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Defeating Man-in-the-Browser Malware

How to prevent the latest malware attacks against consumer and corporate banking

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Contents

Introduction

The Internet offers financial institutions the promise of delivering new services at a fraction of the cost of traditional channels. As more consumers move online, this migration helps reduce operating costs and increase their customer base. The challenge lies in being able to offer these services across new and sophisticated channels — for example, the mobile channel — while not sacrificing security or usability.

Unfortunately, the benefits of the Web are also available to criminals; and the world of organized crime has been quick to exploit its weaknesses. Criminals are using very persuasive and often personalized tactics to entice users to take specific actions that will result in the attacker's ability to misdirect or take over a user's online banking session — or their entire machine.

While many safeguards are deployed within financial institutions, criminals are evolving their techniques rapidly. Instead of phishing attacks that lead to fake websites designed to harvest usernames and passwords, the techniques are now more sophisticated and effective against previously deployed defenses.

Phishing and spear-phishing attacks[1] are now designed to deploy malware, which takes over users' browsers and executes malicious transactions. The malware is crafted to avoid detection by antivirus tools. The result is known as a "man-in-the-browser" attack.

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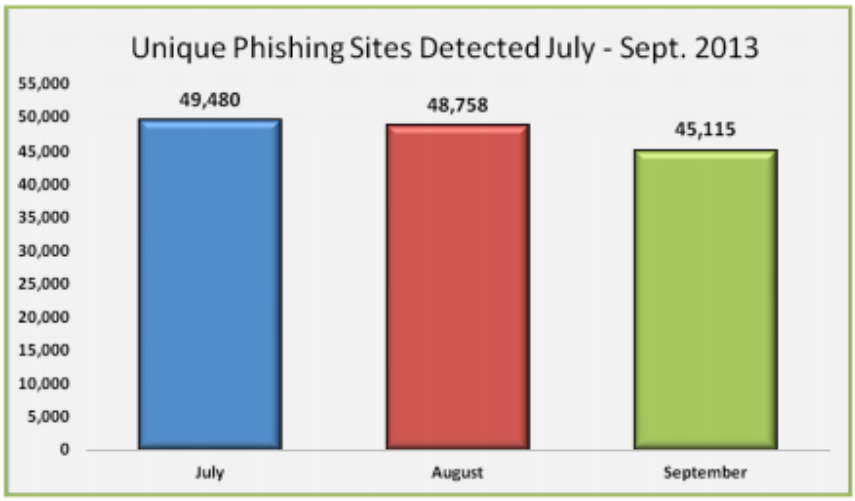
[1] A spear-phishing attack is a highly targeted form of phishing, using specific messages and information tailored to a particular user or small user group.

The Anti-Phishing Working Group (APWG) recently reported more than 49,000 unique phishing sites in July 2013 alone. During a two-month span in 2013, the number of phishing sites detected jumped almost 30 percent.



Source: Anti-Phishing Working Group

Individual users and organizations around the world are being targeted and successfully defrauded of millions of dollars. But more importantly, attacks against organizations are now more targeted.

Verizon's 2013 Data Breach Investigations Report found that malware was at the root of 40 percent of the year's targeted breaches.[2] While these numbers are down from 2012, data points tell us that man-in-the-browser isn't just used to intercept banking sessions.

"Direct installation of malware by an attacker who has gained access to a system is again the most common vector," stated the Verizon report.

That said, man-in-the-browser attacks remain state of the art in online-banking fraud. While traditional security techniques are proving ineffective, there are a few proven and effective approaches for neutralizing the threat.

In this document, we first explain the mechanics of a man-in-the-browser attack, and then review the various counter-measure possibilities, comparing their effectiveness — against both today's attack vectors and the ability to adapt to future techniques.

[2] "2013 Data Breach Investigations Report," Verizon RISK Team, April 2013.

What is a Man-in-the-Browser Attack?

The man-in-the-browser (MITB) attack leverages what is known as a Trojan Horse (or simply a Trojan). A Trojan is malicious software that is somehow installed — often initiated by various social engineering tactics — and resides concealed on the user's computer, frequently undetectable by traditional virus scanning.

