A Comparative Study of the Safety Between Internet Explorer and Firefox

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***Abstract*—Internet Explorer (IE) and Firefox (FX) are two major web browsers today. The safety level of IE and FX is consequently a great concern. In this work, we tried to find out and explain the statistic trend of the vulnerabilities of IE and FX and analyzed the safety level of IE and FX. We not only focused on the total sum of vulnerabilities of each browser, but also studied the browsers' vulnerabilities from a new angle: To study the vulnerability relations between different versions of the browsers. We developed two methods to count the vulnerabilities. One is to ignore the version difference, and another is to take version difference into consideration. We found that FX had many more minor versions than IE and consequently many more vulnerabilities than IE. The vulnerability of both FX and IE increased linearly with time and the increasing rate of FX surpassed that of IE when considering the version difference. Besides, we analyzed the intersections of vulnerabilities between different versions of FX and IE and gave a qualitative relation that could be used to predict the vulnerability trend of FX and IE.**

Keywords-web browser; vulnerability; security; firefox; internet explorer

I. INTRODUCTION

With the astonishingly fast development of the global network, web browsers, which are the interfaces between the virtual cyberspace and numerous web users, are becoming a vital concern to the community of programmers as well as hackers. To satisfy the various needs of web users, vendors are constantly improving and increasing the function of web browsers. Web browser today is more like a small and independent operating system with a lot of plug-ins and gadgets attached to it. The codes of today's web browsers are much more complicated and vulnerability-afflicted and with larger attacking surface than before. As a result, web browsers are becoming more and more vulnerable and attractive to hackers.

Various web browsers are playing a vital role in our daily life. Web browsers are involved in several security-critical applications such as e-commerce, online shopping, and internet banking. Moreover countless important actions which need privacy protection are done via the browsers, such as logging in our blogs, twitter, writing our personal dairy, sending and reading emails. The codes of the browsers are becoming more complicated and vulnerability-afflicted, and the attacking surface [1] of the browsers is larger than before.

If a web browser can not guarantee privacy and security, users will undoubtedly be harmed. Consequently, users do have an urgent requirement to know the security level of popular browsers. However, the security level of popular web browsers is difficult to evaluate and there can be many different outcomes when one evaluates the problem from different angles.

To our best knowledge, the comparative study of the safety of open source web browser and non open source web browser is a relatively new topic. Woo *et al.* [2] analyzed the vulnerabilities of web browsers and used a mathematic model to describe the trend of vulnerabilities. Their model was brilliant and concerned many possible factors. However, their study as well as many others ignored the inner relationship between a web browser's many major and minor versions. In this work, we also analyzed the safety of the web browsers but from a new angle. We studied the spread and inheritance rates (see the definition in part III) of the browsers, which reflected the relation between vulnerabilities and different versions of IE and FX.

In this work, we selected two most popular web browsers, Internet Explorer (IE) and Firefox (FX) (see Table I), as our study samples. We not only counted the total sum of vulnerabilities of each browser, but also the vulnerabilities with version difference and time difference. We made statistic analysis to figure out the respective trend of vulnerabilities of the two browsers and evaluated the safety level of the two browsers.

TABLE I. MARKET SHARE OF BROWSERS IN 2011 [3]

Browser	**IE**	**FX**	**Chrome**	**Safri**	**Opera**
Market share (%)	55	21.88	11.97	6.98	2.04
Browser	**OperaMini**	**Netscape**	**Flock**	**ACCESS**	**Netfront**
Market share (%)	1.13	0.8	0.04	0.04	
Browser	**Konqueror**	**Mozilla**	**Playstation**	**Obigo**	
Market share (%)	0.03	0.03	0.02	0.01	

II. VULNERABILITY STATISTICS OF FX AND IE

National Vulnerability Database (NVD)[4] XML files (the files about all the published vulnerability reports of softwares) were used as our original data. We converted the XML files into Microsoft Access 2003 database files. Then we made further SQL queries of these files via Microsoft

978-0-7695-4951-4/13 $26.00 © 2013 IEEE
DOI 10.1109/ISISE.2012.42

Access 2003 to obtain information that concerned our study. Finally we collected the SQL queries and made five new databases which contained all the useful information about web browsers.

We counted the vulnerabilities published every month of FX and IE respectively from 2006 to 2010. Two counting methods were used in this work: one is to count the number of vulnerability reported (If a vulnerability report appears in two different versions of a given browser, we count it twice); the other is to count the number of different vulnerability reported [We regarded it as a new vulnerability report when the CVE-ID (a specific string used to identify a particular vulnerability) of the vulnerability report is new]. We simply called the former method 1 and the latter method 2.

