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# Introduction

This document describes the threat modelling and assessment undertaken to meet the Cybersecurity requirements for Server, RMS, adminUI and Programmer.

# Threat modelling of Server

The Server capability is implemented based on Digital Twin concept, wherein each physical resource (e.g. pacemarker, patient, doctor, clinical data) is associated with a virtual or digital resource (hereafter referred as thing (https://www.w3.org/WoT)). The thing contains only the data (refer appendix for sample data) associated with the physical resource. There are no control commands present in thing to manipulate the physical resource. Each thing is protected and controlled based on an access policy.

The threat modelling of the Server functionality was performed by decomposing Server into use cases to arrive at external dependencies and determine the attack surface (based on the entry and exit points) to identify assets, risks (threats) associated with those assets, quantify them and determine countermeasures.

## Decompose of Server

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Use case** | **Entry** | **Exit** | **External dependencies** | **Asset** |
| Create an access policy for a thing | Authentication token, policy payload (with userId, scope, read and/ write permissions) | HTTP status code (401 if token is invalid, 201 if created successfully) | Docker, Ubuntu, Keycloak, GCP | Policy |
| Update access policy | Authentication token, policy payload (with userId, scope, read and/ write permissions) | HTTP status code (401 if token is invalid, 400 if policyId is not present, 403 if policy is insufficient, 201 if updated successfully) | Docker, Ubuntu, Keycloak, GCP | Policy |
| Create a thing | Authentication token, thing payload (with namespace, attributes (for static data), features (for dynamic data) | HTTP status code (401 if token is invalid,  403 if policy is insufficient, 201 if created successfully) | Docker, Ubuntu, Keycloak, GCP | Thing |
| Update a thing | Authentication token, thing payload (with thing identifier, features (for changed data) | HTTP status code (401 if token is invalid,  400 if thingId is not present, 403 if policy is insufficient, 201 if updated successfully) | Docker, Ubuntu, Keycloak, GCP | Thing |
| Get a thing | Authentication token, thingId | HTTP status code (401 if token is invalid,  201 with empty response if thingId is not present or policy is not sufficient or with latest attributes and features of given thingId) if thingId is present and policy is sufficient | Docker, Ubuntu, Keycloak, GCP | Thing |
| Search thing | Authentication token, namespaces, filter | HTTP status code (401 if token is invalid,  201 with empty response if thingId is not present or policy is not sufficient or with latest attributes and features of matching filter | Docker, Ubuntu, Keycloak, GCP | Thing |

### Attack surface analysis

The attack surface comprises of entry points, exit points and external dependencies. As the exit points are generic hence ignored from exploitation point of view and its assumed that the adversary will most likely exploit the entry points through the public facing interface and the external dependencies through brute force or cloud infrastructure vulnerabilities.

The below table maps the standard adversary techniques and tactics from MITRE Attack framework (<https://attack.mitre.org/>) that are applicable in the context of Server functionality along with STRIDE threat quantification/ranking (refer appendix) and countermeasure

|  |  |  |  |
| --- | --- | --- | --- |
| Techniques | Tactics | Threat type | Countermeasure |
| InitialAccess | [Exploit\_Public-Facing Application](https://attack.mitre.org/techniques/T1190) | Spoofing | Client (RMS, Programmer, Patient app) using server functionality to consider OWASP Top 10 security risks |
|  | Phishing | Spoofing | Internal process to be established to provide awareness on avoiding phishing traps |
|  | Replication Through Removable Media | Spoofing | Internal process to be established to prohibit usage of removable media in laptops/desktops connected to Server |
|  | Supply Chain Compromise | Spoofing | Internal process to be established to control the OS security update, remote connectivity tools, video capture tools on the laptops/destkops connected to Server |
|  | Valid Accounts | Spoofing | Internal process to be established to bring awareness in not sharing the password and logging out from RMS, Programmer, Patient app |
| Credential Access | Adversary-in-the-Middle | Spoofing | Data should be encrypted in transit |
|  | Brute Force | Spoofing | Keycloak logs to be analysed for brute force target account. The concern user should be notified to change the password or the account should be disabled using keycloak admin console |
|  | Steal Application Access Token | Tampering, Information Disclosure | The clinical and device data should be analysed on a daily basis to detect suspicious activity (e.g. incorrect data format, invalid field data, contradictory data) on new or updated things. Identify the compromised account from the policy associated with the tampered thing.  Restore the latest data from history streaming.  The concern user should be notified to change the password or the account/token should be disabled/invalidated using keycloak admin console.  The laptop/desktop should be tagged as compromised and not used till faulty software or OS is removed/reformatted. |
|  | Multi-Factor Authentication Interception | Spoofing | Multi-factor authentication to be based on out of band OTP authenticator |
|  | Network sniffing | Spoofing | Data should be encrypted in transit |
|  | Unsecured Credentials | Spoofing | Internal process to be established to encrypt files containing credentials on the laptops/desktops connect to Server |
| Discovery | Account Discovery | Repudiation | GCP console to be checked periodically for super user activity.  In case of suspicious act, the GCP account email password should be modified and keys rotated. |
|  | Cloud Infrastructure Discovery | Repudiation | GCP production instance will configured with GCP compute API disabled |
|  | Log Enumeration | Repudiation | GCP console to be checked periodically for super user activity. In case of suspicious act, the GCP account email password should be modified and keys rotated. |
| Privilege Escalation | Abuse Elevation Control Mechanism | Elevation of Privilege | Policy owner should be restricted to super user |
| Lateral Movement | Remote Services | Tampering, Information Disclosure | Only scp, https and http port should be enabled on GCP instance for external access  SSH should be based on PKI and limited to super user and a secondary user  Database not exposed to public interface and accessible in the docker and or host environment  Keycloak should be restricted to admin user to create users and individual user to fetch only its information  Docker group to contain only super user to manage (start, stop, update image) the containers for Server functionality    Refer to Steal Application Access Token |
| Impact | Data Manipulation | Tampering | Refer to Steal Application Access Token |
|  | Endpoint Denial of Service | Denial of Service | Rate limit (request/sec) should be enabled to temporarily disable Server functionality  GCP in-built network DoS protection  Nginx should be enabled to block all non-api transactions |

