Tracing Hackers: Part 1

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In the computer security arena, every now and then, a vulnerability comes along causing a significant impact. The impact of a vulnerability is based on factors such as popularity of the vulnerable platform and the ease of exploitation of the vulnerability. Lots of research gets done on a vulnerability, beginning from its origin to the various permutations and combinations of exploit code that come out subsequently. In recent years, we have seen self-propagating exploit code (in other words, worms) becoming quite popular.

Very little is known about the events taking place in the time period between the instance that a vulnerability gets discovered by an individual or a small group of individuals, and the moment when the exploit code becomes publicly available on the Internet. To zero in on the origins of a particular piece of exploit code is quite a daunting task. Very little research has been done on the subject outside of government or military organizations. Tracing back origins is a very tricky task, especially if one has to reconstruct events backwards. This paper addresses this very issue — trying to roll the film reel backwards from the time the exploit code becomes widespread in public, and filling in the blank frames to the beginning of the movie. This may not be the ultimate 'big-bang' theory of the exploit universe, but it provides us with new viewpoints on exploits and their originators.

One of the problems the computer security industry and law enforcement agencies face is tracking and tracing back malicious computer attacks to their origin, and associating the attacks with real individuals. Malicious computer attackers may use several techniques to fool tracers by disguising their real location, so they cannot be traced back and prosecuted. A highly skilled malicious computer attacker can 'get away with it' with the technology of today when combined with the lack of skills, methodologies, resources and time available to the law enforcement agencies.

So how can technology overcome the obstacles and provide the law enforcement agencies with the tools and methodologies needed to trace the real attackers?

Using monitoring, intelligence gathering, and electronic surveillance systems that are operational today by many intelligence agencies[1], sometimes in a joint effort, we are able to locate, precisely, exploits and exploit code and bind them to the originator of that exploit with a high degree of accuracy. Not only are we able to determine the virtual identity of the code writer/attack generator, but also to track their real identity in real life.

Looking back at the 11 September tragic events and examining publications in the past, it is known and published that several intelligence agencies maintain the ability to electronically gather and store any communications activity whether it is on the Internet or done by any other electronic means[2]. It is not known for how long this communication intelligence is being stored for, and what exactly is being logged although we can imagine that the logs contain everything these agencies can receive (and retrieve).

The data collected is good for locating individuals that have committed crimes in real life by using some of the Internet's abilities. A good example of this is using the logged information to track airline ticket buyers that were using the Internet. The data stored can also be used to track malicious computer attackers/black hats with an amazing degree of accuracy, as I will demonstrate.

So, how is it possible to trace back these malicious computer attackers?

We will discuss two methods; the first will be discussed in this issue while the second will be covered in the May edition of *Computer Fraud & Security.*

The first method — looking for a needle in a haystack

It is all a matter of patience, rather than advanced technology and techniques that are based on tracing events, which have occurred in the past.

We are going to refer to two time frames, the recent past, and the distant past.

Recent Past

In the recent past we can identify, in real-time or in near real time, an attack attempt.

How can we differentiate between attack attempts and regular traffic if the attacks are not known?

By determining what traffic is legitimate and what is not legitimate. According to patterns in applications, for example, or patterns in shell code or the shell code encode as another example, IPv4 legitimate traffic and other means.

In terms of intrusion detection systems what we are going to observe in the recent past is the exploit's signature.

What can we do with it?

We can look at the stored information for the same exploit code signature, and trace it back as long as we can.

We can draw borders in time between the period that network signatures for the exploit we look for started to appear on the Internet to current time or any period of time we wish.

Tracking the activity on some mailing lists can, sometimes, give the knowledge of some of this timeline, but not all of it.

We can divide this time frame, or window frame, into one more window.

The extra window is the time that the exploit was shared among a small number

[1] FBI Congressional Statements, Carnivore Diagnostic Tool, Donald M. Kerr, Assistant Director, Laboratory Division, before the United States Senate, Committee on the Judiciary, 09/06/2000: http://www.fbi.gov/congress/congress00.htm.

