ESET TECHNOLOGY

The multilayered approach and its effectiveness

Authors:
Jakub Debski, Chief Product Officer
Juraj Malcho, Chief Technology Officer
Peter Stančík, Security Research and Awareness Manager
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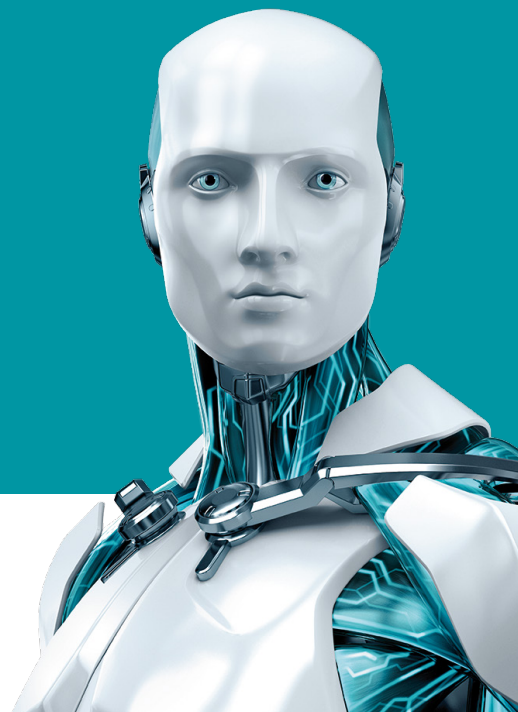

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CONTENTS

OBJECTIVES

In this document we summarize the ways in which ESET uses multilayered technologies to go far beyond the capabilities of basic antivirus. We do this by explaining which layers are involved in solving specific problems and what benefits they provide to the user.

NEXT-GENERATION SECURITY SOLUTIONS

Most established antivirus companies grew out of a desire to help people who had problems with viruses or malware, and their technology evolved to meet the widening range of threats that security vendors were starting to address. Today, antivirus is perceived as a commodity business and security is a subject that resonates with everyone, whether or not they understand what it actually means. More recently, we have a seen a proliferation of new, self-proclaimed "next-generation"—or as we like to call them "post truth"—companies.

These typically have little experience of developing anti-malware solutions, but aggressively market their solutions as "innovative" while dismissing established vendors as "dinosaurs." As with most silver-bullet salesmen, many of their claims are misleading and, ironically, their detection capability normally relies on a third-party detection engine from an established vendor, since very few of the dozens of solution providers now in the market have the experience or capacity to enable them to develop their own core detection technology. ESET's technologies are all proprietary and have been developed in-house.

One common assertion that "next-gen" vendors make is that AV is dead. AV is not dead. However, the simple detection by static signature that—according to newcomers—is compromising the effectiveness of the established anti-malware industry is, if not dead and gone, only a tiny component of the battery of technologies a modern security product deploys against current threats.

MULTIPLE THREATS, MULTILAYERED PROTECTION

Established anti-malware companies that are still in business today have maintained their market share by evolving to address current threats.

These threats are not static and their evolution did not stop in the early 2000s. Today's threats can't be fought effectively by just building on technology from the 1990s. Fighting modern malware is a cat-and-mouse game in which we face teams of skilled and (financially-) motivated bad guys. So security companies need to refine their products constantly, both reactively and proactively, to provide effective solutions, adding different layers by which modern malware can be detected and/or blocked. A single point of protection or a single method of defense is simply not enough.

That is one of the reasons why ESET too has evolved from an antivirus vendor into an IT security company.

Multiple threats, multiple platforms

Microsoft operating systems are not the only platforms on which malware runs nowadays. The field of combat is changing quickly as attackers try to seize control of previously unexplored platforms and processes.

- Anything that can be controlled to perform malicious activities can be used for attacks.
- Anything that runs executable code to process external data can potentially be hijacked by malicious data.

Linux servers have been a major target for attackers (Operation Windigo, *Linux/Mumblehard*), Macs running OS X hosted one of the biggest botnets ever (*OSX/Flashback*), mobile phones are common targets (*Hesperbot*) and attacks on routers are becoming a serious threat (*Linux/Moose*). Rootkits are getting closer to the hardware (attacks on firmware or using the *UEFI rootkit*) and virtualization opens new vectors of attack (Bluepill, VM escape vulnerabilities). Also, web browsers and other applications have become as complex as operating systems and their scripting mechanisms are often used for malicious purposes (*Win32/Theola*).

Different distribution vectors

Historically, the first malware appeared as self-replicating processes, at first within systems and then as file-infecting and/or disk-infecting viruses spreading from PC to PC. As Internet use has become almost universal, so the number of ways of distributing malware has grown enormously.

Malicious objects can also be sent by email as attachments or links, downloaded from web pages, dropped by scripts in documents, shared on removable devices, deployed remotely by taking advantage of poor authorization and weak passwords, executed via exploits or installed by end users tricked by social engineering techniques.

Malware design

The era when malware was written mainly by teenagers as a prank or to show off is long past. Nowadays, malware is written with the aim of monetization or information theft, and serious money is invested in its development by both criminals and governments.

In the hope of making detection more difficult, malware is written in different programming languages, using different compilers and interpreted languages. Code is obfuscated and protected using customized software to make detection and analysis harder. Code is injected into clean processes in an attempt to avoid behavioral monitoring—which is designed to spot suspicious activity—and to hamper removal, thus ensuring persistence in the system. Scripts are used to avoid application control techniques and "in-memory only" malware bypasses file-based security.

To sneak past protection, the bad guys flood the internet with thousands of variants of their malware. Another method is to distribute malware to a small number of targets to avoid attracting the attention of security companies. To avoid detection, clean software components are misused or malicious code signed using certificates stolen from legitimate companies, so that unauthorized code is harder to spot.

Also, at the network level malware makes less use of hardcoded command-and-control (C&C) servers to send instructions and receive data from compromised systems. Decentralized control of botnets using peer-to-peer networking is commonly used, and encrypted communication makes identification of attacks harder. Domain generation algorithms reduce the effectiveness of detection based on blocking known URLs.

Attackers take control of legitimate websites that have good reputations and even legal advertising services are used to serve up malicious content.

IMPORTANT NOTE

There are many ways that attackers can avoid detection so that a simple, single-layer solution is not enough to provide protection At ESET we believe that constant, real-time, multilayered protection is required to assure the highest level of security.