### Threat analysis

The quantified threats from the attack surface analysis are ranked using DREAD model (refer appendix) as below

#### Tampering

|  |  |  |
| --- | --- | --- |
| Damage potential | Tampered clinical data on the attack day may cause disruption in RMS eCRF functionality but data can be recovered from the history | 5 |
| Reproducibility | Not easy if the internal process is adhered | 2 |
| Exploitability | Not easy if the internal process is adhered | 2 |
| Affected users | If a doctor account is compromised, then patients linked to that doctor will be impacted | 5 |
| Discoverability | Can be found by reverse engineering of api payload | 10 |
| Score |  | 4.8 |

#### Denial of Service

|  |  |  |
| --- | --- | --- |
| Damage potential | Unable to add or update data during the period when Server is temporarily off | 8 |
| Reproducibility | Not easy with adaptive intrusion detection | 2 |
| Exploitability | Not easy to attack with non-api requests | 2 |
| Affected users | All | 10 |
| Discoverability | Can be found easily through the standard DoS methods | 10 |
| Score |  | 6.4 |

#### Information Disclosure

|  |  |  |
| --- | --- | --- |
| Damage potential | Information related to clinical data and device data used as the source for ransom or sold on darknet | 8 |
| Reproducibility | Not easy if the internal process is adhered | 2 |
| Exploitability | Not easy if the internal process is adhered | 2 |
| Affected users | None | 0 |
| Discoverability | Can be found by reverse engineering of api payload | 10 |
| Score |  | 4.4 |

#### Spoofing

|  |  |  |
| --- | --- | --- |
| Damage potential | The authentication tokens can be stolen and used for a maximum session period of 10 hours | 5 |
| Reproducibility | Not easy if the internal process is adhered | 2 |
| Exploitability | Not easy if the internal process is adhered | 2 |
| Affected users | None | 0 |
| Discoverability | Can be found easily through the standard spoofing methods | 10 |
| Score |  | 3.6 |

#### Repudiation

|  |  |  |
| --- | --- | --- |
| Damage potential | The adversary would get to know that google cloud is the cloud provider | 5 |
| Reproducibility | Not easy as access to GCP project is restricted to super user | 2 |
| Exploitability | Not easy as GCP project is setup with Google APIs disabled | 0 |
| Affected users | None | 0 |
| Discoverability | Can be found easily through the standard GCP accessibility methods | 10 |
| Score |  | 3.4 |

#### Elevation of Privilege

|  |  |  |
| --- | --- | --- |
| Damage potential | As super user owns all the policies hence elevation of privilege through other user account is not likely | 0 |
| Reproducibility | Not easy | 0 |
| Exploitability | Not easy | 0 |
| Affected users | None | 0 |
| Discoverability | Can be found by reverse engineering of api payload | 10 |
| Score |  | 2 |

### Threat prioritization

The below table list the high priority threats with score > 5.0 and contingency to overcome the impact of countermeasures.

|  |  |
| --- | --- |
| Threat | Contingency |
| Denial of Service | Deploy redundant GCP instances to minimize the down time  Deploy adaptive intrusion detection to block the adversary network traffic |

# Vulnerability assessment of Server

The following extract is from executing the docker vulnerability scanner targeted to Java (jar), which is the only executable runtime that runs in the docker container. There are other OS specific vulnerabilities reported, which are not critical as no other executables other than java process runs in the server docker container.