[2] The European Union investigation into Echelon: http://www.europarl.eu.int/committees/echelon_home.htm.
Meet the FED panel, Defcon 8: http://www.defcon.org/html/defcon-8-post.html.

of people. Sometimes it is owned solely by the exploit writer for a period of time (sure I could have added another window for that). As we go further back in the time window, where we saw network signatures that match with the exploit, we are also able to reduce the number of people that have shared the exploit.

When the exploit signatures just started to appear it is the time that our window can be narrowed sufficiently and be used to conclude that the exploit writer (or someone that was given it or bought it directly) is responsible for the damage that the exploit caused in that period of time, and for the activities of it. There is always a narrow window in time in which an exploit was shared among a small group of individuals and/or is being tested by a research group against public machines.

Who owns the exploit in this small window of time?

Sometimes, because of the nature and level of damage that an exploit might cause it is held only by its writer. Sometimes the writer offers the exploit for sale to criminal entities and/or commercial entities and/or government agencies[3]. It is all a matter of price and gain. If the exploit writer is a member of some group they might share this exploit among friends.

Usually the exploit code gets leaked and sooner or later the underground computer security community gets hold of it (and eventually other people as well). Or the knowledge of the vulnerability existence leaks and then exploit code is created by others. This is also the time that, usually, there is an increase in damage caused by the use of that exploit, and more and more damage reports are being collected from system administrators and systems such as distributed IDS systems and the Honeynet[4] project.

We might face a slightly different scheme of distribution (and ownership) when, for example, the exploit code writer faces some problems during the coding stage or in the initial testing phase. For example, when the code writer has trouble making some component of the exploit work correctly and turns the code over to someone with better skills to fix, finish or help.

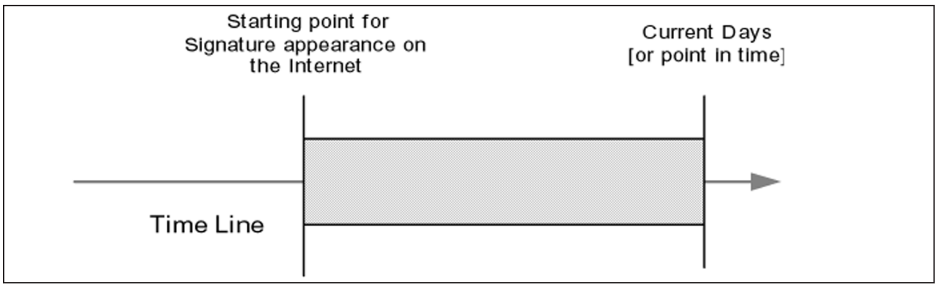

Starting point for Signature appearance on the Internet
Current Days [or point in time]
Time Line

Figure 1

On the other hand, there are certainly other scenarios where the exploit code will not be shared. For example, if the author of the exploit possesses higher coding skills or understanding in a certain field of technology.

The time where an exploit will only be owned by one person or by a small group of people depends not only on the gain that person or group might have from using the exploit, but also from the psychology of person or the group dynamics (fame, glory, ignorance, control). Eventually the exploit code will be leaked out (a good example is the telnetd exploit from the hacker group teso[5]).

We have identified the time frame in which the usage of the exploit increased. We also identified a small time frame, usually at the beginning of the larger time frame where a small group of people were the only ones who shared this exploit code tested, perfected and then utilized in a hostile manner.

The early stages in the exploit code evolution and distribution is our key to solve the problem.

Using this information we can also identify IP addresses of hosts that issued the attacks. Usually they will be compromised hosts, which the malicious computer attackers broke into earlier in time and were used as launch pads for different attacks. We do not expect our attackers to connect directly to these hosts; they might use a chain of compromised hosts to hide their activities.

So how can we advance from this point on?

Distant Past

You still need to remember that we are dealing here with huge amounts of information and logs taken at different times.

In recent days, or in the near future, someone from an intelligence agency, intelligence community or from a law enforcement agency will get hold of the exploit code itself.

