The Web Accessibility Crisis of Korea's Electronic Government: Fatal Consequences of the Digital Signature Act and Public Key Certificate

Hun Myoung Park
International University of Japan
kucc625@iuj.ac.jp

Abstract

Korea's e-government ranked top in e-government benchmarking for the past five years but showed relatively lower scores in Web accessibility. As a result of the Digital Signature Act, public key certificate was introduced and digital certificate software was developed using de facto technology standards, Microsoft ActiveX. Government, certificate authorities, and certificate consumers all overlooked the implications of using Microsoft standards and ignored criticisms of those who do not use Microsoft products. Government failed to implement digital signature policy successfully. Its consequences include unbelievable Microsoft monopoly with almost 99 percent market shares of Microsoft products, chronic addiction to Microsoft standards, bad computing practices, and fatal Web accessibility problems. ActiveX should be removed immediately to support diverse operating systems and Web browsers. Eventually current client-side certificate should be switched to server-side system. This paper calls for careful evaluation of Korea's e-government.

1. Introduction

Since the World Wide Web (Web) was introduced in the early 1990s, e-government has evolved from the presence and interaction stages to transaction and transformation ones [6], and there has been growing interest in e-government benchmarking, such as the Global E-government of Brown University (insidepolitics.org), the United Nations' E-government Development Survey (unpan.org), and the Digital Governance in Municipalities Worldwide Survey [11, 29, 30]. Despite methodological and technological problems (e.g., sampling and weighting) of the benchmarking, its scores have often been used as measures of e-government sophistication in the globe. [1]

Table 1. Korean E-government Ranking

Year	Brown University		United Nations	
	Overall Ranking	W3C WCAG Accessibility	Overall Ranking	Web Measure
2010	-	-	1 (2)	1 (2)
2009	-	-	-	-
2008	1 (3)	13 (27)	6 (4)	6 (3)
2007	1 (4)	*(22)	-	-
2006	1 (4)	42 (18)	-	-
2005	86 (3)	*(17)	5 (1)	4 (1)
2004	32 (3)	52 (17)	5 (1)	4 (1)
2003	93 (2)	*(20)	13 (1)	18 (1)
2002	2 (4)	120 (74)	-	-
2001	47 (1)	6 (1) **	15 (1)	1 (1)

Source: http://www.insidepolitics.org /; http://www.unpan.org/
* Zero score; ** Majority scored zero; U.S. ranking in parenthesis

One of the interesting findings for the past five years in e-government benchmarking is Korea's e-government that ranked the first place during 2006-2008 in the Global E-government and 2010 in the UN E-government Development Survey (first and third columns in Table 1). By contrast, the U.S. e-government shows high (1st to 4th), but relatively stable and consistent rankings (presented in parenthesis) across year. [2] Also, Seoul Metropolitan City Government Web site stayed at the top during three

[1] Each benchmarking employs different measures. For example, the Global E-government is based on online information, electronic services, privacy and security, disability access (accessibility), foreign language access, ads/fees, and public outreach, whereas the E-government Development Survey on Web measure index from the five stage e-government evolution model (emerging, enhanced, interactive, transactional, and networked presences), telecommunication infrastructure index, and human capital index [29, 30]. Also, the scale and level of measurement vary across benchmarking. Therefore, rankings tend to be less consistent even in the same benchmarking.

[2] Table 1 implies a sharp contrast between Korea's "selection and concentration" strategy in e-government development and American incremental and balanced approach.

consecutive test years of 2003, 2005, and 2007 in the Digital Governance in Municipalities Worldwide Survey [11]. According to IT Times (04/15/2011), ITU commented in 2003 that "the development of information and communication that Korea has achieved over the last 40 years is a miracle and there is no more recommendation to be made."[3] Surprised and puzzled at this result, many scholars and practitioners often ask, "How came? What happened in Korea?" And they are willing to learn the "Korean secret" and best practices for their e-governments.

Many scholars began to show interest in Web accessibility for those with various types of disabilities and aging population [2]. Despite its highest overall ranking in the benchmarking, Korea showed relatively poor scores in Web accessibility and these scores are, if not random, inconsistent (second column in Table 1). Although its accessibility ranking was improved from 120th in 2002 to 13th in 2008, Korea scored zero in 2003, 2005, and 2007. Again, U.S. shows relatively stable and consistent rankings (figures in parenthesis) in e-government accessibility during the same period. Are the measures used in benchmarking reliable enough? How can a best e-government be poorly accessible? How can we interpret this paradox? Is the Korean e-government really the best model that deserves such high international recognition?

The purpose of this paper is to examine the underlying secret of Korea's e-government development and explain unintended consequences of the development strategies and practices. This paper begins with discussion on Web accessibility in e-government and critical success factors of Korean e-government. Section 4 explains how the Digital Signature Act and public key infrastructure (PKI) in Korea led to use Microsoft standards (as opposed to Web standards) for digital certificate. Consequences of addiction to Microsoft standards are presented in section 5. Then discussed are policy implementation failure, client-side versus server-side certificate, and realistic solutions to escape from Microsoft addiction. Final section concludes with a critical question to be considered seriously before adopting strategies and practices of Korea's e-government.