Java (jar)

Total: 3 (UNKNOWN: 0, LOW: 0, MEDIUM: 1, HIGH: 2, CRITICAL: 0)

┌───────────────────────────────────────────┬────────────────┬──────────┬────────┬───────────────────┬────────────────────────┬──────────────────────────────────────────────────────────┐

│ Library │ Vulnerability │ Severity │ Status │ Installed Version │ Fixed Version │ Title │

├───────────────────────────────────────────┼────────────────┼──────────┼────────┼───────────────────┼────────────────────────┼──────────────────────────────────────────────────────────┤

│ ch.qos.logback:logback-classic │ CVE-2023-6378 │ HIGH │ fixed │ 1.2.11 │ 1.3.12, 1.4.12, 1.2.13 │ logback: serialization vulnerability in logback receiver │

│ (ditto-things-service-3.3.2-allinone.jar) │ │ │ │ │ │ https://avd.aquasec.com/nvd/cve-2023-6378 │

├───────────────────────────────────────────┤ │ │ │ │ │ │

│ ch.qos.logback:logback-core │ │ │ │ │ │ │

│ (ditto-things-service-3.3.2-allinone.jar) │ │ │ │ │ │ │

├───────────────────────────────────────────┼────────────────┼──────────┤ ├───────────────────┼────────────────────────┼──────────────────────────────────────────────────────────┤

│ io.netty:netty-handler │ CVE-2023-34462 │ MEDIUM │ │ 4.1.86.Final │ 4.1.94.Final │ netty: SniHandler 16MB allocation leads to OOM │

│ (ditto-things-service-3.3.2-allinone.jar) │ │ │ │ │ │ https://avd.aquasec.com/nvd/cve-2023-34462 │

└───────────────────────────────────────────┴────────────────┴──────────┴────────┴───────────────────┴────────────────────────┴──────────────────────────────────────────────────────────┘

|  |  |  |
| --- | --- | --- |
| CVE-2023-34462 | netty: SniHandler 16MB allocation leads to OOM | The impact is low as the request body is limited to 100 KB |

# Vulnerability assessment of Server external dependencies

### Keycloak

version: 23.0.2

Keycloak is an open source from RedHat which is used for authentication and identity information management of users

|  |  |  |
| --- | --- | --- |
| [**CVE-2023-6134**](https://www.cvedetails.com/cve/CVE-2023-6134/) | A flaw was found in Keycloak that prevents certain schemes in redirects, but permits them if a wildcard is appended to the token. This issue could allow an attacker to submit a specially crafted request leading to cross-site scripting (XSS) or further attacks. This flaw is the result of an incomplete fix for CVE-2020-10748 | The impact is low as all users are local and not SSO (wherein redirects will be required) and Keycloak in-built UI interface are used for management (which runs in separate browser tabs). |

### mongodb

version: 5.0

|  |  |  |
| --- | --- | --- |
| [**CVE-2023-1409**](https://www.cvedetails.com/cve/CVE-2023-1409/) | If the MongoDB Server running on Windows or macOS is configured to use TLS with a specific set of configuration options that are already known to work securely in other platforms (e.g. Linux), it is possible that client certificate validation may not be in effect, potentially allowing client to establish a TLS connection with the server that supplies any certificate. This issue affect all MongoDB Server v6.3 versions, MongoDB Server v5.0 versions v5.0.0 to v5.0.14 and all MongoDB Server v4.4 versions. | There is no impact as mongodb runs in Ubuntu |
| [**CVE-2022-24272**](https://www.cvedetails.com/cve/CVE-2022-24272/) | An authenticated user may trigger an invariant assertion during command dispatch due to incorrect validation on the $external database. This may result in mongod denial of service or server crash. This issue affects: MongoDB Inc. MongoDB Server v5.0 versions, prior to and including v5.0.6 |  |
| [**CVE-2021-32040**](https://www.cvedetails.com/cve/CVE-2021-32040/) | It may be possible to have an extremely long aggregation pipeline in conjunction with a specific stage/operator and cause a stack overflow due to the size of the stack frames used by that stage. If an attacker could cause such an aggregation to occur, they could maliciously crash MongoDB in a DoS attack. This vulnerability affects MongoDB versions prior to 5.0.4, 4.4.11, 4.2.16. |  |
| [**CVE-2021-32037**](https://www.cvedetails.com/cve/CVE-2021-32037/) | An authorized user may trigger an invariant which may result in denial of service or server exit if a relevant aggregation request is sent to a shard. Usually, the requests are sent via mongos and special privileges are required in order to know the address of the shards and to log in to the shards of an auth enabled environment. | The impact is low as Mongodb is deployed as docker container in standalone mode (no cluster) and accessible to only Server in the docker network |
| [**CVE-2021-32036**](https://www.cvedetails.com/cve/CVE-2021-32036/) | An authenticated user without any specific authorizations may be able to repeatedly invoke the features command where at a high volume may lead to resource depletion or generate high lock contention. This may result in denial of service and in rare cases could result in id field collisions. | Mongodb is accessibly only from Server for things payload which are protected with rate limit and size limit |
|  |  |  |