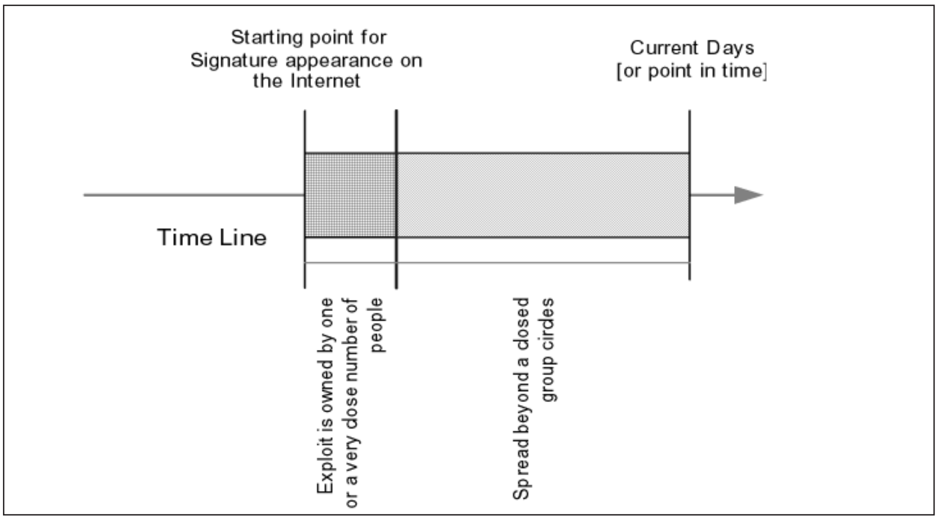

Starting point for Signature appearance on the Internet
Current Days [or point in time]
Time Line
Exploit is owned by one or a very dose number of people
Spread beyond a dosed group cirdes

Figure 2

[3] Evidence gathered from the Underground community.
[4] http://project.honeynet.org