2. Web Accessibility and E-government

Web accessibility means, according to World Wide Web Consortium (W3C), that people with disabilities (e.g., visual, auditory, physical, speech, cognitive, and neurological disabilities) can perceive, understand, navigate, interact with, and contribute to the Web contents. It is to provide equal access and opportunity to people with low literacy and low bandwidth connection, older people, and those who use old technologies and diverse devices. The U.S. Section 508 of the Rehabilitation Act of 1998 requires that "when Federal agencies develop, procure, maintain, or use electronic and information technology, Federal employees with disabilities have access to and use of information and data that is comparable to the access and use by Federal employees who are not individuals with disabilities, unless an undue burden would be imposed on the agency" (§1194.1).[4]

In addition to these political, social, legal implications, Web accessibility has technical and financial benefits: reducing time and cost of development and maintenance, reducing computing resource requirement and server load, increasing Web interoperability and device-independence, and preparing for new technologies [28, 32, 33]. In particular, device-independence is crucial for those who use minor operating systems and/or Web browsers, and for those who use electronic devices (e.g., assistive devices, PDA, and smartphone) other than ordinary computers.[5]

E-government is defined as "the use by the Government of web-based Internet applications and other information technologies, combined with processes that implement these technologies…" (§3601 of the U.S. E-Government Act of 2002). E-government heavily depends on Web for input and output functions; Web is a core technological building block of e-government that is used to communicate between and among governments and citizens. Such input and output interface must support diverse citizens and devices in order not to discriminate against one group (e.g., the blind and Linux user) and in favor of other groups. Accordingly, Web accessibility became a major scientific theme in client-centered e-government and individual countries have developed their own accessibility regulations and guidelines [10, 12]. W3C's Web Content Accessibility Guidelines (WCAG) 1.0/2.0 and the U.S. Section 508, which are very similar to each other, have been widely used for assessing Web accessibility.

[3] http://www.koreaittimes.com/story/14184/smart-government-strengths-it

[4] It also requires that "individuals with disabilities, who are members of the public seeking information or services from a Federal agency, have access to and use of information and data that is comparable to that provided to the public who are not individuals with disabilities, unless an undue burden would be imposed on the agency."

[5] A Web page may appear different depending on operating systems and Web browsers because of their different default settings and rendering methods. For instance, Firefox, Mozilla, and Netscape use Gecko as their rendering engine; Apple Safari and Google Chrome employ WebKit; and Trident is embedded in Microsoft Internet Explorer (IE). Each rendering engine has its own way to interpret markup languages of a Web document and create corresponding Web page.

Web accessibility is a part of general accessibility of electronic and information technology and has been discussed as laws and guidelines mainly in North America and Europe since the late 1990s. Jaeger [13, 14] reports that most American federal government Web sites do not comply with the Section 508. Lazar, Beere, Greenidge, and Nagapa [18], Potter [25], Ellison [8], Fagan and Fagan [8] assess e-government of American federal and state government, while Williamson [31] examines 322 American secondary educational institutions. All studies report insufficient compliance with regulations in most public Web sites.

Marincu and McMullin [20] and Paris [24] analyze European e-government, and Shi [26] examines Web sites of Chinese local government. They suggest that most government Web sites do not comply with the W3C standard. Becker [3] discusses the importance of Web accessibility for older generations.

There are a large number of Web accessibility evaluation tools that support various languages, guidelines, operating systems, technical standards (e.g., HTML/XHTML and CSS), plug-ins, etc.[6] However, no automatic evaluation tool can examine Web accessibility perfectly because 1) some checkpoints of guidelines are not clear enough, 2) others need to be examine by human beings, and 3) Web contents are changing over time [1, 5, 10, 13].[7] If automated tools fail to evaluate individual guidelines correctly, their results may be totally misleading. Along this line, Jaeger [13] suggests a multi-method evaluation approach including automated testing, expert testing, and user testing.

The Global E-government employs Bobby (now IBM Rational Policy Tester Accessibility Edition) and Wave (http://wave.webaim.org) to evaluate the compliance with W3C's WCAG. Automated tools are likely to be sensitive to specific use of technical standards and sample; a poorly written Web page and/or an outlier (Web site) might result in totally different results. Accordingly, it is not so surprising that the ranking of a country in the Global E-government is not consistent across year.

Before discussing Web accessibility issue of Korea's e-government, the next section briefly explains the major factors that contributed to the success of current Korean e-government.

[6] See the list on http://www.w3.org/WAI/ER/tools/complete

[7] Centeno et al. [5] classify 65 WCAG 1.0 checkpoints into objectively automated rules (14 checkpoints), subjectively automated rules with fuzzy conditions (2), semi-automated rules (31), and manual rules (18). Objectively automated rules, which are clearly and specifically defined so that nobody might misunderstand, can be checked automatically, whereas manual rules require human judgment (p.88).