### Nginx

Version: 1.18

Nginx serve as reverse proxy and SSL termination

|  |  |  |
| --- | --- | --- |
| [CVE-2022-41741](http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2022-41741) | NGINX Open Source before versions 1.23.2 and 1.22.1, NGINX Open Source Subscription before versions R2 P1 and R1 P1, and NGINX Plus before versions R27 P1 and R26 P1 have a vulnerability in the module ngx\_http\_mp4\_module that might allow a local attacker to corrupt NGINX worker memory, resulting in its termination or potential other impact using a specially crafted audio or video file. The issue affects only NGINX products that are built with the ngx\_http\_mp4\_module, when the mp4 directive is used in the configuration file. Further, the attack is possible only if an attacker can trigger processing of a specially crafted audio or video file with the module ngx\_http\_mp4\_module. | No impact as files are not streamed |
| [CVE-2022-41742](http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2022-41742) | NGINX Open Source before versions 1.23.2 and 1.22.1, NGINX Open Source Subscription before versions R2 P1 and R1 P1, and NGINX Plus before versions R27 P1 and R26 P1 have a vulnerability in the module ngx\_http\_mp4\_module that might allow a local attacker to cause a worker process crash, or might result in worker process memory disclosure by using a specially crafted audio or video file. The issue affects only NGINX products that are built with the module ngx\_http\_mp4\_module, when the mp4 directive is used in the configuration file. Further, the attack is possible only if an attacker can trigger processing of a specially crafted audio or video file with the module ngx\_http\_mp4\_module. | No impact as files are not streamed |
| [CVE-2021-23017](http://cve.mitre.org/cgi-bin/cvename.cgi?name=CVE-2021-23017) | A security issue in nginx resolver was identified, which might allow an attacker who is able to forge UDP packets from the DNS server to cause 1-byte memory overwrite, resulting in worker process crash or potential other impact. | No impact as the reverse proxy have proxy\_pass set to localhost |

### Docker

Version: 19.03.15

No vulnerabilities found

### Ubuntu (Known Exploited Vulnerability)

|  |  |  |
| --- | --- | --- |
| [**CVE-2021-3560**](https://www.cvedetails.com/cve/CVE-2021-3560/) | It was found that polkit could be tricked into bypassing the credential checks for D-Bus requests, elevating the privileges of the requestor to the root user. This flaw could be used by an unprivileged local attacker to, for example, create a new local administrator. The highest threat from this vulnerability is to data confidentiality and integrity as well as system availability. | No impact as D-bus is not used in Server |
| [**CVE-2021-3493**](https://www.cvedetails.com/cve/CVE-2021-3493/) | The overlayfs implementation in the linux kernel did not properly validate with respect to user namespaces the setting of file capabilities on files in an underlying file system. Due to the combination of unprivileged user namespaces along with a patch carried in the Ubuntu kernel to allow unprivileged overlay mounts, an attacker could use this to gain elevated privileges. | No impact as kernel used is 5.11+ |

### GCP

<based on security control centre report from GCP>

### Firebase

No vulnerabilities found for Firebase Storage

# Threat modelling of RMS

The RMS functionality is implemented as a web application, wherein only the authenticated user based on its type (admin or clinician) get access to eCRF data management, patient dashboard, device interrogation and message pages.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Use case** | **Entry** | **Exit** | **External dependencies** | **Asset** |
| Login page | username, password, OTP | RMS landing page on success. Generic error message in case of invalid credentials | Server | List of Patient ID, clinical data, device interrogation, messages |
| By-pass Login page | Type random relative path | No data | None | None |

The adversary will most likely exploit the user laptop/desktop and OTP authenticator device.

The below table maps the standard adversary techniques and tactics from MITRE Attack framework (<https://attack.mitre.org/>) that are applicable in the context of RMS functionality along with STRIDE threat quantification/ranking (refer appendix) and countermeasure

|  |  |  |  |
| --- | --- | --- | --- |
| Techniques | Tactics | Threat type | Countermeasure |
| Credential Access | Adversary-in-the-Middle | Spoofing | Internal process to be established to detect compromised routers, need to elevate privilege to modify network settings in laptop or desktop (e.g. change in proxy server, dns server etc) |
|  | Input Capture | Spoofing | Internal process to be established to allow software updates from trusted sources |

The main threat from RMS point of view is

#### Spoofing

|  |  |  |
| --- | --- | --- |
| Damage potential | RMS eCRF page can be used for maximum 10 hours to view and update clinical data  RMS device interrogation page can be viewed | 8 |
| Reproducibility | Not easy if the internal process is adhered | 2 |
| Exploitability | Not easy if the internal process is adhered | 2 |
| Affected users | If a doctor account is compromised, then patients linked to that doctor will be impacted | 10 |
| Discoverability | Not easy | 2 |
| Score |  | 4.8 |

|  |  |
| --- | --- |
| Threat | Contingency (if countermeasure fails or is not adequate) |
| Spoofing | Use hardened laptops/desktops with basic installation (e.g. OS + chrome browser) and connect to reliable hotspot |

# Threat modelling of adminUI

The adminUI functionality is implemented as a web application similar to RMS, wherein only the super user get access to add patient, add clinician, add device, assign device to patient and clinician, map patientId to patient

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Use case** | **Entry** | **Exit** | **External dependencies** | **Asset** |
| Login page | username, password, OTP | adminUI landing page on success. Generic error message in case of invalid credentials | Server | Add Patient, Clinician, Device, Assign, Map patientId |
| By-pass Login page | Type random relative path | No data | None | None |

The adversary will most likely exploit the user laptop/desktop and OTP authenticator device.

