follow the stages provided by Lee and Kwak [22].
- *Interoperability levels* adopt the categorization provided by the New European Interoperability Framework [23].

The resulting literature classification schema is used to categorize each study.

A. DESIGN PERSPECTIVE

In the design perspective, several model types and focus categories are distinguished.

1) MODEL TYPE

A model is an abstraction that allows people to focus on the essentials of a (complex) problem, keeping out non-essential details. Since there is a limit to what a person can understand at any given time, models provide support in activities such as e-government development or development of large software systems.

e-government models fall into five categories:

(1) *Architecture*: software architecture is the fundamental structures of a software system. Since most e-government assumes the use of the Internet (and usually the Web) to distribute information, structural models of a system components are categorized as architecture.
(2) *Framework*: a standardized set of concepts, practices and criteria to approach a particular type of problem, and which serves as a reference to address similar problems.
(3) *Ontology*: a representation, formal naming and definition of the categories, properties and relations among the concepts, data and entities that substantiate one or many domains of discourse.
(4) *Meta-model*: a model that describes another model. A meta-model is not an aggregated or less detailed view of another model, but a model at a different abstraction level and which makes claims about the structure of another model (or set thereof) but not about its content.
(5) *Conceptual model*: a model of e-government concepts.

2) MODEL FOCUS

The conceptual interest of e-government model focuses into five categories:

(1) *Economic/cost driven*: the model goal for cost reduction, resource management, process management, or efficiency.

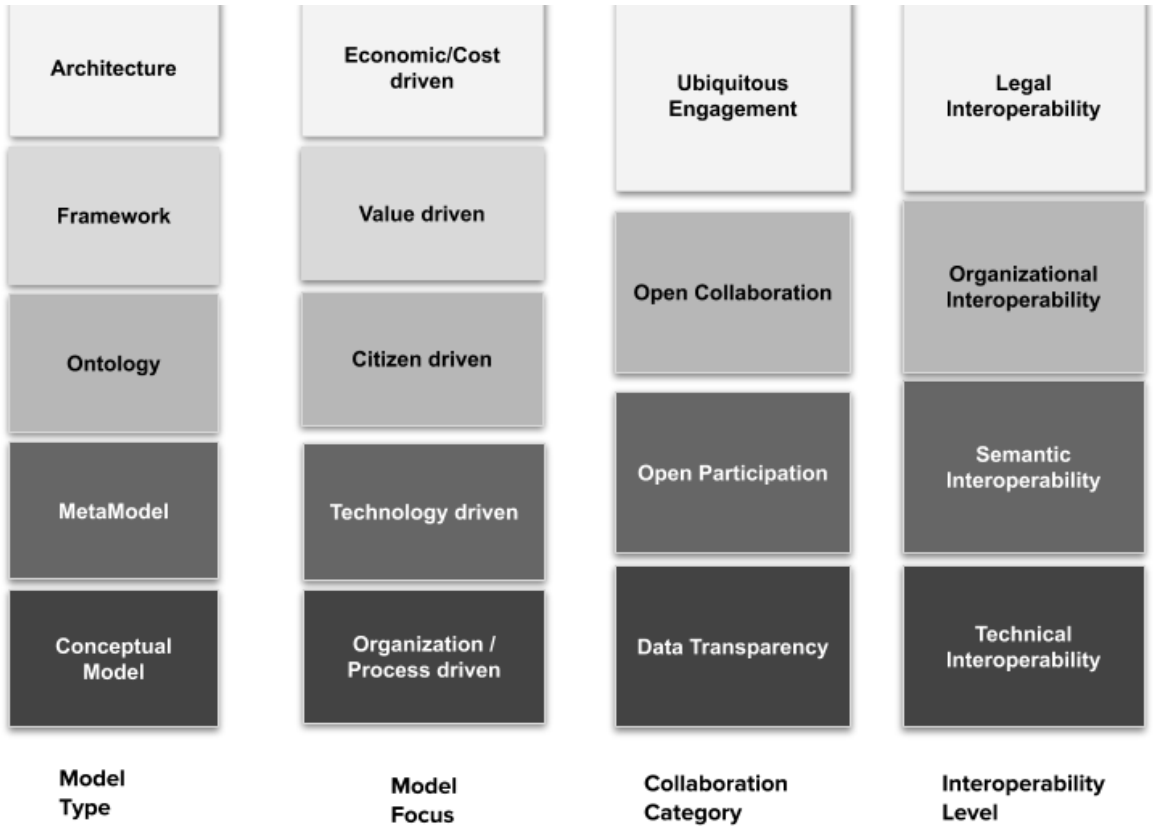

FIGURE 1. The literature classification schema.

(2) *Value driven*: the model focus is improving decision making, service provisioning, protection, or security and safety.
(3) *Citizen driven*: the model focus is to represent aspects like citizen participation, collaboration, transparency or shared governance.
(4) *Technology driven*: the model represents a platform components, or the use of particular technologies or tools.
(5) *Organization/process driven*: the model describes a process or organization and its components.

B. RESEARCH DIRECTION PERSPECTIVE

The research direction perspective includes the collaboration and interoperability categories.

1) COLLABORATION

The process of two or more people or organizations working together to complete a task or achieve a goal.

We consider four categories:

(1) *Ubiquitous engagement*: continuous participation of external stakeholders, which is permanently taken into account at all stages of the collaboration cycle.
(2) *Open collaboration*: cooperation of politics and administration with external stakeholders, such citizens and organizations.
(3) *Open participation*: opening politics and administration to the ideas and knowledge of external stakeholders.
(4) *Data transparency*: open access to administrative data, and especially Open Government Data.

2) INTEROPERABILITY

Interoperability is the ability of a product or system to work with others, with completely understood interfaces, in either implementation or access, without any restrictions present or future.

Four interoperability categories are considered:

(1) *Legal*: related to public administration, including relevant legislation about data exchange, including data protection.
(2) *Organizational*: documenting some business processes and agree on how these processes will interact to deliver a public service.
(3) *Semantic*: relative to the meaning of data elements and relationships among them, including vocabularies for data exchange and mechanisms to ensure that data elements are understood in the same way by communicating parties.
(4) *Technical*: the technical aspects of linking information systems, including interface specifications, interconnections services, data integration services, data presentation and exchange, and others.

TABLE 1. Criteria used to classify articles.