3. Critical Success Factors of Korea's E-government

The most important factor was strong leadership and full support of two former presidents, Kim Dae-Jung (1998-2003) and Roh Moo-Hyun (2003-2008), who are strikingly contrasted with the incumbent president Lee Myung-Bak.[8] Among major initiatives are the Cyber Korea 21 (1999), Digital Signature Act (1999), Electronic Government Act (2001), E-government portal (2002), e-Korea Vision 2006 (2002), Broadband IT Korea Vision 2007 (2003), IT839 (2004), and u-Korea Plan (2006) [22]. These efforts enabled to build good governing institutions like Special Committee for E-government, and invest a large amount of money on information infrastructure and human capital (education and training).

Small territory and condensed population of Korea made it easier and less costly to construct backbone infrastructure (broadband network). So-called "selection and concentration" strategy focused more on hardware and service provision than software and demand sides.

The most prominent feature was citizens' attitude toward information technology and e-government. Most Korean citizens receive higher level of education and are willing to adopt new technology. They are more likely than other citizens to change computers and electronic devices (e.g., smartphones). Korea has also been known for its high wireless and broadband subscriber rates.[9] Ethnic homogeneity and sense of belongingness attract citizens to use Internet and telecommunication services heavily, contributing to fast technology diffusion [19].[10]

4. Public Key Certificate and ActiveX in Korea's E-government

This section describes public key infrastructure in Korea and then explains how public key certificate and ActiveX controls influenced Web accessibility of Korea's e-government.

4.1. Digital Signature Act of 1999

[8] Korean government lists five success factors of its e-government: strong government leadership, IT governance, customer-oriented services, performance based program management, and technology support. http://www.korea.go.kr/new_eng/main/index.do.

[9] Korean ranked top during the middle of the 2000s in the number of broadband subscribers per 100 Inhabitant and proportion of optical fiver connection [23].

[10] Internet use rate was 56.6 percent in 2001 and increased to 70.2 in 2005 and 77.8 in 2010. http://www.itstat.go.kr/ (IT Statistics of Korea)

In 1999 the Ministry of Information and Communications (MIC) initiated the Digital Signature Act (last revised in 2010) in order to facilitate electronic transaction and ensure its security. This Act describes effects of digital signature and roles of certificate authority (CA) under public key infrastructure (PKI).

Six CAs (currently five) were authorized and supervised by MIC (now this job is done by the Ministry of Public Administration and Security). Two dominant CAs are Korea Financial Telecommunications Clearings Institute (KFTCI) and KOSCOM. The former is in charge of public key certificates for banks, while the latter for securities firms. These for-profit companies are supposed to provide banks and firms with necessary CA software packages, which should be reviewed and approved by Financial Supervisory Services (FSS), a government agency to supervise various financial affairs. Obviously CAs may not refuse to provide certificate services and discriminate against some groups of users.

4.2. Public Key Certificate

A pubic key certificate (digital certificate) is "an electronic document that uses a digital signature to bind a public key with an identity" under PKI environment and to verify that a public key belongs to an individual.[11] Use of public key certificate is often known as a way of ensuring security of electronic transactions.[12]

The Electronic Financial Transaction Act, specifically the provision 7 of its Electronic Financial Supervision Regulations, requires use of public key certificate in all electronic financial transactions. FSS is in charge of regulating the use of digital certificate in financial transactions. The digital certificate practice of KFTCI and KOSCOM was widely used in finance as well as other industries.

There are multiple ways to put this digital certificate concept into practice. Since no algorithm supported 128bit encryption by the end of 1990s, Korea developed an encryption algorithm called "SEED" and used it for public key certificate.[13] The question here is how to implement the encryption algorithm.

[11] http://en.wikipedia.org/wiki/Public_key_certificate

[12] In the U.S. and most countries digital certificate is processed under secure socket lay or transport layer security protocols. End users do not need to know what the public key certificate is and to install CA software on their machines.

[13] 128 bit encryption in Microsoft IE 5.5 was introduced in the early 2000s and nowadays Web browsers can support up to 256 bit encryption.

4.3. Use of ActiveX for CA Software

Despite presence of general tools and computer programming languages like C and Java, software programmers utilize Microsoft ActiveX, "a framework for defining reusable software components,"[14] and develop digital certificate software (CA software). They appeared to think that ActiveX is a *de facto* technology standard and thus is efficient and easy to use. Majority of people including the general public were already familiar with Microsoft standards (e.g., its products and ActiveX), which play the similar role as "Wintelism" that Borrus and Zysman [4] argue.

Unfortunately, ActiveX (controls) is running only on the Microsoft Windows (up to XP) and IE (up to version 7) and is well known for its fatal security problems [7]. Like Java (Applets) and Adobe (Micromedia) Flash, ActiveX can be used to develop stylish Web applications on Windows machines, but in turn it can manipulate file systems and transfer data in local machines without permission from users. It is not surprising, therefore, that many malicious software programs have been written in ActiveX to attack porous vulnerabilities of Microsoft Windows and IE. Hit by crossfire of criticisms on security problems of ActiveX, Microsoft decided to give up its ActiveX and replace it with Silverlight in Windows Vista and later versions.

