



API Security

API Owner

Escuela de APIs

{api  addicts}



Isabelle MAUNY

- Co-founder @42Crunch
- 42Crunch delivers an API Security Platform
- Company behind apisecurity.io
- Working with APIs and integration since 2005!
- French native, in Spain since 2003

- isabelle@apis.coach



What are our customers saying?

API Security is a universal issue.

12 September, 24

Issue 254: WhatsApp and IBM WebMethods vulnerabilities, **3rd-party API and LLM risks**, API access controls

29 August, 24

Issue 253: Breached companies face litigation, **SQL injection in Cisco APIs**, API Security for Automotive & Finance

15 August, 24

Issue 252: API Security in APAC, Crowdstrike and canary tests, **API vulnerabilities in solar platforms and React apps**, Costs of a data breach

1 August, 24

Issue 251: FCC mandates API security, **API vulnerabilities in dating apps and Docker plugins**, Life360 API data leak

18 July, 24

Issue 250: Authy API breach, **US agencies push secure by design**, APIs grill IoT devices, shares by our readers

4 July, 24

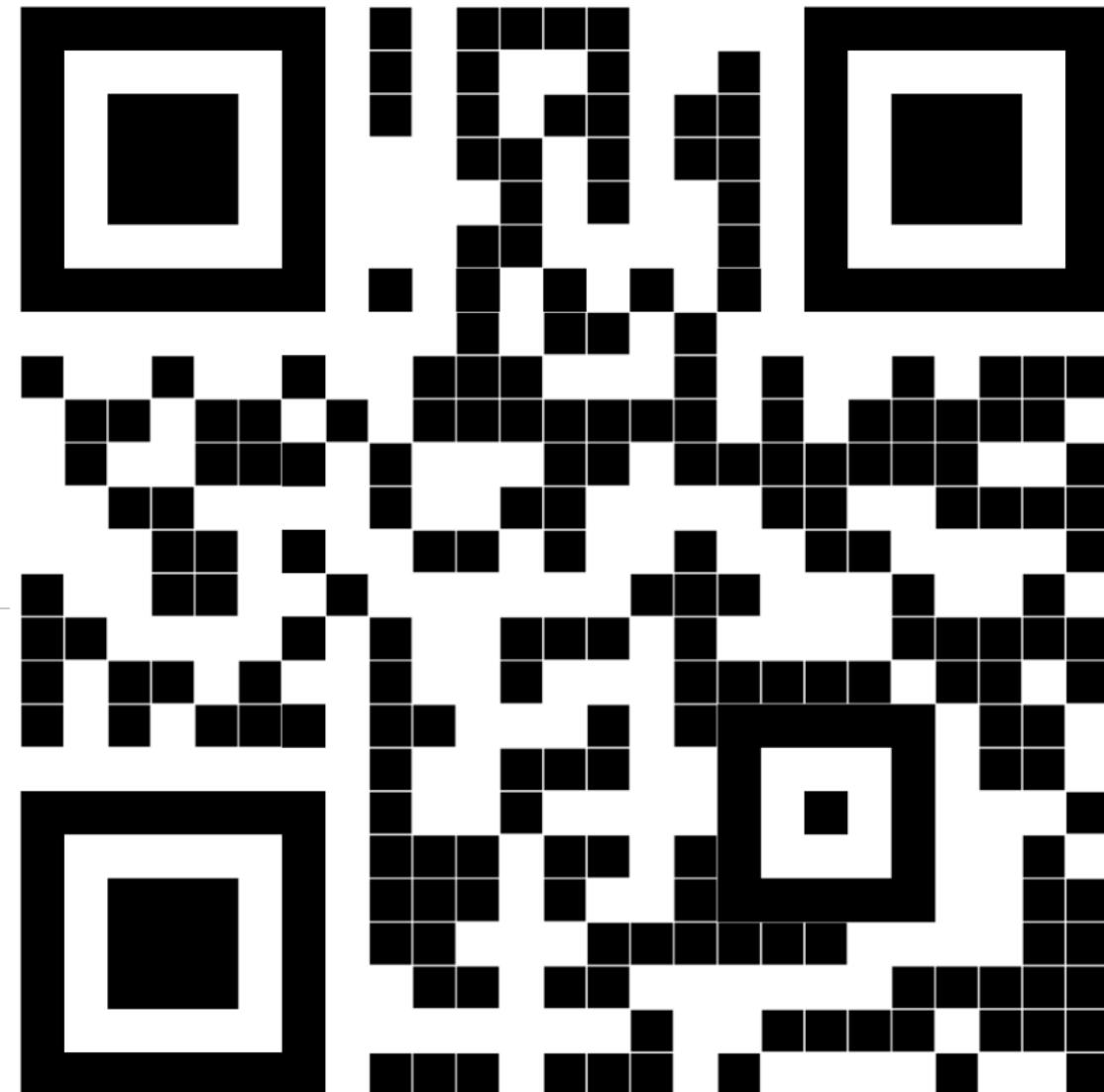
Issue 249: **Major API breach at Optus**, CocoaPods exposed, Bad Bots and API DoS attacks, Webinar: 2024 API breaches