Dimension	Category	Criteria
Model Type	Architecture	An architecture is described explicitly.
	Framework	A framework described explicitly.
	Ontology	An ontology is described explicitly.
	Meta-model	A meta-model is described explicitly.
	Conceptual model	Any conceptual model is described explicitly, such as processes, workflows and data models.
Model Focus	Economic / Cost driven	When the proposal is aimed at resources efficacy or efficiency, then its focus is classified in this category. For example: cost reduction, optimal use of resources and resource management.
	Value driven	When the proposal is intended to improve decision making; service provision; protection or security, then its focus is classified in this category.
	Citizen driven	When the proposal is intended to represent aspects such as citizen participation, collaboration, transparency or shared governance, then its focus is classified in this category.
	Technology driven	When the proposal is intended to represent the components of a platform; the use of particular technologies or tools, then its focus is classified in this category.
	Organisation / Process driven	When the proposal is intended to represent the arrangement of components of a process, then its focus is classified in this category.
Collaboration Strategy	Ubiquitous engagement	When the proposal considers a continuous participation of external stakeholders, which is represents in the stages of the collaboration cycle explicitly, then its focus is classified in this category.
	Open collaboration	When the proposal includes some policy and management in order to obtain ideas and knowledge of external stakeholders, then its focus is classified in this category.
	Open participation	When the proposal provide some guidelines to open ideas and knowledge of external stakeholder
	Data transparency	When the proposal considers open access to administrative data, then its focus is classified in this category.
Interoperability Level	Legal	if the model considers aspects related to data exchange, including data protection legislation, then its focus is classified in this category.
	Organisational	When the proposal documents some business processes and describes how these processes will interact to deliver a public service, then its focus is classified in this category.
	Semantic	When the proposal describes any data exchange form, then its focus is classified in this category.
	Technical	When the proposal considers aspects such as interface specifications, interconnections services, data integration services, data presentation, and similar ones,then its focus is classified in this category.

C. USING THE CLASSIFICATION SCHEMA

The literature classification schema allows to analyze each paper's content and extract its key elements. We use explicit classification criteria (Table 1) to determine when to assign each paper to a schema category.

III. LITERATURE REVIEW METHOD

There is a growing number of proposed models to conceptualize all or some relevant aspects of e-government, and it becomes essential to summarize and provide overviews of those proposals. Existing literature is analyzed with a Systematic Literature Mapping [24]. This provides a systematic and objective approach to identifying the nature and scope of available empirical study data, in order to answer specific research questions. The review process has three major stages: (1) planning the review, (2) conducting the review, and (3) reporting the review.

The following subsections describe the study phases.

A. FIRST PHASE: PLANNING THE REVIEW

A systematic literature review (SLR) on a specific topic is useful when there is a rising interest and accumulation of research on that topic [25]. A comprehensive review also takes into account a manageable quantity and quality of relevant literature, as emerges from a coherent conceptual structuring of existing research. Also, a detailed review facilitates developing a theory, closing areas where a wealth of research exists, and discovering areas where research is needed.

1) RESEARCH QUESTIONS

This review aims to identify which models are being used to conceptualize e-government, and which aspects are being modeled.

Three research questions are addressed (see Table-2), corresponding to the study objective and in accordance with customary SLR standards [26]. The research questions are framed by three criteria:

- **Population**: scientific literature that presents an e-government conceptualization.
- **Intervention**: models that address specific issues, e.g. representing technical characteristics of e-government or relationships among e-government components.
- **Outcomes**: quantity and type of related evidence about e-government models; ff particular interest is

TABLE 2. Research questions (Scope of the literature review).

ID	Research question	Objectives
RQ1	Which type of representations are used?	Understanding the kind of models proposed in the literature. We use the classification provided by [20] which recognises architecture, framework, ontology, meta-model, model, and process/methodology.
RQ2	Which concerns de the proposals focus on?	Understanding the concerns that researchers are trying to model. We use the classification of model of concerns [21], which recognises cost/economic, value, citizen-centred, technology, and organisational process.
RQ3	How are the key concepts (collaboration and interoperability) addressed in the proposals?	Since models of collaborative processes must address collaboration [22] and interoperability [23], we seek to understand how these key concepts have been dealt with in the literature.

determining the type of e-government model and how it uses key concepts (e.g. collaborations, interoperability, IT governance, and quality services criteria).

In this study, restrictions regarding specific outcomes are not considered. To answer the research questions, data is collected from the literature; this involves defining a search strategy, identifying data sources, selecting studies, and analyzing and synthesizing data.

2) PROTOCOL REVIEW

Given the absence of previous similar studies, no gold standard to assess searching thoroughness was defined. Instead, a protocol review and pilot testing were conducted before the actual review. Its purpose is to manage the research objectives and to define how to achieve them, by defining research questions and planning how sources and selected studies will be used to respond to them. The review protocol comprises the search strategy including search terms, sources to be searched (i.e. databases), and inclusion and exclusion criteria. The protocol describes how the criteria are applied, e.g. how many reviewers evaluate each prospective primary study, and how disagreements among reviewers are resolved. The review protocol also includes the methodology for data extraction and synthesis.

3) PILOT TESTING

To avoid introducing bias by the accumulating data, a pilot test was conducted with an initial screening process, to ensure that the extracted information is both standardized and relevant. Pilot testing must address three main questions:

1) Are eligibility criteria expressed clearly enough?
2) Do screeners interpret the criteria consistently?
3) Are any relevant papers not identified as such?

It is common practice to run a pilot test with a small sample of included papers (e.g. 10) [27] to assess data extraction and quality appraisal.

The pilot testing protocol used is:

1) Define with topic experts the initial set of eligibility criteria.
2) Identify reviewers to conduct the screening process.
3) Define the process for resolving disagreements in screening decisions; in this case, arbitration by a third party, previously identified.
4) Select a random subset of the full set of studies to use as training set, i.e. representative of the topic areas in the full set.
5) Define the success conditions for the training process.
6) Screen the studies in the training set; each study should be assessed by all the reviewers who are conducting the screening process.
7) Discuss each disagreement and difficult decision between the reviewers who are conducting the screening.
8) Reach consensus on each decision, using the disagreement resolution process defined above.
9) Clarify and add detail to eligibility criteria as required.
10) Determine whether the success conditions for completing the training process have been fulfilled.

The pilot testing yield some reassuring conclusions:

- Reviewers quickly became familiar with the set of eligibility criteria.
- There was only one classification disagreement in the total group of test items, and the arbitration procedure was quick and effective.
- The review and consensus process were conducted online and distributed; a Google Drive template was used for the review to quickly identify disagreements.
- The review and consensus process was quick and did not require further discussion, and the classification criteria were quickly understood by the reviewers.

The pilot testing showed consistency of decisions throughout the screening process.

B. SECOND PHASE: PERFORMING THE REVIEW

Collecting data from the research literature (to answer the research questions) involves searching and screening of articles published in indexed scientific press.

1) SEARCH STRATEGY

The review goal is to find primary studies about collaborative e-government processes, using an unbiased search strategy.

The search strategy was developed through the review of the data needed to answer each research question. To identify existing evidence as completely as possible, several data sources are considered.

The search string has three parts (see Table-3).

An appropriate set of search keywords was reached iteratively, after some initial results of little relevance. The first

TABLE 3. Search terms.