Figs. 1(a) and (b) show the number of vulnerability of IE and FX from 2006 to 2010 counted by methods 1 and 2, respectively. It can be seen from Fig. 1 that the quantity of vulnerability counted by method 1 is much more than that counted by method 2. Our statistic results basically agree with the IBM's risk report (When it comes to critical and high vulnerabilities, Mozilla FX has twice the number of disclosed vulnerabilities as that of IE) [5].

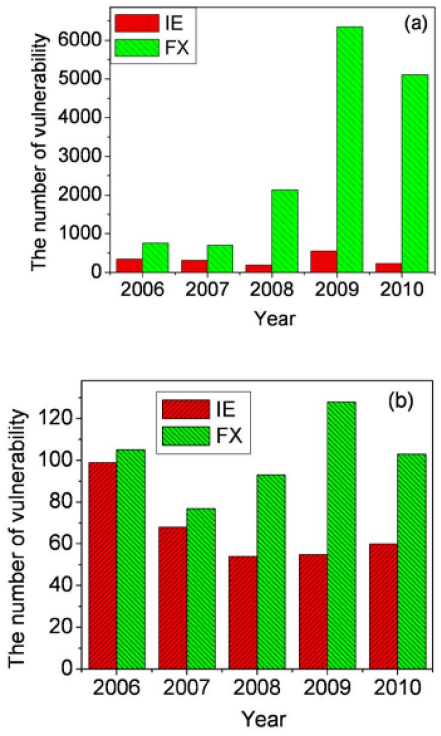

Figure 1. The number of vulnerability of IE and FX counted using methods 1(a) and 2(b)

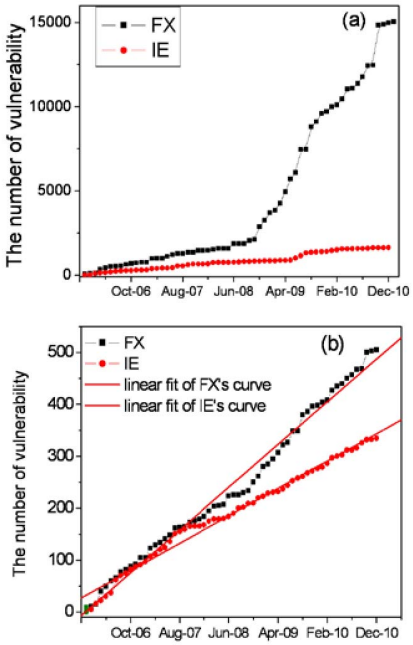

Figure 2. Developing trend of number of vulnerability of IE and FX counted by methods 1 (a) and 2 (b).

At a given time, the quantity of vulnerability of FX is more than that of IE counted by both the methods, and generally the number difference between these two browsers increases with the year increases, indicating that IE is safer than FX.

Figs. 2(a) and (b) show the time dependence of the number of vulnerability counted by methods 1 and 2, respectively. In Fig.2 we first assumed that both the browsers had no vulnerability before 2006 to make the analysis simpler, then we added every month's vulnerability to the total vulnerability sum, so every point in the graph represents the total vulnerability sum of a browser at the time shown on the horizontal axis. It is seen from Fig. 2(a) that counting by method 1, FX's vulnerability shows an accelerating trend after Feb. 2009, whereas the IE's vulnerability increases slowly with time.

Unlike in Fig. 2(a), in Fig.2(b), both the curves approximately tend to linearly increase with time; however, the curve corresponding to IE has a small slope (~5.28) while that corresponding to FX has a bigger slope (~8.23). This indicates that the FX's number of vulnerability increases faster than IE's.

III. INHERITANCE AND SPREAD RATES OF VULNERABILITES OF IE AND FX

Tables II and III are the number of vulnerability of different versions and the intersection of neighboring versions from 2006 to 2010 for FX and IE.

