Ebook

Attacks on Multi-factor Authentication

Cybercrimes evolve in their tactics and launch new mechanisms that circumvent protection systems. Learn how these attacks work and how to protect yourself from them.

AXUR

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MFA definition

MFA	It is the multi-factor authentication. It is an authentication process whereby access to the system is granted only if the user presents more than one factor or proof of identity. In an attempt to preserve the initials of the term in English, some Spanish definitions translate it as “multifactor de autenticación.”
2FA	When only two factors are required, using the acronym 2FA (two-factor authentication) is expected.

Executive Summary

Identity management is one of the significant challenges of information security. Many companies have migrated their services to more robust, multi-factor authentication due to the weakness of the traditional username and password authorization process.

The first results of multi-factor authentication have been surprising after blocking numerous invasion techniques. Even today, the mere existence of a second authentication factor continues to hamper less sophisticated attacks.

On the other hand, we must prevent this probable success from becoming a trap that prevents us from seeing that attacks are defeating multi-factor authentication.

Some authentication mechanisms that were once considered robust (such as sending SMS) are now insufficient and, according to the United States Cybersecurity and Infrastructure Security Agency (CISA), are no longer part of the "gold standard" of multi-factor authentication. To rely exclusively on weaker mechanisms is to be exposed to a greater risk than anyone can imagine.

Phishing was reinvented to work against MFA, and criminals developed new categories of malware committed to stealing authorized sessions and taking advantage of the gaps that appear when implementing authentication. In 2022, two MFA solution providers suffered invasions regarding account security transgressions and breaches in telecommunications networks that deliver single-use codes.

Digital service providers, which offer multi-factor authentication to their users, face even more significant obstacles. There is no visibility into the user's security practices, and it could be more effective to bet on their awareness. Moving away from convenient authentication mechanisms, such as SMS, can result in the user abandoning MFA entirely, and this could weaken the account security even more.

This document shows how attacks work, cites examples of uses, and suggests the use of compromised credential monitoring as a simple way to improve the reliability of the authentication process, whose integration into the ecosystem is facilitated by not depending on any changes in the existing authentication process.

Monitoring is independent of visibility into user practices, which avoids setbacks. In addition, access to leaked information provides the means for the organization to detect breaches and be able to block improper access and even protect email accounts used to retrieve information in MFA systems.

After describing this scenario, it becomes clear that monitoring can help mitigate MFA vulnerabilities and disrupt attacks that result in ransomware, data breaches, and financial losses to the company.

The importance of credentials and MFA

Before we address the usage and limitations of multi-factor authentication, we will mention why it is necessary to pay attention to the authentication process. We know that malicious actors can use credentials to gain access to corporate systems. Still, there are two issues that make this threat more alarming: the weakness of the credential itself and the indirect and broad relationship it can have with the entire ecosystem of the company.

In the case of the traditional username and password system, without additional factors, the protection depends entirely on the password.

This scenario presents several risks:

The choice of password is up to the user: The chosen credential is only sometimes strong enough, and even if the system imposes specific rules regarding the length of the password and the types of characters required, the controls still need to be improved. The user can also choose passwords of a unique nature (containing dates, names of relatives, pets, among others) or repeat passwords used in other systems (including personal service accounts) that the malicious actor has previously attacked.

The password may have been stored in an insecure place: Whether it is a note on a piece of paper, an e-mail left in a personal account, or a photo saved on the cell phone, it can not be guaranteed that there has not been any violation of the security policy that weakens the user's password.

Passwords can be stolen from malware, phishing, and other attacks: Even if the password is strong and not stored in an insecure place, the user can be attacked directly.

Universal access: Adopting software-as-a-service platforms and migrating to cloud computing allow the company's staff to work from anywhere. In this way, the invaders can use the leaked passwords anywhere in the world. Beyond making it difficult for police authorities to act, universal access increases the importance of the credential as an access mechanism, as it makes the defense traditionally offered by the company's physical perimeter dispensable. Thus, there are various attacks, threats and damages to the company that can materialize from the leak of a password, regardless of the weakness it has.

Here are some examples:

Ransomware: Many attacks that lead to a hijack of information and the paralysis of companies' activities start with a corporate credential: access to e-mail, virtual private network (VPN), and cloud systems. Whenever they are needed, attackers use lateral movement techniques to deepen the initial access gained, increasing the range of the attack with this method.

Data breach: All the information accessible to the company staff whose passwords have been compromised will also be at risk.

Financial damages: Access to financial, purchasing, and contract management systems can result in direct economic losses for the company nagement systems can result in direct economic losses for the company.