20 June, 24

Issue 248: API penetration of apps and modems, **GraphQL and its discontents**, API security for supply chain and automotive

31 May, 24

Issue 247: **Dropbox and Dell breaches**, vulnerability in Next.js, API growth causing concerns



<https://apisecurity.io>

 IS**You**

when was the first input validation cheat sheet published by OWASP?

 ChatGPT

The first OWASP Input Validation Cheat Sheet was published on September 7, 2005. This resource was created to provide developers with guidance on how to effectively validate input data to prevent common security vulnerabilities such as injection attacks (e.g., SQL injection, XSS).

Nothing New !

Says the wise ChatGPT

 IS**You**

what is OWASP ?

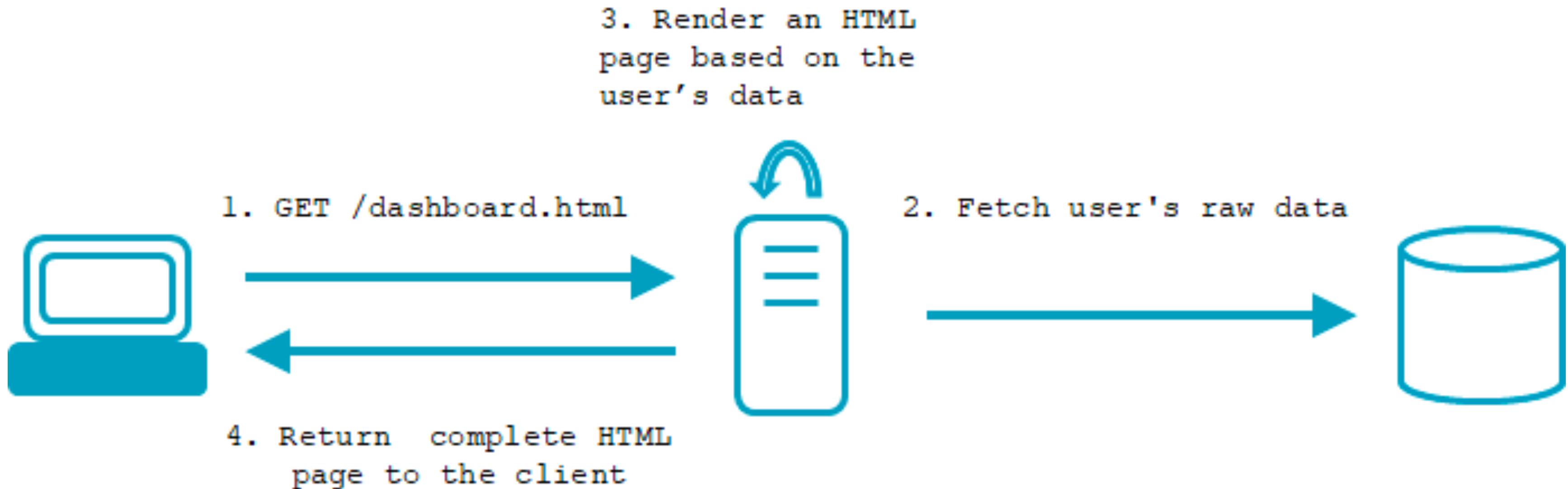
 ChatGPT

OWASP stands for the Open Web Application Security Project. It is a non-profit organization focused on improving the security of software. OWASP provides resources, tools, and documentation to help developers, security professionals, and organizations understand and mitigate security risks in web applications and software systems.

**SO, WHY ARE APIs
SUCH A PROBLEM?**

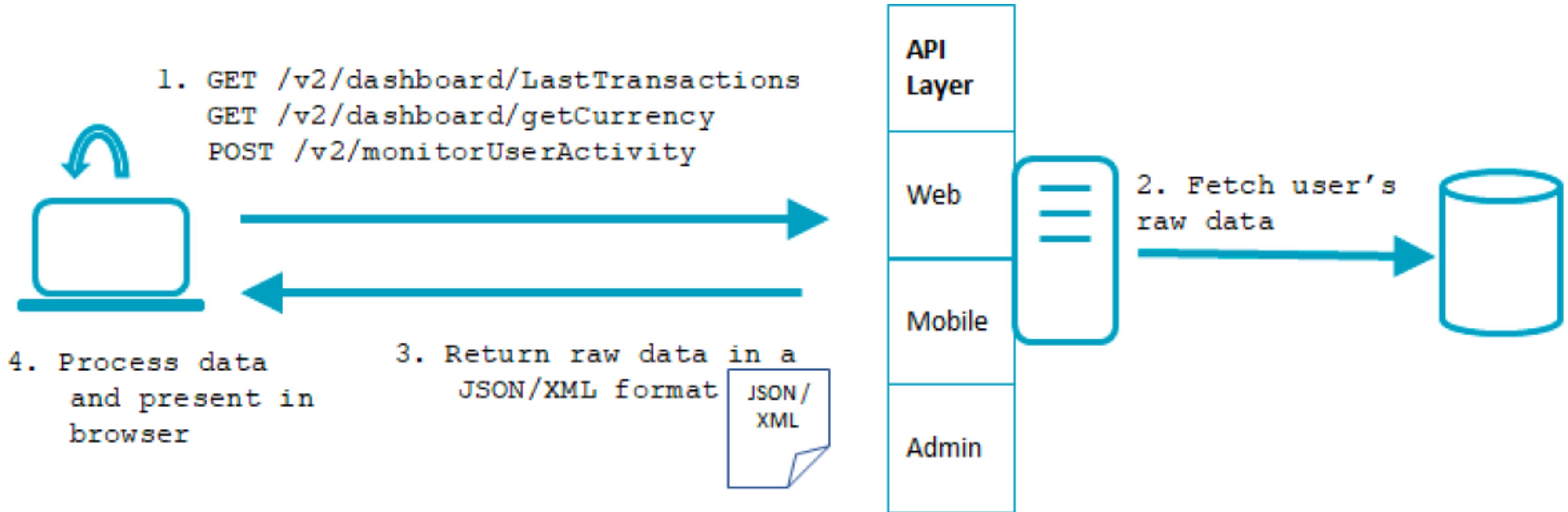


“Traditional” web architecture



<https://apisecurity.io/encyclopedia/content/owasp/owasp-api-security-top-10.htm>

