Recommender systems for e-governance in smart cities: State of the art and research opportunities

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ABSTRACT

E-governance can be considered as the core and most important challenge of smart cities initiatives. It refers to the use of information and communication technologies in the public sector with the aim of improving information and service delivery, reinforcing government transparency, accountability and credibility, and encouraging citizen participation in decision-making processes. In this paper, we survey the state of the art in recommender systems for the e-governance domain, showing that there are few studies on the topic and that published recommendation approaches are quite simple and focus on a very limited number of applications. Moreover, we propose a number of challenging e-governance scenarios where recommender systems could be exploited, and thus represent new research opportunities.

KEYWORDS

recommender systems, e-governance, e-government, smart cities

1 INTRODUCTION

Today, 54% of the world population is living in cities, a proportion that is expected to increase to 66% by 2050, as stated by the 2014 revision of the World Urbanization Prospect produced by United Nations[1]. The uncontrolled growth of the population and the raising demand for resources, under poor organization and management, not only make cities principal sources of congestion, pollution and waste, but also exacerbate a variety of socio-economic problems, such as the increase of poverty, unemployment and criminality in the cities. Managing urban areas thus represents one of the most important development challenges of the 21st century, including new actions on infrastructures, energy sustainability, natural environment, education, health care, and public safety, to name a few.

Cities, however, are also a key part of the response to such problems. In particular, the concept of *smart city* has been conceived as an approach to address urban problems, by making use of Information and Communication Technologies (ICT) to increase the quality, efficiency and interactivity of urban services, reduce costs and resource consumption, and improve the interactions between government, citizens and businesses [1].

The definition of smart city differs among disciplines, and has evolved over time. In [8], Chourabi et al. identify eight critical factors of smart city initiatives: (1) *management and organization*, which should be addressed in the context of e-government projects; (2) *technology*, referring to new-generation integrated hardware, software, and network technologies that provide information systems with real-time awareness of the real world, and advanced analytics; (3) *economy*, including factors around economic competitiveness as entrepreneurship, innovation, productivity and flexibility of the labor market, as well as the integration in national and global markets; (4) *built infrastructure*, referring to the availability and quality of the ICT infrastructure, such as wireless connection (fiber optic channels, Wi-Fi networks, wireless hotspots), and service-oriented information systems; (5) *natural environment*, i.e., the use of technology to increase sustainability and to better manage natural resources; (6) *people and communities*, whose quality of life, and levels of information, education, and participation may be affected by ICT; (7) *policy context*, where governmental actors and external pressures, e.g., policy agendas and politics, may influence the outcomes of IT projects; and (8) *governance*, which, with the use of ICT, should be accountable, responsive, and transparent, allowing collaboration, data exchange, service integration, and communication.

Among these factors, (smart) *governance* can be considered as the core and most important challenge of smart cities initiatives [8][12]. Governance refers to a new form of governing where a network of public and private actors share the responsibility of defining polices, and regulating and providing public services. Examples of these actors –commonly referred as *stakeholders*– are government agencies, citizens, markets, and organizations.

In the late 80s, the concept of governance gained momentum, as a response to the citizens' demand for transparency and good management in public administration, which had to face its crisis of legitimacy. Actors within the institutions realized the need for openness and considering new forms of governing and management. In 1992, in its "Governance and Development" report[2], the World Bank pioneered the introduction of

[1] United Nations World Population Prospect, https://esa.un.org/unpd/wup/

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[2] The World Bank. 1992. *Governance and Development*. Washington, DC, April 1992. http://documents.worldbank.org/curated/en/604951468739447676/Governance-and-development

governance in the field of economic development, by identifying four areas of governance, namely *public sector management*, *accountability*, *the legal framework for development*, and *information and transparency*. The report cites experiences and best practices in each area, aiming for a more transparent and efficient way of governing. Moreover, in 2001, the European Union published a white paper[3] aimed to bring citizens closer to the European institutions. This entailed encouraging strategies to consolidate governance, by means of initiatives and grants.

In this context, with the consolidation of the Web and social media, the goal of efficient implementations of governance models has brought the adoption of ICT, originating *electronic governance* (or *e-governance*) frameworks.

E-governance has been defined as the application of ICT in the interactions of government with citizens and businesses –e.g., delivery of services, exchange of information, communication, and transactions–, and in internal government operations, aiming to simplify and improve democratic, business and governmental aspects of governance [6]. The number of e-governance solutions has increased remarkably in recent years, providing the involved stakeholders with a wide array of e-services between, which have been classified as government-to-citizens (G2C), government-to-businesses (G2B), and government-to-government (G2G) services.

