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Reference Architecture for Participatory Budgeting in an eGovernment Landscape

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List of Abbreviations

eGov eGovernment
ERP Enterprise Resource Planning system
IaaS Infrastructure as a Service
NIST National Institute of Standards and Technology
PaaS Platform as a Service
PB Participatory Budgeting
SaaS Software as a Service
SSO Single Sign On

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1 Introduction

Participatory Budgeting (PB) puts a part of the public budget directly in the hands of the constituents. The citizens can craft proposals for spending the budget, and these proposals are later voted on by the community, with the proposals receiving the most votes getting implemented. This democratic process to allocate parts of the budget increases the inclusion of otherwise overlooked groups, triggers debates on how to spend the budget, increases the public's understanding of governmental processes, and thus strengthens the quality of democracy. Further, PB increases state performance by increasing accountability[1].

In recent years, the idea of PB spread worldwide and increasingly took hold in European administrations. However, a central guideline on how to implement such a system in an existing architecture of information systems is missing. The objective of this report hence is to derive a technical reference architecture for these PB applications. A reference architecture is an archetypical architecture of a system that can be used as a blueprint for new implementations.

Based on a systematic literature analysis, we identified already existing PB initiatives. In the next step, to ensure compatibility of the PB software with the rest of the government's IT landscape, we identified stereotypical eGovernment (eGov) processes. Based on these two analyses, we integrated the core features of PB into a universal service-oriented eGov architecture.

2 Literature Review

A systematic literature analysis was performed to identify the current state of the art on reference architectures for PB. This analysis is grounded in the methodology for systematic literature reviews in information systems research proposed by Barbara Kitchenham[2]. The main research question posed was "which architectures were developed that are relevant for the IT-support of participatory budgets"?

PB is an increasingly global phenomenon. Thus, researchers from different regions and continents published results. To capture the variety of different outlets, the study's authors decided to use the metasearch engine *Scopus*, which offers extensive coverage of peer-reviewed research output. Table 1 shows the used search strings and the associated relevant results. A

[1] Shah, A. (2007).
[2] Kitchenham, b. (2004).

paper is considered relevant if it the paper presents a technical architecture or reference architecture that is relevant for a PB system or if the paper presents an e-government architecture where a PB system can be integrated. Not considered were architectures that are heavily specific for a particular use-case without offering possibilities to generalize aspects.

Table 1: Search Terms and Results

#	Search String	Results	Relevant
1.1	*TITLE-ABS-KEY*(("participatory budget*" *OR* pb) architecture *AND* reference)	24	0
1.2	TITLE-ABS-KEY(("participatory budget*") AND architecture)	9	1 [3]
1.3	*TITLE-ABS-KEY*(("participatory budget*" *OR* "idea management" *OR* "innovation management") *AND* architecture)	125	1 [4]
2.1	*TITLE-ABS-KEY*((egov* *OR* e-gov*) reference architecture)	89	2 [5]
2.2	*TITLE-ABS-KEY*((egov* *OR* e-gov*) *AND* architecture *AND* framework)	440	9 [6]

3 Developing the Reference Architecture

All of the identified architectures differentiate between the core elements of user, the application server, and the data storage. While some of the initiatives[7] do not further specify the underlying architecture, most of the other papers[8] further detail and propose a layered structure. The layered architectural structure is thus also inherited for the newly created reference architecture (cf. Figure 1).

The first layer (*Access Layer*) of the eGov reference architecture is concerned with access to the system. It addresses the various devices that the end-users utilize. While some