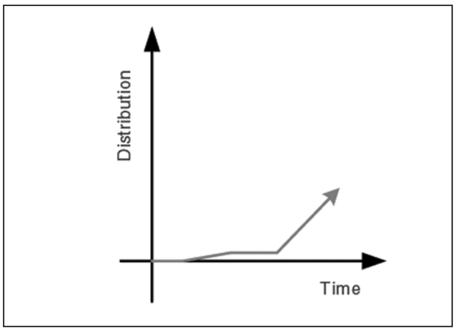


Figure 3

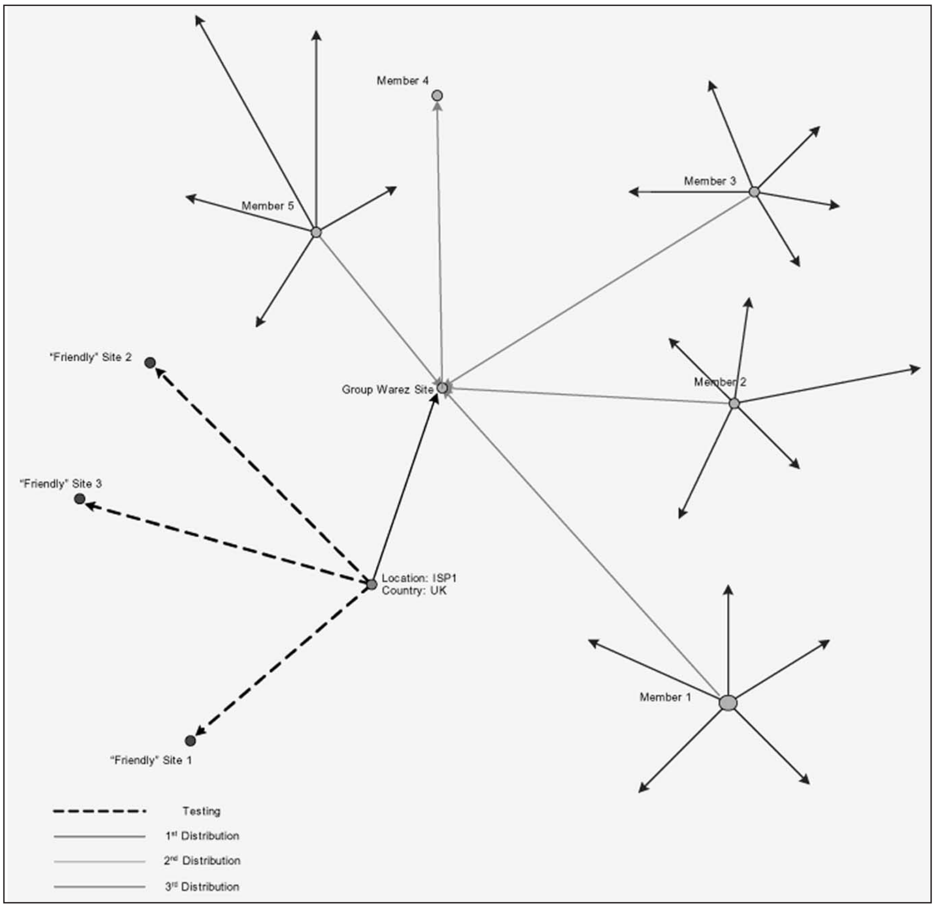


Figure 4

Until this point we were relying on signatures of the exploit, but nothing more than that.

Since we are now holding the actual code of the exploit we can search our database and logs for any code transfer from any given point using any electronic means of transport (protocol wise – i.e. SMTP, FTP, SSH or SSL). This means that our signature now will be the actual exploit code (and not the exploit networking signature).

We are not limited for searching the exploit code in the form of a precompiled code only. We can also look for the exploit code in a binary form, compressed form, tared form, gzipped form, etc.

We will also have to consider that the exploit author had to test their code and perfect it in a live environment (in some cases it may take a lot of iterations until the exploit code will be good enough to go to 'production'). In these instances some black hats may not wish to have their code leak so will potentially launch their attacks against known hosts/friendly hosts (i.e. my friend has this SUN Solaris box — I'll own him, it'll be a bit of a laugh and he'll understand) from their own machines. It is, sometimes, much more likely at this stage of development, they will use a host that has some connection to them — their school, their mate's, their company's server…This is, sometimes, how you get the lead that can assist in narrowing down not only their geolocation, but also their network of compatriots.

In these situations, the code used in the developing exploit may not differ a great deal from the end product, so using all the stored network traffic we should be able to pinpoint the attacker testing the exploit against these known hosts. In these instances one observes a situation depicted by the illustration (Figure 4)[6].

With this example, you see initially very small attacks originating from one network against what we will term 'friendly hosts'; we then see code with a signature matching this exploit being transferred using the File Transfer Protocol (FTP) from the author to the group's warez server. Once there we see five downloads to separate networks all over the world. From this we can see that this historic data has become invaluable in watching the original propagation of the exploit. You may even find where the exploit leaked to the public domain if you keep digging long enough.

In addition, we can start looking for any code uploads to the compromised hosts that were used to launch the exploits, and trace back from that point in time.

This means that if the writer of the malicious code transferred the code to different hosts until the writer reached the real launch pad, we will be able, looking at the logged transactions, to identify which hosts where used to bounce through until we reach the attacker's real workstation on the end of a leased line, dial-up or DSL line.

The narrow window of opportunity when the exploit code was starting to be used in the wild gives the tracers even more opportunity to locate exactly the source of the exploit code, and its creator. It gives the people who are performing the trace the IPs to start with and then start tracing back and to exactly locate these malicious attackers in the huge pile of information they might have.

The time taken to spread and upload the exploit to different machines and the time we have started to see the exploit being used in the wild might overlap partially as well.

[5] http://www.securityfocus.com/bid/3064
[6] Idea contributed by Ollie Whitehouse [ollie@atstake.com]