API-based API architecture



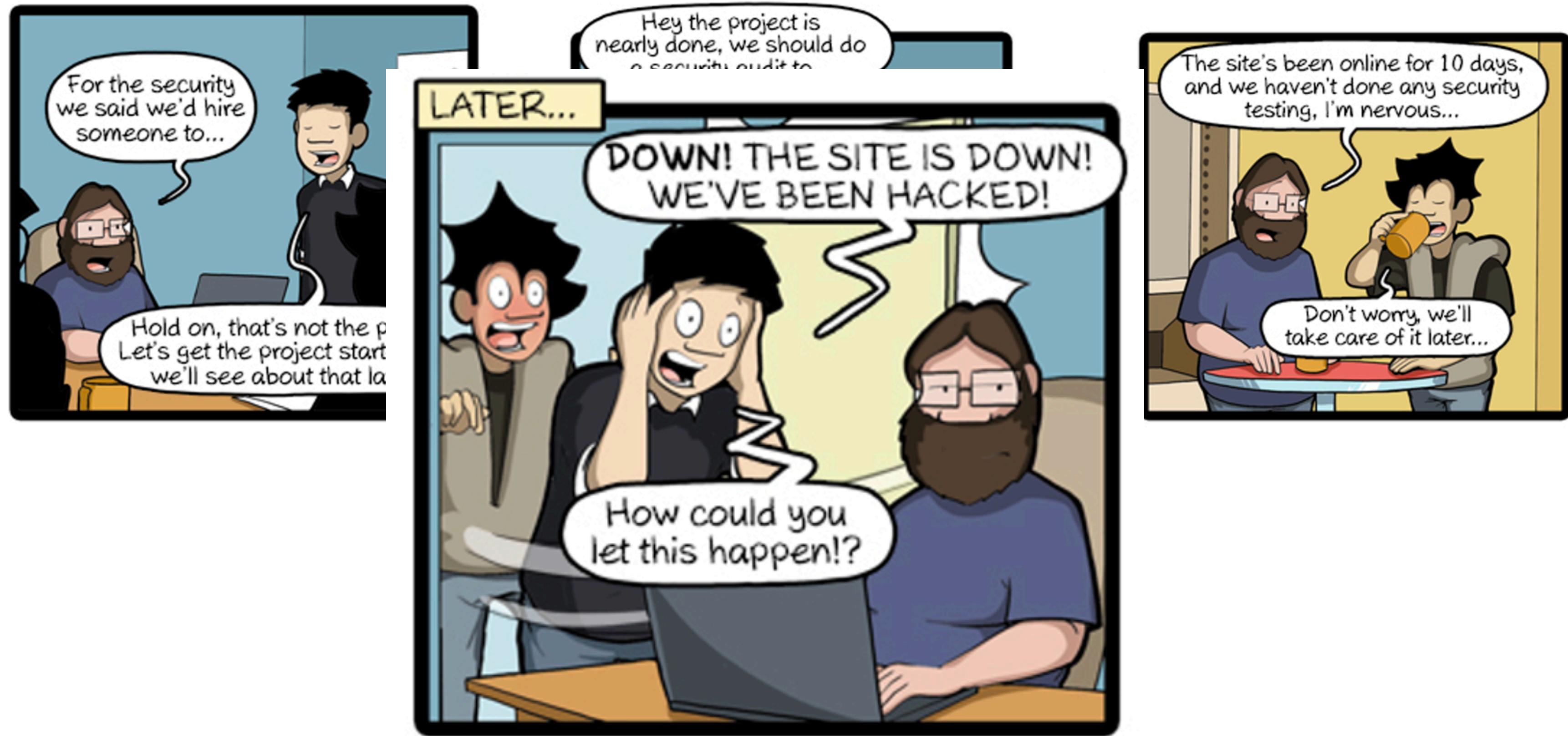
<https://apisecurity.io/encyclopedia/content/owasp/owasp-api-security-top-10.htm>



APIs are the heart of application development and integration

“APIs are popping up like mushrooms in my data centers”

From a desperate Fortune 500 CISO



CommitStrip.com

Security is still an afterthought!

Start testing security scenarios as early as possible

Bad design!

APIs suffer from **many design flaws**, which are hard, sometimes impossible to fix without a redesign.

