Cloud Computing in eGovernment:

Benefits and Challenges

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Abstract—**Over the past years, implementation of and research on cloud computing in the eGovernment context have increased substantially. A wide range of benefits and challenges is suggested in the literature. However, these suggestions appear fragmented and disconnected and do not offer a clear overview of the main challenges and benefits. Therefore, there is a need for clarification about both benefits and challenges of cloud computing, especially in the eGovernment context. To address this need, the literature on cloud computing and eGovernment is reviewed in this paper. The findings show that despite the extensive number of benefits and challenges, some stand out from the rest. This paper presents an overview of these, explains them in detail, and suggests avenues for further research.**

Keywords-cloud computing; eGovernment; benefits; challenges.

I. INTRODUCTION

Governments and public organizations in both developed and developing countries are increasingly adopting eGovernment solutions throughout their service portfolios [1][2]. Most often, eGovernment services are provided through the Internet [3][4]. While eGovernment services show substantial potential related to increased efficiency and effectiveness, there are also considerable challenges in transitioning to digital services. The challenges discussed in the eGovernment context are often related to investment and development costs [1], insufficient Information Technology (IT) skills [5], the lack of compatibility and shared standards [3], and the lack of compatible infrastructure [3]. These obstacles are especially challenging for developing countries [6][7]. A proposed solution to several of these challenges is to adopt cloud computing to support eGovernment [4][8]-[10].

Today, the existing literature outlines a plethora of possible benefits and challenges in relation to cloud computing and eGovernment. However, the literature does not present an accessible overview of what the main benefits are and how challenging the adoption of cloud solutions can be.

This paper's objectives are to identify 1) the benefits and 2) the challenges, both associated with cloud computing in the eGovernment context.

To address the objectives, the following research questions are formulated:

1. What are the main benefits of cloud computing in eGovernment?
2. What are the main challenges of cloud computing in eGovernment?

These questions are addressed by performing a systematic review of peer-reviewed scientific literature on the use of cloud computing in eGovernment.

The rest of this paper is structured as follows: Section II describes the use of cloud computing in the eGovernment domain and explores possible implications for its use in public service provision. Section III presents the methodology for the literature analysis. Section IV explains the results of the analysis. Section V discusses the findings, providing answers to the two research questions. Finally, Section VI presents the conclusion and several suggestions for further research.

II. CLOUD AND EGOVERNMENT

As a theme in conjunction with the government, cloud computing emerged in 2009 [11], where the exploration of implementation [12][13] and associated key issues [14] were studied. The potential use of cloud computing technologies in eGovernment was supported by Cellary and Strykowski [15], who recommended cloud infrastructure as the default solution for digital public services generally. Cloud adoption by the government has been studied repeatedly [9][16]. On this basis, Mohammed et al. [17] suggested an eGovernment cloud adoption model that would list the factors contributing to the adoption of the technology in public service.

Cloud computing is perceived as a possible solution to the challenges that governments face regarding the dramatic increase in computational data [13]. The Internet of Things (IoT) devices collect significant amounts of data, especially in the smart city context. Sensors collect environmental data, with the potential to be used for evidence-based decisions,

increasing the effectiveness, efficiency, and responsiveness of public services [18]. E-participation platforms, crowdsourcing, and social media mining also contribute to the increase in the data collected by governments. However, due to its properties (complexity, heterogeneity, and volume), Big Data cannot be efficiently analyzed using traditional methods [19]. Cloud computing can provide the necessary storage and computational capacities [18][20] to store and analyze very large volumes of data. In this regard, cloud computing is considered one of the crucial components of the realization of smart cities, usually viewed in combination with IoT [21]-[23], providing the necessary capacities and aiding in automated decision making [24].

In Gartner's latest overview of the top trend hype cycle for digital government [25], cloud computing is identified as a growing hype. The European Union (EU) explicitly mentions cloud computing in Agenda 2020, underlining its importance and estimating that the European cloud market would reach €44.8 bn by 2020 [26]. Following the recommendations of the European Commission's Cloud Strategy 2012 [27], many EU countries have developed their own national cloud strategies [28]. However, only a few countries have backed up these strategies with the development of their government cloud infrastructure to support public administration, with several notable exceptions, such as the UK, Spain, and Denmark [29][30].