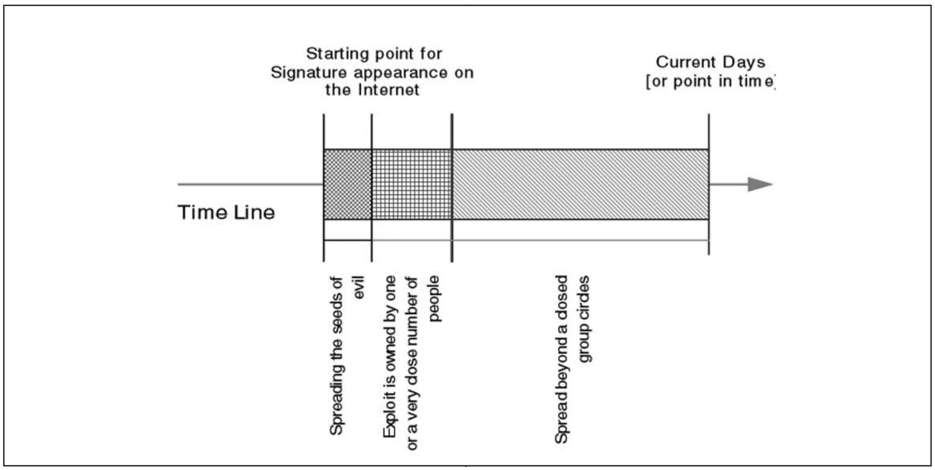

Starting point for Signature appearance on the Internet
Current Days [or point in tim e]
Time Line
Spreading the seeds of evil
Exploit is owned by one or a very dose number of people
Spread beyond a dosed group cirdes

Figure 5

The time frame keeps moving backwards but our window of opportunity only increases.

Eventually, because of the vast amount of information stored in today's surveillance systems, these systems will be able to locate a malicious computer attacker, back to the point of origin.

People may be sceptical about features and the amount of information that a system like this can store. If you have watched the movie Enemy of the State (1998) staring Gene Hackman and Will Smith and you did not believe the things you saw in that movie three years ago, I suggest you go and read the European Union's report on Echelon, and the FBI's press releases and congressional public reports of Carnivore, as well as other publications.

What will happen if the exploit was written in a country that has no surveillance mechanisms in place? Any virtual crossings of the electronic boundaries of these countries onto the networks of the countries that does impose this kind of surveillance technology will 'show up on the screens' of those monitoring systems. We might miss several pieces of the puzzle since some early propagation might occur inside that country, but the origin of the exploit code and the source for the trouble will be revealed.

It is interesting to understand what that country's pipe to the Internet is and how this connection is made. If we take satellite communications for example, it is long known that this type of communication is being monitored.

As an example one might choose a country and try to map its global crossings. A simple way to do so is to use the traceroute or tracert programs against the IP addresses of that country's biggest ISPs. These ISPs usually will use high bandwidth connections to the Internet backbone, connecting that ISP with one or more major Internet crossings. By mapping these Internet crossings we can speculate who is potentially 'listening' at the other end. You need to use different Internet locations outside of the country you have chosen to check this against.

One might be surprised to notice that most of the Internet traffic goes through numerous connection points only.

Here we are getting into another area of profiling exploit code writers and malicious computer attackers. This can be done according to several keys that will be outlined in the profiling section of this article.

Profiling[7]

Criminologists and police forces use profiling techniques to help catch criminals, usually the worst kind. Using profiling techniques in solving, and tracking computer crimes is also helpful. The means to do so are totally different in terms of the technology used from those used in real-life crimes.

Adding a good profiling system to a modern surveillance system adds additional power and abilities to it.

IDS systems generally fail to reveal if an attacker is using more that one source/host in order to collect data and/or attack a specific site.

The problems associated with these types of attacks can be overcome by using a combination of passive fingerprinting and psychology — profiling.

Humans often follow behavioural patterns that are predictable by theory (this is due to the fact we are creatures of habit). So most malicious black hat attackers probably have their own unique habits also. There are certain proportions of behaviour that an individual may exhibit that are idiosyncratic patterns that are usually unique to an individual. What if we can identify a style or an operational pattern? (And what if we can guide its actions…?) I can give an example of black hats that have monetary motives; others might have a political agenda and so on.

Motivations can be of considerable assistance in understanding the nature of exploit events. Many may remember the old motivation acronym used by counter-intelligence agencies for years-—MICE, which stood for **M**oney, **I**deology, **C**ompromise and **E**go. An adaptation of this acronym — MEECES, can be applied to the motivations driving computer exploits. In short, MEECES stands for **M**oney, **E**go, **E**ntertainment, **C**ause (basically ideology), **E**ntrance to a social group, and **S**tatus. Each of these motivations plays a role in shaping the behaviour of the objectives of the exploit, the selection of means by which the exploit works, the types of hosts that are targeted, etc.[8]

Will this mixture of technical and psychological profiling allow us to predict and guide a certain unknown individual's actions? Will it allow us in the future when the same pattern of behaviour (and of course some technical necessities combined with it as well) pop up to mark a certain individual in future incidents and attacks? I believe that we can track this over time…

Just think about the information a modern surveillance system holds, tracks and stores.