THE BENEFITS OF ESET'S CORE TECHNOLOGY

ESET's scanning engine is at the core of our products and, while the underlying technology has been inherited from "old-style antivirus," it has been greatly extended and enhanced and is constantly being developed to cover modern threats.

The purpose of the scanning engine is to identify possible malware and make automated decisions about how likely the inspected code is to be malicious.

For many years, ESET's performance was based on smart algorithms and manually-crafted assembly code to address performance bottlenecks caused by deep code analysis using the sandboxing technology integrated into the product. However, we have improved this approach. Now, for maximum performance, we use binary translation together with interpreted emulation.

With in-product sandboxing you have to emulate different components of computer hardware and software to execute a program in a virtualized environment. These components can include memory, the file system, operating system APIs and the CPU (central processing unit).

In the past, the CPU was emulated using bespoke assembly code. However, it was an "interpreted code," which means that each single instruction had to be emulated separately. With binary translation you execute emulated instructions natively on a real CPU. This is many times faster, especially in the case of loops in the code: introducing multiple looping is a protective technique common to all executables where measures have been applied to protect them from analysis by security products and researchers.

ESET products analyze hundreds of different file formats (executables, installers, scripts, archives, documents and bytecodes) in order to accurately detect embedded malicious components.

The figure on the next page shows various core ESET technologies and an approximation of when and how they can detect and/or block a threat during its lifecycle in the system.

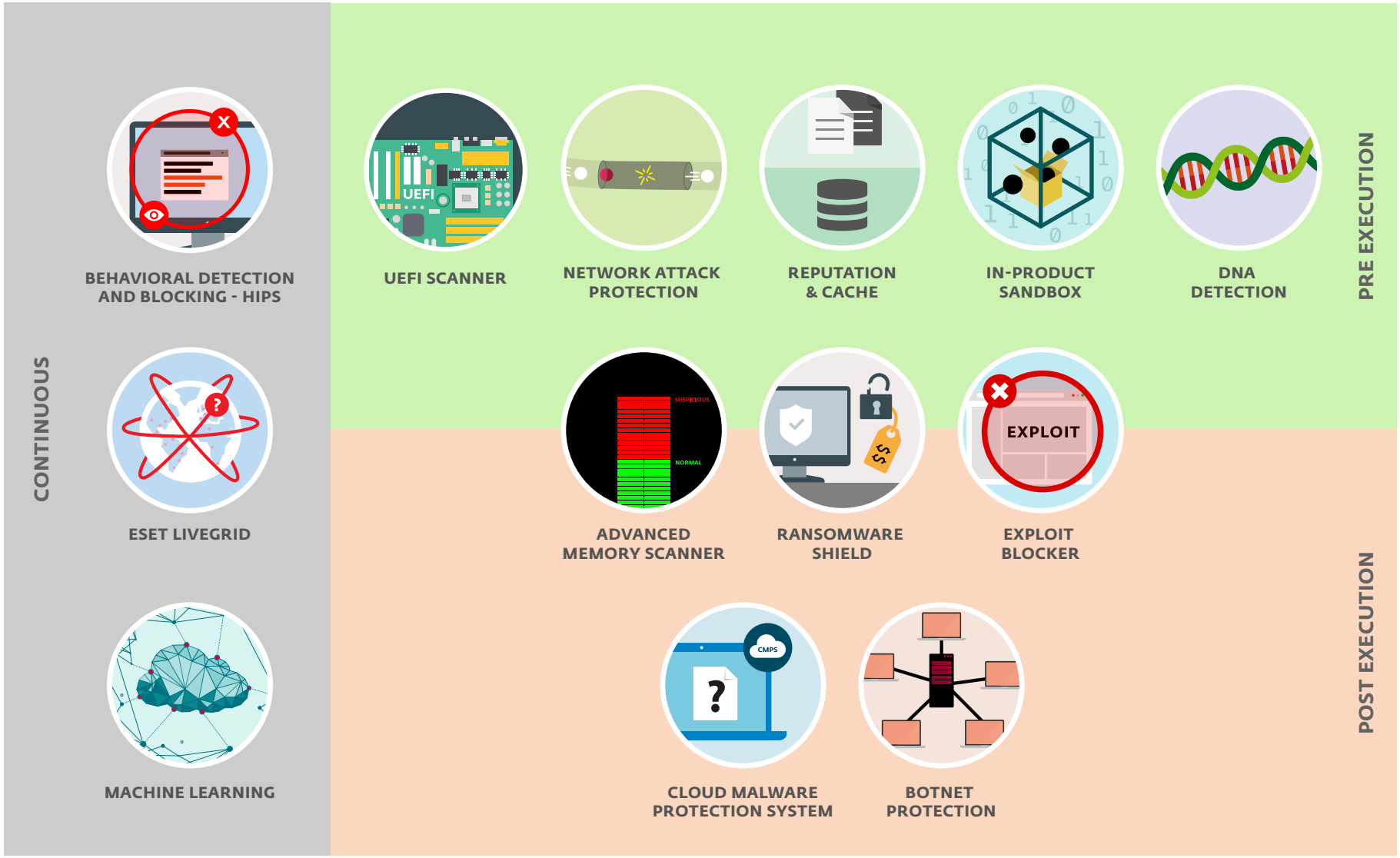
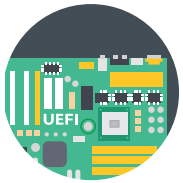


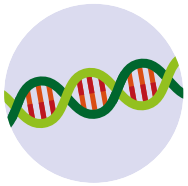
Fig. 1: ESET layers of protection



UEFI scanner

ESET is the first internet security provider to add a dedicated layer into its solution that protects the Unified Extensible Firmware Interface (UEFI). ESET UEFI Scanner checks and enforces the security of the pre-boot environment that is compliant with the UEFI specification. It is designed to monitor the integrity of the firmware and if modification is detected, it notifies the user.

UEFI is a standardized specification of the software interface that exists between a device's operating system and its firmware, replacing Basic Input/Output System (BIOS) used in computers since the mid-1970s. Thanks to its well-documented layout, UEFI is easier to analyze and parse thus allowing developers to build extensions for the firmware. However, this also opens the door for malware developers and attackers who can infect the UEFI with their malicious modules.