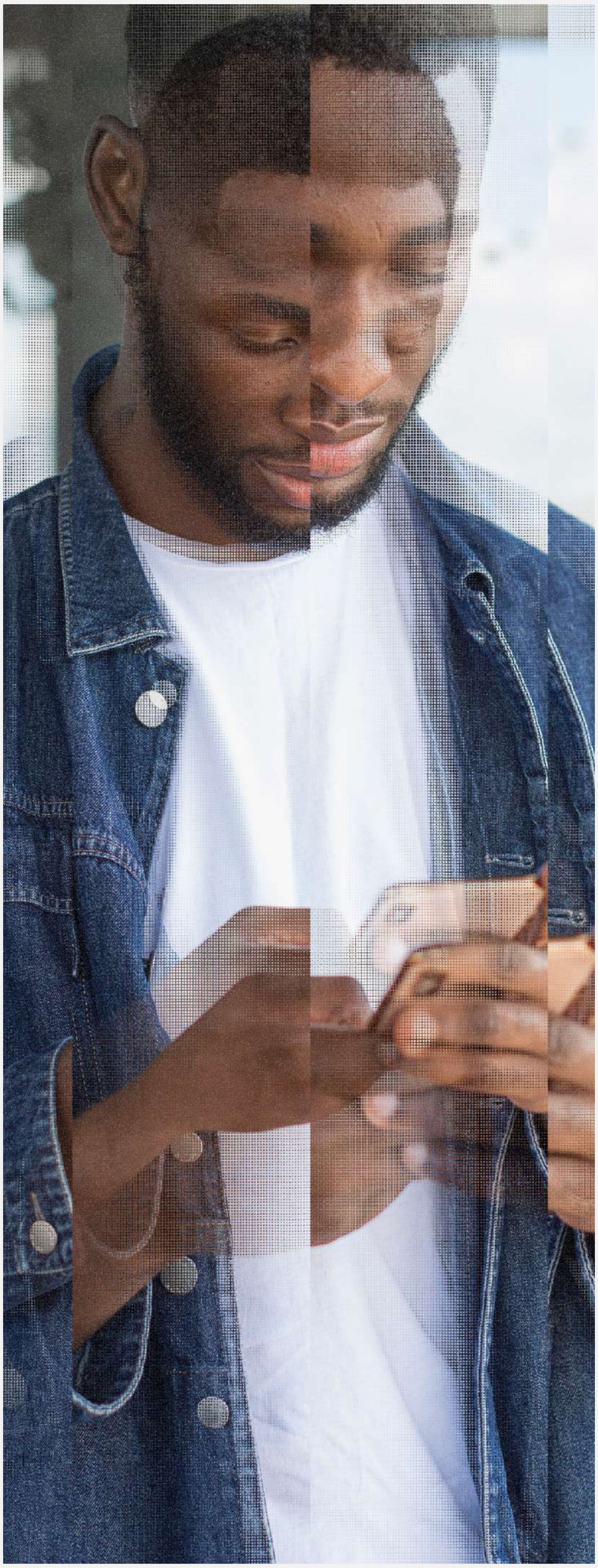
Business Email Compromise (BEC): Criminals can issue fake payment orders and data requests by pretending to be company executives and directors using a leaked password.

Other damages and costs: Data breaches, ransomware, and other actions perpetrated by invaders can cause damage to the brand and trust of business partners and customers beyond justifying the imposition of fines and other actions by privacy and consumer protection regulatory entities.

The need to strengthen the authentication process becomes apparent as systems become interlinked to the organization's IT ecosystem (including software-as-a-service platforms and other third-party systems, such as recruitment, marketing, social media, etc.).

Based on this scenario, concepts such as multi-factor authentication, step-up authentication (also called authentication context or step-by-step authentication), and just-in-time access, among others, and the evolution of the idea of least privilege (such as Zero Trust), emerge.

In this way, the issue of credential protection is evolving, updating, and improving constantly. AFM is one of these developments, but the subject matter risks and complexity show that there is not a definitive solution for all contexts. In the following chapters, we'll address the limitations mainly related to traditional MFA, where login requires at least two authentication factors.



Limitations of MFA

Since confidentiality is one of the pillars of information security, mechanisms that recognize those authorized to access specific resources are needed. Password authentication, even though it is a traditional means, is vulnerable to several attacks: the password can be stolen, cracked, or repeated by the user, for example.

In this context, one of the simplest attacks is phishing. In any case, where it is possible to send a communication to the user (usually an e-mail), the invader may try to persuade the victim to reveal their password on a fake screen and thus trap their login credential.

The most obvious goal of multi-factor authentication is to make unsophisticated attacks, such as traditional phishing, unfeasible by reinforcing simple authentication through additional steps.

However, the incorporation of additional steps only results with increasing complexity. In this way, MFA is often implemented without a proper picture of the attack surface and the role it should play.

As a result, some difficulties and setbacks arise:

The malware threat is beyond the scope of MFA:
Although many malicious codes are created to steal credentials, MFA does not provide adequate protection against the action of these malwares. When malware acts directly from the user's endpoint (it means that attackers control the device during the access of the users), attackers take advantage of the authenticated session that is underway. And unless MFA is intended for specific actions, it won't act in these cases.

The authorization itself can be attacked:
The MFA improves the process of obtaining authorization, but it does not strengthen the authorization mechanism itself. In basic MFA implementations, this aspect is not considered, and authentication is identical to that of a single-factor account.

The MFA may require a new account recovery process:
If the recovery of an MFA-protected account happens in the same way as the recovery of a non-MFA account, the weakest link in the chain is moved from the credential to the recovery process. However, even if account recovery is properly implemented, attacks against this process are not eliminated.

Additional MFA factors can also be attacked:
In isolation, each factor is vulnerable to specific attacks. Because the password is an ancient and common target, attacks against the other factors often go unnoticed.

Below, we'll see how these limitations and difficultie manifest themselves in practical, real-world MFA implementations.

MFA or 2FA?

The concept of MFA encompasses any situation in which users of an application need to combine more than one type of verification or authorization to gain access to the environment. The correct implementation of this method requires that the "factors" used be of a different nature: something you "know" (a password), something you "are" (biometrics), or something you have (password, card, cell phone, among others).

Recently, users' location has also emerged as a reasonable factor. In Brazil, this factor already appears as a complement in systems that control work shifts, and it determines the authorization to start working at a predetermined location.

Some complexities are involved in using MFA, even though, in theory, it is not limited to specific implementations. In fact, it's quite unusual that more than two factors are required in the authentication process, which is why MFA is better known by the name of 2FA, or "two-step verification."

Although occasionally, there are inconsistencies when translating from terminology that originates in the English language into Latin languages, this term is a variation of "2FA" that appears in applications security options. On WhatsApp, for example, it's called "two-step verification."

It can be more difficult to add more than one factor in the corporate field, either because of the need to support more than one product or platform or due to the costs that arise from the acquisition of specialized hardware or support services.

In a few words, even if MFA provides for more than two authentication factors, using three or more factors is not common practice.

A third-factor authentication generally does not provide security progress consistent with the increased complexity and inconvenience for users. For this reason, additional factors are usually restricted to high-risk applications and systems.