No.	Terms
1	model, meta-model, framework, ontology, architecture
2	e-Government, e-gov
3	collaborative processes

part of the search string includes several terms used as synonyms for e-government. conceptualizations, such as model, meta-model, framework, ontology, and architecture, which represents the focus of this article. The second part of the string includes the term ''e-government''. Finally, the concepts ''collaboration'' and ''interoperability'' were initially included but later replaced with ''collaborative processes'' because they yield too many unrelated papers.

The search chain was built from Table-3: terms within a row are connected with ''OR'', and the resulting terms are connected with ''AND'', yielding the search string `(model OR metamodel OR architecture OR framework OR ontology OR approach) AND (e-gov OR e-government) AND ("collaborative processes") .`

2) INCLUSION AND EXCLUSION CRITERIA

Inclusion and exclusion criteria filter out studies not relevant for answering the research questions.

Inclusion criteria for papers are:

- **Includes an e-government conceptualization**: the abstract explicitly mentions the term e-government and a category of e-government model (e.g. model, meta-model, framework, ontology and architecture).

Exclusion criteria for papers, as applied to the paper titles, abstract, and conclusions, are:

- **Research focus unrelated to e-government**: the article was outside the field of e-government.
- **Research focus related to e-government, but not related to e-government conceptualization**: the article is within the field of e-government, but an e-government conceptualization is not part of its contribution.
- **Research focus related to e-government, but insufficient information on e-government conceptualization**: an e-government conceptualization is not part of the article contribution, and its terms were only mentioned in the abstract initial sentence.
- **Duplicate studies**: if the same study is reported in several articles, only the most recent one is included.
- **Article already been included from another source**: replication between sources.
- **Article in a language other than English**: English-only.
- **Technical reports and theses**: excluded since they are not peer reviewed publications.

3) STUDY SELECTION

This step identifies those primary articles that provide direct evidence about the research question.

The search is restricted to studies published between 2008 and 2019, to achieve wider coverage of the study area. The initial step run a search on several digital library search engines, using the terms described in Table-3; sources include high-level publication editors [28]: Elsevier's Scopus, IEEE Xplore Digital Library, ACM Digital Library, and Springer Library. DBLP Computer Science Bibliography are also used when conference proceedings were not available on their website.

The actual selection of primary studies involves three filters to select the most relevant results and reduce significant clutter.

Figure-2 summarizes the full systematic literature review process in a diagrammatic format, indicating the number of studies at each phase.

Studies were selected by three reviewers. Each of them gave an opinion on whether or not to include each study in the final list. Once all the studies had been evaluated, if all reviewers had the same decision (i.e. approve or reject), this consensus was considered final. Those studies for which there was no agreement were read again, and reviewers voted again. If still there no consensus, a third round was carried out. The final list reflects total consensus of the reviewers.

4) SNOWBALLING

To ensure that no major works have been left out due to the survey design or search terms, we performed a breadth-first search using a backward and forward snowball method. An initial manual search using Google Scholar yielded over 100 articles; three of them that mentioned e-government models were reviewed, but they covered e-government maturity models, and were thus excluded as irrelevant to collaborative e-government processes. Thus, no additional relevant articles were found, giving reasonable confidence on the design and search.

5) PRIMARY STUDIES QUALITY ASSESSMENT

Primary studies quality assessment guide interpretation of findings and determine strength of inferences [26].

The quality of each specific evaluated article was assessed with a repeatable and traceable manual procedure, as follows:

- Three reviewers (also co-authors of this article) extracted separately information from each article.
- Two of the reviewers assessed independently the article using the criteria, and provided a rationale for each response.
- The reviewers compared their responses, and reached a consensus assessment.
- This partial consensus was compared with a third independent assessment, it was discussed, and a final consensus was reached.

To assess the study itself, we use the quality criteria proposed by York University's Database of Abstract of Review of Effects (DARE) [29], which puts forth three questions with scoring Y (yes) = 1, P (partial) = 0.5, and N (no) = 0:

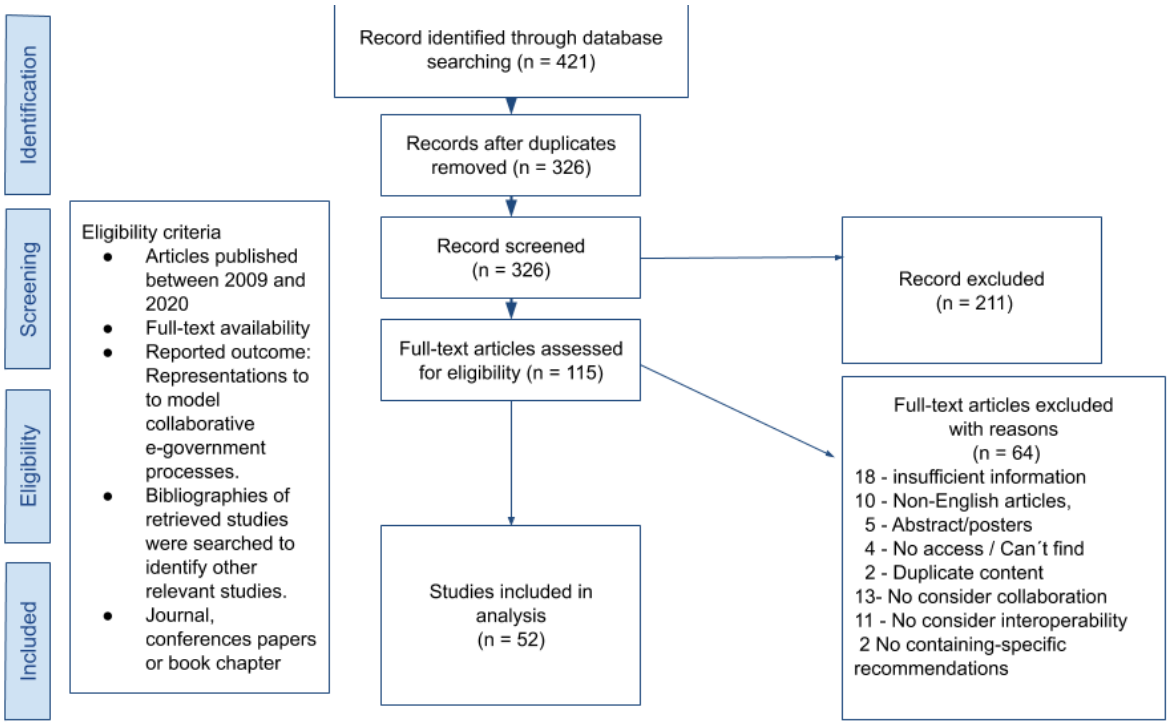

FIGURE 2. The full systematic literature review process.

1) Is the literature search likely to have covered all relevant studies?
2) Are the research articles clear and coherent?
3) Did the reviewers assess the quality/validity of the included studies?

The study was assessed by the research team as follows:

- Question 1: yes; the search covered five well-known digital libraries, and deployed additional search strategies, e.g. referencing all journals that address the subject matter.
- Question 2: yes; information about each article is presented in a clear way, can be traced, and can be followed to relevant additional papers.
- Question 3: yes; the inclusion criteria are explicitly defined in the study documentation.