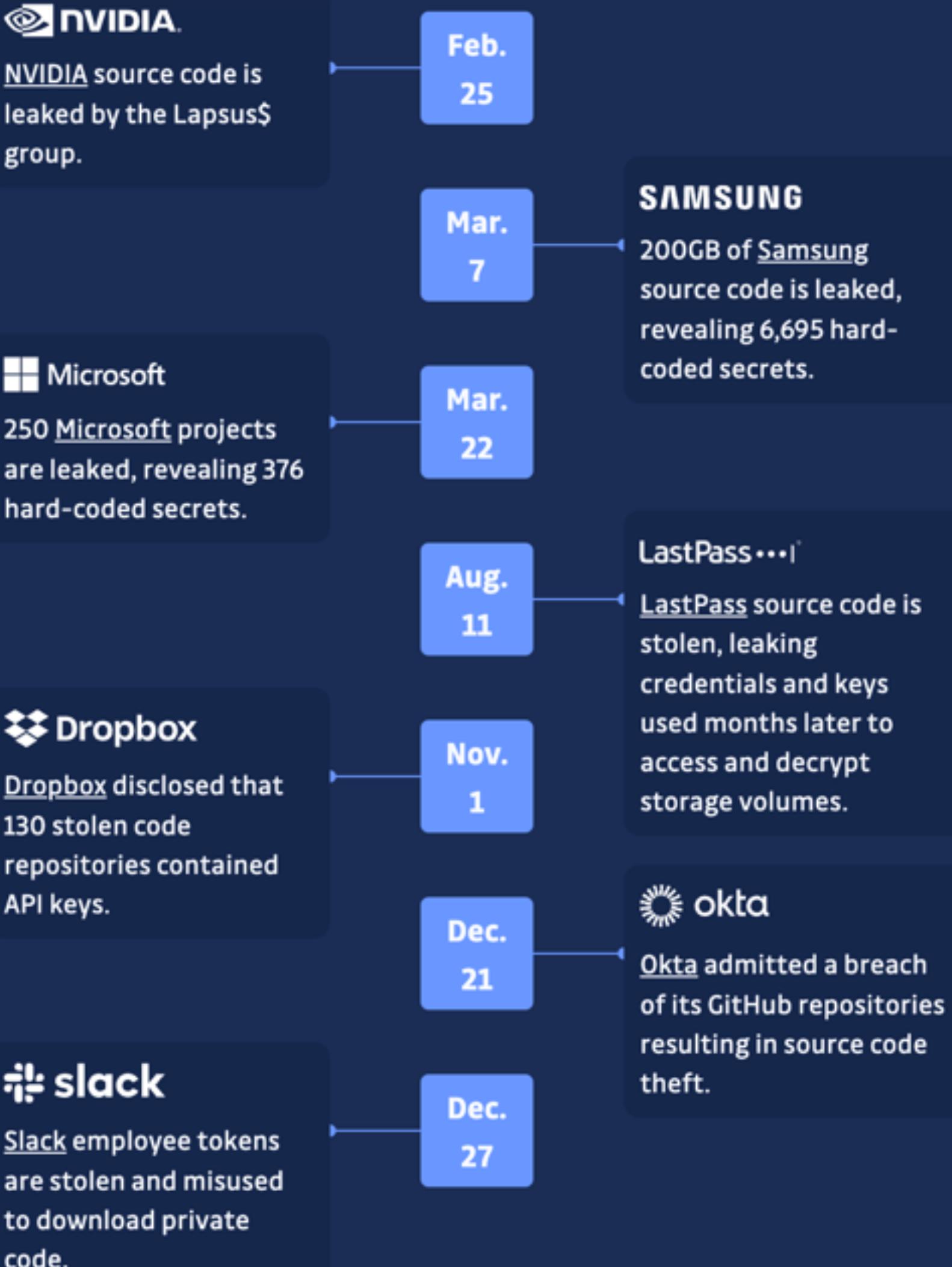


Loosing the keys

- Hardcoded tokens and keys
- Committed in Github
- Leaked in Paste.bin
- Leaked in Docker images

Secret scanning tools are your friend!