While it's important to note that the attacker will need to circumvent two authentication factors (and not three or four), it's safe to say that some MFA attacks would continue to get good results even if more authentication factors were added. This is because, as we have already observed, security is not always proportional to the number of factors.

Since the term "MFA" includes 2FA and many attacks have enough potential to work on both, there is usually no separation or dissociation between them. In other words, an attack against 2FA is an attack against MFA and vice versa.

Authentication factors

Authentication mechanisms are divided into three factors: something you know, something you own, and something you are (users' inherent characteristics). Each factor is a category. A system requiring two passwords does not use two factors because the two requests fall under the same factor

When an authentication process requires a password generated in real-time in a mobile application, the purpose of the one-time code is to verify that the user is in possession of the device (cell phone or key capable of generating the password), considering the factor"something you own."

Even if the one-time password, generated by an app or received via SMS, is a "password," it should not be confused with a password itself since the last mentioned verifies something the user knows and is included in another factor.

There is no single mechanism for each factor, leading to a great deal of variation in the forms and types of MFA on the market. As it is frequent that the same user employs multiple forms of MFA, authentication factor overload makes things easier for invaders, as users can easily confuse one method with another.

Mechanisms used as authentication factors

Knowledge users "know"	· Password · PIN · Pattern Drawing
Possession users "own"	**Smartphone** · Temporary Password Generator Key (OTP) · Telephone line (SMS) · Pre-access (PUSH notification, authenticated app) **Devices in general** · Private key saved on the device **Other** · Email · USB cryptographic key (U2F/FIDO) · Smartcard (PKI) · Token Password Generator
Natural/Own users “are"	· Voice · Iris · Face · Fingerprints

The use of multiple authentication factors causes inconvenience to users and, for this reason, it is not surprising that the mechanism became more flexible. In this context, users choose whether to use a code generated by an application, an authorization on the cell phone, or a USB cryptographic key. Although they all work, only one is necessary to meet the factor's requirement. Redundancy can be useful for users in the event that an issue arises in the configured mechanisms (cell phone failure, absence of signal to receive SMS, among others).

Unfortunately, this practice leads to reduced user security, as the attacker needs to compromise only one mechanism to access the account. For example, if a user uses codes received via SMS or an app, the attacker can access the account through the mobile network, chip, mobile device, or password. If we remove the SMS option, the invader is forced to resort to the last two options, since the telecommunication service is no longer included.

This is why it is necessary to be aware that the use of more than one authentication mechanism within the same factor contributes to the usefulness and availability of the account but not to confidentiality.

The attacks on MFA

This chapter will address specific attacks that can evade multi-factor authentication. Attacks are divided into two large categories: those that work independently of the mechanism adopted and those that are directed to specific mechanisms.

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Malware:

The use of additional factors in authentication has no effect on the performance of malware. Malicious code installed on the victim's device can allow remote control of the system, giving the invader the same level of access as the user after login.

The malware can also serve as an accessory to other MFA attack modalities, such as session cookies theft, spear phishing, and MFA fatigue.

One of the main advantages that malware uses is the ability to spread using traps without a direct connection to the authentication system. The victim may install malware while trying to download a common program and without suspecting it, their information will be stolen after granting improper permissions to the malware that was supposed to be a trustworthy program.

This scenario is quite usual, even for those who do not show unsafe behaviors when browsing. Scammers use social media profiles, online advertisements, and other mechanisms to spread links that lead to downloads of adulterated software. The prevalence of malware in ads led the FBI to recommend the use of a web ad blocker as a preventive measure. Malware can also target companies' employee's personal devices, stealing credentials along a reduced visibility path for the security and technology sectors.

In 2022, **Axur extracted 435.98 million stolen credentials** from the analysis of 7.4 TB of files generated by credential stealers and shared in the criminal underworld.

While the traditional solution to malware activity is to use an antivirus, this measure alone has not proven to be more effective. Credential stealer malware can be constantly reconfigured, adapted, and recycled, and it is possible that the antivirus update arrives after the credentials have been stolen.

Phishing, spear phishing and vishing:

While multi-factor authentication is often cited as a preventive measure against phishing consequences, this attack can be adapted to work in an MFA context. Spear phishing (a message written for a specific recipient) has the potential to be particularly effective in cases where the invader already has information about the victim.

Possibilities include:

Theft of recovery codes:

Most MFA systems allow the use of pre-generated recovery codes. The goal is to ensure that users retain access to the account in unforeseen situations, such as the loss of a cell phone, USB key, or phone line. Instead of stealing the password, phishing will be used to steal the recovery code, which is fixed so it will be available for later use.

The initial stage of other attacks:

The phishing message may contain links used to spread malware, steal cookies, or perform interception attacks.

At the beginning of 2023, Reddit, a social network, announced that an employee was the victim of spear-phishing that cloned the view inside the company t o deceive the user. In the case of vishing (voice phishing or phishing by phone call), the scammer tries to call the victim and confuse them by requesting the code received by SMS or confirmation from another mechanism for a different purpose (a promotion or security check, for example). After the victim performs the requested action or reports the code, the attacker has all the necessary information to carry out the access at that moment.

In 2022, **Axur detected 34 thousand phishing pages**

In 2022, network equipment provider Cisco was targeted for vishing. According to the company's report, the attacker defeated the MFA of an employee's Google account who had stored and synced the corporate network password in his Chrome browser, and thus, the attacker obtained the synchronized passwords after accessing the victim's Google account.

These attacks are usually more effective after the basic credentials (username and password) are obtained by another means (malware, for example). Repeated passwords are also risky, as many login systems validate the password (which may have been leaked from another service) before requesting the second factor.

After validating the password, attackers can initiate second-factor phishing attempts, confident that they have the correct password to defeat the first-factor.

Session theft and cookies (pass-the-cookie):
MFA requires several tests to grant login authorization. However, the authorization is usually stored in a web browser or app cookie. Every visit, the users make a check of the cookie parameters and if a valid authorization is verified, users continue browsing or using the application.