The global DARE score of the study is 1.0.

6) DATA EXTRACTION

Several data were extracted from each article: *authors; source; conference/journal; publication year; summary; a brief opinion regarding its strengths and weaknesses and the study's objectives*.

If several studies were reported in the same article, each relevant study would have been treated separately; however, this situation did not present itself.

7) DATA SYNTHESIS

The final list of selected studies includes 52 primary studies (see the full list Table 7), organized with the classification framework presented in Section II (see Figure-3).

C. THIRD PHASE: REPORTING THE REVIEW

The final phase of this systematic review is writing up the review results and circulating them to potentially interested parties.

The reminder of this section reports them using the classification scheme introduced in Section III-B3.

1) MODEL TYPES

Table-4 summarizes the studies per model type.

- **Architecture**: description of a system-s major components, relationships (structures), and interaction. Software architecture and design includes several contributory factors such as Business strategy, quality attributes, human dynamics, design, and IT environment. The appearance of new technologies, such as Cloud and Containers, leads to the definition of new architectural patterns, such as Microservices, Serverless Pattern, among others. But, it is recognized that the process of adoption of such technology is not immediate. Several architectures oriented Services for e-government have been proposed [30], but, to our knowledge, architectures based on these new concepts and which also include key concepts such as collaboration and interoperability, have not yet been adopted. We guess for this reason there are not proposed e-government architectures in the set of selected studies.
- **Framework**: a standardized set of concepts, practices and criteria to approach a particular type of problem that serves as a reference, to face and solve new problems of a similar nature. This category concentrates the most

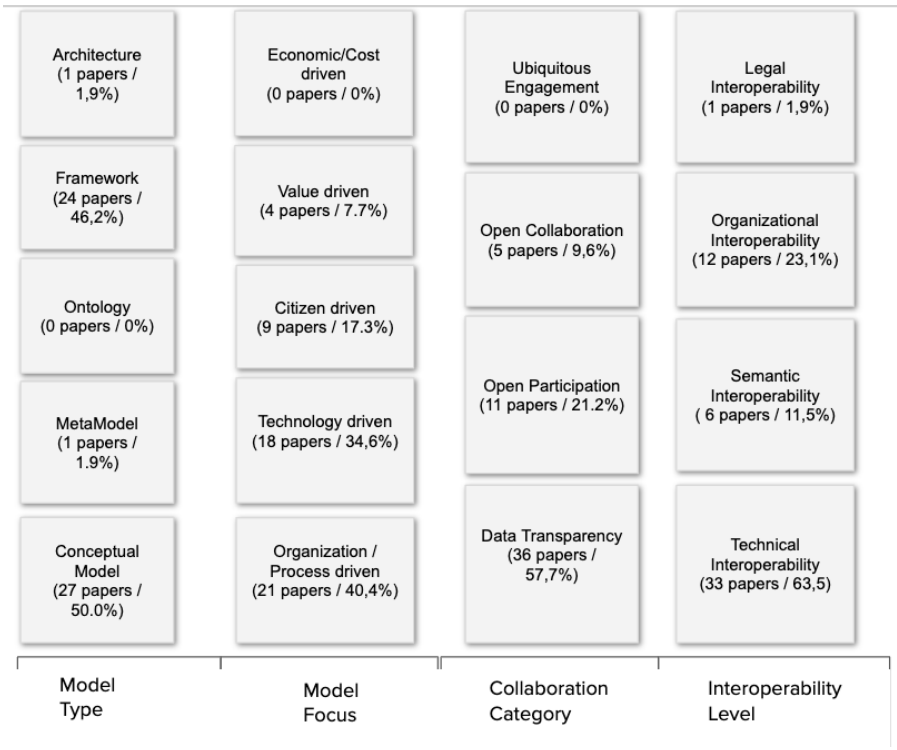

FIGURE 3. Data synthesis: Overview of included studies.

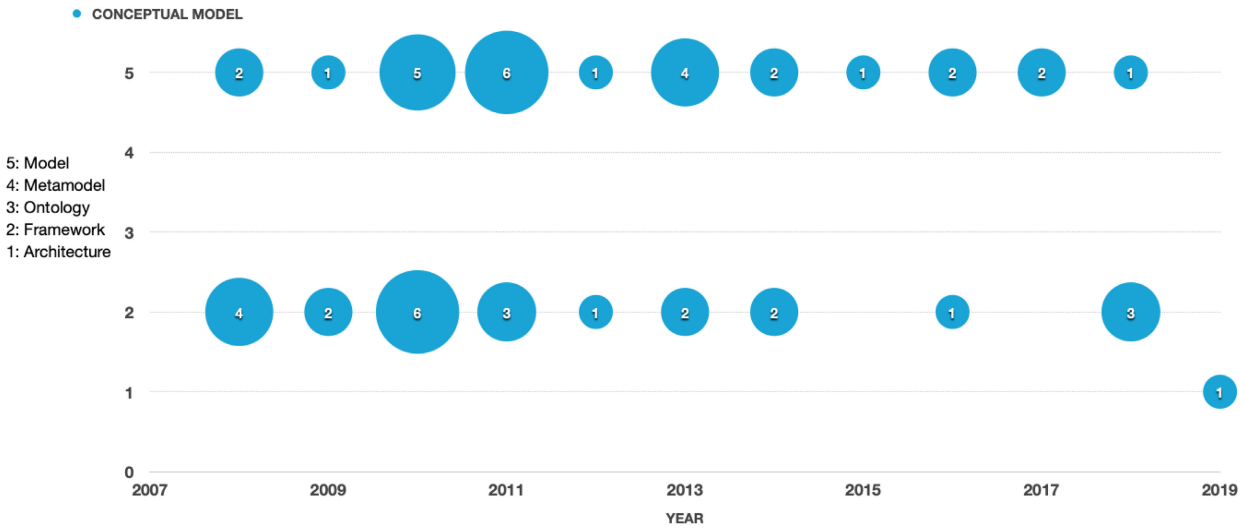

FIGURE 4. Articles per model type.

studies related to proposals to conceptualize e-government (24 of 52). Since e-government is defined as the use of the internet and the world-wide-web for delivering government information and services to citizens, business and other government agencies [19] most studies focus on providing technological solutions that include technical aspects, procedures and some regulations for particular e-government actors, such as businesses, organizations and citizens.

- **Ontology**: an explicit specification of a conceptualization. Even when ontologies were found in the set of analyzed studies, they were only used as artefacts to add semantics to some parts or components of a software application, but they did not have the purpose of

TABLE 4. Articles per model type.

