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# Modelling Impacts of Maintenance, Staff Management and Collaboration on E-government Website Availability: A Qualitative System Dynamics Approach

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## Abstract

This paper proposes a qualitative system dynamics model to elucidate complex feedback relationships between e-government website maintenance, staff management, and organizational collaboration which eventually influence or are influenced by dynamic level of website availability. Keeping or improving website availability level over time is critical for an e-government system in order to maximize website services delivery benefits for citizens and businesses. To construct the conceptual model, an empirical system dynamics model of e-government software maintenance from previous research is used as a main reference. The research acknowledges dynamic complexity of e-government software maintenance and critical role of information technology staff management. Normally, diverse government units are responsible for various different services delivered through an e-government website. Therefore, organizational collaboration factors, which have been shown as significant factors influencing e-government website enactment by previous research, are also adopted and integrated in the conceptual model. The resulting conceptual model provides more insight into website maintenance management and basis for a stock-and-flow model development of system dynamics method.

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## 1. Introduction

To maximize benefits for citizens and businesses, an e-government website must be highly available and usable over time. It is not only that the website exists whenever being accessed but also all information contained in the website is of high quality as well as all services delivered through the website are functional as intended [1]. However, over time the quality of information could degrade, hyperlinks could be broken, undetected programming errors emerge, and new requirements also come to surface affecting the website level of availability in delivering services. All these things cannot be

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concealed from the users [Cartwright 2000 in [2]], hence threatening the value of e-government services. For this reason, an e-government website needs continual maintenance in response to those dynamic levels of the website availability especially in order to avoid diminishing services delivery.

Website maintenance has attracted attention of a number of studies. Duan and Chen [3] and Vasconcelos and Cavalcanti [4] attempted to devise formal methods that can help maintain website content automatically, while Souer et al. [5] proposed a framework which is expected to be an effective process and structure to maintain web content management systems. Taylor et al. [6] underlined the significance of various maintenance issues that must be seriously considered during website development. In a more specific issue, Coomes and Liew [7] investigated the important role of main stakeholders involvement during development and maintenance of a website in order to ensure usability of a website. Factors affecting decision making during library website maintenance, such as organization policy, were investigated and revealed by [8]. A more comprehensive study on library website maintenance management was undertaken by [9] which includes content maintenance, workflow organization, and staff skills required for maintenance. Distinct from those studies, Kong et al. [10] implemented a system dynamics method to model the impacts of the agile methodology values on the productivity of exploration stage of website maintenance. System dynamics was also used by [11] to model the complexity of accessibility of municipal government websites development and enhancement, and by [12] to explicitly reveal complex and dynamic relationships of institutional and organizational factors that eventually affect a particular degree of e-government websites enactment.

This previous research indicates that more understanding on the maintenance of website is still necessary. Especially, little has been done on the maintenance of e-government website services to make sure it is available over time. Previous research also suggests that website maintenance involves very complex activities and its success in achieving maintenance objectives depends on many factors. In the area of maintenance of e-government software, Gunadi [13] has modelled dynamic feedback relationships of maintenance activities, information technology (IT) staff management factors and software availability level, and explained the way these important factors and their relationships eventually bring about a certain level of software availability could be achieved. Research on e-government websites conducted, for example, by [14] and [12], to explore and investigate effect of institutional and organizational factors with respect to e-government website enactment. Especially, Luna-Reyes and Gil-García [12] modelled dynamic complexity and relationships of these factors using system dynamics. However, their study did not include the role and influence of IT staff and their management in achieving e-government website enactment success.