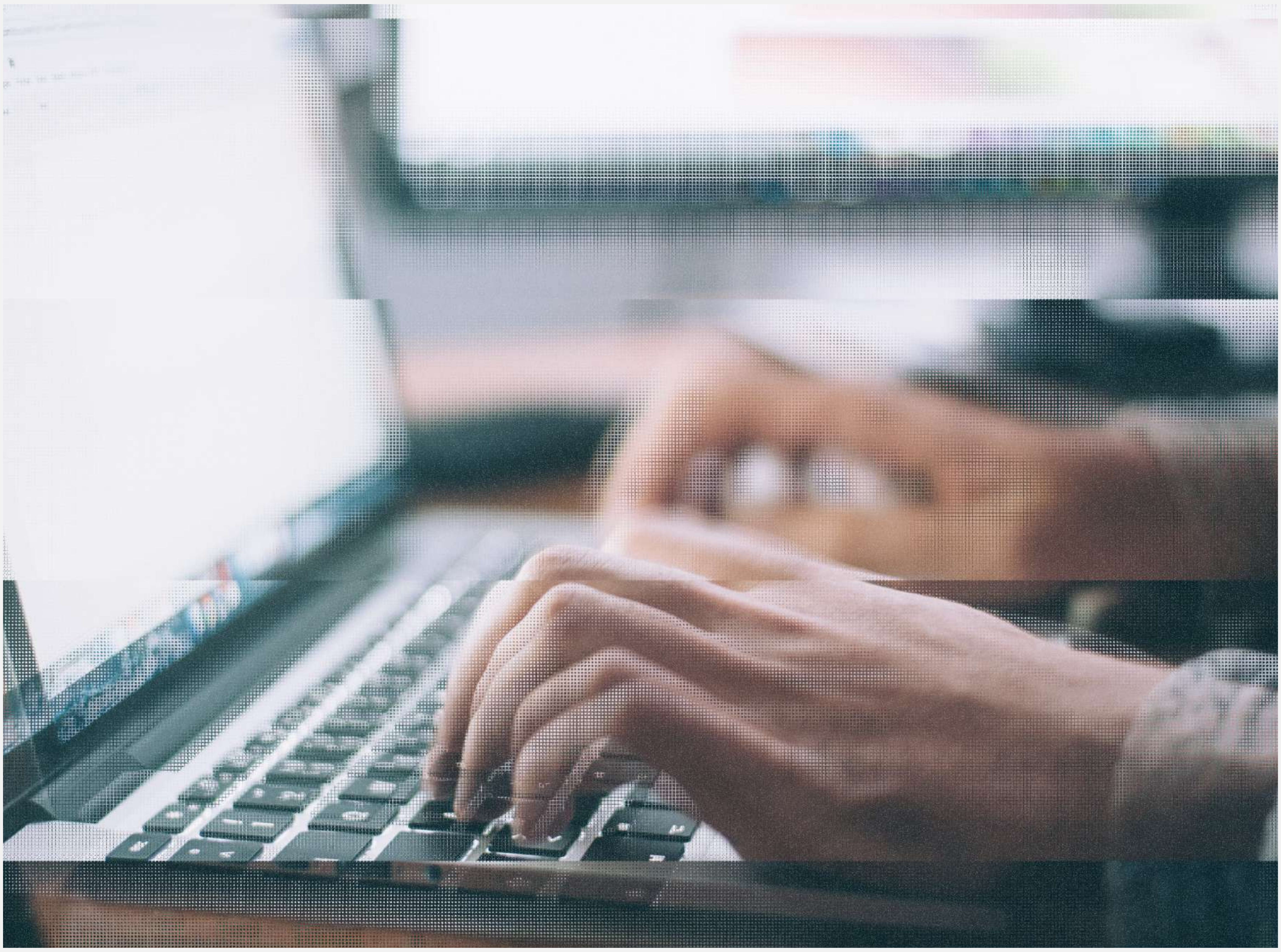
If this authorization code is obtained, it can be used to log directly into the account without going through the login process. Some services and platforms incorporate checks to prevent the cookie sent to one browser from working in another, but the effectiveness of this protection may vary from case to case. This type of attack is called pass-the-cookie.

Credential stealers' malware usually includes authorized session cookies in the stolen information package of infected computers. The dataset is sold to others interested in the criminal underworld, and they evaluate how best to use the captured session.

Social engineering allied to phishing can also be used to steal the session. In this case, the user is persuaded to paste a code into their web browser in order to steal the cookies that interest the attacker.

The risk is even higher in crypto services. In this case, any malicious actor on the same network can perform session stealing. In 2010, an app called Firesheep carried out how this attack could easily be performed on public Wi-Fi networks, for example.

Today, most large platforms and applications use c ryptography, such as TLS (Transport Layer Security). However, corporate applications that use MFA must use proper cryptography to prevent their sessions from being stolen on shared networks.



Interception & intermediation (aitm):
The "man-in-the-middle" attack, today called "adversary in the middle", is characterized by a scenario in which the malicious agent manages to position itself "between" the user and the service being accessed.

This scenario is easily constructed through a link sent in a phishing scam. In some more specific situations, redirecting the user's access to a fake page is possible. This redirect may go unnoticed if the victim ignores the address bar and other browser prompts.