E-governance approaches, however, have been increasingly examined and questioned. Many critics have claimed that the development of electronic public services has been mostly guided by supply side factors, and that technological possibilities rather than user needs have determined too often the design of online public services [26]. In reaction to this, the need for (more) user-centered e-governance services becomes more prominent. Hence, progress has to be done on the development of personalized approaches that not only allow for more efficient e-services, but also increase the users' satisfaction and engagement [9].

It is in this scenario where recommender systems have new, challenging opportunities. The overwhelming load of information and services in e-governance applications allows for the development and use of particular recommendation solutions for different stakeholders and tasks. In the literature, there are few studies on recommender systems for the e-governance domain, and the majority of them proposes very simple recommendation approaches mainly focused on two particular application cases, namely providing the citizens with personalized government e-notifications and e-services, and assisting the finding of business partners in government e-services.

In this paper, we shall review the state of the art, and shall extend the scope of recommender systems in e-governance, proposing potential application cases for G2C, G2B and G2G services. For each case, we shall depict data sources and types of recommendation approaches that could be explored by researchers and practitioners. Before, in the next section, we provide a brief explanation of e-governance, describing its main stakeholders and their interactions.

2 E-GOVERNANCE

The public sector, and consequently the e-governance domain, is complex and involves a variety of stakeholders. Some theories have considered main 'groups' of stakeholders, such as *government*, *citizens* and *businesses*, while others have segmented stakeholders in terms of 'roles.' For instance, in [21], Rowley identify twelve e-government stakeholder roles: *people as service users*, *people as citizens*, *businesses*, *small-to-medium sized enterprises*, *public administrators (employees)*, *government agencies*, *non-profit organizations*, *politicians*, *e-government managers*, *design and IT developers*, *suppliers and partners*, and *researchers and evaluators*. In this context, an individual may belong to several groups and play multiple roles, e.g., she could be a service user, a citizen, and an employee in a business.

Simplifying the framework to *government*, *citizens* and *businesses*, three major e-governance components reflecting the relationships existing among such stakeholders are commonly accepted:

- **Government-to-citizens (G2C) e-governance**, which aims to provide citizens with a variety of online information and e-services in an efficient and cost-effective manner, and to strengthen the relationship between government and citizens using ICT. G2C services allow citizens to access government documents (e.g., legislations and regulations), make transactions (e.g., payment of taxes and city utilities), and perform bureaucratic tasks (e.g., changes of address, and application for facilities and grants). In a two-way communication, G2C services also allow citizens to message directly to public administrators, send remote electronic votes, propose, discuss and vote public initiatives.
- **Government-to-businesses (G2B) e-governance**, which aims to facilitate interaction between the government and corporate bodies and organizations of the private sector with the purpose of providing businesses information and advice on e-business best practices. G2B services allow entrepreneurs to online access information about legislations and regulations, and relevant forms needed to comply with governmental requirements for their business (e.g., corporate tax filing and government procurement).
- **Government-to-government (G2G) e-governance**, which aims to facilitate the online non-commercial interaction between government organizations, departments and authorities with the purpose of reducing costs, e.g. derived from paper clutter, excessive communications, and unnecessary staffing.

The different interests, objectives and benefits of target stakeholders entail dominant characteristics of e-governance services [21]. Distinct features thus may contribute to the quality a particular e-service: variety of functionalities, perceived ease of use, aesthetics, customer support, information, communication, delivery, security, reliability, trustworthiness, responsiveness, accessibility, compatibility and personalization.

3 RELATED WORK

In the research literature, relatively little work has been done to apply recommendation solutions in e-governance. Moreover, to the best of our knowledge, the majority of the published studies have focused on the G2C context (mostly in government e-service recommendations), a few have addressed the G2B context (mostly in business partner recommendations) contexts, and none has been conducted in the G2G context. Next, we summarize identified papers for each case.

In the ***G2C context***, Janssen et al. [15] presented a centralized software architecture for supplying e-government services, which has a component for identifying the services that best satisfy citizen requirements and the scheduling of the activities necessary to supply these services. In a project conducted for the

[3] The European Union. 2001. *European Governance - A White Paper*. Brussels, July 2001. http://europa.eu/rapid/press-release_DOC-01-10_en.htm

information-managers council of Dutch municipalities with over 100,000 inhabitants, the implementation of the proposed architecture would allow addressing interoperability problems of applications within a municipality and between municipalities. Focusing on driver license renewal processes and task workflow, the authors evaluated the architecture by means of a simulation that allowed them to get insights about the pros and cons the framework implementation may have for the decision makers.