Distinct from previous studies, this research-in-progress aims to develop a conceptual model that is able to accommodate and explain the complexity of e-government website maintenance especially when the complexity involves feedback relationships of availability level of e-government websites and factors associated with website maintenance, staff management, and collaboration. While it is acknowledged that other factors might also influence the availability of the website services, previous separate research has shown the important roles of the aforementioned factors in e-government [12, 13, 15]. Attention on human behavior and communication processes is still lacking (Curtis et al, 1988 in [16]) especially in website maintenance [9]. This research will adapt the qualitative system dynamics model developed by [17] and integrate factors associated with organizational collaboration from [12] into the proposed qualitative system dynamics model. It is expected that the eventual model can be used to assist e-government website maintenance management successfully such that the availability level of e-government website services can be maintained or improved over time.

## **2. E-government website complexity**

E-government is a government information system which is used to better deliver government services to citizens and private sectors, improve citizens participation, and improve effective decision making

[13]. Many of e-government services are delivered through website which can be accessed anytime from anywhere [18] to seamless process and procedure of government services. Therefore, ensuring functionality of an e-government website is of paramount important [19]. Considering the fact that many governments have been allocating huge amount of resources to support e-government in delivering services, further efforts are required to realize e-government successes in the long term in order to maximize its benefits [20]. Maximum long term benefits services, especially through government website, can only be guaranteed if the e-government website is available and usable at high level from time to time.

An e-government website can be used to present wide variety of information, to communicate with citizens and even to conduct and complete transaction relevant to citizens and businesses needs [21,22]. As a very complex socio-technological entity a thorough understanding on e-government websites which involves technology, management, and organization dimensions [23] is necessary. Gil-García [14] has shown there are significant relationships between the degree of enactment of e-government websites, managerial practices, organizational and institutional arrangement.

From technology perspective, a website can be defined as “a collection of documents or files that are published on the World Wide Web and intended for use by the general public” [24]. The documents or files visible by public are known as webpages, which are normally hosted on computer servers specifically assigned for websites. The website is a virtual place where people can meet, discuss and collaborate based on their knowledge through web of documents organized non-sequentially as hypertext [25].

Any e-government website can be composed as a homepage, which appear the first time when the URL (Uniform Resource Locator) of the website is being accessed, provide overall overview of the information and services and is considered as the most important page, and a number of webpages where detail of information or services are delivered [8]. Often each of the pages is developed and maintained separately by various different associated government units. Any e-government website can deliver static and/or dynamic content and services. A static website normally provides same information in a standard form from time to time disregarding specific users. A dynamic website changes its content and appearance periodically and automatically or even provides a way for interaction and transaction. A web portal is a website that provides more variety of services towards its users. The services provided by organizational units are integrated into a web-portal such that visitors might consider the portal as a single entry point to obtain online services from the units [19]. Dart [26] identifies a number of different possible characteristics of an e-government website. For example, it can: be informational, be used to deliver file for users, be utilized to obtained information from the users, act as an interactive way of communication, be business transaction oriented, provide particular services, act as user interface for database or documents access, and be oriented to specific workflow of a business process. In addition to this characteristics, website technology keeps evolving [27] causing more difficult task for government to ensure website usability and functionality from time to time.

It is e-government managers' responsibility to exercise leaderships in organizing resources and ensuring high-level website services availability over time. Managers decide the kind of information and the degree of complexity of services provided for the targeted audience and make sure that the website is usable [22,23]. Services provided through website can indicate level of integration of various processes associated with different government units [21]. In addition, management must ensure information originated from different units and presented in an e-government website should be of high-quality: current, accurate, relevant, etc. [23].

Website management must manage various issues regarding the way different government units collaborate so that information presented is consistent, data duplication is avoided, those who responsible for the content is trackable, information on business processes is reliable [28] by devising

formal processes for website maintenance. Further, they have to allocate, motivate, and support, and improve skills of available human resources to guarantee sustainability of website services [9,17].

On the organizational dimension, an e-government website, its presentation and availability over time, identifies a government organization especially in the way it coordinates effort to deliver and realize its mission [29]. The website could acts as the main service gate which integrates a various number of different services of different government units [30]. Most of the e-government website consists of a homepage, which is under the responsibility of a general office or an IT unit of the government, and a number of webpages represents government sub-units responsible for specific services [12]. The degree of integration and coordination among staff from diverse government units is normally reflected in the way the website is organized and enacted and website services are delivered [12].