DNA detections

Detection types range from very specific hashes (useful, for example, in targeting specific malicious binaries or specific versions of malware, for statistical purposes or simply to give a more precise detection name to malware that we have previously detected heuristically) to ESET DNA Detections, which are complex definitions of malicious behavior and malware characteristics.

The pattern matching used by old-school antivirus products can be bypassed easily by simple modification of the code or use of obfuscation techniques. However, the behavior of objects cannot be changed so easily.

ESET DNA Detections are precisely designed to take advantage of this principle. We perform deep analysis of code, extracting the "genes" that are responsible for its behavior. Such behavioral genes contain much more information than the indicators of compromise (IOCs) that some so called "next-gen" solutions claim to be "the better alternative" to signature detection.

ESET behavioral genes are used to construct DNA Detections, which are used to assess potentially suspect code, whether it's found on the disk or in the running process memory.

Additionally, our scanning engine extracts many discriminator genes, which are used for anomaly detection: anything which does not look legitimate is potentially malicious.

Depending on the adjustable threshold level and matching conditions, DNA Detections can identify specific known malware samples, new variants of a known malware family or even previously unseen or unknown malware which contains genes that indicate malicious behavior. In other words, a single well-crafted DNA behavioral description can detect tens of thousands of related malware variants and enable our antivirus software not only to detect malware that we already know about, or have seen before, but also new, previously unknown variants.

Moreover, automated clusterization and application of machine learning algorithms to our malicious sample sets allows us to identify new malicious genes and behavioral patterns for detection by our scanning engine. Such genes can be easily matched against a huge whitelist set to ensure that they generate no false positives.

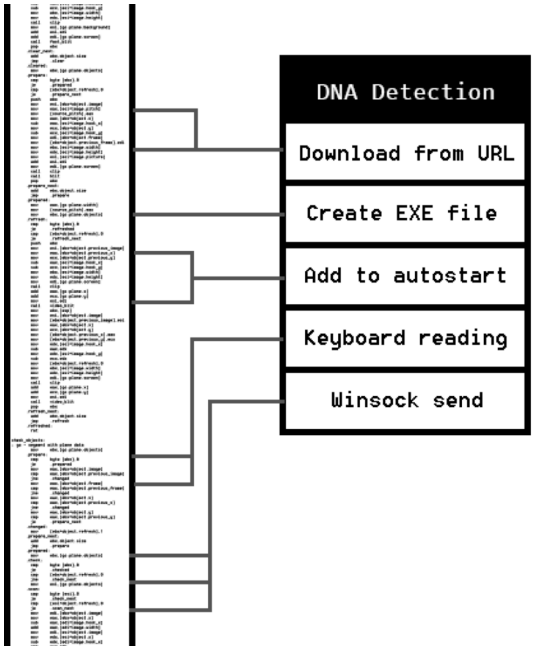


Fig. 2: DNA Detection example

Machine learning

ESET has been experimenting with machine-learning algorithms to detect and block threats since the 1990s, with neural networks being introduced into our products in 1998. Since then we have implemented this promising technology all across our multilayered technology.

This includes our DNA detections, which use models based on machine learning to work effectively with or without cloud connection. Machine-learning algorithms are also a vital part of the initial sorting and classification of incoming samples as well as of placing them on the imaginary "cyber-security map."

But most importantly, ESET has developed its own in-house machine-learning engine dubbed ESET Augur. It uses the combined power of neural networks (such as deep learning and long short-term memory) and a handpicked group of six classification algorithms. This allows it to generate a consolidated output and help correctly label the incoming sample as clean, potentially unwanted or malicious.

The ESET Augur engine is fine-tuned to cooperate with other protective technologies such as DNA, sandbox and memory analysis as well as with the extraction of behavioral features, to offer the best detection rates and lowest possible number of false positives.

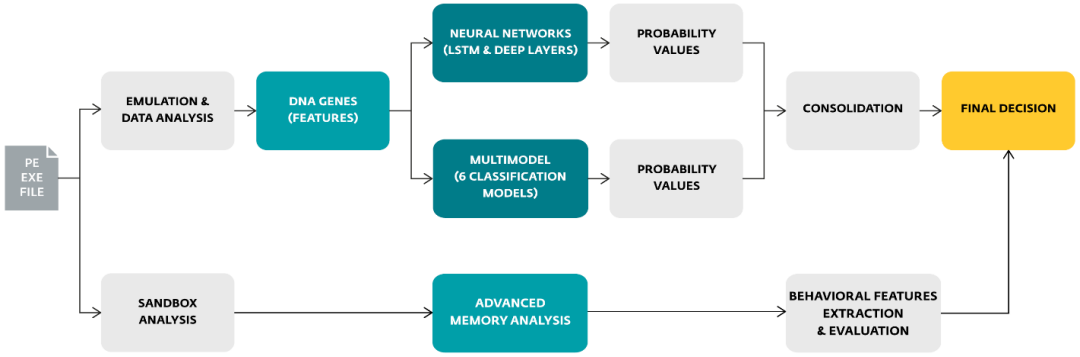


Fig. 3: Scheme of ESET's machine-learning engine Augur

ESET LiveGrid

The simplest way to provide protection using a cloud system is by exact blacklisting using hashing. This works well for both files and URLs, but it is able to block only objects that match the hash exactly. This limitation has led to the invention of fuzzy hashing. Fuzzy hashing takes into consideration the binary similarity of objects, as similar objects have the same or a similar hash.

ESET has moved fuzzy hashing to the next level. We do not perform hashing of data but hashing of the behavior described in DNA Detections. Using DNA hashing, we are able to block thousands of different variants of malware instantly. (See charts on right.)

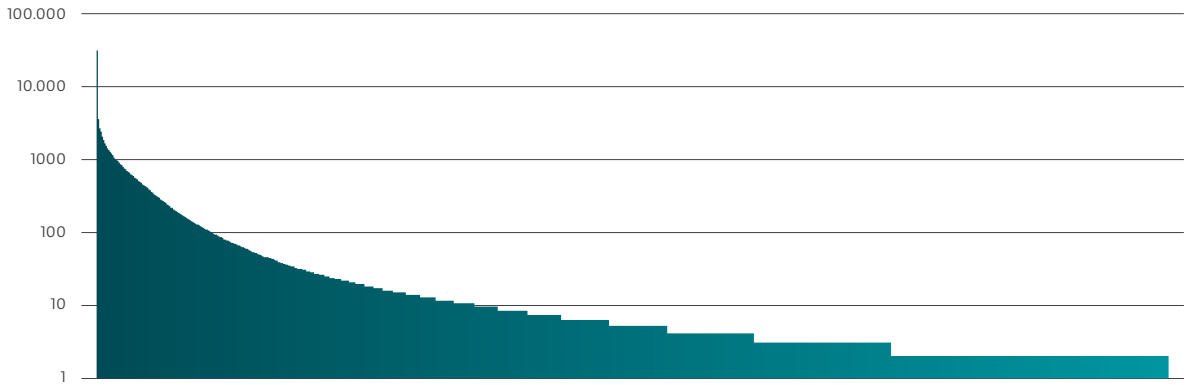


Fig. 4: Number of unique files (y-axis) detected by individual DNA hashes (x-axis).