De Meo et al. [10] presented a personalized multi-agent system aimed to recommend the most interesting e-government services to citizens by taking into account both their preferences and the capabilities of the devices they use. A service is represented as a set of description keywords, and a set of constraints necessary to access it, while a citizen has a user model composed of demographic data, past interests in the form of keywords, service access log records, and characteristics of the used device. According to the citizen's profile and current exigencies, expressed as a keyword-based query, a content-based recommendation agent filters and ranks the available services. The authors evaluated the system with 30 users and a set of 90 services derived from the Italian Government website, comparing precision and recall results for different levels of personalization, and with and without considering the device constraints.

Martín-Guerrero et al. [19] presented a recommender of government services in a citizen web portal. The approach first performs a clustering of users, and next provides collaborative recommendations based on the generated clusters. The underlying model for a particular user is composed of a vector representation, where each component is associated to a descriptor (type/category) of services available in the web portal, and has a value that is defined in terms of the citizen's probability to access to the corresponding services, estimated from access log records. The authors conducted an offline evaluation with a dataset from Infoville XXI –an official government website that provides more than 50,000 citizen families from Valencia, Spain, with more than 2,000 services grouped into 22 descriptors, and more than 2 million access records. On data from 4,800 users and more than 30,000 web accesses, the authors show empirical evidences about the benefits of exploiting the clustering information in the recommendation process.

Terán and Meier [25] proposed a recommendation framework for e-elections, aimed to assist voters in making decisions by providing information about candidates close to the voters' preferences and tendencies. The framework was implemented in Smartvote, a recommender system for communal, cantonal and national elections in Switzerland. Its recommendations are based on similarities between voters and candidates –whose profiles are created by filling a questionnaire of 30 to 70 questions about values, attitudes and political issues on 11 categories related to family, health, education, society, economy, environment, transport, energy, justice, security, and state institutions. The system performs a fuzzy based clustering algorithm, and generates a graphical representation of political parties distributed in generated clusters, helping citizens to analyze politicians based on similarities among them.

Al-Hassan et al. [2][3] presented an ontology-based hybrid recommender system for e-government tourism services, aimed to allow citizens and tourists to locate the most interesting destinations and find the most preferable attractions and activities with less time and effort. The system combines the item-based CF similarity with a new Inferential Ontology-based Semantic Similarity (IOBSS), which measures semantic similarity between items in a specific domain by considering their hierarchical relationships, shared attributes, and some implicit connections. The authors conducted a set of initial experiments on a dataset extracted from Australian e-government tourism services, and composed of ratings from 400 users for 500 items, including destinations, attractions, activities and events. They empirically showed promising results validating the better effectiveness of system with respect state-of-the-art semantically enhanced CF approaches.

Sabucedo et al. [4] presented a semantic-based hybrid recommender system to provide citizens with support for the discovery of Public Administration services, such as grant requests, address changes, transport discounts, and university enrolls. The system combines several content-based and collaborative filtering models, which exploit user-item and item-item similarities computed with both heavy-weighted (ontology-based) and light-weighted (folksonomy-based) semantics, and are adjusted with popularity item information. The authors conducted a small, preliminary user study evaluating generated recommendations on a dataset from 50 users and 200 services from the regional government of Galicia and the Spanish government.

Baldassarre et al. [7] presented ASSO, a knowledge-based system that assists citizens to create bundles of services mandatory by legislation or recommended according to the citizens' needs. The system utilizes interactive user profiling, semantic links available in a service ontology available as Linked Open Data, and a service matchmaking tool. Preliminary feedback about the system was received from the Italian Association of Municipalities, which encouraged the authors to deploy a distributed infrastructure replicating ASSO principles to involve various municipalities and public administrations.