III. METHODOLOGY

Any literature review relies on systematic, rigorous, and well-established methods to help avoid cherry picking, biases, and a poor selection of relevant literature. Otherwise, the sample would likely not contain an accurate overview of existing knowledge and would therefore be of limited scientific value [31]. This review is based on Okoli [32] and
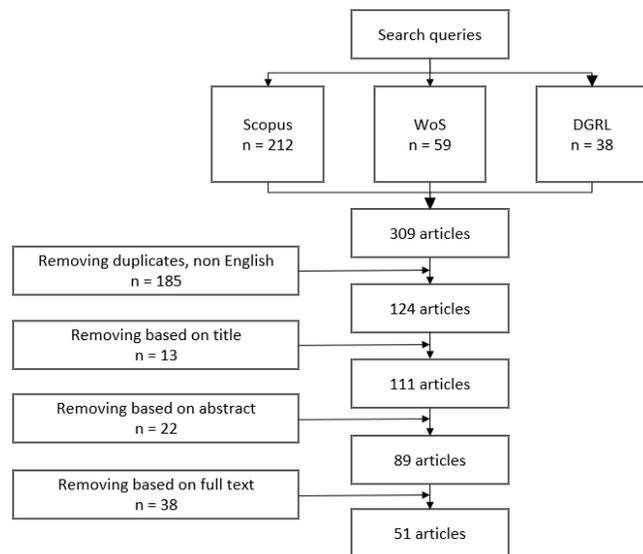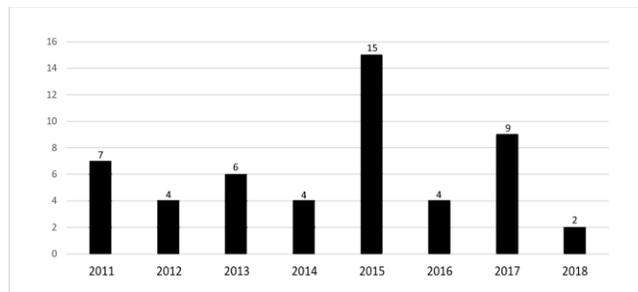
Figure 2. Literature per year.

Webster and Watson [33] methods, whose goal is to identify and analyze relevant literature to answer this present study's research questions.

To explore the research questions and identify existing knowledge in the literature, the following search queries were used: ("cloud computing") AND ("e-government" OR "eGovernment" OR "electronic government").

Three databases were searched for relevant articles: Scopus, Web of Science, and Digital Government Reference Library (DGRL). The DGRL is a highly regarded EndNote library consisting of over 10,299 references of peer-reviewed publications in the domains of digital government/governance and digital democracy.

Additionally, we applied the following inclusion criteria: 1) contain the search phrases based on the research questions and 2) be peer reviewed and published in journals or conference proceedings. The exclusion criteria required discarding the articles that were 1) irrelevant to the research objectives, 2) not in English, and 3) not offered for download or otherwise inaccessible. This process yielded a literature sample of 51 articles (Figure 1). The articles were published between 2011 and 2018 (Figure 2).

IV. RESULTS

A. Benefits of Cloud Computing

The studies discussing cloud computing in eGovernment settings report a number of benefits. Some benefits are studied in depth, while others are superficially mentioned. Out of the 51 papers, 46 mention benefits to some extent. In total, 49
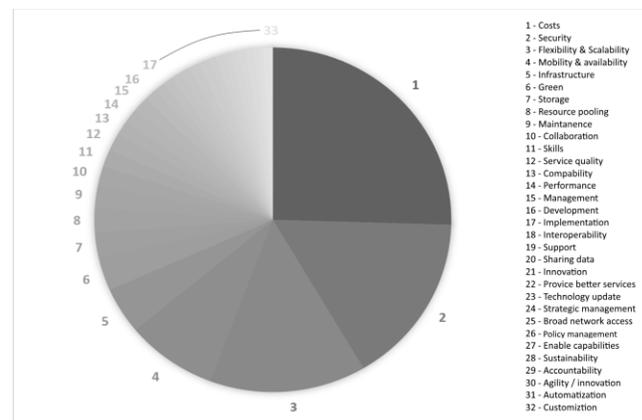
Figure 1. Literature review process.
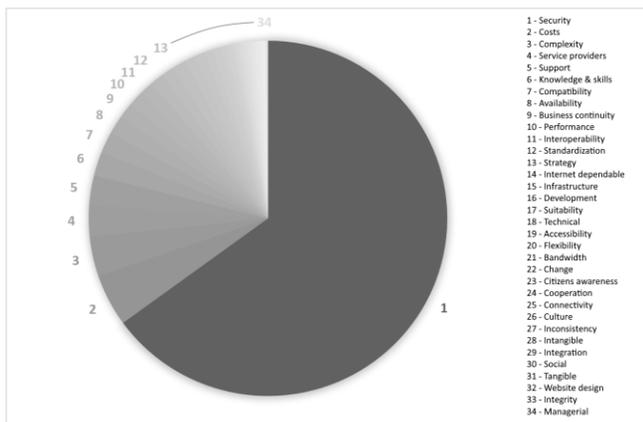
Figure 3. Benefits