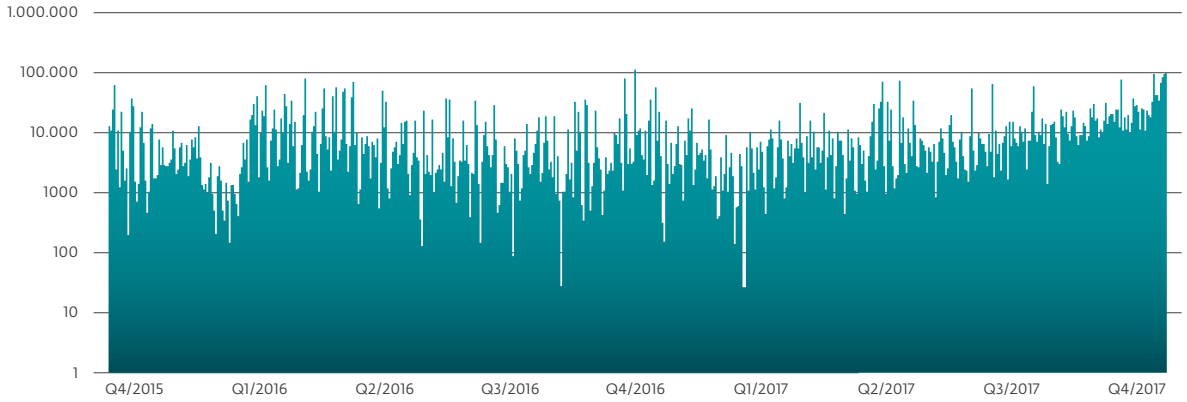


Fig. 5: Number of unique files (y-axis) detected by DNA hashes per day (x-axis)

Cloud Malware Protection System

The ESET Cloud Malware Protection System is one of several technologies based on ESET's cloud-based system, ESET LiveGrid. Unknown, potentially malicious applications and other possible threats are monitored and submitted to the ESET cloud via the ESET LiveGrid Feedback System. The samples collected are subjected to automatic sandboxing and behavioral analysis, which results in the creation of automated detections if malicious characteristics are confirmed. ESET clients learn about these automated detections via the ESET LiveGrid Reputation System without the need to wait for the next detection engine update. The mechanism's turnaround time is **typically under 20 minutes**, which allows for effective detection of emerging threats even before regular detections are delivered to users' computers.

Providing instant blacklisting to users is not the only purpose of the ESET Cloud Malware Protection System. If a user decides to participate in the sample submission process, whenever a new sample with questionable reputation is identified it is sent to ESET for deep analysis. To make use of the full potential of the Cloud Malware Protection System, users should also enable the ESET LiveGrid Feedback System, which allows us to collect any suspicious samples with questionable reputations in order to conduct deep analysis.

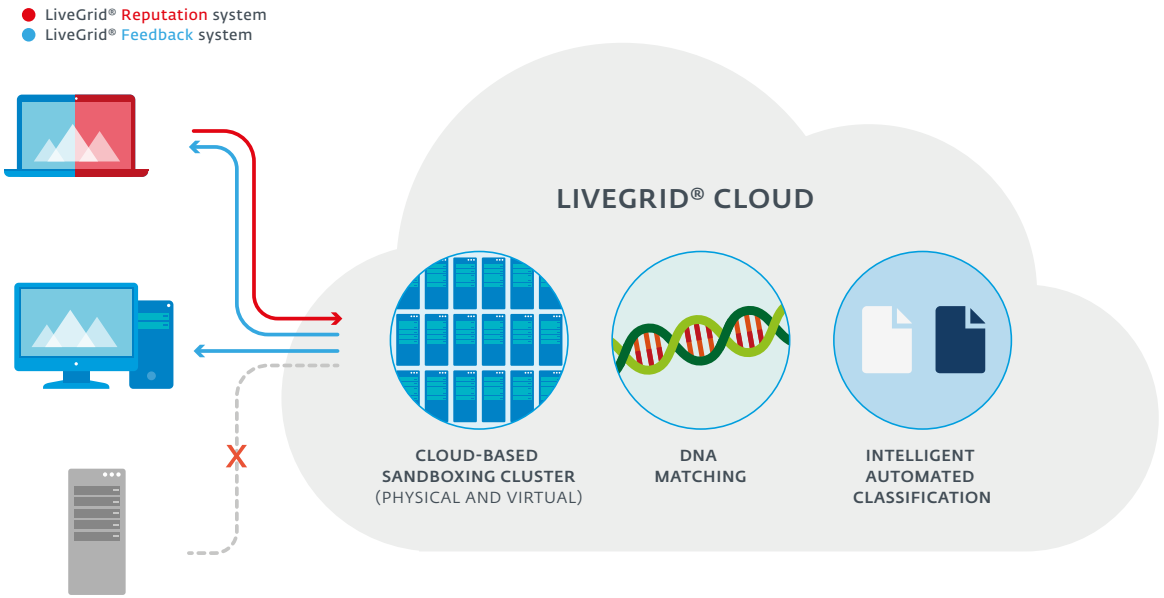


Fig. 6: ESET Cloud Malware Protection System

Reputation & cache

When inspecting an object such as a file or URL, before any scanning takes place our products check the local cache (and ESET Shared Local Cache, in the case of ESET Endpoint Security) for known malicious or whitelisted benign objects. This improves scanning performance.

Afterwards, our ESET LiveGrid® Reputation System is queried for object reputation (i.e. whether the object has already been seen elsewhere and classified as malicious or otherwise). This improves scanning efficiency and enables faster sharing of malware intelligence with our customers.

Applying URL blacklists and checking reputation prevents users from accessing sites with malicious content and/or phishing sites.