[7] I would like to thank Max Kilger and Jeff Stutzman for their comments for this section.

[8] Contributed by Max Kilger.

We should also not forget the deterrence component of this kind of profiling. By letting people know in general terms (without revealing the secret recipes) that there are profiles built over time and that eventually they result in apprehension, the psychological feelings of risk increase for the author for each new exploit written. At some point the author encounters a threshold at which they make the decision that 'odds are against them' and they decide to curtail their activities. It does not work for everyone but works for a large percentage of people.

Usually, the way to discover a correlated attack is to look at the type of queries launched from several, usually unrelated IP addresses against a common victim site or network (sometimes from geographically disparate regions). It can be an information gathering exercise or even exploitation attempts. This works for the obvious and most common things. For example we can name information gathering such as scanning, especially port scanning.

One malicious IP address (host) scans port 21 while another host tries to connect to port 53. Usually the time gaps between the different attempts will be short, and the tool used will be the same. The picture gets unclear whenever the time frame gets longer.

How then can you correlate attempts? Is it pure luck? Expertise of the people who look at the data? Different processing of time periods on the collected data? Craftware? Sorcery? What happens if the targeted site is a high profile one? What will happen then? Black hats' malicious attempts might be mangled with script kiddies stuff. How do you really understand what is going on?

Also remember that in some cases black hat attackers will handover the compromised host to a script kiddie once their objective has been achieved. This will allow the script kiddies to divert the heat away from the attacker, as they will typically fill up the logs, which will produce a good enough case against the kiddies, in question.

In my own humble opinion you don't have the understandings of exactly what is going on. There is simply too much out there to process. Sometimes you try to process the logs (if you save them for further processing) in different manners so you might hit something after it happened. Usually, it is never on a real-time basis. However, this must never be discounted, as for a forensics exercise these types of logs are invaluable.

Another approach that might help the security community is a very simple one: let the legitimate traffic go by, mark the non-legitimate. Process them in a different manner. You can use it the way you like. For example, with firewalls, you let the legitimate traffic in and drop the non-legitimate. (As an example we might look at a TCP packet which both the SYN and the FIN flags are set.) With intrusion detection systems you process the non-legitimate traffic differently than legitimate traffic. It is also a good idea to look for new problems or new exploits in the non-legitimate or unusual traffic. The definition of non-legitimate and unusual is still out of the scope of this paper due to the complex methodologies behind understanding what traffic is considered normal, this increases in complexity when we look at protocols such as SOAP, which balance on top of HTTP.

What we need is to approach this problem from several perspectives. We need to isolate the unknown from the obvious. Usually exploits will belong to the non-legitimate or the unusual traffic that we might see.

So we see a new attempt/exploit in the wild. From it, how are we able to learn more about the people who are using it?

Usually the 0-day[9] exploit will be owned by a small number of people, sometimes by one individual. From looking at unusual traffic gathered by different sensors on different networks we can get a picture of hosts which are under the direct control of that individual or group of people and the nature of the operating systems they are using to launch their attacks from, as well as the nature of the operating system the exploit was written on (usually a favourite operating system is a holy thing among black hats, as well as development platforms).

The passive operating system information we gather will help us to profile the attackers according to their code writing style. Other questions like did the attacker spend a lot of time writing the hack? might not be answered sometimes. Skilled coders recognize the ease or difficulty in certain exploits and can evaluate the difficulty and therefore skill level (and time involvement to some degree) necessary to have authored the code.

We can look at a number of parameters inside the exploit code

Did the code writer use a borrowed portion of the networking code from someone else, or from another tool (i.e. how many exploits have been seen reworked from LSD shell code)? What are the IP header fields the attacker is introducing and with what parameters? Which IP header fields share the same parameters again and again?

We can look at a number of parameters drawn from the network traffic we see

Did the individual launch an information-gathering attempt beforehand? Did the exploit succeed in its aim? If not did the attacker try to knock over the attacked host with whatever was in the arsenal? Did the attacker show frustration? Panic? Anger?