Type	Included studies	No. of studies
Architecture	[40]	1 (1,9%)
Framework	[41], [42], [14], [43], [44], [45], [46], [47], [48], [49], [50], [51], [52], [53], [54], [55], [16], [56], [57], [58], [15], [59], [60], [61]	24 (46,2%)
Ontology	-	0 (0%)
Metamodel	[11]	1 (1,9%)
Conceptual Model	[62], [35], [34], [63], [33], [32], [31], [64], [65], [66], [67], [68], [69], [70], [71], [39], [72], [73], [38], [37], [74], [36], [75], [76], [77], [78]	26 (50.0%)

specifying an e-government conceptualization. For this reason, they were not counted.

- **Metamodel**: a model which is intended to give an all-inclusive picture of a process, system, etc., especially by abstracting from more detailed individual models contained within it. One study [11] proposes a meta-model for structural representation of public services.
- **Conceptual Model**: a representation of concepts that shows how it is, how it works, or what components make it up. Several models were found in the data-set although they do consider only some e-government concepts; some of them include key concepts, like collaboration (e.g. [31]–[35]).
  Several types of conceptualization were found (systems, processes, and methodologies), even though they represent only a partial view of e-government; e.g. [36] presents a collaborative process for public administration inter-organizational business processes modeling. Some studies restrict e-government to Internet-enabled applications, with business processes do not use technology or focus on interactions between government and external groups; e.g. [37] describes a semantic platform for e-government; [38] presents a system for e-government, and [39] proposes a collaborative network. They are classified as models in this study.

Figure-4 shows the number of articles per year of publication and per type of representation (e.g. model, metamodel, ontology, framework, and architecture). The size of each bubble is proportional to the number of studies (as is the bubble label). Most articles with clear model types occur in 2010 (11 studies, five models and six frameworks) and 2011 (8 studies). From then on, e-government representation proposals decreased slowly, but saw a resurgence the last couple of years. The most published types of model have remained the same all along: frameworks, and (general) models.

TABLE 5. Articles per model focus.

Type	Studies	Number of studies
Economics / Cost	-	0 (0%)
Value	[64], [46], [47], [48]	4 (7,7%)
Citizen	[41], [42], [65], [66], [67], [35], [11], [55], [38]	9 (17,3%)
Technology	[40], [62], [14], [45], [68], [76], [50], [51], [71], [53], [54], [77], [78], [58], [37], [60], [32], [61]	18 (34,6%)
Organisation & Process	[43], [74], [44], [34], [36], [75], [69], [49], [70], [63], [72], [52], [73], [16], [33], [31], [39], [56], [57], [15], [59]	21 (40,4%)

2) MODEL FOCUS

Some models aim to reduce costs, others to improve the decision-making process or provide transparency and citizen participation. Table-5 summarizes the articles per model focus.

1) **Cost/economics drive**: although e-government aims to improve efficiency, effectiveness, cost and transparency, no studies have been found within the list of selected articles that consider economic aspects.
2) **Value drive**: four articles (7,7%) aimed at adding value on issues such as improving decision making and improving the provision of services were found. Mainly they were focused on the improving the provision of services, as they included aspects of web services.
3) **Citizen drive**: some studies represent aspects related to citizens such as participation, and collaboration (17,3%) all supported through the use of web applications.
4) **Technology drive**: this focus is the one that concentrates the most studies (34,6%). Indeed, it seems reasonable considering that e-government is defined as the inclusion of technology in a government's internal and external processes. Several studies describe technological aspects of their proposals, mainly describing software applications.
5) **Organization & Process**: studies describing processes and organizational approaches were also found (40,4%). Although it was inferred from the abstracts that some proposal were about modeling e-government, they were actually limited to describing aspects of processes and ways of organizing processes. Some studies were only limited to collaborative networks (e.g. [39]) or presented descriptive studies of administrative situations that were presented as models (e.g. [38], [59]), so they were classified in this category.

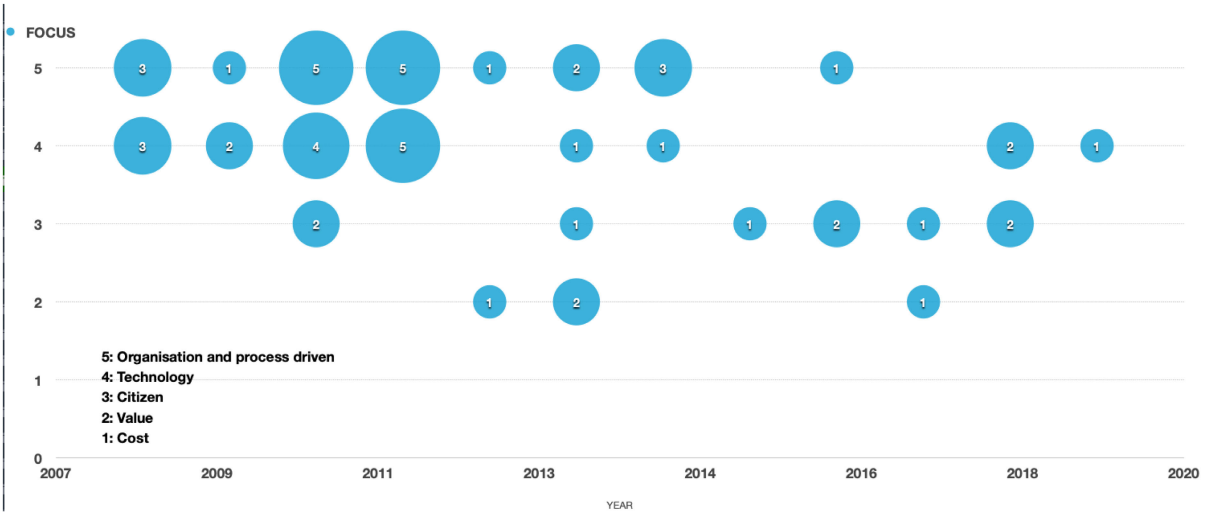

FIGURE 5. Articles per model focus.

Figure-5 shows the number of articles per year of publication and per model focus (i.e.. cost, value, citizen, technology, and organization and process driven). Most articles with a clear model focus occur in 2010 (11 studies, five on Organization & Process, four on Technology, and two on Citizen) and 2011 (10 studies).

The most addressed model focus has shifted, from Technology and Organization & Process (2008 to 2013) towards Citizen and (some) Technology; strikingly, the initially co-dominant Organizational & Process has vanished from the literature. Unfortunately, the method and results of this study do not allow to decide whether this reflects maturity, abandonment, migration to another community, or some major (yet unlikely) terminological shift.

3) COLLABORATION

All reviewed articles considered the term ''collaboration'' (by definition and as per the search string), but they differ in the type of collaboration they describe. Table-6 (left side) summarizes the articles in this category.