It is commonly in the form of a browser helper object, user script, or Active X control. It wakes up when the user visits a target site, and functions by transparently capturing and modifying information as it moves between the browser's user interface and the Internet.

In this way, the malware can show the user a completely consistent picture of the transaction he or she is executing, while actually executing a totally different transaction with their bank. Transaction details may be modified or totally unrelated transactions may be launched — all without the user ever understanding that an attack is underway.

Most traditional defenses are rendered completely ineffective, because the Trojan is difficult to detect through traditional virus-scanning, and it has direct access to authentication data (e.g., static and one-time passcodes or even biometrics) and details of the transaction.

The criminal community is heavily focusing its attacks today on corporate-banking customers, as the available funds are often greater, transaction limits are higher and the corporate customer has access to a wire transfer or Automated Clearing House (ACH) services through the online banking interface.

However, there are many examples of attacks on high-value banking customers as well, with the possibility of the average user being attacked in future being very real. Examples of well-known man-in-the-browser attacks include the Zeus and Silentbanker Trojans, each which have been successfully installed on millions of PCs.

Interestingly, there are even man-in-the-browser attacks like Russian-born Spy Eye that actually first attack existing malware (e.g., Zeus), taking over all of the information captured already and then attacking the user.

What is Social Engineering?

Social engineering is the act of manipulating a person into taking specific actions or sharing confidential information without the use of any technical hacking methods.

Uses of social engineering include sending targeted phishing emails that resonate with particular users (often referred to as spear-phishing or harpooning) and cause them to take action that results in an unwanted result.

Example: *A group of 20,000 financial services executives were targeted with specific emails that looked like subpoenas, causing more than 10 percent to follow links and become infected with a Trojan.*

MITB Attack Phase One: Infection

The first phase of an MITB attack is the infection of a target computer. A number of techniques have proven to be effective, typically relying on social engineering to trick a user into doing something unwise, but sometimes exploiting other browser or network vulnerabilities. The most common techniques in use today are as follows:

1. **Infected Download**
   A phishing or spear-phishing email suggesting that a user visit a site for some compelling reason, such as a breaking news report, free software download or celebrity images. Unlike a traditional man-in-the-middle attack, these phishing emails don't always claim to come from a financial institution looking to "confirm" identification details, because the goal is to deploy malware, not harvest usernames and passwords.

   The user clicks on the link and is taken to a malicious website where malware-infected software is offered for download as a "necessary" video codec, pirated software package, interesting PDF document, or the like. When the user executes or opens the download package on their computer the malware is installed while the user remains unaware.

2. **Browser Vulnerability**
   As with Method 1 above, a user is tricked to visit a malicious site, which then exploits unpatched browser vulnerabilities to silently install malware.

Current estimates put the number of computers infected with malware at 31.88 percent, representing millions of users globally infected. Through the third quarter of 2013, the financial industry (21.74 percent) and payment services (56.39 percent) represented more than 78 percent of all industries targeted.[3]

[3] "Phishing Activity Trends Report: Third Quarter 2013," Anti-Phishing Working Group, February 10, 2014.

MITB Attack Phase Two: Transaction Takeover

In the second phase of the attack, the user launches their browser. The Trojan is automatically and silently activated, transparently storing or actively relaying the user's activities unmodified between the browser and the Internet, while unbeknownst to the user monitoring all of their activity.

The Trojan is capable of recognizing when the user visits a designated online-banking site to do their banking (Trojans are coded to watch for one or more online banks).

