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Secure Your AWS EC2 Instance Metadata Service (IMDS)

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3 • 21 Min Read
and Lior Zatlavi
loud Security

IMDS, an important AWS EC2
, to understand its two versions
WS security.

Using Amazon Elastic Compute Cloud (AWS EC2)? If so, whether you realize it or not, you are likely using Instance Metadata Service (IMDS), a significant component of how an EC2 instance works. If you care about your EC2 instances' security, you'll want to know a few things about IMDS.

We'll start by reviewing IMDS. To help you maintain a high security bar, we'll cover the two versions of the API that IMDS supports and the difference between them. We'll also discuss the preferred option, and why you'll want to use it as much as possible. We'll go over the steps that can help prevent attackers with unauthorized users or third-parties from exploiting vulnerable software deployed on the EC2 and gaining access to your environment – and what to do about it.

Before starting, note that IMDS is secure software with potential gaps in the existing version. This post is a technical review meant to help you with an important component of the widely used EC2 service so you can have a more secure AWS environment.

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ly simplest way) for giving an EC2 instance access to
t is by using an instance profile attached to it. The
IAM role (only one) that the Amazon EC2 service is
le's trust relationship will be as such:

```
            }
        }
    ]
}
```

When the EC2 service performs the *sts:AssumeRole* call and retrieves the temporary credentials generated by STS, AWS stores the credentials in IMDS, which runs on a "link local" IP address of 169.254.169.254. The credentials are then made available to services running on the EC2 instance via an IMDS API.

IMDS is therefore an AWS mechanism that triggers the creation of, stores and makes available the security credentials used by applications and services (most notably, of course, the AWS SDK). IMDS is consequently a vital component of the EC2 instance that saves developers the need to manage credentials storage which, if done incorrectly, can cause security issues.

That said, attackers with unauthorized user or third-party credentials can leverage IMDS features to be able to extract and use the stored credentials to authenticate on behalf of the EC2.

Initially, IMDS supported one API version, called IMDS Version 1, or IMDSv1, for extracting IMDS-stored credentials. AWS subsequently introduced IMDS Version 2, a second API version, called IMDSv2. Version 2 API contains "belt and suspenders" yers) protections to better secure the credentials as

sions and their differences, as well as why and how to . We'll also look at how to responsibly manage support IMDSv1 to machines that don't. We will which a machine with IMDSv2 can still, due to a cked – and the importance of managing such ations with the necessary security controls.

DSv1

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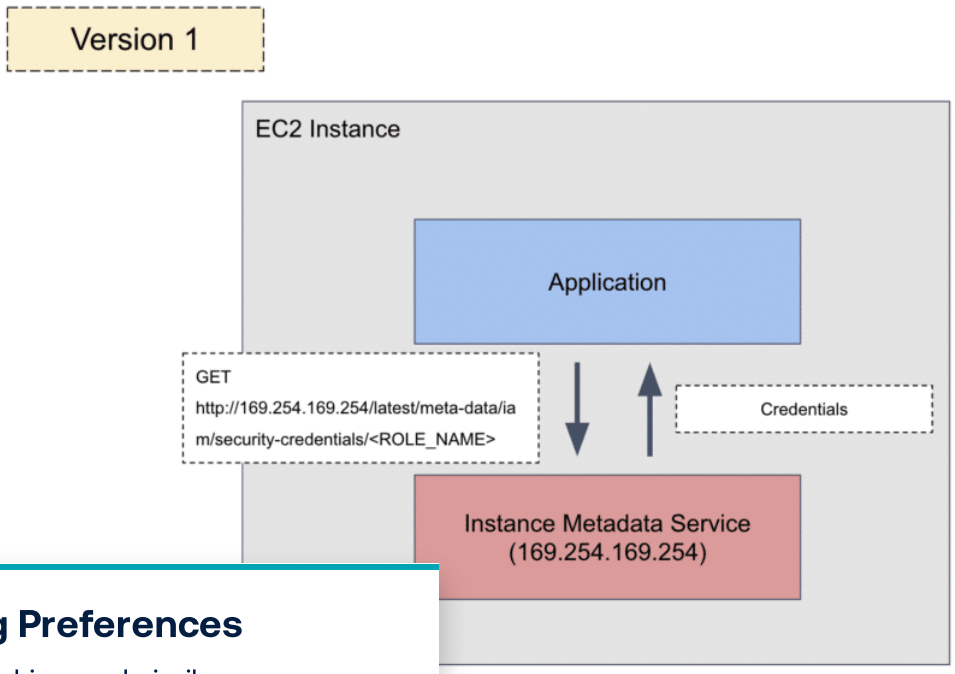
```
http://169.254.169.254/latest/meta-data/iam/security-credentials/<ROLE_NAME>
```