1) **Ubiquitous engagement**: no studies were found to match this category (i.e. continuous participation of external stakeholders in the stages of the collaboration cycle). This suggests that collaborative e-government processes have not yet reached maturity levels that address ubiquitous participation by citizens.
2) **Open collaboration**: 30 studies (57,7%) were classified in this category. Most of them describe some improvements in the cooperation of politics and administration with external stakeholders (e.g. [48], [55]). Several articles explicitly mention the term collaboration as part of their proposal, but do not provide enough detail to determine a particular category. Most of them mention open collaboration and are classified in this category.
3) **Open participation**: eleven studies (21,2%) were classified in this category. Several address opening politics and administration to ideas and knowledge of external stakeholders.
4) **Data transparency**: eleven studies were found (21.2%). This category considers open access to administrative data, in particular in terms of Open Government Data. Some articles present case studies that describe the proposal outcome in an application domain; e.g. [43] presents a case study in the tourism domain.

Many studies do not explicitly describe how collaboration is implemented in their proposals. Most of them promote collaboration with external organizations, and are classified as ''open collaboration.''

Figure-6 shows the number of articles per year of publication and per collaboration category (i.e.. ubiquitous engagement, open collaboration, open participation and data transparency). Most studies that address collaboration occur in 2010 (11 studies, one on data transparency, eight on open participation, and two on open collaboration) and 2011 (10 studies).

From 2011 on there is a decreasing number of articles addressing collaboration. The focus of recent work has moved from open participation (which dominated overwhelmingly from 2010 to 2015) towards data transparency.

4) INTEROPERABILITY

Interoperability is the ability of unrestricted sharing of resources among several systems. This may be data sharing among several components or machines via software/hardware, or exchange of information and resources among several computers via local area networks (LANs) or wide area networks (WANs). Table-6 (right side) summarizes the articles in this category.

1) **Legal**: one study was found in this category ([43] that address legislation for data exchange.
2) **Organizational**: twelve studies were found (23,1%) that address the organization of business processes,

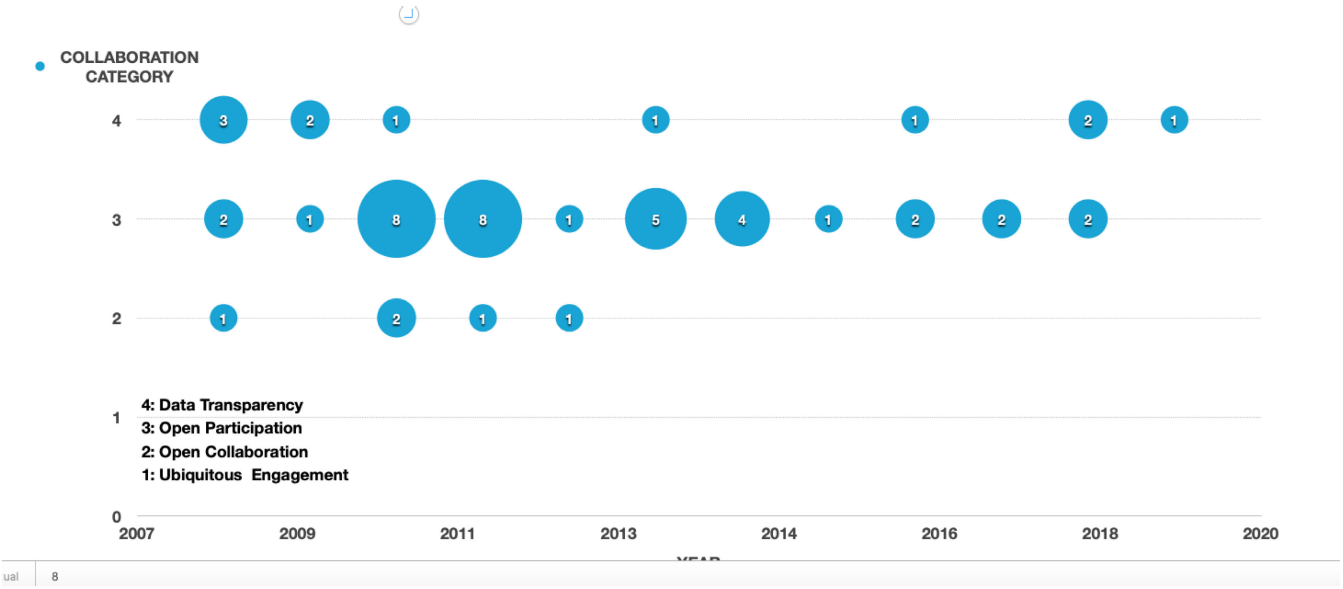

FIGURE 6. Publications classified by collaboration category.

3) **Semantic**: Six studies were found (11%) in this category; some semantics artefacts are provided, e.g. that include collaboration or interoperability in e-government. Vocabularies and ontologies are used to describe data exchange, and ensure that data elements are understood in the same way by communicating parties.
4) **Technical**: 23 studies were found (63,5%); most of them present technological aspects (such as web services) to describe how interoperability is achieved.

Just like in the case of collaboration, many proposals do not explicitly describe how interoperability is implemented. Most of them describe some recent technological aspect, and are thus classified as "Technical interoperability."

Figure-7 shows the number of articles per year of publication and per type of focus (i.e.. legal, organizational, semantic, and technical). The highest number of studies that address interoperability occur in 2010 (11 studies, eight on technical interoperability, two on semantic interoperability, and one study on organizational interoperability) and 2011 (9 studies).

From 2011 on there is a decreasing number of articles addressing interoperability, just like happens with collaboration. However, unlike collaboration, interoperability literature has not been thoroughly dominated by a single aspect; instead, a plurality of works address technical aspects but a steady trickle of work addresses semantic and organizational aspects (but not legal at all).

IV. ANALYSIS OF RESULTS AND DISCUSSION

This section answers the main research question, by answering the three research questions introduced in Section III.

RQ1. What model types have been published?

Several type of e-government conceptualizations were identified, mostly frameworks and models, but no ontologies were found. Since e-government is the use of technological communication devices to provide public services to citizens in a country or region, it could be expected that many proposals would address technology-related aspects; however, only one software architecture for e-government was found that considers both collaboration and interoperability. Since not many articles are found, it seems to safe to assume that defining these architectures is a labor-intensive task; in fact, several countries have developed their own e-Government reference architecture (e.g. the European Union (EU) [79]). Ontologies do not seem to be used to conceptualize collaborative e-government, but have been used as semantic artefacts in some technological implementations.

Table-4 and Figure-4 illustrate the results obtained to answer RQ1. Most articles propose models, ranging from a process to a collaborative network; most of them were published between 2010 and 2013. Other studies provide solutions and case studies that include technical aspects, but mainly as a technological framework.

As the concept of e-government is analyzed by different communities (e.g. business, social, political, technological, etc) from different viewpoints, it seems reasonable that the results obtained show a wide diversity of types of e-government conceptualizations. Some offer little detail since they are general proposals; others describe technological aspects in detail to address some relevant e-government aspect, such as interoperability.

RQ2. What is the target of the models?