- Gitguardian
- GitLeaks (OSS)
- Github Secret Scanning





A BIT OF VOCABULARY

Security Goals Overview

INTEGRITY

Message has not been tampered with

CONFIDENTIALITY

Message can only be seen by target audience

AVAILABILITY

Resistance to attacks, such as Denial-of-service (DOS)

AUTHENTICATION

Identity of the caller is known.

AUTHORIZATION

We can guarantee the caller has proper permissions to access a resource

AUDIT

System has non-perishable trace of all machine/human interactions.

NON-REPUDIATION

There is (legal) proof that the action has taken place.

SECURITY PRINCIPLES



API Security is risk based

- Threat Model
- Data Classification
- Actors Identification



You can't protect what you don't know!

- API Catalog
- API Governance
- API Security Status



No Trust



An API on the Internet is a public API



GUIDING FRAMEWORK





OWASP API Security

Top Ten - 2023

- API1:2023 Broken Object Level Access Control
- API2:2023 Broken Authentication
- API3:2023 Broken Object Property Level Authorization (**Updated**)
- API4:2023 Unrestricted Resources Consumption
- API5:2023 Broken Function Level Authorization
- API6:2023 Unrestricted Access to Sensitive Business Flows (**New**)
- API7:2023 Server Side Request Forgery (**New**)
- API8:2023 Security Misconfiguration
- API9:2023 Improper Inventory Management
- API10:2023 Unsafe Consumption of APIs (**New**)



BAD PROBLEMS USUALLY OCCUR WHEN MULTIPLE OF THESE ARE COMBINED

Testing Pixi

- Github project: <https://github.com/isamauny/apisecurity-training>
 - Local build with docker compose
 - Postman Collection
- API runs at <http://localhost:8090>
- Cloud version available here: <https://pixiapp.uksouth.cloudapp.azure.com>