Figure 4. Challenges

benefits are identified in the first round of analysis. In the second iteration, some of the benefits found in the first round are grouped together, resulting in 32 distinct benefits.

A pie chart (Figure 3) illustrates the relative proportions of the papers that focus on each benefit and how focused they are. Table I (Appendix) lists the benefits and the associated literature, where three benefits stand out: cost reduction, security, and flexibility and scalability.

B. Challenges of Cloud Computing

Our analysis indicates differences in the extent to which the various challenges are studied. In total, 38 papers include discussions on cloud computing challenges. A total of 54 challenges were identified in the first iteration. A second iteration of the analysis resulted in 34 distinct challenges.

Similar to the benefits, a pie chart (Figure 4) illustrates the relative proportions of the papers that focus on each challenge and how focused they are. Table II (Appendix) lists the challenges and the associated literature. The challenges that stand out are security issues, costs, and complexity.

V. DISCUSSION

In this section, the findings from our analytical efforts are summarized and discussed, focusing on benefits and challenges.

Of the 51 papers reviewed, only seven use theories in their research. This indicates a lack of theoretical development in the eGovernment field in relation to cloud computing.

A. Benefits of Cloud Computing

Of the 32 identified benefits, cost reduction, security, and flexibility and scalability are mentioned much more frequently in the literature than the rest. Therefore, these three benefits are further explored.

1) Cost reduction

Cost reduction is a key driver for public organizations considering migrating to cloud solutions [1][8][34]. Of the 51 papers, 38 suggest cost reduction as an advantage for public agency use of cloud computing. Costs relating to the purchase and the installation of information and communication technology equipment, software, and infrastructure can be greatly reduced [1][7][11][28][35]. Public organizations can

also upgrade or downgrade their capacities as needed and pay only for the resources used (economy of scale) [10][11][36][37]. Several researchers believe that human resource costs can be reduced as well [10][11]. Savings on software licenses can also occur, especially when using open source programs [10][38]. By purchasing large quantities of hardware and software, cloud service providers can offer more economical solutions. Opportunities, such as the creation of server parks near power stations, affordable sites, and so on, can also contribute to lower costs [10]. A study estimates that government agencies would save between 50% and 67% of eGovernment operation costs by moving governmental applications into private or public clouds [28]. For example, the governments of the UK and Spain use cloud computing to reduce costs [28][29].

2) Security

Security is regarded as the largest obstacle to public organizations' deployment of cloud computing, but several researchers suggest substantial security benefits. Security can be improved with centralized security management [10][39][40]. Public organizations with one centralized system instead of silo structures can provide security enhancements [10]. Cloud computing can also offer backup solutions (e.g., use cloud storage to upload the backup or the supplier's own backup and disaster recovery solutions), which will likewise satisfy the requirements of off-site storage in different locations [39]. Restoration and recovery can be performed swiftly [39]. Private cloud solutions with stricter security are more appropriate for governments than public cloud solutions [6]. Cloud-based solutions for security have been developed, for instance, "identity in the cloud," which is an authentication service based on cloud technology [41].