Like RMS, the main threat from adminUI point of view is

#### Spoofing

|  |  |  |
| --- | --- | --- |
| Damage potential | adminUI page can be used for maximum 10 hours to add dummy Patient, Clinician, Device, Assign, Map patientID or reassign existing device assignment, patientID mapping etc. | 8 |
| Reproducibility | Not easy if the internal process is adhered | 2 |
| Exploitability | Not easy if the internal process is adhered | 2 |
| Affected users | All users associated with changes to existing data | 10 |
| Discoverability | Not easy as adminUI access is restricted to a single user from Calyan | 2 |
| Score |  | 4.8 |

|  |  |
| --- | --- |
| Threat | Contingency (if countermeasure fails or is not adequate) |
| Spoofing | Use hardened laptops/desktops with basic installation (e.g. OS + chrome browser) and connect to reliable hotspot |

# Appendix

## Operating system

Ubuntu 20.04.1

rsa-key-20200312@pms:~$ uname -a

Linux pms 5.15.0-1042-gcp #50~20.04.1-Ubuntu SMP Mon Sep 11 03:30:57 UTC 2023 x86\_64 x86\_64 x86\_64 GNU/Linux

## Nginx

1.18.0

rsa-key-20200312@pms:~$ nginx -v

nginx version: nginx/1.18.0 (Ubuntu)

## Docker

rsa-key-20200312@pms:~$ docker version

Client: Docker Engine - Community

Version: 19.03.15

API version: 1.40

Go version: go1.13.15

Git commit: 99e3ed8919

Built: Sat Jan 30 03:17:01 2021

OS/Arch: linux/amd64

Experimental: false

Server: Docker Engine - Community

Engine:

Version: 19.03.15

API version: 1.40 (minimum version 1.12)

Go version: go1.13.15

Git commit: 99e3ed8919

Built: Sat Jan 30 03:15:30 2021

OS/Arch: linux/amd64

Experimental: false

containerd:

Version: 1.6.21

GitCommit: 3dce8eb055cbb6872793272b4f20ed16117344f8

runc:

Version: 1.1.7

GitCommit: v1.1.7-0-g860f061

docker-init:

Version: 0.18.0

GitCommit: fec3683

## Eclipse Ditto

3.3.2

ditto-things-service-3.3.2-allinone.jar

ditto-policies-service-3.3.2-allinone.jar

ditto-gateway-service-3.3.2-allinone.jar

ditto-connectivity-service-3.3.2-allinone.jar

ditto-thingsearch-service-3.3.2-allinone.jar

nginx 1.21-alpine

mongo:5.0

rsa-key-20200312@pms:~$ docker ps

CONTAINER ID IMAGE COMMAND CREATED STATUS PORTS NAMES

437ca0b27882 eclipse/ditto-gateway:latest "/usr/bin/tini -- sh…" 5 months ago Up 4 days (healthy) 0.0.0.0:8081->8080/tcp docker\_gateway\_1

16cddd82a5c6 nginx:1.21-alpine "/docker-entrypoint.…" 5 months ago Up 2 months 0.0.0.0:8080->80/tcp docker\_nginx\_1

d12ff8aaffae eclipse/ditto-things:latest "/usr/bin/tini -- sh…" 5 months ago Up 27 hours (healthy) 8080/tcp docker\_things\_1

61058dd48540 eclipse/ditto-things-search:latest "/usr/bin/tini -- sh…" 5 months ago Up 2 weeks (healthy) 8080/tcp docker\_things-search\_1

03283f8b9288 eclipse/ditto-connectivity:latest "/usr/bin/tini -- sh…" 5 months ago Up 2 months (healthy) 8080/tcp docker\_connectivity\_1

a2a452a94bc6 mongo:5.0 "docker-entrypoint.s…" 5 months ago Up 2 months 0.0.0.0:27017->27017/tcp docker\_mongodb\_1

25718605bfb8 eclipse/ditto-policies:latest "/usr/bin/tini -- sh…" 5 months ago Up 27 hours (healthy) 8080/tcp docker\_policies\_1

## RedHat Keycloak

13.0.1

b66472279aac quay.io/keycloak/keycloak:13.0.1 "/opt/jboss/tools/do…" 5 months ago Up 2 months 8443/tcp, 0.0.0.0:60070->8080/tcp keycloak\_pms

## Stride threat list

|  |  |  |
| --- | --- | --- |
| **Type** | **Description** | **Security Control** |
| Spoofing | Threat action aimed at accessing and use of another user’s credentials, such as username and password | Authentication |
| Tampering | Threat action intending to maliciously change or modify persistent data, such as records in a database, and the alteration of data in transit between two computers over an open network, such as the Internet | Integrity |
| Repudiation | Threat action aimed at performing prohibited operations in a system that lacks the ability to trace the operations | NonRepudiation |
| Information disclosure | Threat action intending to read data in transit | Confidentiality |
| Denial of service | Threat action attempting to deny access to valid users, such as by making a web server temporarily unavailable or unusable | Availability |
| Elevation of privilege | Threat action intending to gain privileged access to resources in order to gain unauthorized access to information or to compromise a system | Authorization |

## DREAD model

DREAD is a risk assessment model to determine ranking or priority of threats. It based on following factors

* Damage: How big would the damage be if the attack succeeded?
* Reproducibility: How easy is it to reproduce an attack?
* Exploitability: How much time, effort, and expertise is needed to exploit the threat?
* Affected Users: If a threat were exploited, what percentage of users would be affected?
* Discoverability: How easy is it for an attacker to discover this threat?