Behavioral detection and blocking—HIPS

ESET's Host-based Intrusion Prevention System (HIPS) monitors system activity and uses a pre-defined set of rules to recognize suspicious system behavior. When this type of activity is identified, the HIPS self-defense mechanism stops the offending program or process from carrying out potentially harmful activity. Users can define a custom set of rules to be used instead of the default rule set; however, this requires advanced knowledge of applications and operating systems.

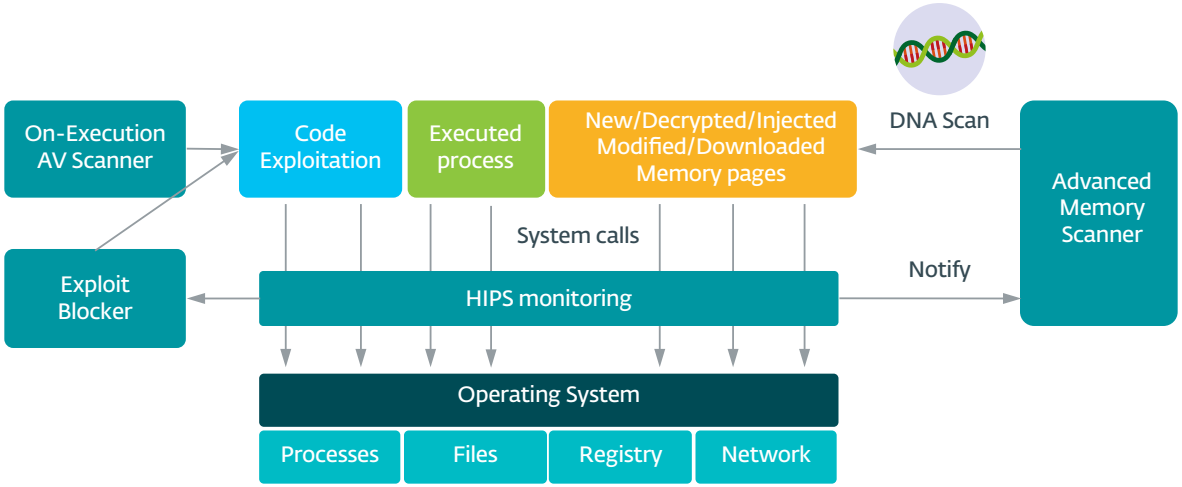
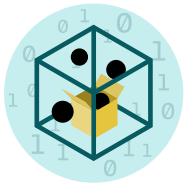


Fig. 7: How ESET's behavioral detection works



In-product Sandbox

Beginning in 1995, ESET split DNA detections into two: Emulation and No Emulation. This helps us to better understand the whole malware process. Our first emulator allowed the famous Doom game to run inside it.

The in-product Sandbox allows us to extract behavioral metadata that we are utilizing in our DNA Detections. Malware can try to evade detection by obfuscating its code base. With a sandbox, we work to see through this obfuscation to target the real behavior of the malware. Throughout this entire process, we use binary translations to ensure we're not slowing down the machine.

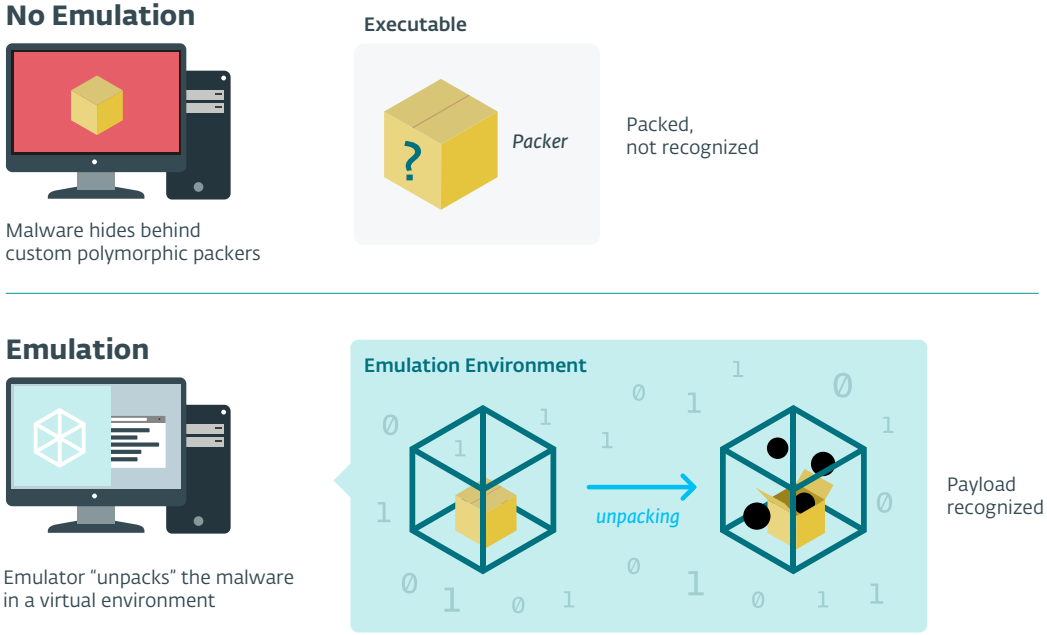
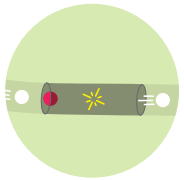
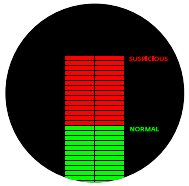


Fig. 8: Why ESET uses In-product Sandbox



Network Attack Protection

Network Attack Protection is an extension of firewall technology and improves detection of known vulnerabilities on the network level. By implementing detection for common vulnerabilities in widely used protocols, such as *SMB*, *RPC* and *RDP*, it constitutes another important layer of protection against spreading malware, network-conducted attacks and exploitation of vulnerabilities for which a patch has not yet been released or deployed.



Advanced Memory Scanner

Advanced Memory Scanner is a unique ESET technology which effectively addresses an important issue of modern malware—heavy use of obfuscation and/or encryption.

These malware protection tactics, often used in run-time packers and code protectors, cause problems for detection approaches which employ unpacking techniques such as emulation or sandboxing. What's more, whether checking is done using an emulator or virtual/physical sandboxing, there is no guarantee that during analysis the malware will display malicious behavior that will allow it to be classified as such.