TABLE II. THE NUMBER OF VULNERABILITIES OF IE'S DIFFERENT VERSIONS AND THE INTERSECTION OF ITS TWO NEIGHBOR VERSIONS FROM 2006 TO 2010

Year	5.*	5.*∩6.*	6.*	6.*∩E7.*	7.*	7.*∩8.*	8*
2006	27	27	92	5	11	/	/
2007	26	25	46	34	50	/	/
2008	23	23	35	27	32	3	10
2009	23	23	42	29	38	20	24
2010	8	8	39	31	35	25	40

TABLE III. THE NUMBER OF VULNERABILITY OF FX'S DIFFERENT VERSIONS AND THE INTERSECTION OF ITS TWO NEIGHBOR VERSIONS FROM 2006 TO 2010

Year	1.0*	1.0*∩1.5*	1.5*	1.5*∩2.0*	2.0*	2.0*∩3.0*	3.0*	3.0*∩3.5*	3.5*	3.5*∩3.6*	3.6*
2006	42	39	96	14	20	/	/	/	/	/	/
2007	11	11	30	27	65	/	/	/	/	/	/
2008	28	28	28	28	80	26	38	/	/	/	/
2009	65	65	65	65	66	65	99	34	52	/	/
2010	47	47	47	47	47	47	56	56	83	70	89

In Tables II and III the symbol "∩" means intersection. And the vulnerabilities were counted by Method 2. It can be seen from Tables II and III that actually many vulnerabilities are shared between the old and newer versions of both the browsers. The intersections are more than 30 percent of either the old or newer version's vulnerability and some newer versions almost inherit all the vulnerabilities of the old version. We call this phenomenon vulnerability inheritance. This is because many potential vulnerabilities (vulnerabilities that have not been patched or reported) are brought from the old version to the new version before being found. Here we also name two phrases: one is inheritance rate, to describe the rate of the vulnerability intersection of the old and newer versions to the vulnerability of newer version; the other is spread rate, to describe the rate of vulnerability intersection of the old and newer versions to the vulnerability of old version.

When we know the inheritance and spread rates of a given browser, we can predict the develop trend of the vulnerability of its new version. The inheritance and spread rates actually reflect a security problem of a browser; therefore, we can use it to study the trend and safety level of a specific browser.

Table IV gives inheritance rate and spread rate of IE from 2006 to 2010. From Table IV we can see that the spread rate of IE decreases with the year increases.

TABLE IV. THE INHERITANCE AND SPREAD RATES OF VULNERABILITIES OF IE'S DIFFERENT VERSIONS FROM 2006 TO 2010, IR AND SR DENOTE INHERITANCE AND SPREAD RATES

Year	IE5.*	IE6.*		IE7.*		IE8.*
	SR (%)	*IR*	*SR (%)*	*IR*	*SR (%)*	*IR (%)*
2006	100	29.3	5.4	45.5	-	-
2007	96.2	54.3	73.9	68	-	-
2008	100	65.7	77.1	84.4	9.4	30
2009	100	54.8	69	76.3	52.6	83.3
2010	100	20.5	79.5	88.6	71.4	62.5

The spread rate of IE5.* is very high and stable: almost all of their vulnerabilities can be found in IE6.* from 2006 to 2010 except in 2007.

The spread rate of IE6.* is also high and stable except in 2006 (2006's value can be ignored because in 2006 IE7 was still a new version and not many vulnerabilities being found during that year). The time dependence of inheritance rate of IE is not as regular as that of spread rate. Generally, the inheritance rate of IE7.* is higher. IE8's inheritance rate quickly increases to > 60% two years after its release.

TABLE V. THE INHERITANCE AND SPREAD RATES OF VULNERABILITIES OF FXS DIFFERENT VERSIONS FROM 2006 TO 2010, IR AND SR DENOTE INHERITANCE AND SPREAD RATES

Year	FX1.0*	FX1.5*		FX2.0*		FX3.0*		FX3.5*		FX3.6*
	SR (%)	*IR*	*SR (%)*	*IR*	*SR (%)*	*IR*	*SR(%)*	*IR*	*SR(%)*	*IR(%)*
2006	92.9	40.6	14.6	70	-	-	-	-	-	-
2007	100	36.7	90	41.5	-	-	-	-	-	-
2008	100	100	100	35	32.5	68.4	-	-	-	-
2009	100	100	100	98.5	98.5	65.7	34.3	65.4	-	-
2010	100	100	100	100	100	83.9	100	67.5	84.3	78.7

Table V gives inheritance rate and spread rate of FX from 2006 to 2010. It can be seen from the Table V that the spread rate of all the FX versions increases with the year increases up to 100% except FX 3.5*, the spread rate of which is also high ~84.3% in 2010. Among the versions, FX1.0* has the highest and more stable spread rate. The inheritance rate is not as regular as the spread rate. However, generally, the inheritance rate increases with year increases, especially that of FX1.5 * and FX2.0* reaches 100% in 2008 and 2010, respectively.

The inheritance rate and spread rate of all the versions of IE and FX are high, indicating that many of the potential vulnerabilities of the two browsers' different versions are overlapped.