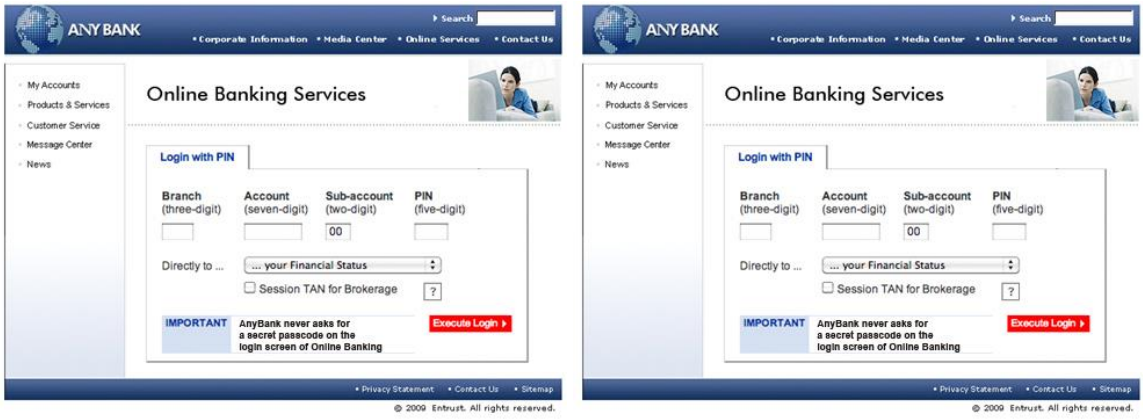
Once the user has successfully authenticated — even with strong authentication like an OTP token — the Trojan can appropriate the user's privileges, enabling it to modify transaction details and initiate new transactions without the user or the bank noticing.

Clearly, this can result in the user's funds being directed to accounts under the criminal's control, either directly or via mule accounts.

Here is one possible attack sequence after the malware has been installed, as seen from the perspective of the end-user, the malware and the financial institution:

Step	End-User	Malware	Financial Site
1	Visits financial institution site	Wakes up as this financial institution is on its target list	Displays login screen
2	Login with username and password	May harvest this, or more likely just wait	Processes login
3	Requests fund transfer form *(ACH or wire transfer)*	Waits	Displays form
4	Enters origin and destination accounts and amount	Intercepts user's request, substitutes alternate amount and destination	Receives malware's request, sends transaction details for review and requests one-time-passcode (OTP) challenge
5		Intercepts site's transaction detail confirmation, modifies them to correspond to user's initial request	
6	Views transaction details (which look fine) then consults OTP token and enters the numeric code into their Web browser	Waits	Receives user's valid OTP code and executes the modified transaction

This is but one example of several variations that are active man-in-the-browser attacks "in the wild" today. The net result of all of forms of attack is a loss of funds for the end-user or business, and a loss of credibility for the financial institution.



The browsers may look identical, but underneath one is a Trojan lurking, undetected by virus-scanning and ready to steal a user's identity as a part of a man-in-the-browser attack.

What Can Be Done?

There are many solutions available on the market today, both active and passive in nature. Each has its own merits and challenges which organizations should consider in their plans for protecting online users.

Active Safeguards

Active safeguards involve the user in some additional authenticating steps, at login time, transaction execution time, or both.

Financial institutions have known for some time that usernames and passwords alone are insufficiently effective protection for user accounts. Numerous other strong authentication techniques are available, and address a wide range of threats that are still relevant. However, man-in-the-browser attacks work around many of these techniques.

The following table summarizes a wide range of active safeguards available today, and rates their effectiveness against man-in-the-browser attacks.

Even if a technique is ineffective against MITB it is not to say that it is ineffective against other threats; the technique may still be suitable as an incremental layer of defense.

Method	Description	Effective Against MITB?	Why?
Username & Password	Username and a weak or strong password	**No**	Malware can intercept or wait until user is past this challenge before taking over
Biometric	Fingerprint reader to unlock login, typing biometrics other methods	**No**	
Grid Card	Grid of letters and numbers provided to users on card or electronically; user enters response to challenge string (e.g. A3 C4 J2)	**No**	
Mutual Authentication	At login, site displays photo or text string, that user has pre-selected, to confirm user is at correct site	**No**	
OTP Token	One-time-passcode token, in hardware or software form, where a numeric display shows a passcode that changes periodically; user enters this passcode when requested by a site	**No**	
Out-of-Band OTP	One-time-passcode delivered to a user "out of band" onto a separate device (e.g., onto a mobile phone via SMS message or to a voice phone line via automated delivery)	**No**	
EMV-CAP[4] OTP	EMV-CAP technology leverages a user's chip-enabled bank card and an electronic physical reader which together can generate a one-time-passcode response; user enters this passcode when requested by a site	**No**	

[4] Europay, MasterCard and Visa: Chip Authentication Program. A smartcard technology for online authentication of bank account holders and their transactions.