A point system of numbers 1-10, representing low to high severity, is assigned to each factor to arrive at a mean [DREAD](https://en.wikipedia.org/wiki/DREAD_(risk_assessment_model)) score

## Database backup & restore

* docker exec –it docker\_mongodb\_1 /bin/sh //enter into mongodb container
* mongodump --archive=/tmp/dump.gz –gzip //dump all thing data
* tar -cf - dump.gz --mode u=+rw,g=+r,o=+r --owner 999 --group 999 | docker cp - docker\_mongodb\_1:/tmp //copy mongo dump to restore in ditto mongo
* mongorestore --archive=/tmp/dump.gz --gzip

## Sample thing data

{

"thingId": "pacemaker:E4-E1-12-54-A7-00",

"policyId": "pacemaker:E4-E1-12-54-A7-00-policy",

"definition": "com.calyan:pacemaker:0.1.0",

"attributes": {

"subjectId": "SubjectDFUP02",

"serialnumber": "AAA88888AAB",

"mfgdate": "2022/08/21",

"blekey\_mfg": "blekeymfg",

"blekey\_patient": "blekeypat",

"blekey\_clinician": "blekeydr",

"macid": "E4-E1-12-54-A7-00",

"model": "0.1",

"technology": "VVIP",

"version": {

"sw": {

"minor": "0.1",

"major": "2.3.1"

},

"hw": "0.0.2",

"fw": "1.2",

"implant": true

}

},

"features": {

"devicebatteryparameters": {

"properties": {

"raw": "a5 a5 a5 a5 6f 24 0a 00 0b 00 0c 00 00 00 0e 00 0f 00 10 00 11 00 12 00 13 00 14 00 15 00 16 00 17 00 18 00 19 00 1a 00 00 00 e8 03 00 00 00 08 a7 0a 1e 00 6d 5c 4d 00 5f 08 00 00 5e 1e e6 63 91 a0 fa ff 4b 4b 00 00 44 0a 00 00 6d 3b 02 00 00 00 00 00 23 9c 0b 00 00 00 00 00 00 00 00 00 40 00 1c 01 85 00 00 00 ac 7f 00 00 00 00 eb 38 5a 5a 5a 5a",

"processed": "10,11,12,0,14,15,16,17,18,19,20,21,22,23,24,25,26,0,1000,2048,2727,30,5069933,2143,1676025438,4294615185,19275,2628,146285,0,760867,0,0,64,284,133,0,32684,0,0"

}

},

"devicestatus": {

"properties": {

"errors": {

"raw": "a5 a5 a5 a5 15 2c 00 00 45 00 02 00 02 00 cb 00 01 00 00 00 93 15 5a 5a 5a 5a",

"processed": [

"Pacing Engine Reset Occurred"

]

},

"batteryvoltage": {

"raw": "a5 a5 a5 a5 0b 1e ff 0f 00 00 f6 6d 5a 5a 5a 5a",

"processed": 0

}

}

},

"devicestoreddata": {

"properties": {

"ventricularmarker": {

"raw": "a5 a5 a5 a5 11 0a 03 00 00 00 03 00 00 00 00 00 9f 47 5a 5a 5a 5a",

"processed": "50,50"

},

"histogrampacing": {

"raw": "a5 a5 a5 a5 51 0a 20 00 00 00 05 00 00 00 0c 00 00 00 24 7c 00 00 12 bf 01 00 00 00 00 00 01 00 00 00 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 01 00 00 00 00 00 00 00 01 00 00 00 00 00 d8 b2 5a 5a 5a 5a",

"processed": "0.02187510681204498,0.0034179854393820283,0.008203165054516869,21.72471545271217,78.23768670745463,0,0.0006835970878764057,0.0013671941757528114,0,0,0,0,0,0.0006835970878764057,0,0.0006835970878764057,0,0.0006835970878764057"

},

"histogramsensing": {

"raw": "a5 a5 a5 a5 51 0a 1f 00 00 00 3b 00 00 00 01 00 00 00 08 00 00 00 39 00 00 00 38 00 00 00 0b 00 00 00 01 00 00 00 04 00 00 00 24 00 00 00 00 00 00 00 02 00 00 00 02 00 00 00 06 00 00 00 03 00 00 00 01 00 00 00 01 00 00 00 3e 00 00 00 00 00 c6 5a 5a 5a 5a 5a",