Malware can be obfuscated in such a way that not all execution paths can be analyzed; it can contain conditional or time triggers for the code; and, very frequently, it can download new components during its lifetime. To tackle these issues, Advanced Memory Scanner monitors the behavior of a malicious process and scans it once it decloaks in memory. This complements the more traditional functionality of pre-execution or on-execution proactive code analysis.

Also, clean processes can suddenly become malicious because of exploitation or code injection. For these reasons, performing analysis just once is not enough. Constant monitoring is needed, and this is the role of Advanced Memory Scanner. Whenever a process makes a system call from a new executable page, Advanced Memory Scanner performs a behavioral code analysis using ESET DNA Detections.

Code analysis is performed not only for standard executable memory but also for .NET MSIL (Microsoft Intermediate Language) code used by malware authors to hamper dynamic analysis. Due to the implementation of smart caching, Advanced Memory Scanner has almost no overhead and doesn't cause any noticeable deterioration in processing speeds.

Advanced Memory Scanner cooperates well with Exploit Blocker. Unlike the latter, it is a post-execution method, which means that there is a risk that some malicious activity could have occurred already. However, it steps into the protection chain as a last resort if an attacker manages to bypass other layers of protection.

Moreover, there is a new trend in advanced malware: some malicious code now operates as "in-memory only," without needing persistent components in the file system that can be detected conventionally.

Initially, such malware appeared only on servers, due to their long uptime—since server systems stay up for months or years at a time, malicious processes could remain in memory indefinitely without needing to survive a reboot—but recent attacks on businesses indicate a change in this trend, and we are seeing endpoints also targeted in this manner. Only memory scanning can successfully discover such malicious attacks and ESET is ready for this new trend with its Advanced Memory Scanner.

Exploit Blocker

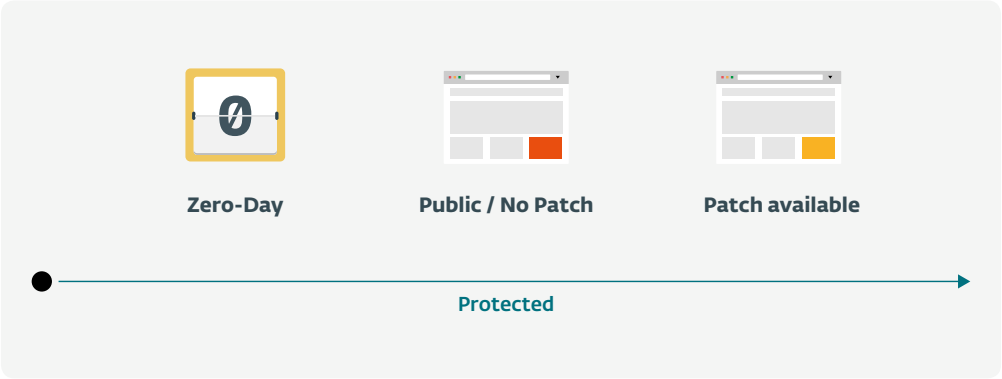
ESET technologies protect against various types of vulnerabilities on different levels: our scanning engine covers exploits that appear in malformed document files; Network Attack Protection targets the communication level; and finally, Exploit Blocker blocks the exploitation process itself.

Exploit Blocker monitors typically exploitable applications (browsers, document readers, email clients, Flash, Java, and more) and instead of just aiming at particular *CVE identifiers* it focuses on exploitation techniques.

Each exploit is an anomaly in the execution of the process and we look for anomalies that suggest the presence of exploitation techniques. As the technology is under constant development, new methods of detection are added regularly to cover new exploitation techniques. When triggered, the behavior of the process is analyzed and, if it is considered suspicious, the threat may be blocked immediately on the machine, with further attack related metadata being sent to our ESET LiveGrid cloud system.

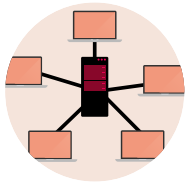
This information is further processed and correlated, which enables us to spot previously unknown threats and so called zero-day attacks, and provides our lab with valuable threat intelligence.

Exploit Blocker adds another layer of protection, one step closer to attackers, by using a technology that is completely different from detection techniques that focus on analyzing malicious code itself.



Ransomware Shield

ESET Ransomware Shield is an additional layer protecting users from the threat also known as extortion malware. This technology monitors and evaluates all executed applications using behavioral and reputation-based heuristics. Whenever a behavior that resembles ransomware is identified or the potential malware tries to make unwanted modifications to existing files (i.e. to encrypt them), this feature notifies the user. Ransomware Shield is fine-tuned to offer the highest possible level of ransomware protection together with other ESET technologies including Cloud Malware Protection System, Network Attack Protection and DNA Detections.



Botnet Protection

One element of malware that is expensive for its authors to change is communication with C&C servers.

ESET's Botnet Protection is proven to successfully detect malicious communication used by botnets, and at the same time identify the offending processes.

ESET's Network Detections extend Botnet Protection technology to address general problems associated with network traffic analysis. They allow for faster and more flexible detection of malicious traffic. Industry standard signatures like Snort or Bro allow detection of many attacks, but ESET Network Detections are specifically designed to target network vulnerabilities, exploit kits, and communication by advanced malware in particular.

The ability to perform network traffic analysis on endpoints has additional advantages. It allows us to identify exactly which process or module is responsible for malicious communication, allows action to be taken against the identified object, and sometimes even allows the communication's encryption to be bypassed.

Botnet Tracker

If a sample or its memory dump is identified by ESET systems as a "botnet" it is sent to ESET Botnet Tracker, which identifies the exact variant of the malware and uses a case specific unpacker/decryptor to extract information about its C&C servers and encryption/communication keys. When these are obtained, it then initiates fake communication from various geo-locations to obtain additional extracted data. This data is then post-processed and utilized to protect ESET customers worldwide. These protections can come in many forms including blocking URLs, creating new detections for the payloads themselves, and informing ESET Threat Intelligence clients about an emerging threat.