AUTHORIZATION



Authorization Levels

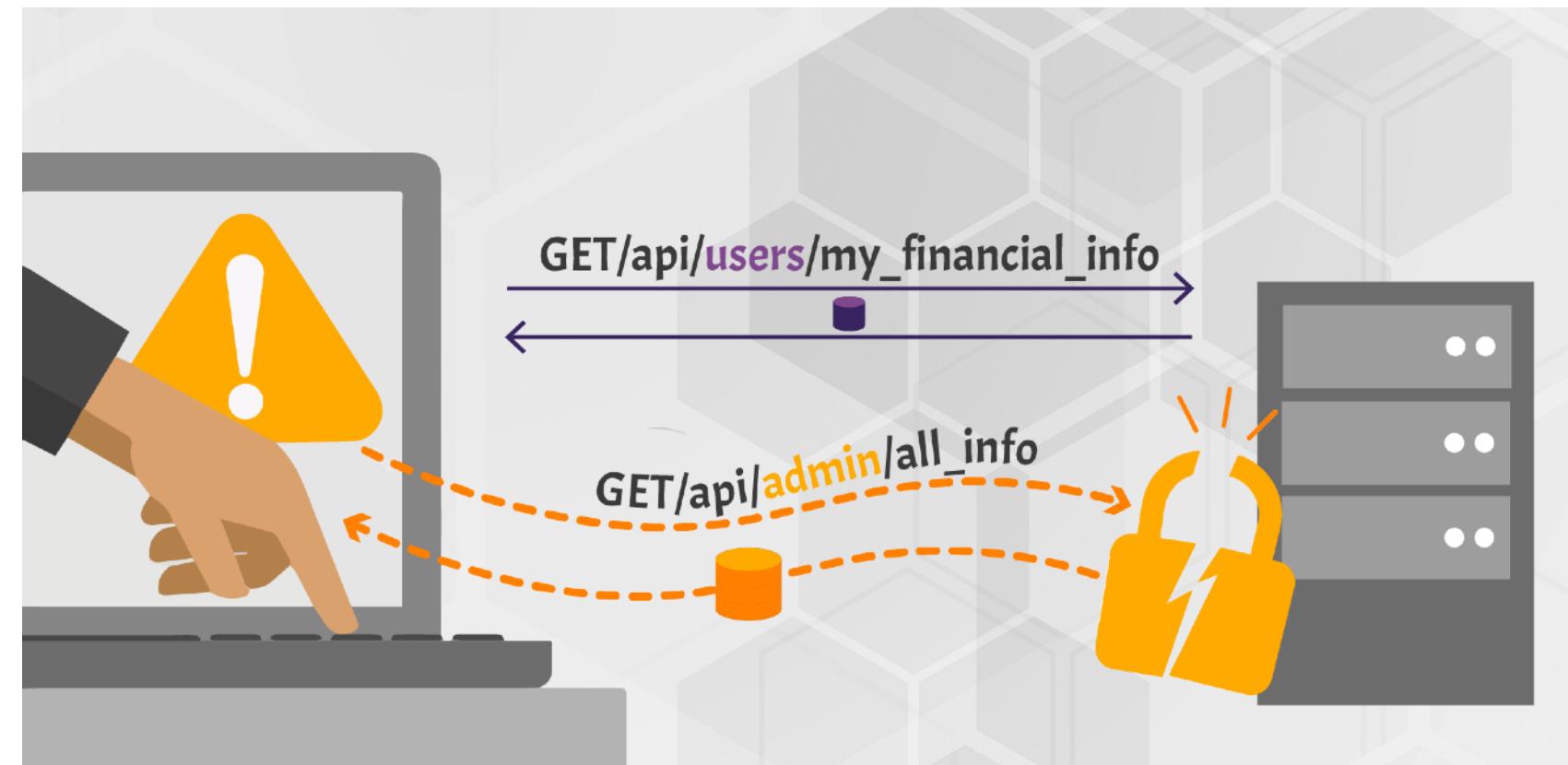
```
"/picture/{id}": { ← API5: BFLA
  "delete": {
    Scan | Try it! Audit ← API1: BOLA
    "parameters": [
      {
        "schema": {
          "type": "string",
          "format": "uuid",
          "pattern": "^[0-9A-Fa-f]{8}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{4}-[0-9A-Fa-f]{12}$",
          "minLength": 36,
          "maxLength": 36
        },
        "name": "id",
        "in": "path",
        "required": true
      }
    ],
    "responses": {
      "200": {
        "description": "Picture was deleted successfully",
        "content": {
          "application/json": {
            "schema": {
              "type": "object",
              "additionalProperties": false,
              "properties": {
                "message": {
                  "type": "string",
                  "maxLength": 100
                }
              },
              "required": [
                "message"
              ]
            }
          }
        }
      }
    }
  }
},
```

The diagram illustrates the structure of a nested API definition. The outermost part defines a resource at `/picture/{id}` with a `delete` method. This method includes a parameter named `id` which is required and has a specific schema: it must be a UUID string. The response to a successful deletion (`200`) is a JSON object containing a single `message` field, which is a string with a maximum length of 100 characters. Annotations are present: a yellow arrow labeled **API5: BFLA** points to the path `/picture/{id}`; a red arrow labeled **API1: BOLA** points to the `delete` method; and a purple arrow labeled **API 3: BOPLA** points to the `application/json` schema within the `200` response.