<ROLE_NAME> is the name of the IAM role that the EC2 uses which can also be retrieved from the IMDS via another HTTP GET request to the following URL:

```
http://169.254.169.254/latest/meta-data/iam/security-credentials/
```



1 credentials query

exposed to misconfiguration or has vulnerable
chanism can be leveraged by an attacker to extract

for this to play out:

gery (SSRF) exposure

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Since this vulnerability exists in many web servers exposed to the internet, the combination of the vulnerability and IMDSv1 availability, along with network access to the instance, is usually all that's needed for an attacker to successfully extract the credentials.

In a retrospective on public cloud breaches, Christophe Tafani-Dereeper, Rami McCarthy and Houston Hopkins describe the exploitation of an SSRF vulnerability to steal application cloud credentials as one of the four main causes of cloud security incidents in 2022.

Misconfiguration as a network device

When an EC2 is misconfigured as a network device with the purpose of routing traffic, the availability of IMDSv1 is also usually very easy to leverage as an attacker can take advantage of an EC2 with network access for routing traffic and IMDSv1 enabled.

A good example of this is a reverse proxy, which is designed to route traffic from other servers, as shown in the diagram below:

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on - Source: Cloudflare website

reverse proxies.

IMDSv2 to the rescue?

In 2019, AWS launched IMDS Version 2 of the API which, as mentioned before, adds significant layers of defense that deal with these exact scenarios.

Before we talk about its defense layers let's understand how IMDSv2 works.

IMDSv2 introduces the use of tokens. Instead of making one HTTP GET request to get the credentials, the authentication works in two steps. First, you need to make a PUT request with the X-aws-ec2-metadata-token-ttl-secondsheader header, which returns a token that is valid for the number of seconds the header specifies.

This first step is illustrated in the diagram below:

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g a PUT request with IMDSv2

n be used by a follow-up HTTP GET request that
called X-aws-ec2-metadata-token, as shown in the
following diagram:

Figure 4: Getting credentials using a token with IMDSv2

The complete process for acquiring the credentials is illustrated in Figure 5:

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pplication acquiring credentials with IMDSv2

the process of acquiring credentials, two
l security:

"IMDSv2 will also not issue session tokens to any caller with an X-Forwarded-For header"

Let's see why.

In the scenario of leveraging an SSRF vulnerability on your EC2 instance: Rather than simply being able to make HTTP GET requests on behalf of the server, the attacker will need the SSRF vulnerability to be able to make PUT requests and send them with headers. As we will soon demonstrate (yes, a bit of a spoiler), getting to the credentials will not be impossible but requires the presence of a vulnerability, which is much scarcer.

In the scenario of an EC2 misconfigured as a network device and used for routing requests to other servers: If the TTL on the PUT requests is kept to a default of 1, the response to the PUT request for the token will not be routed outside the EC2. This is because the only hop it will be allowed to make is from IMDS to the application requesting it within the EC2.

Important Note: As per AWS documentation:

"In a container environment, if the hop limit is 1, the IMDSv2 response does not return because going to the container is considered an additional network hop. To avoid the process of falling back to IMDSv1 and the resultant delay, in a container environment we recommend that you set the hop limit to 2."

Both these cases illustrate how IMDSv2 and the two mechanisms are a great

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VS blog post, denial of requests for a token with the another security layer against misconfigured EC2s, as nclude these headers. Also in the same blog, AWS the PUT request to acquire the token as a protection explaining that "analysis of third-party WAF products ns found that the vast majority do not permit HTTP

You'd be surprised to know how many EC2 instances are launched with, despite there being no need for it, IMDSv1 enabled. This tendency may be because – unless the Amazon Machine Image (AMI) in use is configured with a different default – the default configuration upon launching a new EC2 instance is still to support both IMDSv1 and IMDSv2.