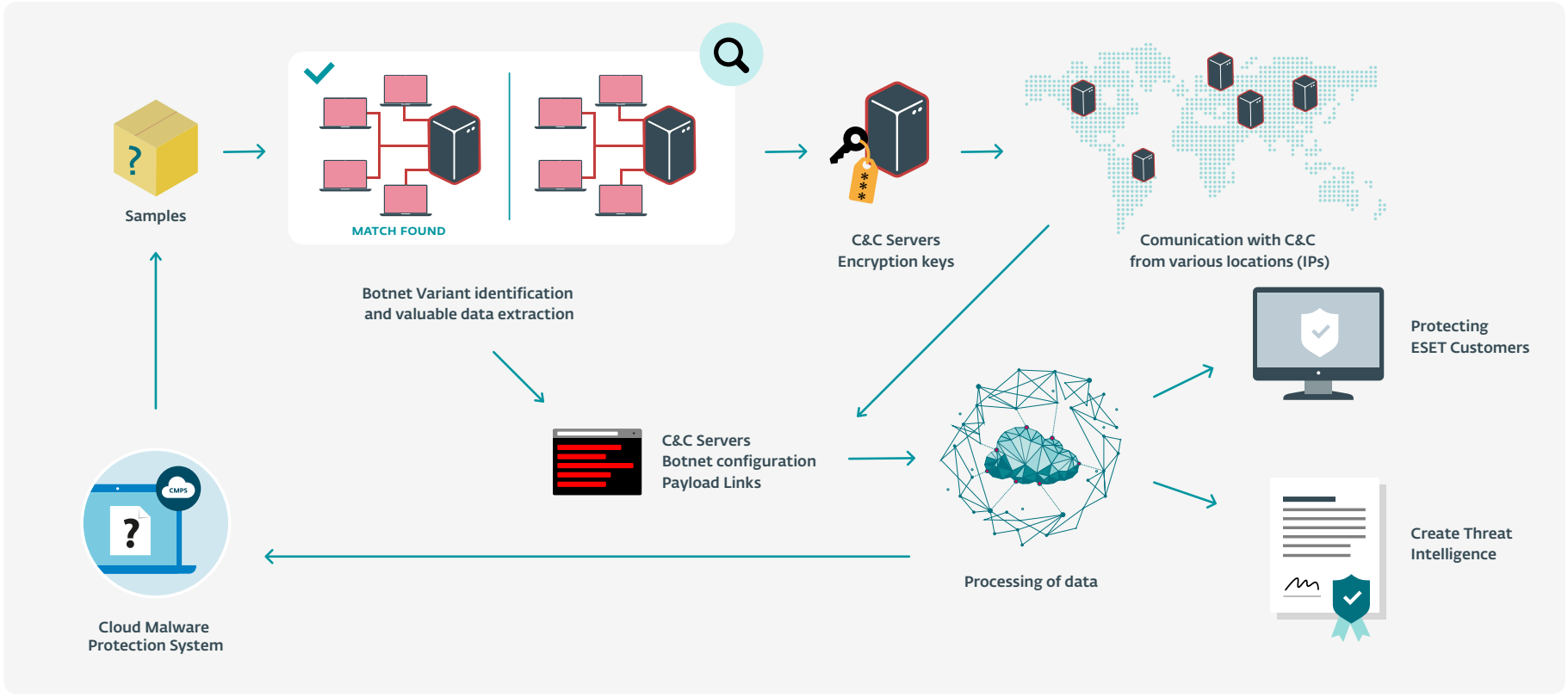


Fig. 9: How ESET Botnet Tracker works

Threat Intelligence

ESET Threat Intelligence (ETI) helps businesses adapt to a world where cybersecurity threats are often targeted and stealthy. By offering infomration gathered from more than 100 million sensors, this service provides organizations with a better overview of the threat landscape, helps them to predict and prevent attacks before they happen and offers data for a more efficient incident diagnosis in the post-attack phase. This unique knowledge strengthens not just the security of the business itself, but can be used to protect the end users as well. Based on the needs of the organization, ESET systems and experts can generate custom botnet reports, targeted malware reports based on YARA rules,or phishing reports. All of these options can be seamlessly integrated into existing SIEM tools via real-time data feeds in STIX/TAXII format.

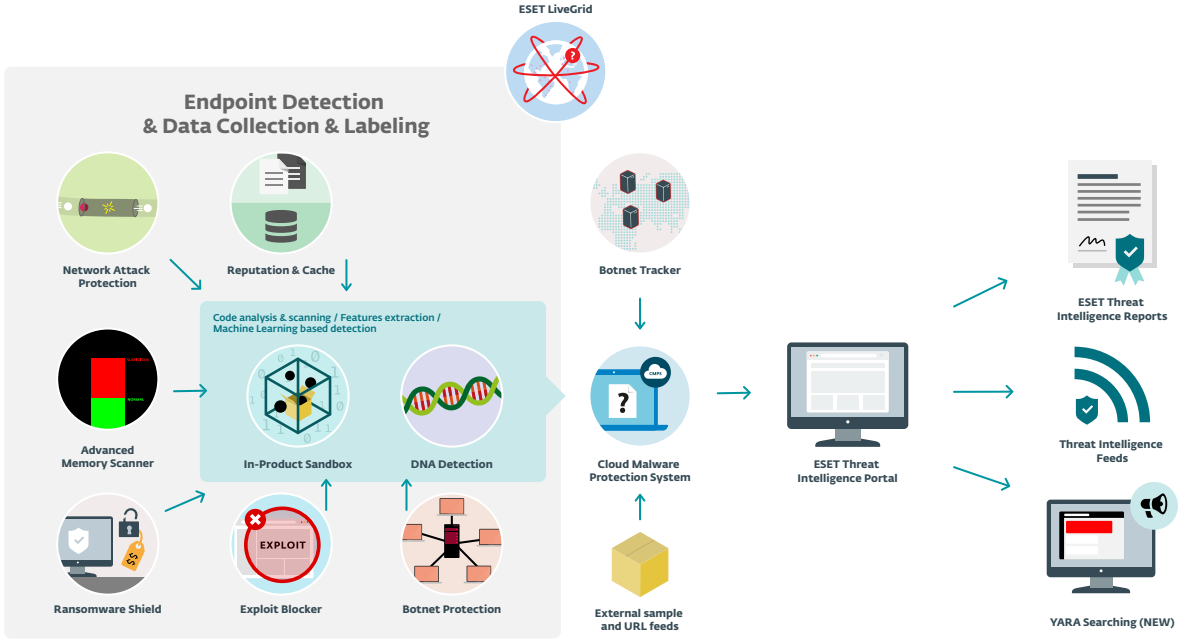


Fig. 10: Threat Intelligence gathering by ESET technologies

REACTIVE VS PROACTIVE PROTECTION TODAY

While DNA Detections are excellent for detecting even whole malware families, they must be distributed to users in order to protect them. The same is the case for the scanning engine, heuristics or any change targeting new threats. Nowadays, communication with ESET's cloud-based LiveGrid system is needed to ensure the highest level of protection for many reasons:

- Offline scanning is mostly reactive. Being proactive nowadays no longer means just having the best heuristics in your product.
  As long as your protection tools are available to an attacker, it does not matter if you are using signatures, heuristics or machine-learning classifiers: a malware author can experiment with your detection technology, modify the malware until it is not detected, and only then release it. ESET LiveGrid counters this malware strategy.
- Updates are not real-time. Updates can be released more often, and can even be pushed to users every few minutes. But can this be done better? Yes: ESET LiveGrid enables instant protection, by providing information whenever it is needed.
- Malware tries to fly under the radar. Malware authors, especially in the case of cyber espionage, try to avoid detection for as long as possible. Targeted attacks—as opposed to mass distributions such as email worms—deploy single pieces of malware to a small number of targets, sometimes to just one. We use this fact against the malware authors: objects that are not popular and do not have a good reputation are assumed to be potentially malicious and analyzed in detail either on the endpoint or using detailed automated analysis via our LiveGrid Feedback system. The ESET LiveGrid Reputation System contains information about files, their origins, similarities, certificates, URLs and IPs.

Automated and manual processing of samples

Every day, ESET receives hundreds of thousands of samples, which are processed automatically, semi-automatically and manually after preprocessing and clustering. Automated analysis is performed by internally developed tools on an array of virtual and real machines.

Classification is performed using different attributes extracted during execution, according to static and dynamic code analysis, changes introduced to the operating system, network communication patterns, similarity to other malware samples, DNA features, structural information and anomaly detection.

All automated classifiers have drawbacks:

- Choosing discriminator features for classification is not trivial and must be performed using the knowledge of humans who are experts in the field of malware.
- Machine-learning classifiers require the participation of human experts to verify the inputs used for learning. With fully automated processing, where samples classified by the system would be used as inputs to the system, a snowball effect from the positive feedback loop would quickly make it unstable. "Garbage in—garbage out."
- Machine-learning algorithms do not understand data and even if information is statistically correct that does not mean it is valid.
- For example, machine learning cannot distinguish new versions of clean software from malformed versions, cannot distinguish an updater linked to a clean application from a downloader used by malware, and cannot recognize when clean software components are used for malicious purposes.

- With machine learning, adding new samples to a learning process may cause false positives, and removing false positives may reduce the effectiveness of true positive detection.
- While automated processing allows instant responses to new threats by detection through ESET LiveGrid, additional processing of samples by detection engineers is crucial for assuring the highest quality and detection rate, and the lowest number of false positives.

Reputation services

ESET LiveGrid also provides reputation for objects. We judge the reputation of various entities including files, certificates, URLs and IPs. As described above, reputation can be used to identify new malicious objects or sources of infection. There are, however, other uses.

Scanning whitelisting

Scanning whitelisting is a feature that reduces the number of times the scanning engine needs to inspect an object. If we are sure that an object has not been modified and is clean, there is no need to perform a scan at all. This has a very positive impact on performance, and helps make ESET products so unobtrusive. As we say, "the fastest code is the code that does not execute at all." Our whitelists are constantly adapted to the ever changing reality of the software world.

Intelligence gathering

If a user decides to participate in sending statistics to ESET LiveGrid, we use this information for global tracking and monitoring of threats. This information gives us copious research data to work on and allows us to focus on the most urgent and problematic cases, observe trends in malware, and plan and prioritize development of protection technologies.

ABOUT FPS AND IOCS

Indicators of compromise (IOCs) are perceived as very important in contemporary corporate security, but they are far from special or advanced, even though they are sometimes stressed by "next-gen" security providers. Pictured here is a breakdown of the most prevalent IOCs and what they are based on.* As we can see, the features they address are extremely basic: in one quarter of cases it's about known MD5s, then filenames, etc. These results make it clear that this is not a method suitable for prevention and blocking, although it can be useful for forensics. It is ironic that some of the "next-gen" vendors who dismiss "obsolete" signature-based detections used in "old AV" praise IOCs so highly even though these are actually the weakest signature-based way to detect malicious files or events.

**Data source: IOC Bucket, April 2015. IOC Bucket is a free community driven platform dedicated to providing the security community with a way to share threat intelligence.*

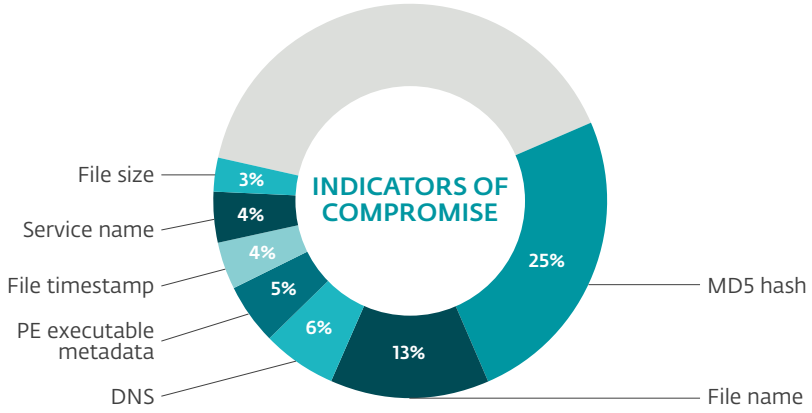


Fig. 11: Analysis of indicators of compromise from IOC Bucket (April 2015 sample).

CONCLUSION

There is no silver bullet in security. Today's malware, being dynamic and often targeted, requires a multilayered approach based on proactive and smart technologies that take into account petabytes of intelligence gathered over many years by experienced researchers. As far back as 20 years ago, ESET recognized that AV—the traditional approach—was an incomplete solution, at which point we started to incorporate proactive technologies into our scanning engine and gradually implemented different layers of protection to strike at different stages of the cyber kill chain.

ESET is one of the few security vendors able to provide a high level of protection based on more than 25 years of research. This allows us to stay ahead of malware, constantly evolving our technologies to go beyond the use of standard, static signatures. Our unique combination of endpoint based and cloud-augmented technologies provides the most advanced security against malware on the market.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