### 3. Website maintenance and services availability

Once an e-government website has been developed and accessible for public, it requires regular and periodic maintenance [31-33]. Website maintenance can be defined as activities undertaken, once a website is launch or implemented, to maintain high levels of its availability and usability to enable easy access for public and smooth services delivery by staff with high level of reliability. Steps in website maintenance can consist of “exploration, development, testing, and deployment of web features” [10]. Website maintenance is required to ensure information accessible by user is relevant, current, accurate [4], and legally reliable. Continual maintenance is also necessary as for traditional software to make sure services can be delivered continuously through website by correcting or preventing error from occurring, adapting or perfecting the website to new requirements [2,34]. Peters [2] provides empirical examples on a broad range of website service components that requires maintenance: image, navigation, hyperlink, content and content format, etc.

Following Gaj and Germani [35], website maintenance is necessary to keep website services availability at a particular or increasing level. Gaj and Germani designed a quantitative measure for information systems service availability. In their case, overall information systems service is composed into subservices which in turn divided into subservice components. Then, they defined availability of the system service as a function of availability of subservice and subservice component. This Gaj and Germani’s notion on service availability is adopted in this study to explain website service availability because of its plausibility and intuitive meaning. In a simple way, a website service is of highly available if an external user can open the website fully as indicated by its URL; information provided in the website can be accessed and is of high quality; webpages can be opened properly; and services presented within the website can be run and completed.

Considering its notion, this level of availability of an e-government website service is dynamics, it can be up or down during operational time of e-government website service. Possible factors that can affect the availability level, hence require continual maintenance, can be identified as follows [2,9,10,24,34,36]:

- Dynamic change of quality level of website content and presentation  
The change can be associated with the nature and users’ need of information. Presentation of navigational structure can also be affected by unorganized additional contents or new pages.
- Errors in programming which emerge or occur during the delivery of services  
These include broken hyperlinks for various reasons, buttons or menus provided cannot be used, error codes that escapes during testing phase, or corrupted software.
- Emerging new requirements to enhance the website  
New regulations or organizational changes need some adjustment on the website, or users request some changes on the look and feel of the website presentation.
- Information technology infrastructure problems

These problems include computer hardware, data storage or communication media is broken and an operating system failure.

With regard to its complexity, e-government website maintenance involves complex activities and resources in term of technology, management and organization. It requires formal guidelines and standard operating procedure which can be used by e-government managers to orchestrate collaborative maintenance effort among various different government units [33,37].

#### **4. Modelling method**

To realize research aim, acknowledge complexity of factors that could influence e-government website maintenance and dynamic behavior of website service availability level, this research implements qualitative system dynamics (SD) approach [38-40], which is represented visually as a causal loop diagram (CLD). The approach is chosen because the resulting model is capable of explicitly revealing feedback relationships between factors; therefore indicating the way two or more factors relate to each other which they might not be close in time and distance and providing comprehension of how an effect factor in turn influences a cause factor. By identifying its possible causal loops, the CLD can generate insight into the dynamic structure of the system [41]. The method is a particularly appropriate modelling approach where time and feedback loops are important, and where considerable complexity, ambiguity and uncertainty exist [42].

Technically, a CLD consists of words or phrases which are linked by curved arrows, each of which has attached polarity and time delay symbols [41]. The arrow represents a causal relationship between two factors. The polarity is symbolized by '+' indicating the two related variables change in the same direction, or '-' showing the two linked variables vary in two different directions; and the time delay is shown by '/' crossing the arrow. A CLD is formulated by referring to the relevant theories and previous research associated with the formulated problem as well as the researcher's mental model associated with the research problem [41].

