Characteristics of Digital Sustainability

Matthias Stuermer
Research Center for Digital Sustainability
University of Bern, Engehaldenstrasse 8, 3012 Bern, Switzerland
+41 76 368 81 65
matthias.stuermer@iwi.unibe.ch

ABSTRACT
The concept of digital sustainability is mentioned in research on digital preservation as well as on openness topics. Both streams of literature point out the necessary discussion how to create, use, and regulate digital resources in order to maximize their value for our society today and in the future. This paper therefore reviews current work on digital sustainability, presents a list of six characteristics how to define digitally sustainable goods, and draws the link to aspects of e-government.

Categories and Subject Descriptors
K.4.1 Public Policy Issues: *Ethics, Intellectual property rights, Regulation, Use/abuse of power*

General Terms
Economics, Legal Aspects, Management, Standardization, Theory

Keywords
Sustainability; Digital Sustainability; Digital Preservation; Open Source; Open Data; Open Government

1. INTRODUCTION
This article explains the concept of sustainability to the digital world based on the definition of sustainable development in the Brundtland report 1987 [16]: *Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs.*

The virtual character of digital goods leads to opportunities as well as challenges. Digital assets are naturally non-rivalrous in the sense of economic goods so they may be used and distributed at marginal cost. However, digital assets are not always public goods because they are excludable. Data may be stored in proprietary formats or software may be available in binary versions only thus for example excluding non-paying users.

Previous research has defined the term *digital sustainability* in two different ways: Digital preservation literature mentions digital sustainability in the context of conserving data and information, openness literature (open source, open data etc.) uses the term digital sustainability to extend its meaning also in the legal context of accessing and modifying source code and data.

2. DIGITAL PRESERVATION
The stream of literature on cultural heritage and digital humanities positioned *digital sustainability* in the field of digital preservation [11]. Its main topic is the technical longevity of digital information ranging from storing data on appropriate hardware devices to standardization of file formats and persistent identifier schemes for data structures. In order to maintain a stable technical infrastructure also economic incentives such as business models and sponsoring organizations for the data repository are necessary argues Kevin Bradley [2]. An extensive review of funding models is also part of the final report of the Blue Ribbon Task Force on Sustainable Digital Preservation and Access [1].

Preserving digital information is a challenge because of the sheer size of data produced in our today's information society. Back in 2011 IBM stated every day 2.5 quintillion (10^{30}) bytes of data are produced [9]. In 2013 the Scandinavian research organization SINTEF estimated that in the last two years alone 90% of all the data in the world had been generated [6]. Thus there are technical as well as economic barriers preserving this data.

Choosing what to preserve is another challenge. For example only in 2010 the Library of Congress decided to store all public messages from Twitter [10]. Gladly Twitter Inc. agreed to hand out all tweets since its inception and providing all future microblogging messages to the library leading 2013 to an archive of 170 billion tweets. Other problems such as security and quality of electronic signatures and longevity of digital certificates are elaborated by Szádeczky [15]. He explains the dilemma of long-term preservation of data while securing it with modern cryptosystems such as asymmetric key cryptography.

3. OPENNESS MOVEMENT
An extended concept of digital sustainability was introduced by Marcus Dapp in recent years based on the work of Volker Grassmuck on information freedom and the tragedy of the commons [7]. Dapp defines digital sustainability as following [5]:

Digital resources are handled sustainably if their utility for society is maximized, so that digital needs of contemporary and future generations are equally met. Digital needs are optimally met if resources are accessible to the largest number and reuseable with minimal restrictions. Digital resources encompass knowledge and cultural artefacts represented in digital form, e.g. text, image, audio, video, or software.

For Dapp openness is a pre-requisite for maximized reuse of digital resources and thus unrestricted access and reuse of digital assets are key for digital sustainability. As a logical consequence open content, open data and open source are considered ideal forms of freely accessible and modifiable digital assets. By definition they provide content, data, and software below open licensing regimes granting unrestricted access, unrestrained use, unlimited redistribution, and unconfined modification.

An additional dimension to this notion is brought by Thorsten Busch in his 2008 essay on open source software and sustainability [3]. He connects the digital divide discussion with literature on open knowledge and open source software. Based on the argumentation that proprietary software creates new vendor dependencies with corporations, developing countries should favor open source software. Busch concludes that from an ethical point of view all firms that claim to be *good corporate citizens* should offer open source solutions to their customers [4].

In 2013 Melanie Griesser merged the concept of digital sustainability with current literature on sustainability in her master thesis [8]. She concludes applying the concept of sustainable develop-

ment on the digital field is possible and very much recommended in order to address current challenges in the information society.

4. CHARACTERISTICS

In order to decide if a digital good is sustainable or not from a digital perspective I propose to define certain characteristics. Formulating a set of requirements has helped open source software [12] as well as open data [14] to become clearly distinguishable from proprietary software respectively non-open data. Based on the rules of sustainable development in the environmental context defined by Spindler [13] I suggest the following six characteristics that define digital sustainability:

1. Intergenerational justice: Digital goods such data, content, and software must be made available in a way that their long-term usability is ensured. This concerns not only the data itself, but also the knowledge required for their interpretation and use. Prerequisite for this is a transparent information architecture. Legal, organizational, technical or financial obstacles must not obstruct their use, modification and redistribution of digital assets.

2. Regenerative capacity: Information and communication technologies are subject to constant change. Therefore, everyone must have the option to participate in the production, development and dissemination of digital goods. It is thus a prerequisite for digital sustainability that implicit knowledge (tacit knowledge) about a digital good resides not only within a person or a single organization. The tacit knowledge must be distributed over many actors allowing them to share their innovations with one another freely.

3. Economic use of resources: Obviously digital goods are not subject to economic rivalry. However, if people are excluded to access digital information, they need to recreate it in order to use it. This contradicts the idea of economical use of resources. Thus unrestricted technical and legal reuse and distribution of digital resources must be ensured.

4. Risk reduction: The production and use of digital goods involve numerous risks, such as the creation of vendor dependencies or the risk of erroneous interpretation. Digital goods should therefore be designed so that they do not create dependencies towards their manufacturers, are trustworthy and can be interpreted correctly by all users. Prerequisite for this is their verifiable and transparent information architecture.

5. Absorptive capacity: Information overload is a reality in today's world. Thus society must be able to absorb digital resources in order to be able to use and adapt them appropriately towards new needs and requirements. This concerns issues such as comprehensible structuring, documentation, discovery, and filtering of information.

6. Ecological and economic added value: Digital goods must be made freely available in order to be shared to the largest extent possible enabling the potential for innovation and full value for society. Therefore it is necessary to establish the appropriate conditions on a regulatory level so freely accessible digital resources promoted and distribution channels such as the Internet are equally accessible to everybody. Closed, proprietary software environments and standards are opposed towards the maximum economic benefit for society.

5. CONCLUSION

The challenge remains to implement this concept of digital sustainability in the e-government world. As in the concept of environmental sustainability also the characteristics of digital sustainability are barely achievable. Today's situation in e-government is as far away from reaching digital sustainability as today's physical world is far away from ecological sustainability. Nevertheless it makes sense to define a vision in order to guide governments in their daily decisions on procuring and managing digital assets in a digitally sustainable way.

Based on this introduction many interesting research questions follow: How can governments facilitate the production of digitally sustainable resources? In what way need public-community-partnerships be organized to optimize collaboration with citizens and innovators? How do public procurement processes need to be designed in order to prioritize digitally sustainable e-government solutions? These and more research questions guide future work on digital sustainability.

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