3) Flexibility and scalability

Flexibility and scalability are benefits of cloud computing in the eGovernment context [1][28][29][35][38]-[40][42]-[44]. The pay-as-you-go pricing model allows an instrument of scaling, depending on user demand [5][28][42], thereby achieving flexibility in the form of rapid elasticity [6][37][43]. This especially allows an increased number of users, user loads, and applications [1][11]. This is possible due to virtualization technologies [45], where nodes can be seamlessly added to the public organizations' resource pools [10]. Public organizations can control these scaling options without interfering with suppliers or humans [2][40]. These options can even be fully automated [10]. Cloud computing also offers access to applications and stored data, anytime and anywhere [39]. Cloud computing has massive storage capabilities [11]. Denmark benefited from cloud computing scalability during the World Climate Conference in 2009, where the expectation of high load peaks made the use of traditional solutions unsustainable [28]. Cloud computing suppliers typically offer flexible contract terms to ensure scalability [39].

4) Other benefits

Interestingly, several authors argue that cloud computing offers environmental benefits because of enhanced efficiency of resources and less consumption of power [1][6][11][42].

Payment models (e.g., pay-as-you-go) may offer considerable benefits as the current climate of economic difficulties affects government budgets worldwide [5][7][28][39].

B. Challenges of Cloud Computing

Security issues, costs, and complexity are the most frequently mentioned challenges, especially security issues (Figure 4). These three challenges are further explored in the following subsections.

1) Security issues

Many studies highlight security as the main issue or one of the most critical challenges for adopting cloud computing in eGovernment [2][11][28][29][35][38][45]. Security risks associated with cloud computing are prominent in eGovernment systems [28][46]. This situation can create trust issues [38][46] that in turn can lead to adoption barriers [9][43]. This matter is crucial for national security [11]. Public organizations transfer much of the security control to cloud computing suppliers, which leads to the government's reduced ability to control data [4][6][37] and therefore requires complete trust [34]. By using cloud computing, public organizations store their data in the cloud, resulting in the challenge of protecting the data [28]. Data that are not kept in the government's premises and are therefore under less control might lead to concerns about unauthorized access and misuse [2].

Moreover, data privacy law enforcement is not globally uniform [6]. Most governments have data protection regulations that do not allow storage of sensitive data in other countries, where cloud computing suppliers offer international mirrored sites for data storage [1]. It is difficult to check whether the cloud computing suppliers fulfill their promises of protection and storage of sensitive data [2]. High data encryption is therefore recommended [2]. It is also important to implement proper access control, authentication, and authorization [47][48]. There is the need for auditing as well, which is another challenge in cloud computing systems. In countries where cloud computing systems are based on public clouds, shifting to private clouds might help overcome this challenge [28]. Other mentioned challenges are users' use of e-payment systems [38] and cloud-based e-voting [6]. All of the above issues require physical security (data and information stored in a secure location) and logical security (protection from threats, such as hacking, intrusion, and viruses) [2]. Cloud computing suppliers are starting to support governments' security requirements. One example is Fabasoft, a supplier that offers secure authentication, supporting the national eID systems of Austria, Germany, and Switzerland [28].

2) Cost

Several studies highlight cost as a crucial challenge [2][4][9][29][49]. This is somewhat confusing, given that cost reduction is viewed as the main benefit of adopting cloud computing solutions. Alkhwaldi, Kamala and Qahwaji [46] highlights high maintenance and operational costs. High costs may also be related to security solutions. Some studies also cite the higher costs associated with activities aimed at preventing lock-in (being dependent on one cloud supplier, with difficulty in changing the supplier or the solutions) [2][4]. Other challenges for cloud computing can be hiring IT experts, facilitation of network requirements, adoption costs, and government budgets allocated for cloud computing [9].

3) Complexity

Several studies emphasize complexity as a major challenge, which adversely affects the adoption of cloud solutions [8][34], thus hindering the realization of the benefits [39]. Complexity also contributes to user dissatisfaction [39]. The lack of standards for cloud computing often leads to problems surrounding its adoption or difficulties in changing suppliers (of cloud services) [1]. Cloud service providers might also procure their services through a third party and therefore increase the risks of chain failure and interruption of cloud services [2].

4) Other challenges

One notable challenge is the potential lack of the IT experts required to manage cloud computing [9]. This issue is interesting because of the finding that one of the drivers of the migration to cloud computing is reducing the need for IT expertise. It is also interesting that despite the research indicating an expected increase in performance [40], another study reports concerns related to under-performance [4].