[3] Alfaro, C. et al. (2010).
[4] Murah, M. et al. (2013).
[5] Baheer, B./Lamas, D./Sousa, S. (2018); Tambouris, E. et al. (2014).
[6] Hilabi, S./Gaol, F./Matsuo, T. (2021); Goddy-Worlu, R./Ayo, C./Geteloma, V. (2019); Abdullah, A. et al. (2017); Al-Husban, M./Adams, C. (2014); Ciobanu, V. et al. (2012); Yanyan, W. (5/7/2010 - 5/9/2010); Chakravarti, B./Varma, V. (2008); Corradini, F. et al. (2007); Yang, D./Han, Y./Xiong, J. (2007); Ebrahim, Z./Irani, Z. (2005).
[7] Hilabi, S./Gaol, F./Matsuo, T. (2021); Ciobanu, V. et al. (2012).
[8] Goddy-Worlu, R./Ayo, C./Geteloma, V. (2019); Baheer, B./Lamas, D./Sousa, S. (2018); Abdullah, A. et al. (2017); Al-Husban, M./Adams, C. (2014); Yanyan, W. (5/7/2010 - 5/9/2010); Chakravarti, B./Varma, V. (2008); Corradini, F. et al. (2007); Yang, D./Han, Y./Xiong, J. (2007); Ebrahim, Z./Irani, Z. (2005).

authors[9] also propose additional channels like the telephone, digital TV, call center, and teleconferencing, the current approach was limited to serving a website through a PC, a mobile device like a smartphone or tablet, or a stationary kiosk[10] computer that is available, e.g., at a government site. The inclusion of additional mentioned channels like a call center would add significant cost and complexity to the eGov/PB system. The advantage of the proposed reduction to kiosks computers and PCs is that setting up a state-of-the-art website that is also mobile-enabled is sufficient to roll out the application to the targeted devices.

The next layer manages the access control through *Authentication and Authorization.* It builds upon the single sign-on (SSO) as proposed in literature[11] and shall enable the use of all governmental applications with just one login. Thus, it also is a prerequisite for the one-stop paradigm[12] (having all necessary resources at one place). This SSO enables a proper rights management. There are many forms one can implement security through authentication. Depending on the implementing municipality's legal, technical, and cultural background, one can use log-in credentials, two-factor authentication, ID-cards, and more. Also, the requirements for registration vary. While some initiatives might only require a simple registration with username and password, others might postulate a residency. After successful authentication, a user is either authorized as a "Citizen" or "Employee" and can access the parts of the applications that are not publicly available.

The layer *Service Bus* comprises the business logic of the eGov system. As seen in the literature analysis, most of the more recent eGov architectures[13] build upon an service oriented architecture (SoA) to manage the complexity and ensure a high degree of modularity. In a SoA system, every capability is a service and decoupled from each other. Furthermore, most of the other ideas are not far from an SoA (cf. interchangeable Java applications[14], portal solution[15]).

[9] Chakravarti, B./Varma, V. (2008); Ebrahim, Z./Irani, Z. (2005).
[10] A kiosk is a public, stationary computer (e.g., at a municipal building) allowing to directly access the governmental website without an own device.
[11] Al-Husban, M./Adams, C. (2014); Chakravarti, B./Varma, V. (2008).
[12] Ciobanu, V. et al. (2012); Yanyan, W. (5/7/2010 - 5/9/2010); Corradini, F. et al. (2007); Ebrahim, Z./Irani, Z. (2005).
[13] Baheer, B./Lamas, D./Sousa, S. (2018); Abdullah, A. et al. (2017); Al-Husban, M./Adams, C. (2014); Yanyan, W. (5/7/2010 - 5/9/2010); Alfaro, C. et al. (2010); Chakravarti, B./Varma, V. (2008); Corradini, F. et al. (2007); Yang, D./Han, Y./Xiong, J. (2007).
[14] Goddy-Worlu, R./Ayo, C./Geteloma, V. (2019).
[15] Ebrahim, Z./Irani, Z. (2005).

Thus, the proposed reference architecture for PB also builds upon this SoA. Here, the PB application is merely one service from many in the government. Even though it can be integrated with other services, it has a high degree of independence within the system and is, e.g., not necessarily bound to the same programming language as the web portal. It just needs the interfaces to get integrated with the already existing system landscape.

As already stated, PB initiatives differ widely depending on the jurisdictional and cultural backgrounds. The instantiation of the application of the PB process is, thus, always bound to local customization. A detailed description of the possible functions of such a system is given in EmPaci Output 4.1.3[16].