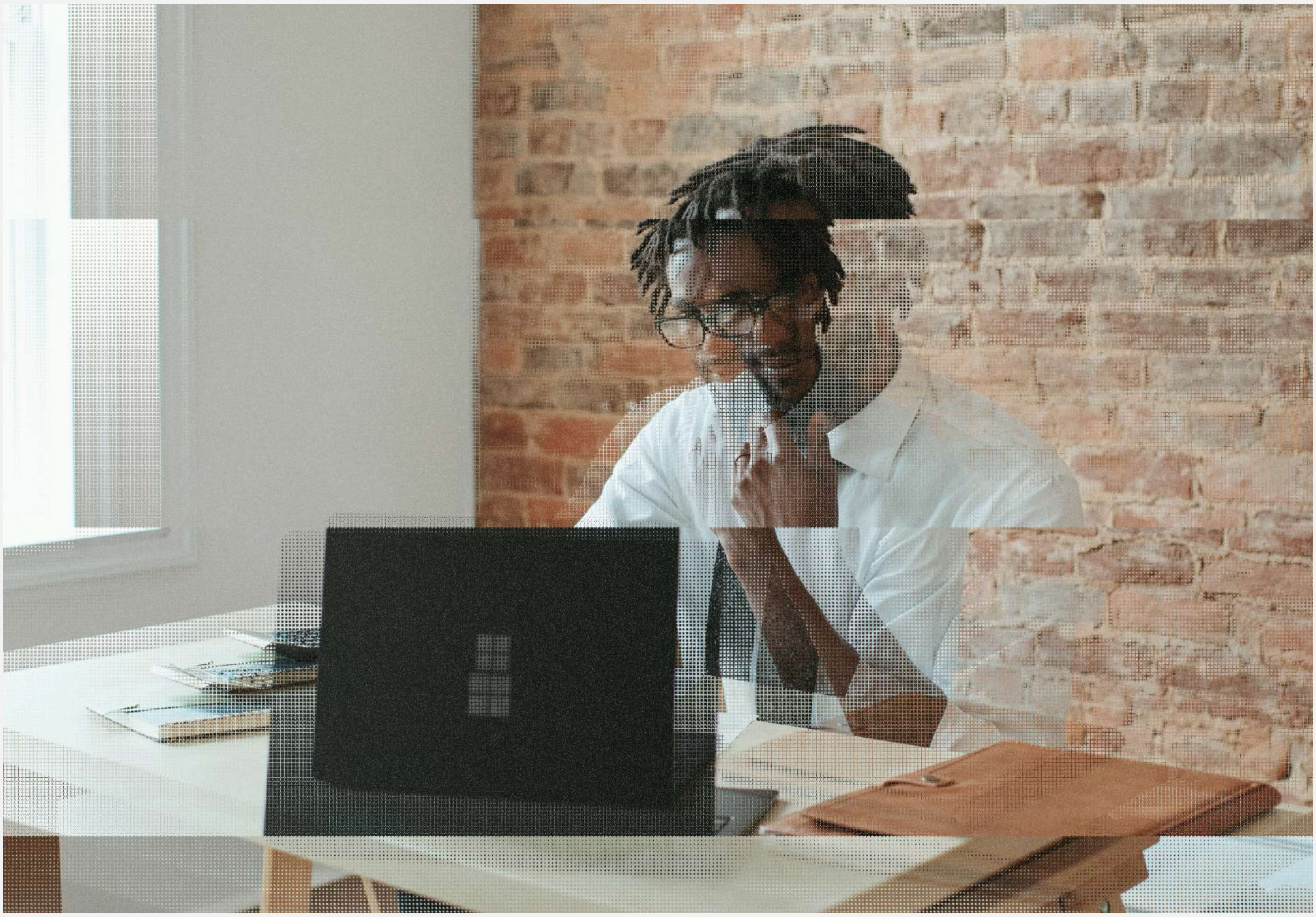
Unlike traditional phishing, in which the fake page only captures the credential that was entered, this attack makes use of an access intermediary (or "proxy"): all the information and interactions made by the user are sent to the real page. If a wrong password is entered, the user will see an error. If there is more than one authentication factor, it will be perfectly repeated.

Differences begin when users finish the login process. At this point, instead of the session cookie and other authorization information being sent to the user's browser, the data is forwarded to the attackers so that they can access the account.

The attack is carried out through the use of a pass-the-cookie tactic or by automating the malicious actions that the attacker intends to perform.

Although it may seem sophisticated, this attack can be easily orchestrated with out-of-the-box and free tools such as Evilginx2, Modlishka, and Muraena. With one of these solutions, the attacker only needs to set up a domain and a web server to create the fake site.

Microsoft has filed such attacks against several of its customers. In July 2022, the company revealed that more than 10,000 organizations using the Azure cloud or Microsoft 365 were targeted by attackers.



Application authorization (OAUTH):