"processed": "9.090909090909092,17.302052785923753,0.2932551319648094,2.346041055718475,16.715542521994134,16.422287390029325,3.225806451612903,0.2932551319648094,1.1730205278592376,10.557184750733137,0,0.5865102639296188,0.5865102639296188,1.7595307917888563,0.8797653958944281,0.2932551319648094,0.2932551319648094,18.181818181818183"

},

"rwaveampwkmax": {

"raw": "a5 a5 a5 a5 c5 0a 51 02 00 00 f1 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 e0 ab 5a 5a 5a 5a",

"processed": "7.240537240537241,NaN,9.194139194139193,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN"

},

"rwaveampwkmin": {

"raw": "a5 a5 a5 a5 c5 0a 51 02 00 00 f1 02 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 e0 ab 5a 5a 5a 5a",

"processed": "7.240537240537241,NaN,9.194139194139193,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN"

},

"leadimpwkmax": {

"raw": "a5 a5 a5 a5 c5 0a b0 ff ee ff b6 ff ee ff ef ff ed ff e8 ff e6 ff ee ff f1 ff ed ff ef ff e7 ff ef ff f1 ff ef ff 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 d5 74 5a 5a 5a 5a",

"processed": "7267,33100.333333333336,7875.108108108108,33100.333333333336,35061.117647058825,31345.947368421053,24767,22843.923076923078,33100.333333333336,39767,31345.947368421053,35061.117647058825,23767,35061.117647058825,39767,35061.117647058825,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN"

},

"leadimpwkmin": {

"raw": "a5 a5 a5 a5 c5 0a b0 ff ee ff b6 ff ee ff ef ff ed ff e8 ff e6 ff ee ff f1 ff ed ff ef ff e7 ff ef ff e6 ff f4 fd 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 04 d9 5a 5a 5a 5a",

"processed": "7267,33100.333333333336,7875.108108108108,33100.333333333336,35061.117647058825,31345.947368421053,24767,22843.923076923078,33100.333333333336,39767,31345.947368421053,35061.117647058825,23767,35061.117647058825,22843.923076923078,912.0381679389313,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN,NaN"

}

}

},

"egmstream": {

"properties": {

"streams": [

[

{

"rawData": "a5 a5 a5 a5 3b 0f 19 07 15 07 16 07 0c 07 16 07 13 07 13 07 14 07 16 07 13 07 10 07 18 07 0e 07 13 07 13 07 15 07 18 07 11 07 14 07 15 07 0a 07 12 07 13 07 13 07 15 07 00 00 9a 62 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "13.865995115995116,13.835470085470087,13.843101343101344,13.766788766788768,13.843101343101344,13.820207570207568,13.820207570207568,13.827838827838828,13.843101343101344,13.820207570207568,13.797313797313796,13.858363858363859,13.782051282051281,13.820207570207568,13.820207570207568,13.835470085470087,13.858363858363859,13.804945054945055,13.827838827838828,13.835470085470087,13.751526251526252,13.812576312576311,13.820207570207568,13.820207570207568,13.835470085470087"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 1c 07 17 07 16 07 ff 06 13 07 14 07 14 07 16 07 15 07 14 07 16 07 08 07 11 07 19 07 14 07 12 07 12 07 12 07 13 07 10 07 14 07 11 07 12 07 15 07 14 07 00 00 a0 8d 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "13.88888888888889,13.850732600732602,13.843101343101344,13.667582417582418,13.820207570207568,13.827838827838828,13.827838827838828,13.843101343101344,13.835470085470087,13.827838827838828,13.843101343101344,13.736263736263737,13.804945054945055,13.865995115995116,13.827838827838828,13.812576312576311,13.812576312576311,13.812576312576311,13.820207570207568,13.797313797313796,13.827838827838828,13.804945054945055,13.812576312576311,13.835470085470087,13.827838827838828"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 1b 07 17 07 13 07 0c 07 14 07 16 07 14 07 13 07 12 07 14 07 14 07 0c 07 13 07 13 07 17 07 13 07 13 07 17 07 14 07 09 07 13 07 11 07 16 07 17 07 13 07 00 00 8f 9b 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

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},

{

"rawData": "a5 a5 a5 a5 3b 0f 1a 07 15 07 05 07 12 07 14 07 13 07 15 07 14 07 11 07 13 07 10 07 18 07 16 07 12 07 0f 07 18 07 18 07 17 07 17 07 07 07 14 07 15 07 1a 07 17 07 13 07 00 00 ee a8 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "13.873626373626374,13.835470085470087,13.713369963369962,13.812576312576311,13.827838827838828,13.820207570207568,13.835470085470087,13.827838827838828,13.804945054945055,13.820207570207568,13.797313797313796,13.858363858363859,13.843101343101344,13.812576312576311,13.78968253968254,13.858363858363859,13.858363858363859,13.850732600732602,13.850732600732602,13.72863247863248,13.827838827838828,13.835470085470087,13.873626373626374,13.850732600732602,13.820207570207568"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 15 07 13 07 0a 07 0c 07 63 07 54 07 63 07 63 07 63 07 63 07 5b 07 63 07 63 07 63 07 63 07 63 07 65 07 93 08 29 28 dd 07 9a 07 71 07 59 07 47 07 3c 07 00 00 32 fb 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,8192,0,0,0,0,0,0",