Method	Description	Effective Against MITB?	Why?
Smart Card & Digital Certificate	PKI digital certificate stored on a smart card or USB cryptographic token; credential used to perform client authentication via SSL	**No**	
Anti-Virus or Anti-Malware Applications	Software deployed to end-user desktop computers, aiming to detect and disable malware	**Maybe**	Malware is changing so rapidly that client software is having trouble keeping up; signature-based detection models are increasingly ineffective and other models are still improving
Separate Computer Used Solely for Online-Banking	A computer can be set aside and reserved exclusively for corporate-banking access, with other websites and applications disabled.	**Yes, but inconvenient**	Malware is less likely to be installed if the computer is not used for other things; demands a discipline that is not commonly found in any group other than dedicated computer security experts; much less convenient than the anywhere, anytime access that most consumers are accustomed; even business banking customers would be hard-pressed to use this type of approach
Hardened Browser on a USB Drive	A hardened browser is shipped to end-users on a USB drive and hard-coded to only connect to the target bank's website; sometimes there is also a PKI credential stored on the USB device, and used for authentication	**Yes, but inconvenient**	Malware has a harder time attacking this browser, but it cannot be ruled out given the malware and secure browser are running on the same host computer; many organizations have disabled USB drives or, at least, have disabled "autorun" capability for external media, making deployment of this solution more challenging; browser updates can also become problematic

Method	Description	Effective Against MITB?	Why?
OTP Token with Signature	Amplifying on the OTP token method described above, some forms of OTP tokens can also be used to electronically sign transaction details, if they are equipped with a small numeric keypad; user is prompted to enter transaction details on the small keypad, then a signature code is calculated by the token	**Yes, but inconvenient**	User enters the transaction details so is aware of the specifics, and the banking site can detect if malware attempts to change them; usability on the token screen and keyboard is weak, and the user could be confused; special hardware must be deployed
EMV-CAP OTP with Signature	Amplifying on the EMV-CAP OTP method described above, specifically equipped electronic readers can also be used to electronically sign transaction details; user is prompted to enter transaction details on a small keyboard on the reader, then a signature code is calculated using the bank card	**Yes, but inconvenient**	
Out-of-Band Transaction Detail Confirmation plus OTP	Amplifying on the out-of-band OTP method above, the user is not only sent a one-time passcode via out-of-band communication (e.g., SMS or voice channel), but is also sent a summary of the transaction that's about to occur; for example: "Wire transfer $15,325 from acct 132382 to 482763. Confirmation code 193713"; user can then review the details, and only proceed in their browser if they recognize the details	**Yes**	User has opportunity to view transaction details in a separate communication channel; financial institution must take care to protect against easy reset of the out-of-band contact details (e.g., mobile phone number), or the malware will do this first then attack successfully; if out-of-band confirmation is sent to an initialized mobile application (vs. simply SMS to a phone) then reset is inherently a more elaborate and protected process

Importantly, users can also take an active role in protecting themselves by deploying some basic defenses against the original infection.

Financial services organizations have an opportunity to provide information on how users can best protect themselves as a part of their communication with end-users, including two essentials measures: keeping the computer's patch status up to date and running anti-virus software.

As described, in some cases the malicious website exploits a browser or OS vulnerability to implant the Trojan, and often the latest version of the OS and browser software will include fixes for any discovered vulnerabilities.

Keeping the version of browser updated can be beneficial as the major browsers operate programs to identify and take down known phishing sites. This has reduced the vulnerability of their users to social engineering exploits.

Of course, there remains a window of vulnerability between discovery and patch, and a machine can be infected before the necessary patch is installed, highlighting the need for both active and passive safeguards.

Passive Safeguards

Passive safeguards are invisible to the user, yet help identify the user or flag suspicious activity. These techniques are attractive because they don't impact the user experience in any way and, as a result, are easily deployed to protect all customers, even those who do not wish to see visible security measures.

The following table summarizes the range of passive safeguards available today, and rates their effectiveness against man-in-the-browser attacks.