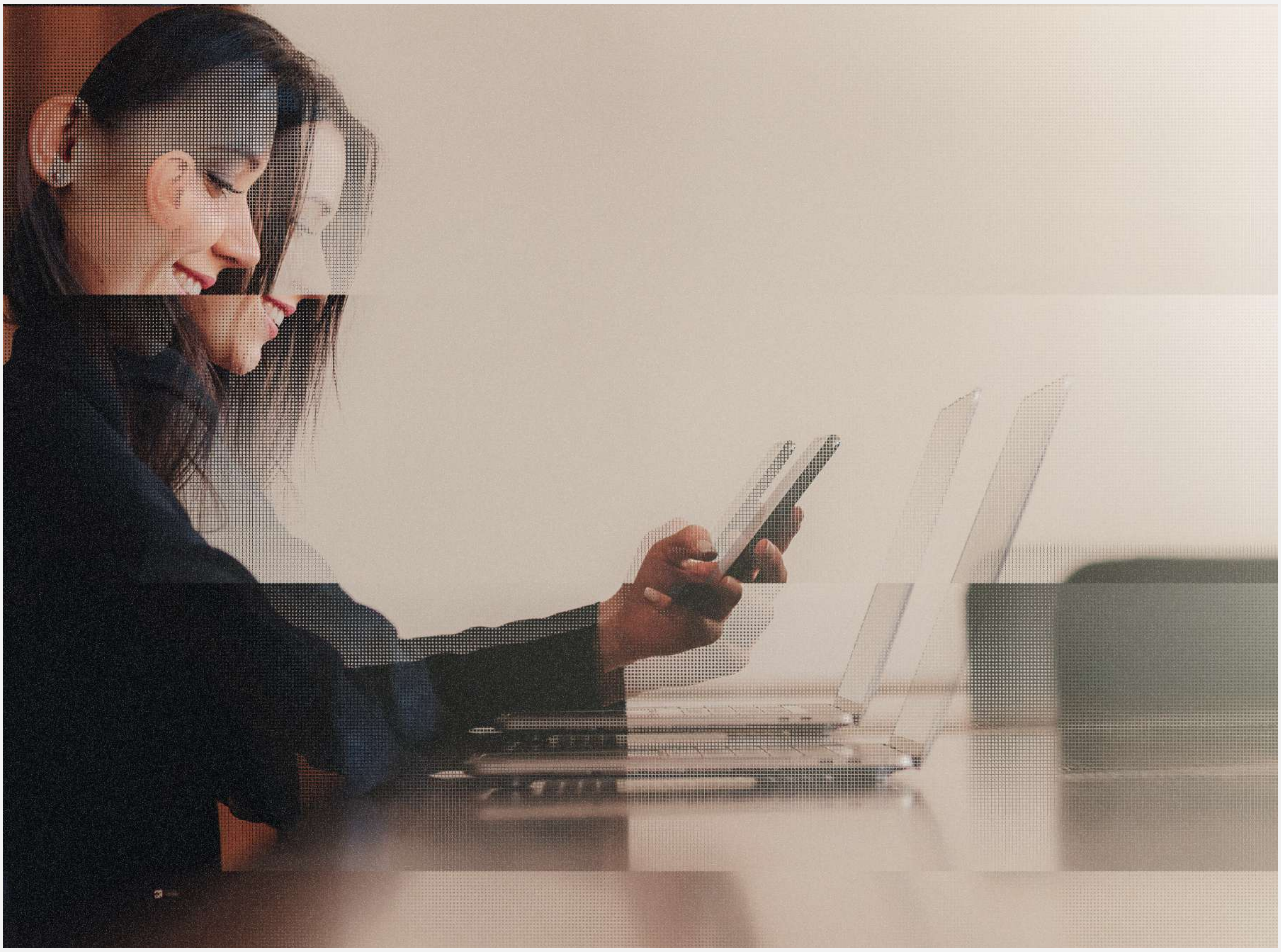
An advantage of many software-as-a-service (SaaS) platforms is the ability to integrate external applications. For applications to be compatible with MFA, they need to be linked to users' access using an authentication key (OAuth) with an application programming interface (API) channel.

In short, it is an access channel dedicated to connected applications, which generates advantages and disadvantages for the invader. Access may be more limited than the actual login, but it will be easier for the invader to automate data collection using the API. However, access will not go through MFA after being granted by the account owner.

As the possibilities of this access channel and how it works are not always clear to all users, attackers take advantage of this to try to convince victims to authorize the applications on their accounts. Another possibility is to use OAuth-authorized applications in order to build continuous access after a successful login. Another variation of this concept may include single sign-on (SSO) tokens, although this usually depends on the implementation or technical vulnerabilities in the login service. Either way, obtaining an authorized OAuth token allows you to evade the authentication process.

Once the permission is granted, it is usually separated from user sessions. That is, access is not removed when the user logs out of all open sessions. If the API or OAuth token cannot be easily canceled, it may remain valid even after changing the account password.

The risk posed by these improper authorizations has caused many services to restrict the use of their APIs. For corporate and OAuth systems, it may be necessary to check environment permissions and configurations to verify whether or not users can delegate this access to third parties.



Attacks on specific mechanisms

MFA Fatigue:

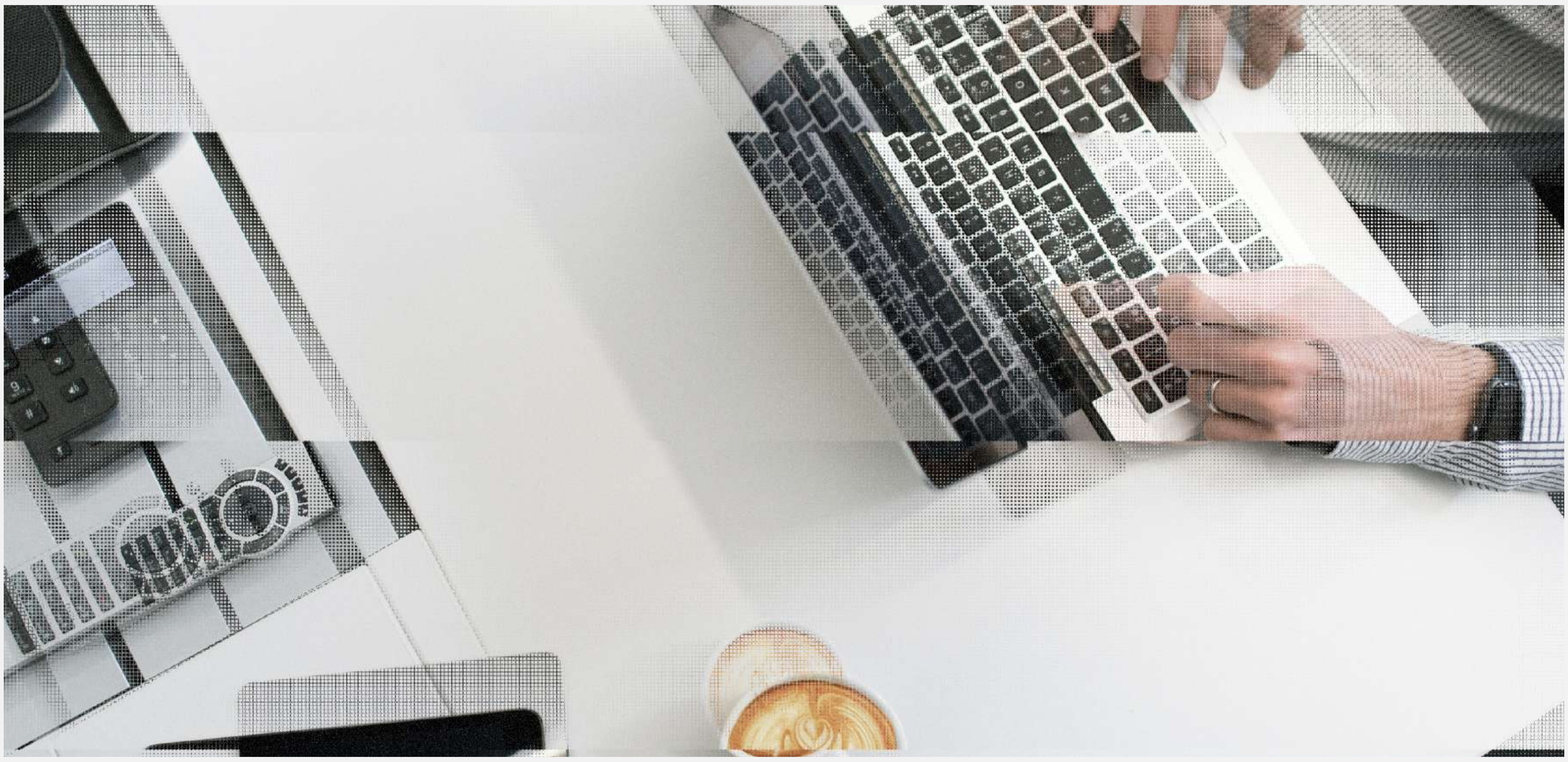
Also called push bombing, MFA fatigue is used to evade MFA systems by push notification. This is the MFA mechanism in which users receive a prompt on the smartphone requesting confirmation of access initiated on another device.