In preparing for this article, we randomly surveyed several dozen real-life AWS environments secured by the Ermetic (now Tenable Cloud Security) platform. The environments had different numbers of EC2 instances: from just over 60 to more than 6,000. We examined tens of thousands of instances overall and we found that over 93% (!) of the instances had IMDSv1 enabled. Upon examining the environments individually, we found that almost 74% of environments had IMDSv1 enabled on over 90% of a given environment's EC2 instances.

Tenable Cloud Security also queries the CloudWatch MetadataNoToken metric, which allows you to check "the number of times the instance metadata service was successfully accessed using a method that does not use a token." In short, the metric checks how many times, if any, IMDSv1 was actually used. Using Tenable results to the queried metric we were able to assess how many instances had not used IMDSv1 enabled access – meaning that IMDSv1 probably could have been disabled with no compromise to the business function of the instance. Interestingly, over 55% (!) of the instances with IMDSv1 enabled met this criteria. When we ually, in a large portion of the instances we detected vasn't recently used, which makes it probable that it y.

are based on actual customer data so they indicate . Let's look at how to mitigate this kind of risk by orting IMDSv1 to enforcing IMDSv2, and how to limit from supporting IMDSv1.

n IMDSv1 to IMDSv2

ced: Enforcing availability of the IMDSv2 API is the superior security configuration over enabling IMDSv1. Absent a requirement to use

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The action for doing so – configuring instance metadata options – is rather simple on its own.

Below, we describe two important aspects of the process for performing the migration: detecting instances with IMDSv1 enabled and retiring this configuration responsibly.

Using AWS Config to detect instances with IMDSv1 enabled

A simple way to detect instances that support IMDSv1 is to use AWS Config (make sure you review AWS Config pricing before enabling it), which has a pre-built AWS managed rule called *ec2-imdsv2-check* that checks to ensure that Version 2 is in use (rather than Version 1).

AWS even has an AWS Systems Manager runbook called AWSConfigRemediation-EnforceEC2InstanceIMDSv2 that allows you to easily fix this finding.

You can also set up automatic remediation of IMDSv1 availability; however, for reasons explained in the next section, we do not recommend doing so.

Retire IMDSv1 availability responsibly

onfirm when enforcing IMDSv2 in EC2 instances -- for
ances -- is that IMDSv1 is not actually needed. The
able needed and used access to such an API; doing
ly on. We therefore do not recommend automatically
ration; rather, you should do so only after careful
sage is no longer needed.

enabled, you have to make sure IMDSv1 is not in

s mentioned before, query the CloudWatch metric

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Figure 6: CloudWatch dashboard

Then choose EC2:

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he EC2 service

etrics":

Figure 8: Choosing "Per-Instance Metrics"

You can then simply add a filter for "MetadataNoToken":

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ataNoToken metric

you if IMDSv1 is in use. If you find it is, you should find
place usage of it with calls to IMDSv2.

ake the job of looking for existing use of IMDSv1 much
this is a crucial part of the due diligence required

retrieved.

Figure 10: CloudTrail event for a call made with IMDS-stored credentials indicates with which API version the credentials were retrieved

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mmended steps to take in the process of enforcing

ry calls to IMDSv1

e proprietary/3rd party software making calls to
eck looking for such occurrences and, where
n calls to IMDSv2.

SDK

DSv1 is the AWS SDK used on the machine. So the
heck that IMDSv1 is not actually required in case the
current used SDK is not of the minimum required version for using IMDSv2 or higher.

After making these changes, make sure your EC2 instances perform properly without any calls made to IMDSv1 (perhaps checking again for the *MetadataNoToken* metric). Only after you've verified that disabling IMDSv1 will not compromise operation of the EC2 instances, enforce IMDSv2.

Note: This process is of course to be done first in a lower environment such as Testing, rather than straight on Production. Also, it goes without saying that proper testing is required when making such a change even for instances where recent IMDSv1 calls weren't detected.

How to enforce IMDSv2 across your AWS accounts

Other than migrating existing EC2 instances to have IMDSv2 enforced, you should aspire to prevent the launch of new EC2 instances not configured with IMDSv2 -- or at least keep a close watch when such instances get launched.