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"heartRateValues": "13.835470085470087,13.820207570207568,13.751526251526252,13.766788766788768,14.43070818070818,14.316239316239315,14.43070818070818,14.43070818070818,14.43070818070818,14.43070818070818,14.369658119658121,14.43070818070818,14.43070818070818,14.43070818070818,14.43070818070818,14.43070818070818,14.445970695970695,16.7506105006105,15.941697191697191,15.361721611721611,14.85042735042735,14.537545787545787,14.354395604395606,14.217032967032967,14.133089133089133"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 3b 07 18 07 1e 07 1e 07 1a 07 1a 07 17 07 17 07 14 07 11 07 09 07 12 07 14 07 16 07 15 07 13 07 18 07 14 07 0b 07 17 07 13 07 16 07 16 07 13 07 18 07 00 00 a1 55 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "14.125457875457874,13.858363858363859,13.904151404151403,13.904151404151403,13.873626373626374,13.873626373626374,13.850732600732602,13.850732600732602,13.827838827838828,13.804945054945055,13.743894993894994,13.812576312576311,13.827838827838828,13.843101343101344,13.835470085470087,13.820207570207568,13.858363858363859,13.827838827838828,13.75915750915751,13.850732600732602,13.820207570207568,13.843101343101344,13.843101343101344,13.820207570207568,13.858363858363859"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 10 07 09 07 15 07 14 07 12 07 14 07 14 07 13 07 15 07 07 07 15 07 15 07 14 07 11 07 14 07 11 07 13 07 0a 07 16 07 15 07 14 07 14 07 12 07 13 07 13 07 00 00 2e 9a 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "13.797313797313796,13.743894993894994,13.835470085470087,13.827838827838828,13.812576312576311,13.827838827838828,13.827838827838828,13.820207570207568,13.835470085470087,13.72863247863248,13.835470085470087,13.835470085470087,13.827838827838828,13.804945054945055,13.827838827838828,13.804945054945055,13.820207570207568,13.751526251526252,13.843101343101344,13.835470085470087,13.827838827838828,13.827838827838828,13.812576312576311,13.820207570207568,13.820207570207568"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 15 07 09 07 13 07 11 07 14 07 13 07 13 07 13 07 12 07 0b 07 13 07 15 07 19 07 13 07 12 07 14 07 13 07 0b 07 14 07 17 07 17 07 12 07 16 07 13 07 12 07 00 00 46 23 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

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"heartRateValues": "13.835470085470087,13.743894993894994,13.820207570207568,13.804945054945055,13.827838827838828,13.820207570207568,13.820207570207568,13.820207570207568,13.812576312576311,13.75915750915751,13.820207570207568,13.835470085470087,13.865995115995116,13.820207570207568,13.812576312576311,13.827838827838828,13.820207570207568,13.75915750915751,13.827838827838828,13.850732600732602,13.850732600732602,13.812576312576311,13.843101343101344,13.820207570207568,13.812576312576311"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 13 07 13 07 12 07 12 07 15 07 10 07 14 07 13 07 08 07 14 07 15 07 11 07 16 07 15 07 13 07 16 07 09 07 12 07 11 07 16 07 17 07 13 07 11 07 11 07 13 07 00 00 22 e1 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

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"heartRateValues": "13.820207570207568,13.820207570207568,13.812576312576311,13.812576312576311,13.835470085470087,13.797313797313796,13.827838827838828,13.820207570207568,13.736263736263737,13.827838827838828,13.835470085470087,13.804945054945055,13.843101343101344,13.835470085470087,13.820207570207568,13.843101343101344,13.743894993894994,13.812576312576311,13.804945054945055,13.843101343101344,13.850732600732602,13.820207570207568,13.804945054945055,13.804945054945055,13.820207570207568"

},

{

"rawData": "a5 a5 a5 a5 3b 0f 0d 07 14 07 15 07 16 07 10 07 15 07 14 07 14 07 08 07 15 07 15 07 14 07 13 07 14 07 15 07 15 07 06 07 14 07 16 07 14 07 15 07 14 07 15 07 13 07 0b 07 00 00 c5 b2 5a 5a 5a 5a",

"vs": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"vp": "0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0",

"heartRateValues": "13.774420024420024,13.827838827838828,13.835470085470087,13.843101343101344,13.797313797313796,13.835470085470087,13.827838827838828,13.827838827838828,13.736263736263737,13.835470085470087,13.835470085470087,13.827838827838828,13.820207570207568,13.827838827838828,13.835470085470087,13.835470085470087,13.721001221001222,13.827838827838828,13.843101343101344,13.827838827838828,13.835470085470087,13.827838827838828,13.835470085470087,13.820207570207568,13.75915750915751"

},

{

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