Digital certificate software programs (plug-ins) are supposed to be provided by CAs after being reviewed by government (FSS for finance industry). However, individual banks and securities firms obtain programs from security software companies and provide them to customers. Individual citizens must download and install digital certificate programs without knowing if these programs are properly reviewed by government.

4.4. Use of ActiveX for Security Software

In addition to CA software, end users must install all security programs including a keyboard security program to prevent keystroke logging (recording all keystrokes to obtain private information). Here is a simple rule for online users: "Click on O.K. all the time. Never, ever choose No!" Otherwise, any electronic transaction (e.g., Internet banking, online stock trading, and online shopping) is not possible in e-government and other Web sites. It sounds absurd, but indeed it is true in Korea.

Required ActiveX programs vary across individual bank and securities company although some companies require the same programs. Some companies use

[14] http://en.wikipedia.org/wiki/ActiveX

different versions of a same program. Some ActiveX programs conflict with each other. It is almost impossible for users to distinguish necessary programs from malware programs (e.g., computer virus, worm, and spyware). As ActiveX programs are piled up, users' systems tend to become slow, unstable, and even vulnerable to attacks.

4.5. Korean Web Accessibility Guideline

Ministry of Public Administration and Security (MOPAS) added Korean Web Content Accessibility Guidelines (KWCAG) to the Standard Guidelines for Developing and Operating Government Web Sites in 2005 and announced in 2007 that compliance with Web standards will be enforced. According to the Web Accessibility Survey that National Information Agency conducted, the Web accessibility score of central government, National Assembly, court, and metropolitan cities increased from 72 in 2005 to 82 in 2006 and 88 in 2007 [21]. In the Global E-government, Korea received zero in 2007 but ranked 13th in 2008 [32].

These figures indicate improvement in Korean E-government but do not necessarily reflect the chronic addiction to Microsoft standards (i.e., Windows, IE, and ActiveX). Largely due to limitations of evaluation method and tools, the result does not say enough about device-independence (i.e., cross-platform and cross-browser supports) of e-government. Obviously, Korea's e-government and major Web sites are never device-independent because ActiveX programs are required. KWCAG was there but was not enforced sufficiently.

4.6. Open Web's Lawsuit

Some groups of people like Open Web (openweb.or.kr) have criticized this Web accessibility problem (i.e., supporting Microsoft customers only) and took this case to the court [16]. However, Open Web lost the lawsuit against KFTCI, a dominant CA, in 2009 and the Supreme Court ordered, surprisingly, that it is not illegal for KFTCI to provide digital certificate services to Microsoft customers only.

Government (MIC/MOPAS/FSS), CAs, and security software companies have insisted that the public key certificate is highly secured. They often respond, "99 percent of people use Microsoft Windows and IE. It is not efficient to support those other than Microsoft customers" [15, 27]. However, this is not a good excuse of discriminating against people who do not use Microsoft products. MIC/MOPAS and FSS have failed to supervise CAs who have bad practices of using ActiveX; MIC/MOPAS should have revoked CA authorization in accordance with the Digital Signature Act since CAs violated the law and discriminated against citizens.

5. Consequences of Use of ActiveX

In order to fully use e-government and public Web sites in Korea, users must 1) use (Korean) Microsoft Windows and IE; 2) lower security level and disarm firewall; 3) install all required ActiveX plug-ins (for hiding keyboard stroke and mouse move); and 4) carry security token or equivalent for digital certificate. These odd conditions resulted in Microsoft monopoly, addiction to Microsoft standards, bad computing practices, and Web accessibility crisis.

5.1. Unbelievable Microsoft Monopoly

Microsoft monopoly in Korea is well represented by the market shares of Microsoft Windows and MSIE for the past several years (Table 2 and 3).

Table 2. Operating System Market Shares (%)

Year (Dec.)	Operating Systems		
	Linux	Mac OS	Windows
2010	.05 (.96)	.51 (5.02)	96.35 (90.29)
2009	.03 (1.02)	.53 (5.11)	99.27 (92.21)
2008	.03 (.80)	.28 (7.94)	99.55 (90.89)
2007	.02 (.63)	.16 (7.31)	99.80 (91.79)
2006	.02 (.38)	.10 (4.68)	99.87 (94.85)
2005	.03 (.31)	.13 (3.64)	99.82 (95.97)
2004	.04 (.29)	.12 (3.25)	99.81 (96.36)

Source: http://internettrend.co.kr/; http://marketshare.hitslink.com/
* World market shares in parenthesis

Table 2 (third column) reports surprising figures of almost 100 percent for Microsoft Windows in Korea from 2004 through 2009. By contrast, the world market share declined from 96 percent down to 92 percent during the same period. Mac OS (second column) occupied .1 to .5 percent in the domestic market, while its global market share increased from 3 percent in 2004 to 8 percent in 2008 and then decreased to 5 percent in 2010. Linux's domestic market share remained below .05 percent, while its world market share slightly grew from .3 percent in 2004 to 1 percent in 2010.