In addition to apps that are prepared to receive push notifications to obtain this confirmation, a similar approach involves the use of a previously authorized device to confirm access to a new session. The Two Mechanisms.

To carry out this attack, the invader makes several login attempts using the victim's credentials. This generates different access confirmation requests, one for each attempt. From this situation, the victim may end up confirming the invader's access either due to fatigue in the face of repeated warning messages, due to an accidental click on the screen, or because they have confused their own access attempt with one from the attacker's attempt.

Attacked Mechanism:
Push Notification / Prior Access

In September 2022, Uber revealed that the cybercriminal group Lapsus$ managed to circumvent its multi-factor authentication using MFA Fatigue.



Sim swap, spoofing, and ss7:

An attacker can interfere with the sending of codes via SMS in two ways: by altering the chip that will receive the code ("SIM swap") or by interfering with the communication protocol between telephone operators, the Signalling System 7 (SS7).

SS7 attacks are rarer and more effective when there are vulnerabilities or errors in the implementation. Even so, the German telephone operator O2 confirmed in 2017 the theft of bank customers' accounts because the criminals managed to redirect SMS confirming transfers to phone numbers controlled by them.

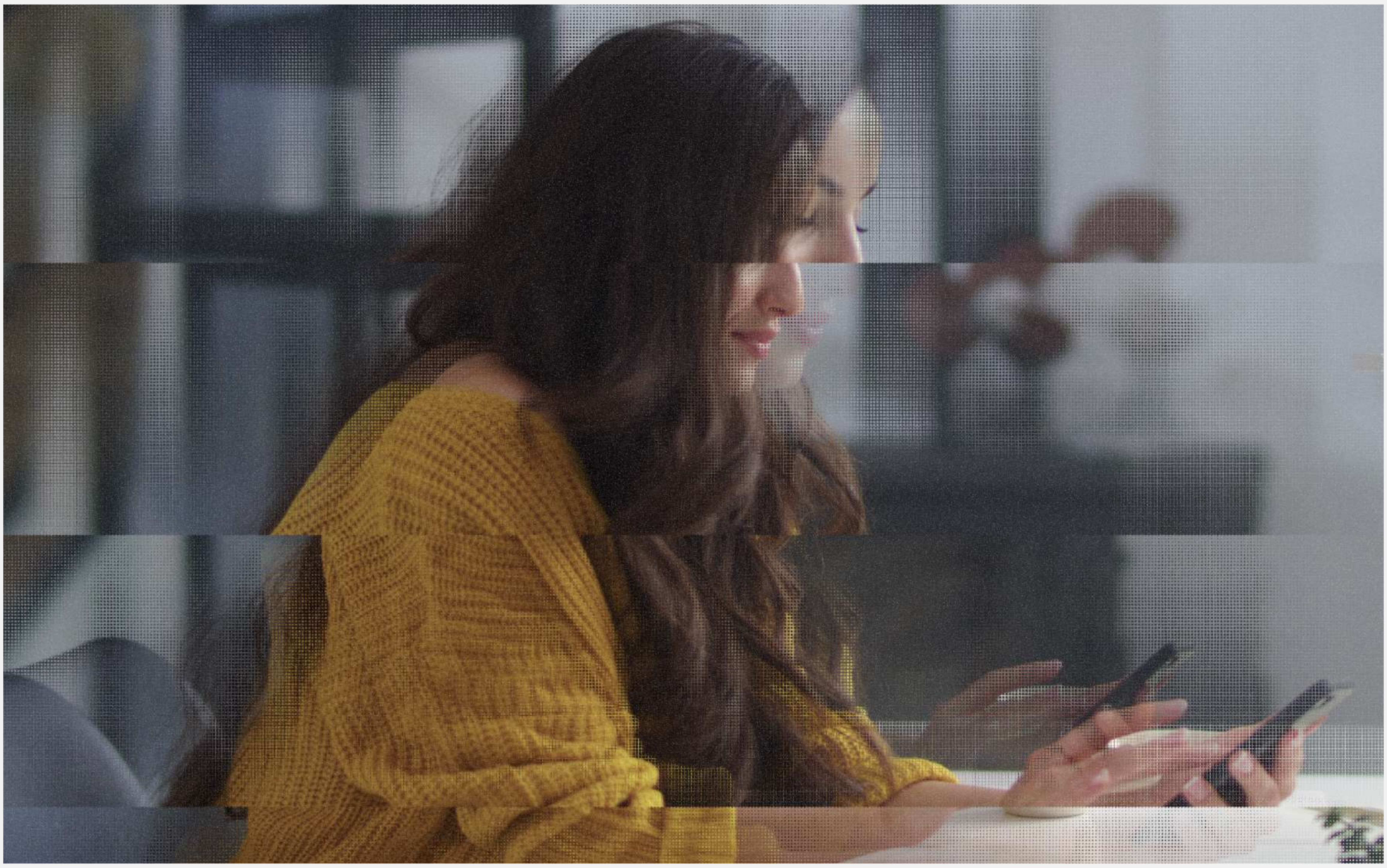
It is worth remembering that the invaders also managed to use the voicemail service of cell phones to record authorization codes received through a phone call. However, these attacks did not happen due to direct interference in the SS7 protocol. Still, the invaders used Caller ID spoofing (call origin falsification) offered by VoIP providers to access voicemails irregularly.