VI. CONCLUSION

This study has aimed to explore and understand the phenomenon of cloud computing in the eGovernment context. To this end, we adopted a literature review approach, collecting and analyzing 51 relevant research articles and discussed cloud computing in the digital government domain.

Our analysis identified 32 distinct benefits of cloud computing in eGovernment. Of the 32 benefits, cost reduction, security, and flexibility and scalability are the most prominent. Among the 34 distinct challenges identified, those related to security are by far the most frequently mentioned in the reviewed literature. No consensus has been reached about the cost benefit of moving to cloud solutions as costs are mentioned among both benefits and challenges of the cloud technology.

The limitations of this study include the choice of search terms (some related terms can also be included in the search) and the selection of databases. Some challenges and benefits are possibly better described in the more general computer science literature, while remaining applicable to the eGovernment domain.

Nonetheless, we believe this review offers a useful overview of the use of cloud computing in eGovernment. It can be a starting point for more in-depth research on the applications of this technology for the provision of public services.

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VII. APPENDIX

TABLE I. IDENTIFIED LITERATURE ON BENEFITS.

Identified Benefit	Literature	Identified Benefit	Literature
Cost reduction	[1][5]-[11][29][34]-[44][46][48][50]-[67]	Security	[1][2][6][8][10][28][35][38]-[42][44][46][50][51][53-56][58][59][62][63][68][69]
Flexibility and scalability	[1][2][5][6][9]-[11][28][29][35][37]-[40][42]-[46][50][51][53][56]-[58][60]-[64][66]-[68]	Mobility and availability	[1][2][6][9]-[11][28][29][35][39][40][42][45][50][54][58][59][61][64][67]
Infrastructure	[5]-[8][10][11][29][39][42][45][46][56][61][68]	Green technology	[1][6][10][11][39][42][46][54][56][57][59]
Storage	[1][6][11][39][40][45][46][62]	Resource pooling	[1][6][7][11][40][42][46][60]
Maintenance	[6][11][28][29][39][55][56]	Enabling capabilities	[1][29][39]
Collaboration	[6][10][46][56][58]	Management	[7][46][58][70]
Sharing data	[2][42][70]	Skills	[5][8][11][56]
Compatibility	[5][8][59][63]	Performance	[6][9][40][58]
Innovation	[38][68][70]	Service quality	[10][38][60]
Policy management	[39][51][63]	Broad network access	[1][60]
Implementation	[11][28]	Development	[37][39]
Support	[34][39]	Interoperability	[28][29]
Agility	[29][52]	Accountability	[6][62]
Customization	[6]	Automatization	[6]
Provision of better services	[39]	Technology update	[39]
Strategic management	[10]	Sustainability	[10]

TABLE II. IDENTIFIED LITERATURE ON CHALLENGES.

Identified Challenge	Literature	Identified Challenge	Literature
Security	[1][2][4]-[6][8]-[11][28][29][34][35][37][39]-[44][46][48]-[50][54]-[56][60][61][64]-[69][71][72]	Costs	[2][4][6][9][29][46][49][55][65][67]
Complexity	[5][6][8][9][34][46][65][67]	Service providers	[2][6][34][37][42][49][54][55][64]
Availability	[2][6][29][40][46][73]	Knowledge and skills	[6][39][42][55][65]
Interoperability	[1][11][28][39]	Compatibility	[8][9][65][67]
Internet dependable	[11][35][65]	Technical	[29][39][46]
Support	[6][56][60]	Performance	[4][29][40][55]
Strategy	[2][11][56][60]	Infrastructure	[40][46][73]
Managerial	[6][29][46]	Business continuity	[11][60][68]
Standardization	[29][60][73]	Flexibility	[6][67]
Development	[4][65]	Accessibility	[46][55]
Intangible	[46]	Integration	[6]
Integrity	[6]	Suitability	[2]
Culture	[46]	Inconsistency	[44]
Connectivity	[6]	Cooperation	[8]
Bandwidth	[34]	Social	[39]
Change	[34]	Citizens' awareness	[6]
Tangible	[46]	Website design	[46]