Web browser's market shares in Table 3 are even shocking. From 2004 through 2009, the domestic figure of MSIE stayed around 98-100 percent, while its world figure declined from 91 percent to 63 percent

(Table 3). The market share of Firefox remained below 1 percent, although increasing slowly, in Korea, but soared from 4 percent and 23 percent in the world during 2004-2010. Apple's Safari showed the similar, but less dramatic pattern as did Firefox. This result suggests that about 30 percent of MSIE users switched to Firefox or Safari. Korean software market appears to be completely isolated from the world market.

Table 3. Web Browser Market Shares (%)

Year (Dec.)	Web Browsers		
	Firefox	Safari	MSIE
2010	.94 (22.81)	2.76 (5.89)	94.47 (57.08)
2009	.95 (24.61.)	.33 (4.46)	98.06 (62.69)
2008	.78 (19.00)	.17 (6.26)	98.70 (72.90)
2007	.48 (14.92)	.09 (4.75)	99.37 (78.58)
2006	.27 (11.49)	.05 (3.28)	99.63 (82.99)
2005	.46 (7.78)	.06 (1.98)	99.37 (87.06)
2004	.31 (3.75)	.04 (1.45)	99.50 (91.16)

Source: http://internettrend.co.kr/; http://marketshare.hitslink.com/
* World market shares in parenthesis

The result of unbelievable Microsoft monopoly is obvious. Microsoft could enjoy extreme monopolistic power; almost 100 percent computer users purchased Microsoft products for relatively higher price. As of January 2007 (KRW1,000 per USD 1), the price of Korean Window Vista home edition was KRW 303,000 (USD 300) in Korea and USD 199 in the U.S. Korean Windows business edition sold for KRW 446,000 (USD 446) and USD 299, respectively (http://widelake.net/185). The prices of Japanese Windows in Japan, however, are equivalent to those in the U.S. Microsoft asserts that OEM edition of Microsoft Windows are same across countries. But the price varies depending on individual contracts, which are often undisclosed.

5.2. Addiction to Microsoft Standards

Given that public key certificate handled by ActiveX controls running exclusively on Microsoft Windows and IE, Mac OS and Linux users must have additional Windows. Put different, government, CAs, banks, and securities firms have implicitly or explicitly forced citizens to purchase Microsoft products by excluding non-Microsoft customers from digital certificate services.

As citizens use Internet for banking, stock trading, and shopping, their computers are "painted" with ActiveX plug-ins and thus they become more and more addicted to the Microsoft standards. ActiveX has been criticized for its critical compatibility and security problems. As long as CA software and other plug-ins are developed using ActiveX, e-government should suffer from the same problems. In addition to ordinary computer users, mobile device (e.g., tablet PCs and smartphones) users cannot use Web (http protocol) to fully access e-government because Google's Android and Apple's iPhone OS are loaded on these devices; these users must install customized applications (apps) provided by individual companies (e.g., banks and securities firms).[15]

Accumulation of many ActiveX controls is harmful to users' computers. ActiveX plug-ins tend to consume many computer resources and thus slow down the system speed. Each Web site requires different, although same in some cases, ActiveX plug-ins, some of which might conflict with each other. Also, ActiveX requires users to lower security level (e.g., disabling firewall and anti-virus vaccine programs).

These features of ActiveX controls imply high vulnerability of individual computers and entire information systems.[16] It is almost impossible for ordinary users to single out bad ActiveX plug-ins that, once installed, are out of control. Disarmed Windows machines are more likely than Mac machines and Linux boxes to be targeted by Hackers (crackers), who try to steal their private information and make them "Zombie" PCs.

The lack of software diversity and dominance of Microsoft products can endanger entire information systems and retard development of software industry [15]. Many IT incidents (e.g., DDoS attacks) occurred during the past several years appear to be related to chronic use of Microsoft standards. Because of the addiction to Microsoft standards, domestic package software industry has dominated while software export has remained negligible. [22]

5.3. Bad Computing Practices

Current digital certificate systems appear to ask all citizens to have computer knowledge, in particular in computer security. However, many citizens are not interested in security issues (e.g., public key certificate and ActiveX) and do not have professional knowledge. They are unable to distinguish malicious ware from many ActiveX controls required by e-government.

[15] Mobile devices with Microsoft Windows loaded began to disappear in the market. Recently, Korean venders like Samsung and LG, who have chased Microsoft standards, encounter a bad circumstance where they have to compete with Google and Apple on mobile operating systems.

[16] It is reported that Java applets and Adobe Flash also have security issues but are not as vulnerable as ActiveX controls.

Consciously and unconsciously most citizens have been trained to disarm security function and then simply click on "O.K." whenever they are asked whether or not to install ActiveX plug-ins. These bad practices or habits appear to be related to vulnerability of individual computers and eventually entire information systems.