Several targets were found according to the analysis framework. Most of the studies are mainly focused in technological and both organization and process aspects. This result is consistent with the definition of e-government that uses

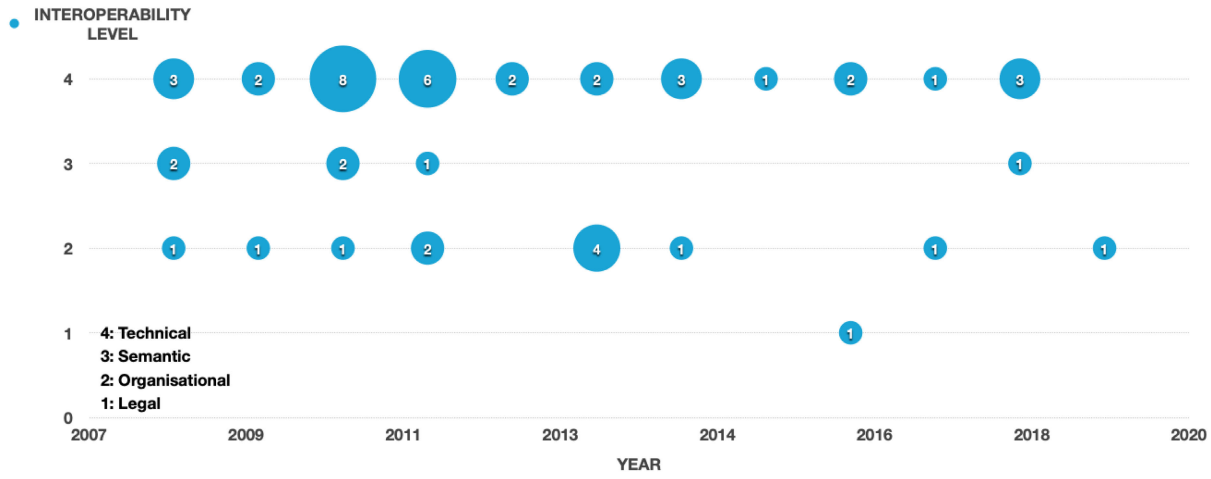

FIGURE 7. Articles per interoperability level.

TABLE 6. Results obtained for collaboration and interoperabity categories.

Collaboration		Interoperability	
	Total		Total
Ubiquitous Engagement	0 (0,0%)	Legal	1 (1,9%)
Open collaboration	30 (57,7%)	Organisational	12 (23,1%)
Open participation	11 (21,2%)	Semantic	6 (11,5%)
Data transparency	11 (21,2%)	Technical	33 (63,5%)
Total	52 (100%)	Total	52 (100%)

technologies to improve processes in order to achieve efficacy and efficiency in the relationship with internal and external actors (e.g. citizens, organizations, and others). As economic target was not found, we thought that providing e-government conceptualizations to establish costs and benefits would be an interesting challenge.

RQ3. How are key concepts (such as collaboration and interoperability) included in current models?

In terms of the key concepts both collaboration and interoperability are partially considered in the proposals for conceptualize e-government. Interoperability between different organizations is a complex task, where a key element to enable real collaboration between them is to be able to define without ambiguity the concepts that are involved in each domain and their relations. For this reason, an e-government conceptualization should provide conceptual integrity in order to avoid errors during its implementation.

As a conclusion, in order to define, formalize and exploit knowledge and information related to collaborative e-government processes, metamodels and ontologies are useful conceptualizations that provide an overview of e-government. In addition, such conceptualizations also allow for easy consideration of concepts of collaboration and interoperability. In fact, a meta-model can be specialized towards specific collaborations in the business field, Since many government entities deliver the same services, but in a different way and they have many potential similarities, we think the realization of collaboration e-government needs a systematic conceptualization to be able to deal with the both new and current challenges such as the inclusion of new technologies, dealing with new needs of citizens, between others.

V. RESEARCH CHALLENGES

The findings, and especially the absences, from this systematic review allow to identify several research challenges:

- *Using new technologies*: new technologies like Cloud, microservices, IoT, serveless, etc. can be used to increase the scope of applications and to facilitate processing of large amount of data, thus allowing to focus on processes rather than technology.
- *Including artificial intelligence and ontologies*: artificial intelligence is becoming a crucial part of daily human lives today and it assists in almost every scenario. Given the complex nature of the public sector, with several distributed government institutions and multiple semantic differences of interpretation, achieving interoperability and integration is a key challenge for complete and effective e-Government. The use of ontology and Artificial Intelligence (AI) systems could play an important role in assisting the goal of interoperability and

TABLE 7. Articles per model focus.