The *Data Layer* is the gateway for accessing the databases and document storage. It is proposed by the authors of footnote[17]. This data can be from systems like an Enterprise Resource Planning system (ERP), from the central governmental resident register, a PB database, or other application-specific databases. An audit trail provides additional security by logging the access on security-sensitive data[18]. The databases can utilize technologies like SQL-like databases, document-centric NoSQL-databases, or even Blockchains, e.g., for ensuring secure voting.

The *Infrastructure Layer* is the provisioning of the computational resources and networking infrastructure of the services. The publications upon this reference architecture is built regard this layer as the provision of servers, networks, datacenter, hardware, and more[19]. The fully or partly virtualization of these parts of infrastructure through the use of cloud providers has the potential to reduce IT costs while at the same time improving reliability. A recent literature study on the effects of cloud computing for eGov outlined its potential[20]. Even though no paper was identified as relevant for eGov architectures that included a cloud infrastructure, this might be due to the often older literature and the recent emergence of cloud technologies, combined with the at times hesitant adaption of new technologies in governmental services. As cloud computing and the (at least partially) infrastructure virtualization is expected to rise

[16] Rostock University (2020).
[17] Hilabi, S./Gaol, F./Matsuo, T. (2021); Goddy-Worlu, R./Ayo, C./Geteloma, V. (2019); Al-Husban, M./Adams, C. (2014); Murah, M. et al. (2013); Ciobanu, V. et al. (2012); Yanyan, W. (5/7/2010 - 5/9/2010).
[18] Chakravarti, B./Varma, V. (2008).
[19] Baheer, B./Lamas, D./Sousa, S. (2018); Ebrahim, Z./Irani, Z. (2005).
[20] Fathey, M./Olayah, F./Ali, Abdullah, Gazem, Nadhmi A. (2020).

in the upcoming years[21], this technology is included in this reference architecture as a possible deployment model.

The proposed infrastructure layer is based on the National Institute of Standards and Technology (NIST) definition for cloud computing[22]. It differentiates four different deployment models:

1) In a **public cloud**, a provider shares computational resources with the general public, and the servers are on the premises of the cloud providers.
2) In a **private cloud**, the virtualization infrastructure is run entirely for (and also possible by) a single organization.
3) The **community cloud** provides a shared infrastructure for exclusive use by selected users (e.g., a governmental cloud run by the state for administrations).
4) The **hybrid cloud** combines two or more infrastructures, e.g., private and public or community and public. This combination allows executing non-sensitive tasks in a public cloud while sensitive data remains within the premises.

There are three service models regarding the cloud virtualization level:

1) In a **Software as a Service** (SaaS) model, the organization books the whole software from a provider and pays per use (e.g., per active user). The provider takes care of the provisioning, licensing, and updating of the services. Even though some applications can also be installed in a private cloud and managed through a provider, these services normally run off-premise.
2) In a **Platform as a Service** (PaaS) model, the provider handles everything except the installed software. This includes the operating system, runtime environments, and servers.
3) In an **Infrastructure as a Service** model (IaaS), the provider handles the server, networks, and virtualization infrastructure like networks. Here, the consumer controls everything from the operating system to the application.

[21] Statista (2021), URL: statista.com.
[22] Mell, P./Grance, T. (2011).

However, eGov applications can also run **On-Premise** without the use of a cloud virtualization infrastructure. Further, the decision for or against running the infrastructure in the cloud is not binary. It is also possible to run just specific, new applications on this virtualization infrastructure. Most likely, some kind of SaaS application is already in use, like Microsoft Office 365 or Zoom.