5.4. Web Accessibility Crisis

Like the U.S. Korea has its own Web accessibility guidelines but suffers from accessibility problems. Unlike other countries, Korea has misused Microsoft standards and thus encountered a fatal problem in cross-platform and cross-browser supports. CAs provides public key certificate programs written in ActiveX that runs only on Microsoft Windows and IE. Banks, securities firms, and other commercial Web sites require various ActiveX plug-ins installed in users' computers. Government (MIC/MOPAS/FSS) and court appeared to overlook, if not ignore, the significance of this issue.

The Global E-government of Brown University and Web Accessibility Survey of the National Information Agency suggest that Korean e-government has improved its Web accessibility recently (Table 1). However, these results are largely based on automated tests, which have limitations in detecting use of Microsoft standards.

Many Korean Web sites deny access of user agents (e.g., Web browser and automated tools) that do not use ActiveX plug-ins (e.g., keyboard security programs) that are required in the Web sites. Automation tools may be blocked and thus useless in some cases. Even when you can access a Web site, you might not be able to view contents without some ActiveX plug-ins for browsing. Or you might not be able to log on without ActiveX control and cookies; the Web site will keep asking you to type in your network ID and password.

E-government seems to check first if you are a Microsoft customer and then provide services only if yes; otherwise, you will be kicked out of the e-government immediately [16]. If you visit such a Web site using Firefox and/or Linux machine, you will just get a blank screen and/or sometime encounter a shocking message like, "*This Web site was optimized to Microsoft Internet Explorer*" or "*This Web site does not support Netscape*." Believe or not, only Microsoft customers can take full advantage of Korean e-government.

6. Discussion

This section discusses implementation failures of digital signature policy, client-side versus server-side certificate, and strategies to escape from Microsoft addiction.

6.1. Failures in Policy Implementation

The Digital Signature Act itself does not include significant mistakes, but there must be failures in implementation. MIC/MOPAS and FSS failed to monitor CAs and commercial companies who had predilection to ActiveX. Use of ActiveX in digital certificate reinforced the familiarity to and comfortableness of Microsoft standards, and vice versa. To make it worse, automated evaluation tools can hardly detect this type of Web accessibility, in particular, cross-platform and cross-browser issues. The use of Microsoft standards was rarely considered as a critical issue in Korea. This situation appears to be a vicious circle or trap.

The early stage of public key certificate appeared to be successful because of its 128 bit encryption algorithm and soaring increase in electronic transactions during the Kim Dae-Jung administration (1998-2003). This early success paradoxically hindered Korean e-government and e-commerce from tracking global technology standards in encryption and secured connection during the later part of the 2000s. Korea's e-government and most Web sites still use 128 bit encryption and ActiveX even though more secured 256 bit encryption methods and Microsoft eventually abandoned its ActiveX years ago.

Despite criticisms and policy suggestions made by those who do not use Microsoft products and thus are excluded from electronic services, government recognized the fatal problem of Microsoft standards only after Windows Vista no longer supports ActiveX. The consequence appears to be a challenging deadlock.

6.2. Client-side versus Server-side Certificate

Korea's e-government and most Web sites ask individual citizens to install CA software and security plug-ins on their local machines and then process digital certificate for their own risk. Citizens must have several ActiveX plug-ins installed, store digital certificates in media, and/or carry security tokens. This is client-side certificate (as opposed to server-side certificate) that transfers responsibility from CAs and companies to individual citizens. Therefore, winners here are CAs and banks/securities firms, whereas losers are general citizens, who have to take care of digital certificate by themselves, and purchase Microsoft products and good computers (broadband services).

Under server-side certificate using Secure Socket Layer (SSL) or Transport Layer Security (TLS) protocols, individual citizens do not have to install any additional plug-ins and to pay attention to digital certificate. All the processes are hidden behind the scenes; citizens just need to memorize their network ID, password (passphrase), and/or reserved private information (e.g., color of my first car and favorite food) without knowing how digital certificate is processed. Servers are responsible for transactions and digital certificate and support various operating systems and Web browsers other than Microsoft Windows and IE.

Table 4. Comparison of Security Features

	Korean E-gov.	Global Standard
Digital Certificate	Client-side	Server-side
Responsibility	Citizens	CAs/Firms
Orientation	H/W, Business-friendly	S/W, Client-centered
Encryption Algorithm	SEED (128 bit)	Open standards (Up to 256 bit)
S/W Preference	Microsoft Windows & IE	Open Source S/W
Secured Connection	ActiveX (Plug-ins)	SSL/TLS (Web browsers)
Security S/W	ActiveX (Required)	General Tools (Optional)
Keyboard Security S/W	ActiveX (Required)	General Tools (Optional)
Telnet/FTP	Telnet/FTP	Secured Shell/FTP

MOPAS, FSS, CAs, and security software companies oftentimes argue that current public key certificate system is more secured than server-side certificate approach. However, client-side certificate system appear to be more inefficient, inconvenient, costly and vulnerable than server-side counterpart because 1) the former requires additional plug-ins that are written in ActiveX and installed in clients' computers, 2) diminish diversity of software (i.e., operating systems and Web browsers), and 3) citizens have to know certain level of computer knowledge.[17] Also the client-side certificate system is less accessible and more business-friendly (as opposed to client-centered) than the global server-side standard.