Id	Title	Year	Cite
P01	Toward a business intelligence model for challenges of interoperability in egov system: Transparency, scalability and genericity	2019	[40]
P02	Development paths towards open government – an empirical analysis among heritage institutions	2018	[62]
P03	Adopting and managing open data: Stakeholder perspectives, challenges and policy recommendations	2018	[41]
P04	A crowdsourcing based framework for E-government: Suspect identification and investigation	2018	[42]
P05	Towards Setting Up a Collaborative Environment to Support Collaborative Business Processes and Services with Social Interactions	2018	[14]
P06	Explaining value co-creation and co-destruction in e-government using boundary object theory	2017	[64]
P07	Collaborative Activities and Methods	2017	[65]
P08	E-Government Relationships Framework in the Tourism Domain. A First Map	2016	[43]
P09	Citizens and Local Government Management Innovations. Implementation of the New Public Service (NPS) in Municipal Institute Family, San Pedro Garza García, Nuevo León, México	2016	[66]
P10	The City as an Interface Between Citizens and Public Administrations	2016	[67]
P11	Citizen Participation in Digital Government: A New Model Identifying Levels of Expertise and Responsibility in Collaborations	2015	[35]
P12	Agriculture-related disaster relief information management and interoperability	2014	[74]
P13	Framework for assessing institutional readiness of government organisations to deliver open, collaborative and participatory services	2014	[44]
P14	Connected public service delivery	2014	[45]
P15	Extending the Social Network Interaction Model to Facilitate Collaboration through Service Provision	2014	[34]
P16	Electronic information sharing in local government authorities: Factors influencing the decision-making process	2013	[46]
P17	Evolving government-citizen ties in public service design and delivery	2013	[11]
P18	A collaborative approach to public administrations interorganizational business processes modeling	2013	[36]
P19	Harmonizing eGovernment Initiatives in the Philippines: A Collaborative Institutional Framework	2013	[68]
P20	Research collaboration in universities and academic entrepreneurship: the-state-of-the-art	2013	[47]
P21	Ontology-Based Compliance Checking on Higher Education Processes	2013	[75]
P22	Open government and e-government: Democratic challenges from a public value perspective	2012	[48]
P23	ICT to Evaluate Participation in Urban Planning: Remarks from a Case Study	2012	[69]
P24	Towards a pragmatic methodology to bridge the gap in e-government interoperability: A case of patient refereral information exchange	2011	[76]
P25	Inter-organisational electronic information sharing in local G2G settings: A socio-technical issue	2011	[49]
P26	Web service-based e-Government public service channels workflow integration and simulation	2011	[50]
P27	A collaborative decision framework for managing changes in e-Government services	2011	[51]
P28	A Strategic Benchmarking Process for Identifying the Best Practice Collaborative Electronic Government Architecture	2011	[70]
P29	A Three-Dimensional Model for E-Government Development with Cases in China's Regional E-Government Practice and Experience	2011	[63]
P30	The research on cooperative E-government in grid environment	2011	[71]
P31	Addressing Behavior in Collaborative Networks	2011	[39]
P32	E-Democracy in Collaborative Planning: A Critical Review	2011	[72]
P33	Research on data exchange platform of provincial credit system: A perspective of data processing process	2010	[52]
P34	The challenges of implementing e-government interoperability in Thailand: Case of official electronic correspondence letters exchange across government departments	2010	[53]
P35	Towards a knowledge management portal for a local community	2010	[54]
P36	Creating public value in e-government: A public-private-citizen collaboration framework in Web 2.0	2010	[55]
P37	The Inter-organizational Business Collaboration Oriented Role Model for E-government	2010	[73]
P38	Research on Organizational Collaboration Oriented OB4LAC in E-government	2010	[77]
P39	Multinational E-Government Collaboration, Information Sharing, and Interoperability: An Integrative Model	2010	[16]
P40	A knowledge-based adaptive collaborative work system implementation framework	2010	[33]
P41	eGovernment Ontologies: Social Participation in Building and Evolution	2010	[78]
P42	Towards Autonomous Administrations of Decentralized Authorization for Inter-domain Collaborations	2010	[56]
P43	Designing for Light-Weight Collaboration: The Case of Interactive Citizens' Advisory Services	2010	[38]
P44	Requirements analysis for an e-government system to support multi-organisational collaborative groups	2009	[57]
P45	The Research of Government Collaboration Patterns Based on the Government Information Resource Interchange Framework	2009	[58]
P46	Toward an E-Government Semantic Platform	2010	[37]
P47	InterDataNet: Interoperability framework to support collaborative creation and management of official documents in e-Government processes	2008	[15]
P48	Conceiving Interoperability between Public Authorities A Methodical Framework	2008	[59]
P49	Enabling Reuse of Citizen Centric Government Processes Through Service Oriented Architecture	2008	[60]
P50	A Collaboration Model for E-government Based on Semantics and Multi-agent .	2008	[32]
P51	Ontology-Based Framework for E-Government Knowledge Collaboration Service	2008	[61]
P52	Task-Based Government Organization Business Collaboration Model	2008	[31]

integration. Ontologies provide a common definition of heterogeneous resources, while AI techniques make process integration dynamic and automated. To our knowledge, the use of AI together with ontologies is quite limited in e-government.

- *Incorporating Linked Data*: linked data can be used in e-government websites to improve the quality of government information, and addresses head on the interoperability issues. Linked data is a term used to describe a recommended best practice for exposing, sharing, and

connecting pieces of data, information, and knowledge on the Semantic Web using URI's and RDF.

- *Modeling with focus on economic aspects*: since no e-government models were found with focus on economic aspects, modeling and quantifying the costs and benefits of e-government collaborative processes is a wide open research challenge.
- *Developing meta-models*: a meta-model for collaborative processes of e-government is an interesting research challenge. In fact, since interoperability among heterogeneous organizations is a complex task, a key element to enable real collaboration among them is to define unambiguously the involved concepts and relationships. Since many government entities provide the same services, but in different ways and with potential similarities, a meta-model could facilitate the realization of e-government in several fields through conceptualization from a general perspective, and then create specific flexible models adapted to domains of interest.

VI. THREATS TO VALIDITY

Some threats to internal validity (i.e. to the study's correctness) are:

- *Consideration of synonyms*: the terms used in the search string may have some synonyms, and the search may have overlooked some studies; for example, sometimes authors only mention the term approach or methodology, but do not describe specific types of models, technologies, or collaboration or interoperability. This threat was mitigated with inclusion and exclusion step that inspected the citations of included articles to find whether any other relevant studies were missing; this was done by three researchers, and disagreements among them were discussed until consensus was reached. This, to a significant degree, confirms the validity of the entire search process.
- *Evaluation quality*: the quality of the studies selection and evaluation, as well as their weighting factor, may not represent adequately their importance. This threat was mitigates by grouping the chosen attributes into subsets, to facilitate ranking and improve selection.

Some threats to external validity (i.e. to the study's generalizability) are:

- *Review based on the authors' experience*: studies assessment was based on the judgment and experience of the authors, and other researchers might have judge differently. This threat was mitigated by providing an analysis protocol with a systematic way of reaching agreement.

VII. CONCLUSION AND FUTURE WORK

Governments worldwide are engaging into digital transformation initiatives to improve efficiency, effectiveness, cost, and transparency. Since existing e-government solutions are typically isolated, their integration and interoperability require deploying collaborative processes.

This articles describes a study to understand current approaches to modeling e-government collaborative processes and their integration and interoperability approaches. The research questions are: Which kind of representations (architecture, framework, ontology, meta-model, model or process) are used to model these processes? Which concerns (cost, value, citizen, technology, organization) do they focus on? How do they address collaborative processes concepts (interoperability and collaboration)?

The design, execution and results of the Systematic Literature Review (SLR) is described. Articles were organized with a novel literature classification schema consisting of model category, model focus, collaboration scheme, and interoperability level.

Initial search found 326 publications, but only 52 were left after applying exclusion criteria. Key findings are:

1) The most published type of model have consistently been Frameworks and (general) Models, but not Meta-models or Ontologies.
2) The most addressed model focus has shifted, from Technology and Organization & Process (2008 to 2013) towards Citizen and (some) Technology; the former has vanished from the literature.
3) Work on collaboration was dominated by open participation, but interest has shifted towards Data Transparency.
4) Work on interoperability has been mostly about Technical aspects, but with a steady trickle about Semantic and Organizational aspects.

Several contributions are offered. Firstly, the study proposes and deploys a novel literature classification schema to analysis studies of e-government conceptualizations, going beyond previous classifications. Second, the current state of conceptualizations for e-government is described on the basis of this classification schema; this collection of articles, which provides an overview of existing works, is a useful starting point for researchers conducting work in this field. Third, the formulate concise proposals shifted for future research, on the basis of the identified limitations of the existing work; We hope that these proposals will help close existing gaps in design and conceptualization of collaborative e-government processes, and inspire research in this area.

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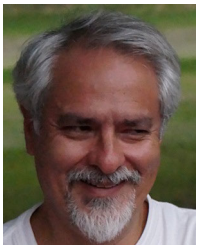

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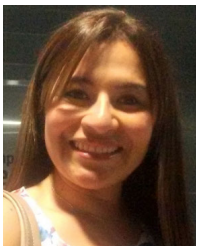

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