#### **5. Conceptual model development**

To fulfill the research aim, an empirical qualitative system dynamics model developed by [17] will be adapted and used as a main reference. This research and other relevant studies as the aforementioned in previous section [8,9,11,15,22,29,36,37] are used as sources for identification of factors and their causal relationships. Organizational collaboration and legitimacy of process that were shown to be instrumental factors for e-government website enactment [12] are also adopted.

Overall conceptual model is presented in Figure 1 which is developed gradually by exploring main factors and their feedback relationships. This resulting model is used to understand and explain factors and feedback relationships underlying process influencing e-government website availability over time. This conceptual model development focuses on important factors adapted from Vroom's expectancy theory (effort, performance, and reward), staff competency, legitimacy of formal process for maintenance, organizational collaboration, website maintenance process, and website availability level. It is assumed that level of the availability degrades over time and increases once effective maintenance is undertaken.

Within the model, it is shown that level of e-government website availability over time is affected by website quality resulting from its development project and infrastructure reliability. On the other hand, organizational dynamics internally as well as changes in citizens and private sectors (or the environment) create pressure to the level of availability causing it to decrease. The affected level of availability materializes into maintenance requests that need response from IT staff or those who responsible for maintenance. Often, the occurrence of website service availability problems do not turn into maintenance requests instantly, but take time. For example, a website user who finds a broken link in a



meet the intended target or the other way around. Motivation of the staff determines the level of effectiveness of their effort. So, effective individual staff effort depends both of these factors.

Often a maintenance workload needs involvement of a number of staff in a sub-organization. Effectiveness of their maintenance effort depends of the degree of their collaboration. Also, in many cases website maintenance requires collaboration of a number of sub-organization associated with the maintained webpages. Degree of collaboration between sub-organizations of interest reflects actual organizational effort for website maintenance.

A high level of website availability indicates that organizational objectives mostly can be achieved. The achievement of organizational objectives can be understood by staff that implemented processes for maintenance do work. Over time, this increases legitimacy of the processes. Legitimate implemented processes will ease the allocation of available competent staff and improve effectiveness of the allocation. Therefore the gap between the required and allocated competence for maintenance will be close each other, which in turn improves the completed maintenance.

Legitimate processes will be adhered closely by various organizations associated with the maintained webpages as well as by staff within the organizations. These legitimate processes bring about the collaboration among the involved organizations and staff is more effective which in turn increases the actual organizational effort. Improvement in the actual allocated organizational effort will close the gap and hence improve completed website maintenance jobs.

In addition to the organizational effort, completing maintenance jobs requires staff competence. From any completed maintenance job, to a certain degree, over time staff will learn from the job that has been completed which can improve staff competence level. This certainly causes average current competence level to increase. On the other hand, when the completed maintenance level is low, either qualitatively or quantitatively, then there is a need to train staff to improve their competence. The actual provided training by organization may less than or more than the needed therefore this creates a gap. When the gap is wide then the average current competence level will be low. Further, this will create a wider gap of required and actual effective competence, which in turn reduces the completed maintenance level. Competence obsolete affected by rapid advancement of website technology also increases training need.

When the completed maintenance increases then the website availability level also increases. If the level is high then this indicates the organization objective can be achieved. The achievement of organization objectives causes the processes become legitimate which in turn affects the effectiveness of competence allocation.

## 6. Conclusion

In response to the research aim, a qualitative system dynamics model has been proposed highlighting significant role of website maintenance success, staff motivation and competence, legitimate processes for website maintenance and organizational reward and collaboration effort as well as underlining the importance of dynamic feedback relationships between e-government website availability levels and those factors. The conceptual model suggests insight on how to maintain or improve website availability level over time by acknowledging that an e-government website is a socio-technological artefact.

This conceptual model certainly contains inherent limitations and is not complete because it only focuses on a limited number of important factors and it does not present explicitly the increase and decrease of the availability level. This proposed CLD model will be used as a basis for developing stock and flow model of the system dynamics method. Further research need to be conducted to validate the conceptual model against a real-world e-government system.

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