Method	Description	Effective Against MITB?	Why?
IP-Geolocation	Based on the end-user's computer IP address, this technique determines the user's geographic location and compares it to typical locations used by this user	**No**	While effective when credentials are stolen and used elsewhere, these techniques fail against MITB because the malware is in the user's regular browser, at the user's typical location
Device-Profiling[5]	A snapshot of the user's browser configuration is taken (via Javascript and HTTP headers) to determine if the user is visiting from their usual Web browser; in a PC browser environment this technique is quite effective at uniquely identifying a computer with no interaction from the user	**No**	

[5] For an example of this profiling technique and its effectiveness, see https://panopticlick.eff.org/

Method	Description	Effective Against MITB?	Why?
Transactional Fraud Detection	The online-banking application is modified to make calls to the fraud detection service at every point an organization thinks may be relevant to fraud Due to the intensiveness of integration across applications, this is typically only done at initial logon and at specific monetary transaction points (e.g., money transfer) where session state and transaction details are passed to the fraud detection service for analysis; the fraud engine looks at transactions and compares them to what would be termed 'normal' for that user or group of users; patterns are detected and warnings raised if appropriate	**Sometimes**	Historically, this analysis has been performed in a batch process, overnight But, it has become essential to perform the analysis in real-time, because, as clearing delays are eliminated, the money can be gone in a matter of minutes The challenge with this approach is that the necessary data to detect a MITB Trojan is typically not captured (due to intensity of effort and cost), with clues of the malware's existence spread out across the lifespan of the session, not only the wire transfer transaction alone

Method	Description	Effective Against MITB?	Why?
Fraud Detection that Monitors User Behavior	The second category is one that captures and analyzes all of the user's Web traffic data from the moment they log on to the moment they complete their session; best-of-breed examples of this type of fraud detection use a "zero-touch" approach to achieve this, removing the need to change the online application, streamlining deployment and increasing the ability to react to changes in fraud	**Yes**	The benefit to a solution that approaches fraud detection in this way is that aberrations in behavior can be highlighted before an actual transaction is undertaken, including the detection of IP changes mid-session, navigating too quickly through a site, or simply navigating in an unusual way for a given user's profiled data "Zero-touch" fraud detection application has access to information at all levels of the communication stack, including source IP address, user-agent type, activity dynamics, etc. Analysis from a single user session, multiple sessions for the same user and multiple sessions for multiple users, gives the system a 360 degree view of how the banking application is being used and, more importantly, abused

Summary

Online fraud has become the domain of serious criminal organizations. The world is in an "arms race" and should expect that criminal ingenuity will continue to be applied; attacks will get more and more difficult to thwart. Countermeasures will continue to evolve and be replaced by more effective approaches.

Traditional two-factor authentication solutions such as one-time passcode tokens, while continuing to be effective in a wide range of scenarios, are no longer effective for high-value transaction environments such as corporate online-banking now that malware is a widespread attack technique.

Fortunately, a number of techniques remain strongly effective against man-in-the-browser attacks, either through use of a separate communication channel with the user, or by relying on fraud detection engines that run on the target website instead of the infected computer.

The proven and effective techniques with the fewest drawbacks are:

1. **Out-of-band transaction detail confirmation,** followed by one-time-passcode generation: this technique leverages devices such as mobile phones that are already being carried by the intended end-users, and enables review of transaction details outside the influence of malware on the user's PC.

2. **Fraud detection that monitors user behavior:** this server-side monitoring of a user's movement through a banking website, inclusive of transaction execution steps as well as the steps leading there, provides flexibility for financial institutions to adapt to constantly evolving malware features, and detect suspicious patterns of activity for immediate intervention.

The combination of flexible authentication technology — enabling easy step-up authentication when risk levels dictate — along with ongoing user behavior monitoring provides a layered defense against malware threats … today and in the future.

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More than ever, Entrust understands your organization's security pain points. Whether it's the protection of information, securing online customers, regulatory compliance or large-scale government projects, Entrust provides identity-based security solutions that are not only proven in real-world environments, but cost-effective in today's uncertain economic climate.

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