Compared with IE, FX has obviously increasing trend of its spread rate and inheritance rate. This should be related to the release time of FX's all versions, for instance, FX 1.5 was released in mid 2005, FX 2 in early 2006, FX 3 in December 2006, and FX 3.5 and FX 3.6 in the summer of 2008 and 2009, respectively. It can be an important reason that it takes time for FX's potential vulnerabilities to be exposed, and because FX was released later than IE, many of its vulnerabilities have probably still not been found.

IV. THE SAFTY LEVEL EVALUATION OF IE AND FX

How to evaluate the safety of browsers is a difficult issue. Here, we simply analyzed the various factors that affect the security of a browser.

According to our analyses hereinabove, FX has more vulnerability than IE. IE is safer than FX if we judge the safety only from this point. However, as we know, the number of vulnerability is not the only parameter to evaluate the safety of browsers.

The version share of a browser is another important factor that affects its safety. There are dangers that simply didn't exist back in 2001 when IE6 was released to the world, and IE7 makes surfing the web fundamentally safer by offering greater protection against viruses, spyware, and other online risks [5]. Newer versions usually have better security mechanism than old versions, and sometimes vendors will stop patching old versions so that old versions will be at great risk of getting disclosed vulnerability exploited. If most users of a browser use the latest or a relative new version, than their risks of being attacked will be markedly reduced. According to Frei *et al.*' report [5], from January 2007 to June 2008, FX surpassed all the other major browsers in terms of the percent of the maximum latest major version share: FX's maximum latest major version made up 92.2% of all the FX versions while IE's latest major version coverage was only 52.5%. And the FX's most secure version share was up to 83.3% while IE's most secure version share was only 47.6%. The statistics explain why people feel that FX is more secure than IE. Most of FX's users use the latest and most secure version while IE's users use various versions. Therefore, even when the statistics show that FX has more vulnerabilities than IE (see Figs 1 and 2), FX's users probably will not feel insecure because most of them use the latest version that is much more secure than IE's old versions. No wonder IE is always blamed for its bad security and vulnerability to web application attacks.

In addition, the vendors' speed of providing patches for their browsers is also a vital factor that affects the security of browsers. If a browser's vulnerabilities can not be patched quickly enough or are even left without any protective measures, the browser's safety level will be greatly reduced, as the unpatched and already exposed vulnerabilities undoubtedly enhance the probability of being exploited and attacked. On the contrary, if a browser's vulnerability can be quickly patched, the possibility for the vulnerability' to be exploited and attacked will be reduced. According to IBM's report [6] that in 2009 Mozilla, the vendor of FX, really did a great job of providing patches for FX who patched all the critical and high client-side vulnerabilities while Microsoft, the vendor of IE, only patched ~83% vulnerabilities. The great patching speed of FX perhaps is due to its effective auto-update. According to Frei *et al.*' work [7], automatic security update mechanism is recommended with little user involvement. Mozilla's quick patching speed and auto-update mechanism made FX less vulnerable than IE.

Furthermore, the severity of vulnerabilities can also influence the safety level of browsers. According to the NVD Vulnerability severity ratings [8], vulnerabilities can be classified into three categories: Vulnerabilities are labeled "Low", "Medium" and "High" severities if they have a CVSS base score of 0.0-3.9, 4.0-6.9 and 7.0-10.0, respectively. It is known from IBM's report [6] that Microsoft, the vendor of IE, accounts for 29% of the total critical and high client-side vulnerabilities while FX only 8%. This may also explain why people still feel that IE is less secure than FX although IE has fewer vulnerabilities than FX.

V. CONCLUSIONS

The vulnerabilities of IE and FX from 2006 to 2011 have been analyzed by two counting methods. We found that FX's different versions (including minor versions) share many vulnerabilities which explains the fact that FX has far more vulnerability reports than IE when counted by method 1. When the vulnerabilities counted by method 2, IE also has less vulnerability, but the difference between the numbers of vulnerability of the two browsers is quite small. If judging the safety level only by the number of vulnerability, IE is safer than FX.

Apart from the number of vulnerability, the vendor's vulnerability patching speed, the users' upgrading tendency, the proportion of a browser's critical and high client-side vulnerability, are all important factors that should be considered when evaluating the safety level of a web browser. FX surpasses IE in all these factors which, we think, can explain why FX is considered to be safer than IE.

The safety level of a browser is hard to quantify, and browsers should be compared and evaluated with the same given important factors. IE and FX each has advantages and disadvantages and we think this phenomenon will continue in the near future.

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