Table 4 compares the security features of Korean e-government and standard e-government that are discussed so far.

6.3. Escape from Microsoft Addiction

Despite recent efforts to escape from Microsoft addiction, it must be time consuming and costly to switch from current client-side approach to the global standard. It won't happen in the near future that Korean citizens can fully use e-government and enjoy Internet banking without annoying ActiveX plug-ins. We can learn a couple of lessons for e-government development from the Web accessibility crisis in Korea.

First, technology alone cannot be the solution to security issue. This is a never-ending game between attackers and defenders. No technology cannot be a permanent answer. A current solution must evolve over time in response to progress of its counterpart. Sophisticated institutions and users' cooperation are needed to supplement technologies.

Second, global standards (e.g., W3C's Web standards) and open source software are recommended for e-government development. It was a fatal mistake that Korea's e-government has rested on its success in the early 2000s and refused to follow technology progress and global standards. As a result, the technology became out of dated and lagged behind from the late 2000s. Also citizens have unconsciously learnt a really bad computing practice; "Install every ActiveX controls and always click on O.K."

Third, e-government should be contents-driven rather than stylish. Korea's e-government is more likely than the U.S. counterpart to be fancy, colorful, and dynamic, but it appears to be unwilling to provide data and information that citizens really want. It is frustrating to encounter a series of pop-ups and then get nothing from the Web site. You might not be able to view a document or Web page only because associated ActiveX is not installed in your machine. More time and effort should be given to development of contents rather than ActiveX controls and Adobe Flash applications.

The most urgent task at this stage is to eradicate ActiveX from Korea's e-government immediately. Several banks already began to provide CA software that support diverse operating systems and Web browsers. Since almost all public Web sites were "painted" with ActiveX controls, it must be time-consuming and costly to get rid of ActiveX that are commonly used for digital certificate and embellishment of e-government. Then current client-

[17] Many Korean Web servers still use traditional telnet and FTP services that already became obsolete in the globe. Recent Web browsers support secured connection with up to 256 bit encryption and keyboard security programs to prevent keystroke logging turns out easy to be bypassed (http://openweb.re.kr).

side certificate system should be replaced by server-side system. An incremental approach is highly recommended to minimize confusion and unexpected cost.

7. Conclusion

Korea's e-government has received global attentions and recognitions from e-government benchmarking for the past several years. Kim Dae-Jung and Roh Moo-Hyun administrations (1998-2008) implemented ambitious e-government development plans and Korean citizens are more likely than other citizens to go online actively. Growing broadband and wireless subscribers eagerly used online information and services. Early adoption of public key certificate enabled to facilitate electronic transaction in e-government and e-commerce during the early 2000s.

However, careless use of ActiveX in digital certificate resulted in Microsoft monopoly and poor device-independence of e-government. The market shares of Microsoft Windows and IE stayed almost 99 percent during the 2000s. Only Microsoft customers can fully access and use e-government. This software homogeneity and enthusiastic citizens contributed to quick development of e-government at the expense of Web accessibility. Cross-platform and cross-browser accessibility is hardly examined in most automated evaluation tools. Hence, device-independence problem has been rarely highlighted.

More and more scholars and practitioners want to learn lessons from Korea's e-government and follow its best practices. Obviously Korea's e-government, despite its addiction to Microsoft standards, has some good practices such as leadership supports and "selection and concentration" approach. However, scholars and practitioners must examine carefully what actually happened during the past decade in Korea. Then they should ask a critical question, "Do I want a top ranked e-government "of Microsoft, by Microsoft, for Microsoft customers only?"

Web accessibility assessment and empirical analysis of cost and benefit of the client-side certificate system are reserved for the future studies.

8. References

[1] S. Abou-Zahra, "Web Accessibility Evaluation," in Simon Harper and Yeliz Yesilada, eds. *Web Accessibility: A Foundation for Research*, London: SpringerVerlag, 2010, pp.79-106.

[2] S. A. Becker, "Accessibility of Federal Electronic-Government ", in Chen, Hsinchun, Lawrence Brandt, Valerie Gregg, Roland Traunmuller, Sharon Dawes, Eduard Hovy, Ann Macintosh, and Catherine A. Larson, eds., *Digital Government: E-government Research, Case Studies and Implementation*,141-155, New York: Springer, 2008.

[3] S. A. Becker, "E-Government Visual Accessibility for Older Adult Users", *Social Science Computer Review*, 22(1), 2004, pp. 11-23.

[4] M. Borrus and J. Zysman, "Globalization with Borders: The Rise of Wintelism as the Future of Global Competition", *Industry and Innovation*, 4(2), 1997, pp. 141-166.

[5] V.L. Centeno, C. D. Kloos, J. A. Fisteus, and L. A. Alvarez, "Web Accessibility Evaluation Tools: A Survey and Some Improvements", *Electronic Notes in Theoretical Computer Science*, 157, 2006, pp.87-100.