Ayachi et al. [5] proposed two hybrid approaches for generating personalized recommendations of government e-services. The first approach provides reactive recommendations of services depending on the citizens' requirements formulated via questionnaires. It is based on a constraint-based technique that relates citizens' needs with service features via CSP solvers, and considers user profiles with demographic and contextual information. The second approach, in contrast, provides proactive recommendations of services by exploiting citizen profiling information extracted from social media. It consists of three components, namely content-, community- and context-based filtering engines. In this case, services are represented in terms of life events (e.g., becoming a parent, finding a job, and couple separation), organizations (e.g., ministries and local governments), and customers (e.g., young people, salaried workers, and people with disabilities), whereas user profiles are updated by mining relevant social media contents, e.g. with critics, opinions and personal announcements. For instance, if a citizen tweets "Finally I got a PhD," she may be recommended with a postdoctoral research fellowship application service.

In the ***G2B context***, Guo and Lu [13] presented Smart Trade Exhibition Finder (STEF), a personalized recommender system able to suggest suitable worldwide exhibitions to individual businesses. The STEF system, which incorporates a semantic similarity into the item-based collaborative filtering (CF) heuristic, aimed to improve e-services of a government trade agency that helps companies to explore international markets and find new customers. The authors preliminary evaluated the recommender system on a dataset with ratings and metadata of 300 trade exhibitions, showing better MAE values for item-based collaborative filtering when using the proposed semantic-based item similarity.

In a series of works, Jie Lu and colleagues investigated several recommendation approaches for supporting Australian government agencies to provide personalized business partner matching e-services. In [16], they proposed a hybrid recommender system named Intelligent Business Partner Locator (IBPL) that integrates a fuzzy set-based semantic similarity and the traditional item-based CF technique. More specifically, the IBPL system considers a similarity between two business partners in terms of both a fuzzy set of interest/preference degrees of exporters for business partners, and a fuzzy set of relevance degrees of a partner's products to a target category in a given product taxonomy. Later, in [17][24], the authors further studied the combination of semantic- and rating-based item similarities in the Hybrid Semantic enhanced Collaborative Filtering (HSeCF) approach, implemented for the BizSeeker recommender system. In this case, the semantic similarity between two businesses is computed as the ratio/overlap (in terms of the binary Jaccard coefficient) of their common categories to all their categories in the taxonomy. On a dataset with 1,602 ratings for 332 businesses from 100 users selected from the Australian Suppliers Directory, the authors empirically shown the effectiveness of HSeCF compared to item-based CF methods, especially when dealing with rating sparsity and item cold-start situations. Finally, in [22][23], Shambour and Lu presented a trust-enhanced CF approach (TeCF) that combines trust-based and multi-criteria user-based CF heuristics, proposing several formulations of user trust, they conducted preliminary evaluations on the well-known MovieLens dataset, showing that a proposed trust-enhanced CF approach (TeCF) outperformed the standard user-based CF in terms of both MAE and coverage metrics, at different rating sparsity levels. Continuing the previous work, Mao et al. [18] proposed to exploit both (positive) trust and (negative) distrust relationships in user-based CF for business partner recommendations.

4 E-GOVERNANCE APPLICATION CASES FOR RECOMMENDER SYSTEMS

In this section, we propose several application cases where recommendation approaches could be exploited to enhance and improve e-governance services. For each case, we depict main recommendation goals, possible user/item profile data sources and representations, and potential recommendation strategies.

4.1 Recommender systems for G2C e-services

Government-to-citizen (electronic) services can be categorized in terms of the degree or level of interaction between the government and the citizens, distinguishing among *information*, *consultation*, *participation* and *co-design* [11][20].

At the *e-information level*, government websites provide information on policies and programs, laws and regulations, budgets, and other issues of public interest. The government also offers software tools –such as email subscription lists, online newsgroups, and web forums– for the dissemination, and timely access and use of public information and services. Recommender systems may assist the accomplishment of these communication tasks in a personalized fashion, by actively informing or helping citizens to locate relevant government decisions and actions, and administrative information and services, which match their interests and needs, thus decreasing their time consumed and increasing their satisfaction.

At the *e-consultation level*, governments offer online consultation (a.k.a. e-voting) mechanisms and tools, which present citizens with choices about public policy topics, allowing for the deliberation in real time, as well as the access to archived audios and videos of public meetings. With them, citizens are encouraged to contribute to the government consultations. In this context, recommender systems may allow citizens to be informed about discussions and others' opinions on consulted issues that could affect their lives or could be related with their profiles, e.g., in terms of their age, gender, marital and parental status, home location, and professional occupation. Recommender systems thus could help government to obtain more citizens' votes, and consequently improve its citizen-centered decision- and policy-making.