However, the most common are SIM swap attacks, which occur when invaders manage to transfer ownership of a mobile line to another chip, often thanks to the operation of accomplices who are part of the criminal gang within telecommunications companies.

Mechanism attacked:
Code via SMS

In the United States, authorities charged several individuals with committing crimes involving SIM swaps, especially to steal crypto assets. Some of them were former employees of telephone operators, such as AT&T and Verizon. This led to the creation of new security procedures to make it more difficult to transfer the line to another chip.

Either way, all SMS-based mechanisms depend on the security of the telecom service provider.



Loss:

Because MFA uses "something you own" as an authentication factor, the invader has the potential to steal the device. The effectiveness of the theft can vary from case to case; for example, SIM cards with chips and locked cell phones may not be useful to the invader. On the other hand, other mechanisms, such as USB keys, do not use any additional authentication to release stored keys.

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Mechanism attacked:
Code via SMS, OTP, USB key, built-in key on the device

How to evolve access security

Many of the viable techniques to transgress multi-factor authentication can only be used after the attacker obtains the victim's credentials (username and password). For this reason, there is an opportunity to improve the security of the process by protecting the credential itself.

Data on leaked credentials, combined with a robust incident response process, helps to detect and mitigate security incidents by pointing out which credentials are at risk so the company can block them.

In the same way, information on the actions of the attackers from Cyber Threat Intelligence (CTI) makes it possible to identify the leakage of authentication tokens or cookies that are in control of the criminals.

This data is obtained through Axur's credential monitoring by tracking the movements of malicious actors and identifying information leaked on the Web (on the Surface Web as well as on the Dark Web or Deep Web).

By receiving an alert about a credential that criminals have gained, the company can initiate the incident response process and prevent this credential from being used in attacks. The possibility of automating this process further increases the chances of mitigating and even avoiding an incident.

Vision outside the perimeter

One of the advantages of Axur monitoring is access to data that has been obtained by credential stealer malware. The information this malwares captures is distributed in "log" files in the digital crime underworld. Log files contain system data, passwords, cookies, and other data specified by the operators of the malicious code.

In this way, monitoring has the ability to make visible the stolen credentials on any device, including in the systems of the remote company's staff, customers, or third parties, adding a layer of protection to both the corporate network and the digital services provided to customers and partners.

For Customers & Partners

For digital service providers requiring login credentials from each customer or partner, relying on the security of users' devices is impossible. Unfortunately, any security breach resulting from a phishing or malware attack on the user will cause disruption for the provider as well, both in terms of improper activity on the account and the cost of the support that will need to be offered to the user to regain access.

Credential monitoring can scan services or domains and detect all leaked credentials for a specific service. The service provider alerts users about the need to change the password or to undo the changes to the account that were caused by the invasion.

For company staff

Through hybrid work in the home office or Bring Your Own Device (BYOD) policies, many companies allow the use of personal devices. The security of these devices is a challenge for the security team, as it is not always possible to record all the activity that takes place on them. In other words, there is a lack of visibility.

In addition to this, employees' personal activity can carry additional risks that are difficult to calculate. Even if your organization's security policy prohibits any type of device use, you may not follow the provisions or policies received regarding using your device to work.

As monitoring can visualize leaked credentials regardless of their origin, malware or phishing activity on the user's personal device will also be detected. This is a visibility that the company would hardly have otherwise.

Benefit for users and company

Even if MFA is available, not all users choose to use it. There are also cases where the company relies on systems that do not offer MFA or can not be migrated to a single sign-on platform.

Monitoring acts in any of these cases. As we can see in the chart below, the scope of monitoring detections ensures benefits for users with or without MFA can alert them to information exposed to potential spear phishing attempts, and can also assist in the investigation of security policy violations.

Monitoring detects:

Stolen passwords: For users or systems without MFA, protecting your passwords means safeguarding the security of the authentication process. For users with MFA, a stolen password can be the precursor to a phishing attack against recovery codes, a phone scam, or an attempt at MFA fatigue.

Stolen cookies: Authentication cookies can be used to access accounts with or without MFA. By detecting and invalidating cookies that fell in control of criminals, all users benefit.

Data that can be used by spear phishing: Spear phishing is characterized by being an extremely personalized message, and the attacker can use the victim's personal information to make the message more trustworthy. With monitoring, high-privilege users can be alerted about personal information that has been leaked and that is likely to be used in this type of attack.

Data that can violate recovery systems: MFA requires organizations and service providers to adopt recovery mechanisms for cases where the second factor is not available. Stolen credentials can give access to email systems or other data related to this process, weakening MFA.

Security policy violations: Credential stealers' logs almost always contain information about users' systems. This information can help the company determine if a corporate account was accessed from personal devices or if it was the user who registered their corporate email with other services.

Want to check your safety?

Schedule a free demo of the Axur platform and learn how threat monitoring can help your business stay protected across your entire external surface.

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