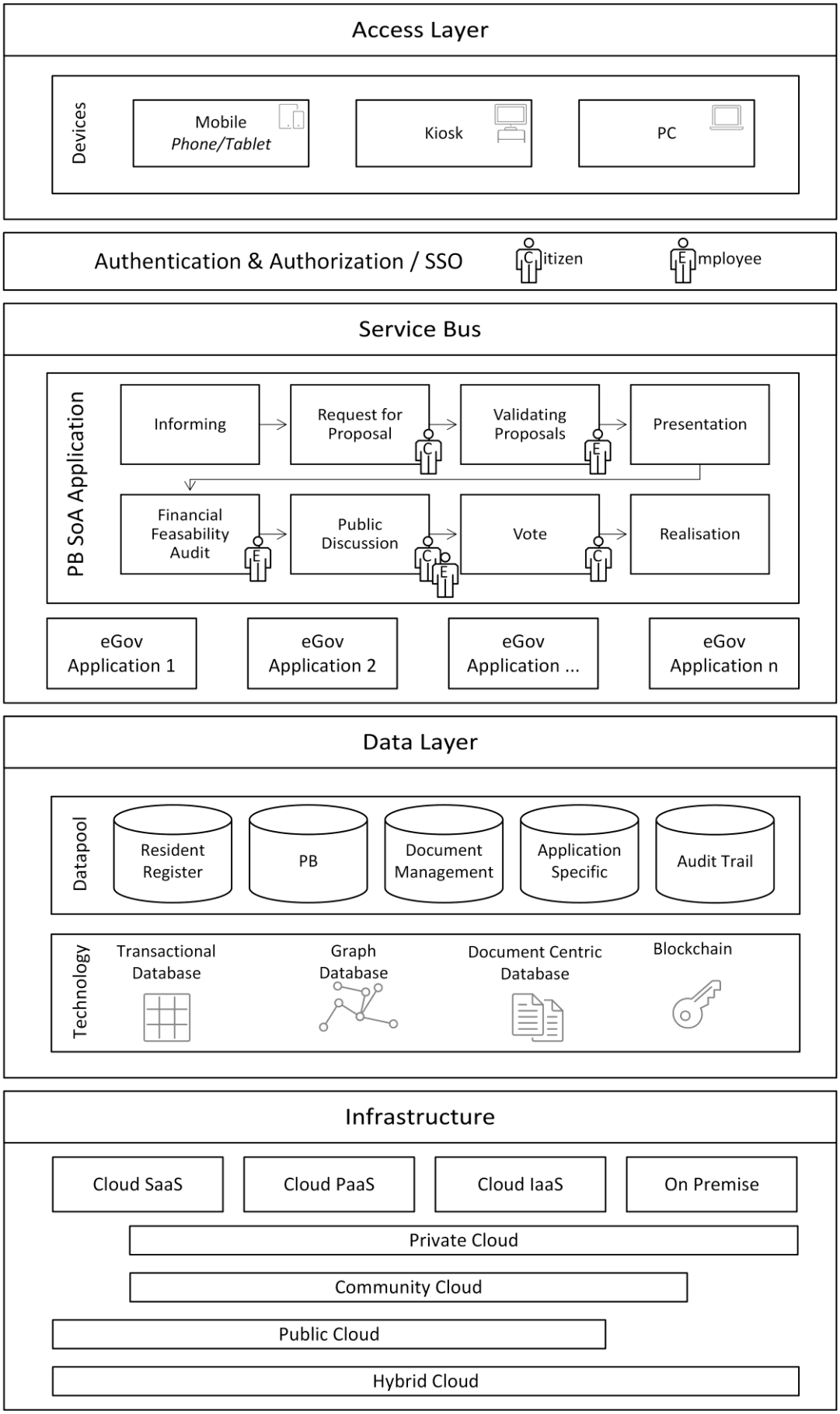

Figure 1: Proposed Reference Architecture for a PB Application in an eGovernment Systems Landscape

4 Closing Remarks

This report presented a reference architecture based on existing literature for integrating a PB application into an eGov landscape. It is targeted at administrations which plan to implement a PB initiative. The reference architecture shall enable these administrations to (1) assess their current eGov architecture, (2) identify the technologies needed to create a PB, (3) identify possible integrations for a PB application into the existing landscape, and (4) adapt the proposed reference architecture to their individual needs.

This research falls into a larger perspective of investigating the use of IT for PB and the success factors of PB in general within the EmPaci project. More information is available on the projects homepage at empaci.eu.

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