[6] D. Coursey and D. F. Norris, "Models of E-Government: Are They Correct? An Empirical Assessment", *Public Administration Review*, 68(3), 2008, pp. 523-536.

[7] W. Dormann and D. Plakosh, "Vulneability Detection in ActiveX Controls through Automated Fuzz Testing", Unpublished working paper, 2008. http://www.cert.org/archive/pdf/dranzer.pdf

[8] J. Ellison, "Assessing the Accessibility of Fifty United States Government Web Pages: Using Bobby To Check on Uncle Sam", *First Monday*, 9(7), 2004.

[9] J. C. Fagan and B. Fagan, "An Accessibility Study of State Legislative Web Sites", Government Information Quarterly, 21(1), 2004, pp. 65-85.

[10] S. Harper and Y. Yesilada, "Web Accessibility and Guidelines," in Simon Harper and Yeliz Yesilada, eds. *Web Accessibility: A Foundation for Research*, London: SpringerVerlag, 2010, pp.61-78.

[11] M. Holzer and S. T. Kim, *Digital Governance in Municipalities Worldwide (2007): A Longitudinal Assessment of Municipal Websites Throughout the World*. National Center for Public Performance, Rutgers University, Newark, NJ. 2008.

[12] P.T. Jaeger, "The Social Impact of an Accessible E-Democracy : Disability Rights Laws in the Development of the Federal E-Government", *Journal of Disability Policy Studies*, 15(1), 2004, pp.19-26.

[13] P. T. Jaeger, "Assessing Section 508 Compliance on Federal E-government Web Sites: A Multi-method, User-centered Evaluation of Accessibility for Persons with Disabilities", *Government Information Quarterly*, 23(2), 2006, pp. 169-190.

[14] P.T. Jaeger, "User-Centered Policy Evaluations of Section 508 of the Rehabilitation Act: Evaluating E-Government Web Sites for Accessibility for Persons With Disabilities", *Journal of Disability Policy Studies*, 19(1), 2008, pp. 24-33.

[15] J.H. Kim, “Software Uniformity in Information Systems” [in Korean], *Digital Public Administration*, 107, 2007, pp. 16-22.

[16] K.C. Kim. *The Uncomfortable Truth of Korean Web* [in Korean], Seoul, Korea: Digital Media Research, 2009.

[17] Korea Association for ICT Promotion, *Annual Statistics of Communication Industry in 2007* [in Korean], Seoul, Korea, 2008, p. 157.

[18] J. Lazar, P. Beere, K. Greenidge, and Y. Nagappa, "Web Accessibility in the Mid-Atlantic United States: a Study of 50 Homepages." *Universal Access in the Information Society*, 2(4), 2003, pp. 331-341.

[19] S.M. Lee, “South Korea: From the Land of Morning Calm to ICT Hotbed”, *The Academy of Management Executive*, 17:2, 2003, pp.7-18.

[20] C. Marincu and B. McMullin, “A Comparative Assessment of Web Accessibility and Technical Standards Conformance in Four EU State”, *First Monday*, 9(7), 2004.

[21] National Information Agency, *Web Accessibility Survey* [in Korean], 2007.

[22] National Information Society Agency, *2007 National Informatization Whitepaper* [in Korean], 2008

[23] OECD, OECD Broadband Subscribers per 100 Inhabitant, 2007, http://www.oecd.org/sti/ict/broadband.

[24] M. Paris, "Website Accessibility: a Survey of Local E-government Websites and Legislation in Northern Ireland", *Universal Access in the Information Society*, 4(4), 2006, pp. 292-299.

[25] A. Potter, “Accessibility of Alabama Government Web Sites”, *Journal of Government Information*, 29 (5), 2002, pp. 303-317.

[26] Y. Shi, "The Accessibility of Chinese Local Government Web Sites: An Exploratory Study", *Government Information Quarterly*, 24(2), 2007, pp. 377-403.

[27] B. R. Suh, “Proposal for Delivery of Universal Services in E-government” [in Korean], *Digital Public Administration*, 107, 2007, pp. 10-15.

[28] J. Thatcher, M. R. Burks, C. Heilmann, S. L. Henry, A. Kirkpatrick, P. H. Lauke, B. Lawson, B. Regan, R. Rutter, M. Urban, and C. D. Waddell, *Web Accessibility: Web Standards and Regulatory Compliance*, New York: Friendsofed, 2006.

[29] United Nations. *UN E-government Survey,* 2001, 2003, 2008, 2010.

[30] D. M. West, *Global E-government Report*, 2001-2008, http://www.insidepolitics.org/

[31] D. M. Williamson, *Analysis of Web Accessibility for Postsecondary Institutional Web Sites Based on the Web Accessibility Initiative of the World Wide Web Consortium and Section 508 of the Rehabilitation Act Amendments of 1998*. Ph.D. Dissertation, Indiana University, 2005.

[32] WWW Consortium, *Web Accessibility Initiative (WAI),* http://www.w3.org/WAI/

[33] WWW Consortium, *Web Content Accessibility Guidelines*, 1999, 2008, http://www.w3.org/