We can look for several patterns after a successful compromise

What happened after the compromise occurred? Did you see the usual script kiddies rootkit being used or was it a simple log clean and go? What was the rootkit uploaded after the compromise? Was it a downloadable rootkit (such as the Linux rootkit)? Or was it the personal signature of a black hat that's uses his/her own rootkit? Did she upload some kind of a program to the compromised host, which is aimed at encrypting her future communications with the compromised host?

We can look for patterns in the way the aftermath is being done

[9] Defined as computer language code written to take advantage of a particular vulnerability, which has been discovered but is not publicly known.

Does this seem an automated process? Some black hats are using programs that are not only exploiting a targeted host, but also have capabilities to automatically cover the tracks of their master and hide the masters' presence in the compromised host.

If this code is being shared among a group of people (which may or may not belong to the same group) according to behavioural patterns within the group we might actually differentiate between certain individuals within that group as well.

A Honeynet usually uses only one machine or a low number of machines acting as honeypots, eyes and ears. What if this kind of technology/thinking could be used by an entity that has multiple sensors across continents…?

This suggests that governments with a global reach, who will deploy global Honeynet networks, will have the ability, not only to get 0-day exploits before anybody else, but will also have the ability to track down the 0-day writers faster and closer to their origin.

These governments will have the ability to use the 0-day exploit code as they please. This suggests the usage of the 0-day exploit code against other servers in other countries before patches are created for this type of exploit (a nice type of Information Warfare), or they also might send the 0-day exploit to a software company where its servers or technologies are being exploited so this problem will be fixed faster.

But bear in mind that fixing the vulnerability faster than the propagation of the exploit code may take place, might tip the exploit writer that something is wrong and probably they are being monitored. Especially if the code is owned only by one person, which is the coder of the exploit.

In cases where some puzzle pieces are missing from the bigger picture, profiling the activities around the exploitation attempts, code testing, and code distribution might lead us to certain individuals with certain behavioural patterns.

In the future when these individuals will not be as careful…

Profiling and reducing the amount of information logged

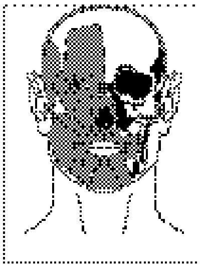
It is known that several capabilities allow an intelligence agency to record a conversation if certain words are mentioned during the conversation. What if a similar technique could be applied to computer code/network traffic? What if we are able to log network traffic and look at suspicious or predefined patterns and only if we find them interesting we will keep this "conversation"? Or even flag the two IP sources and destination addresses as suspicious and try to digitally perform surveillance on that pair of IPs or set of IPs?

The database behind the scene

What we wish to have is not just a 'flat file' database of signatures but a relational database that allows you to do a number of things including:

- Relate commonalties like common code segments among different exploits.
- Build profiles of exploit writers in terms of method of attack, favourite types of hosts to attack or takeover in assisting an attack (might be regional or geographical), etc.
- Psychological profile details that suggest motivation, IRC channels they might hang out on that should be scanned, potential related websites, etc.

SHOCKWAVEWRITER



Interviews and Interrogations

Since we are in the time of recessions and otherwise poor economies around much of this world, there are probably security people out there searching for employment and undergoing the interview process. So, I thought this would be a good time to discuss interviews and interrogations — as it seems many end up using that method.

Recently, I read an article in a security magazine about interviewers and interviewees. Over several decades, I have hired, trained and fired more people than many InfoSec managers supervise in an InfoSec group. Not bragging or complaining, just stating a fact. Based on my past experiences, I pretty much disagreed with about everything the author wrote about the topic.

Let's start with some general comments. First of all, the corporate culture, the amount of budget allocated for hiring, the strongly worded advice of the human resources staff, and the type of position available are issues that must always be considered by the interviewer.

As for the job applicant, that person will do his/her best to be selected. Some even lie to get the job, but let's assume that the interviewee is an honest person — don't laugh, many aren't these days, and some of them work in the security profession.

Quite often these days, interviews are conducted by a committee sitting as if in judgment to determine if the interviewee