At the *e-participation level*, local governments intend to incorporate citizens into decision-making processes, in most cases by means of participatory budgeting. For such purpose, they provide online participation platforms where citizens can propose, discuss, give feedback, and vote for initiatives aimed to solve or improve a wide range of situations and problems in different aspects of a city, such as health and social care, culture and education, energy and environment, and urban mobility and transport. For a particular citizen, the number of initiatives and discussions in an e-participation platform may be overwhelming, and recommender systems could help filtering and ranking those that are more relevant for a particular citizen based on previous explicit interests, initiatives and comments, and implicitly analyzed behavior with others' proposals and discussions. In this way, recommender systems not only may promote the citizens' participation, but also could increase their engagement.

Based on these levels and issues, we identify the following cases where recommender systems could improve G2C e-services:

- **Case 1: providing the citizens with personalized government e-notifications and e-services**. In this case, both content-based [15][10][7] and collaborative filtering [19][3][4][5] strategies could be applied, by considering the profiles of both the target citizen and liked-minded citizens. Besides, we believe that the provision of context-aware e-service recommendations has a potential interest in certain situations where, among other aspects, periods of time (e.g., a particular tax collection campaign), locations (e.g., the target citizen's neighborhood), and personal events (e.g., the pending birth of a citizen's child) should be taken into account.
- **Case 2: keeping the government informed about the citizens' problems, concerns and opinions expressed in e-consultation** [25] **and e-participation platforms, and external social media**, such as online social networks and microblogging systems. Recommender systems thus may act as useful tools of anticipatory policymaking, allowing the government to anticipate to future problems [14]. In this case, natural language processing and opinion mining techniques should be applied to the contents generated by citizens for providing the responsible administrative departments and managers with the most relevant issues, according to identified domains and topics of interest. Content-based filtering thus may be the most appropriate recommendation strategy to use.
- **Case 3: assisting the citizens in finding relevant proposals, discussions, individuals and associations in e-participation platforms**, according to personal interests explicitly declared though votes, or implicitly expressed by means of online comments and social links. Hence, in addition to collaborative and hybrid filtering approaches, social-based recommender systems could be used to exploit the social network structure of the platforms.

4.2 Recommender systems for G2B services

Government-to-business e-services allow companies and government agencies to exchange information and conduct businesses with each other more efficiently than they usually do off the web. For instance, government websites provide companies with single places to find and make use of multiple services, such as updating corporate information, locating applications and forms, sending payments, and requesting answers to particular questions, to name a few. In this context, each company can create and maintain an online profile with heterogeneous information such as its location, business activities and products, resources, and past and on-going projects. Based on such profile, a recommender system may suggest not only government e-services relevant for the company, but also (information about) related government laws, regulations and procedures, which usually are difficult to find and understand for company executives and managers. This would increase the transparency, openness, and efficiency of the legal and administrative processes between companies and government agencies.

Some government web portals also offer e-procurement services, with which companies can learn about (purchasing) needs of the government agencies, and agencies can ask the companies for proposal responses. A recommender system could enhance such e-services by directly providing a list of companies that may be interested in working on particular needs of certain government agency. Conversely, a recommender system may provide a company with a list of existing government agency needs that are related to its business activities. In the latter case, the system could also recommend business partners with which address particular government needs, e.g., by collaborating in the context of a public funded project. This could be done at local, regional or national level, increasing the range of companies working with/for the government.

Moreover, government web platforms may shape virtual workspaces where companies and government agencies can coordinate the work in contracted projects, by sharing a common site to conduct online meetings, review plans, and manage processes. Recommender systems could enhance these services by e.g. suggesting (external) resources, events, and news of interest for the projects.

Considering these applications, we propose the following application cases where recommender systems could improve G2B e-services:

- **Case 4: assisting the finding of business partners in government e-services** [16][17][23][18]**.** In this case, companies and business products would be categorized according to certain taxonomy or ontology, and thus content- and semantic-based recommendation approaches would be the most straightforward to apply. Nonetheless, if ratings or even trust information is available, collaborative filtering and trust-based recommendations may be convenient to enhance the former approaches. The target of the recommendations could be either the public administration –which may need industry partners for the realization of its initiatives and actions, at multiple dimensions, e.g., technological, commercial, financial, social, and political– or the companies –which may need the collaboration of other partners for particular tasks of their businesses and projects (oriented to the citizens or the government).
- **Case 5: informing the companies about events that involve or are related with their businesses and the government agencies** [13], such as public calls, initiatives and projects, grants and subventions, and exhibitions, fairs, seminars and conferences. In this context, we believe that potential recommendation approaches may go beyond these explicit events, suggesting business opportunities according to implicit government and citizens' needs, especially at municipal level. In both cases, mining data published in government web portals, and citizen generated contents in social media, would be a mandatory initial task for any recommender system in this context.
- **Case 6: providing the companies with a personalized, online support in legal and administrative consultancy** on government laws, regulations and procedures, according to their business profiles, and at either local, regional, national or international level. Hence, a recommender system may suggest particular electronic legal/administrative resources and services, such as online application forms of food service establishment permit, liquor license and other local permits for a restaurant.