You can do so by setting an AWS Organizations service control policy (SCP) that limits two actions for AWS IAM identities on the target AWS account:

- Launching of instances without the IMDSv2 configuration
- Modifying the metadata options of existing EC2 instances

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es both aims. It also sets an exception for
orming these operations by an admin for certain EC2

```
s"
:instance/*"
```

```
                }
            }
        },
        {
            "Action": "ec2:ModifyInstanceMetadataOptions",
            "Resource": "*",
            "Effect": "Deny",
            "Condition": {
                "StringNotEquals": {
                    "aws:PrincipalArn": "<ADMIN_ROLE>"
                }
            }
        }
    ]
}
```

IMDSv2 is not a silver bullet

Unfortunately, even with IMDSv2 enforced, your environment may contain vulnerable software and/or misconfigurations that expose IMDS to being effectively harvested for credentials. According to the shared responsibility model, managing and mitigating such exposure is your responsibility.

This is a great reason why you'd want to employ guardrail mechanisms, such as the configuration of data perimeters to enforce access to resources from trusted
can greatly minimize the impact of the exfiltration of

real-life example of a scenario in which an IMDSv2
exploitable due to vulnerable software.

edentials to SSRF on the admin panel

web applications in the cloud, we know this
common scenario. Web applications for
an authenticated admin panel with extended

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Ingredient #2: Juicy SSRF functionality

This ingredient is not commonly achieved but is still seen in the wild. One example of the extended functionalities is a webhook. As defined by Redhat, "A webhook is an HTTP-based callback function that allows lightweight, event-driven communication between two application programming interfaces (APIs)."

Webhooks are frequently used by applications to integrate with other applications. Most applications have the user input a URL for the webhook, and even HTTP custom headers and parameters, to test the webhook functionality.

SSRF on IMDSv2, anyone?

Putting it together

Here's an example to help you understand and be able to remediate an attack: a vulnerable version of a Jira server hosted on AWS EC2 that can be leveraged by an unauthorized user or third party even when IMDSv2 is enforced.

Jira is a project- and issue-tracking software product that helps teams plan, track and discuss work. Originally designed for software development teams, today Jira is a powerful tool for helping teams stay organized and on track, and is especially useful for managing complex projects with multiple stakeholders and dependencies. ustries use it to manage projects of all kinds.

its ability to customize workflows and create custom f a team or organization. This makes it a highly d to a variety of use cases.

as decided they want to use Jira. They install a Jira ation's EC2s and open its security groups to any IPv4 .

on the EC2:

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Figure 11: CLI request to edit the metadata options of an EC2 to enforce IMDSv2

Let's imagine we are attackers. After we scan the external network of Organization A, we notice the Jira instance listening on port 8080.

Figure 12: JIRA console

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min:admin. We randomly use these credentials to try
y work!

s a lot of CVEs. To figure out which are available to us
rsion of the Jira instance we're using:

Figure 13: Locating the JIRA version

The Jira version is 8.13.17, which is vulnerable to CVE-2022-26135 - Full authenticated SSRF in the Mobile Plugin for Jira Data Center and Server. It is worth mentioning that this version is also vulnerable to authentication bypass; for this real-world scenario, we could have used authentication bypass rather than default credentials.

In the Jira mobile plugin, the batch feature allows the performing of actions on multiple issues at the same time. This feature is useful for making the same change to multiple issues or quickly updating the status of a group of issues. One batch ng of resources from locations under the Jira host.

catenated user input through the “location” perform SSRF on the Jira server.

atch request and takes the location, method, headers

```
ean> execute(BatchRequestBean requestBean, Map<String, Str
stBean.getLocation();
on(relativeLocation);

ponse(relativeLocation, 400));

Request request = (new Request.Builder()).url(jiraLocation).headers(Headers.of(headers)).
```

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```
catch (Exception e) {
    log.error("Error when calling url: [" + relativeLocation + "]", e);
    return Optional.empty();
}
}
```

Let's dive into the toJiraLocation function:

```
private URL toJiraLocation(String relativeLocation) {
try {
    return this.linkBuilder.forRelativePath(relativeLocation).toURL();
}
catch (Exception e) {
    log.warn("Cannot parse relative location: [" + relativeLocation + "]");
    return null;
}
 }
```

linkBuilder.forRelativePath:

```
public URI forRelativePath(String path) {
    return URI.create(this.jiraBaseUrls.baseUrl() + path);
 }
```

As you can infer from the code above, the plugin was supposed to take the path
in issue with this code is that it is missing input
slash "/" after the baseUrl *(this.jiraBaseUrls.baseUrl())*
the attack. The slash "/" would make any user input
base URL (Jira host).

can disrupt this behavior by inputting @ and then the
tion parameter. The "@" forces the client to treat the
s for the attacker's domain, leading to a request to

s:

rl.com - http://jirahost@ssrf_target_url.com →

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input/domain.

http://jirahost + .myevildomain.com - http://jirahost.myevildomain.com

By controlling “myevildomain.com” we can use a DNS record to refer the victim to 169.254.169.254, exploiting SSRF.

By exploiting this vulnerability, we can try to access the IMDS credentials of the EC2 that is hosting the Jira server:

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GET request without headers, gets unauthorized

use only IMDSv2 – we got unauthorized access.

nality allowing us to add headers that will be proxied
cify the request method and the body of the request
lespite its using IMDSv2.

t to query

to the SSRF target (IMDS).

Figure 15: Successful PUT request with headers by the attacker to retrieve the token

We, as attackers, can then use the metadata token we took to request any metadata we want from IMDS. Our first target will be the security credentials of the victim's EC2, which we successfully query by supplying the metadata token:

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Figure 16: Getting the credentials using the acquired token

Bingo! We will have access to EC2 instance profile credentials!

Takeaways

e importance of enforcing IMDSv2 and provided some

ing IMDSv2 enforced does not make your
llout of deploying vulnerable software and/or having a

o make sure you use updated software and pay close
t may impact your security posture.

urations that could be relevant in the case we have

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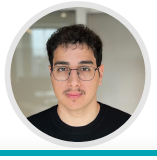
they are secure.

Default credentials - Pre-configured username and password combinations for a system or application. Using default credentials poses a security risk because they are well-known and can easily be discovered by attackers. To mitigate this risk, change default credentials as soon as possible after setting up a new system or application, and use strong, unique passwords for all systems and applications.

- Information disclosure - Making information publicly available, either intentionally or unintentionally. Disclosing information about a server can pose a security risk because it can provide attackers with valuable information they can use to target the server. For example, a Jira server's version number is publicly available by default, so an attacker may be able to find and exploit vulnerabilities specific to the software's version. To protect against this risk, it is important to hide version numbers and take other steps to protect sensitive information, such as restricting access to sensitive directories and using secure protocols to transmit information. However, hiding information is just a guardrail. Keeping all software and systems up to date to ensure that any known vulnerabilities are patched in a timely manner is the first step to a more secure environment.



Liv Matan

Liv Matan is a Senior Security Researcher at Tenable, where he pplication and web security. As a bug bounty found several vulnerabilities in popular software as Azure, Google Cloud, AWS, Facebook, and recognized as Microsoft's "Most Valuable nd has presented at conferences such as DEF CON nd fwd:cloudsec.

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Lior Zatlavi has more than 10 years of experience in cyber security, with most of that time as a security architect, product manager and developer for the Israeli government. Lior served in an elite cyber security unit of the Israel Defense Forces (retired with the rank of Major), after which he worked in a cyber security division of Israel's Prime Minister's Office. After leaving the public sector, Lior worked as an independent consultant, specializing in cloud security and identity management. Lior holds an M.Sc in Electrical Engineering from Tel Aviv University and a B.Sc in Applied Mathematics (cum laude) from Bar Ilan University, Israel.

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October 22, 2024

Tenable Research discovered an SMB force-authentication vulnerability in Open Policy Agent (OPA) that is now fixed in the latest release of OPA. The vulnerability could have allowed an attacker to leak the NTLM credentials of the OPA server's local user account to a remote server, potentially allowing the attacker to relay the authentication or crack the password. The vulnerability affected both the OPA CLI (Community and Enterprise editions) and the OPA Go SDK.

Shelly Raban

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