4.3 Recommender systems for G2G services

Government-to-government e-services aim to support better coordination and cooperation between government agencies, departments and employees.

A common situation is that each governmental organization has developed its own information systems in isolation. Effective and efficient (electronic) communication, however, is needed to get commitment and to support decision-making, which is complicated due to the large number of involved stakeholders, such as politicians, information managers, and administrative departments, and ICT teams. Recommender systems could be the basis to further exploit and increase the government electronic interoperability, by retrieving information resources relevant to particular administrative and legal processes within and between government stakeholders. They, for instance, could be incorporated into e-services for cross-departmental information communication and management.

In addition to (certain) lack of interoperability, governmental organizations are usually characterized by rigid and cryptic, vertical hierarchies [27], which has been shown to generate citizens' disaffection. Initiatives such as the New Public Management, Open Government, and Smart Government aim to provide more transparency and flexibility, and thus restore the confidence on the public sector. In this context, recommender systems accounting for the current needs of government and its public officials, may make the management of human resources more effective and efficient. For instance, in a horizontal perspective, they could recommend the best government employees for certain tasks and positions, and suggest relevant job and academic opportunities for each employee in government projects and learning programs.

According to these issues, we propose the following application cases where recommender systems may improve G2G-services.

- **Case 7: enhancing the government electronic interoperability.** Recommender systems could assist the interchange of data, case files, and other documents between government agents, by suggesting those that might be relevant on certain administrative/legal process. To provide this functionality, database integration among government agencies is needed, which unfortunately is still a pending problem in general, even at local level. Addressed such issue,

for this case, in addition to content-based recommendation approaches, we envision cross-domain recommender systems as effective solutions to aggregate and transfer knowledge from/towards different agents.

- **Case 8: improving the e-management of human resources in government**. As e-services for government agencies, recommender systems may suggest public officials who could perform particular tasks or take certain government positions. For such purpose, each government employee should have associated an academic and professional profile, as well as information about work availability and restrictions. Taking such type of user profiles into account, we believe that constraint-based recommender systems may be an effective approach to improve human resource management processes within and between government agencies.
- **Case 9: providing government employees with personalized recommendations of professional events.** As e-services for government officials, recommender systems could generate personalized suggestions of available job positions, new promotion examinations, and seminars and courses offered by government agencies. The employees' profiles may be the same as those presented in Case 8, for the e-management of human resources in government. In fact, these two recommendation applications can be considered as government-to-employee (G2E) e-services, which in the literature have already been considered as a particular type of G2G e-services.

5 CONCLUSIONS

E-governance is an important challenge and core of smart cities initiatives, and is envisioned to enable the 'smart' governance in the cities. Among the current limitations of e-governance services, the lack of personalization for specific stakeholders has been identified as one of the most prominent. This aspect is where recommender systems have new opportunities. The overwhelming load of information and services in e-governance applications can make more prominent the development and use of personalized recommendation solutions for the different stakeholders and tasks.

Surveying the literature, we have identified that there are still few studies on recommender systems for the e-governance domain, and that the majority have proposed very simple recommendation approaches focused on limited application cases, namely providing the citizens with personalized government e-notifications and e-services, and assisting the finding of business partners in government e-services. For these reasons, in this paper, we have proposed a number of potential applications, depicting some data sources (e.g., government web portals, and social media) and types of recommendation approaches that could be explored.

We have not, however, addressed issues in smart cities that may be considered in the design and implementation of e-governance recommendation solutions, such as the exploitation of real-time sensor data from the Internet of Things, the particular interests, objectives and benefits of the target stakeholders, and the appropriate recommendation goals and evaluation metrics, such as the citizens' engagement. These aspects are of high interest, and would be tackled in further analysis.

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