API5: Broken Function Level Authorization aka *BFLA*

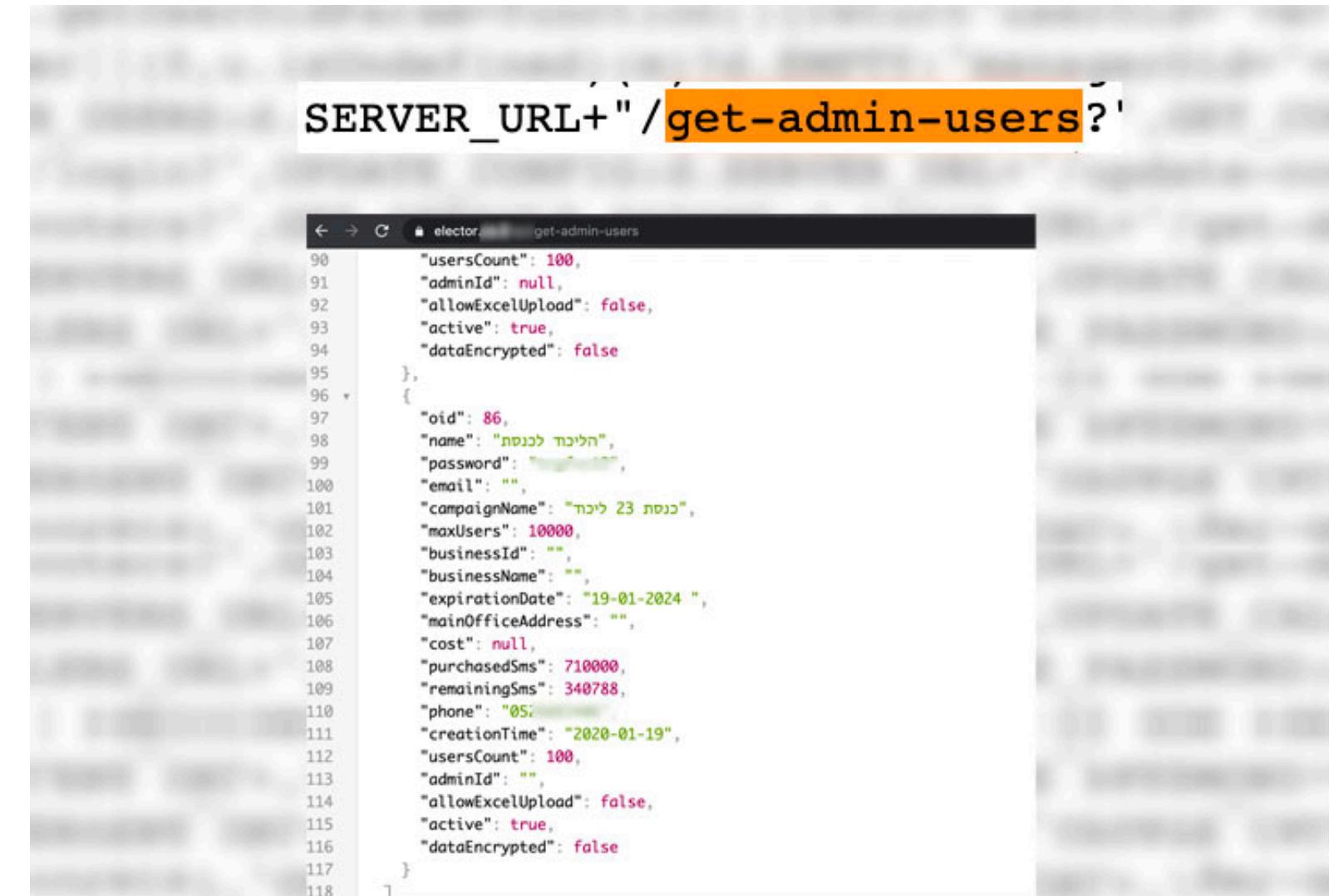
Complex access control policies with different hierarchies, groups, and roles, and an unclear separation between administrative and regular functions, tend to lead to authorization flaws.

By exploiting these issues, attackers gain access to other users' resources and/or administrative functions.



Voting App

- The Attack
 - Data breach using leaked admin userid/passwords
- Core Issues
 - Admin endpoint left open with no authentication
 - Allows to retrieve all systems users, including the password (in clear).
 - **Endpoint was hardcoded in application source code.**



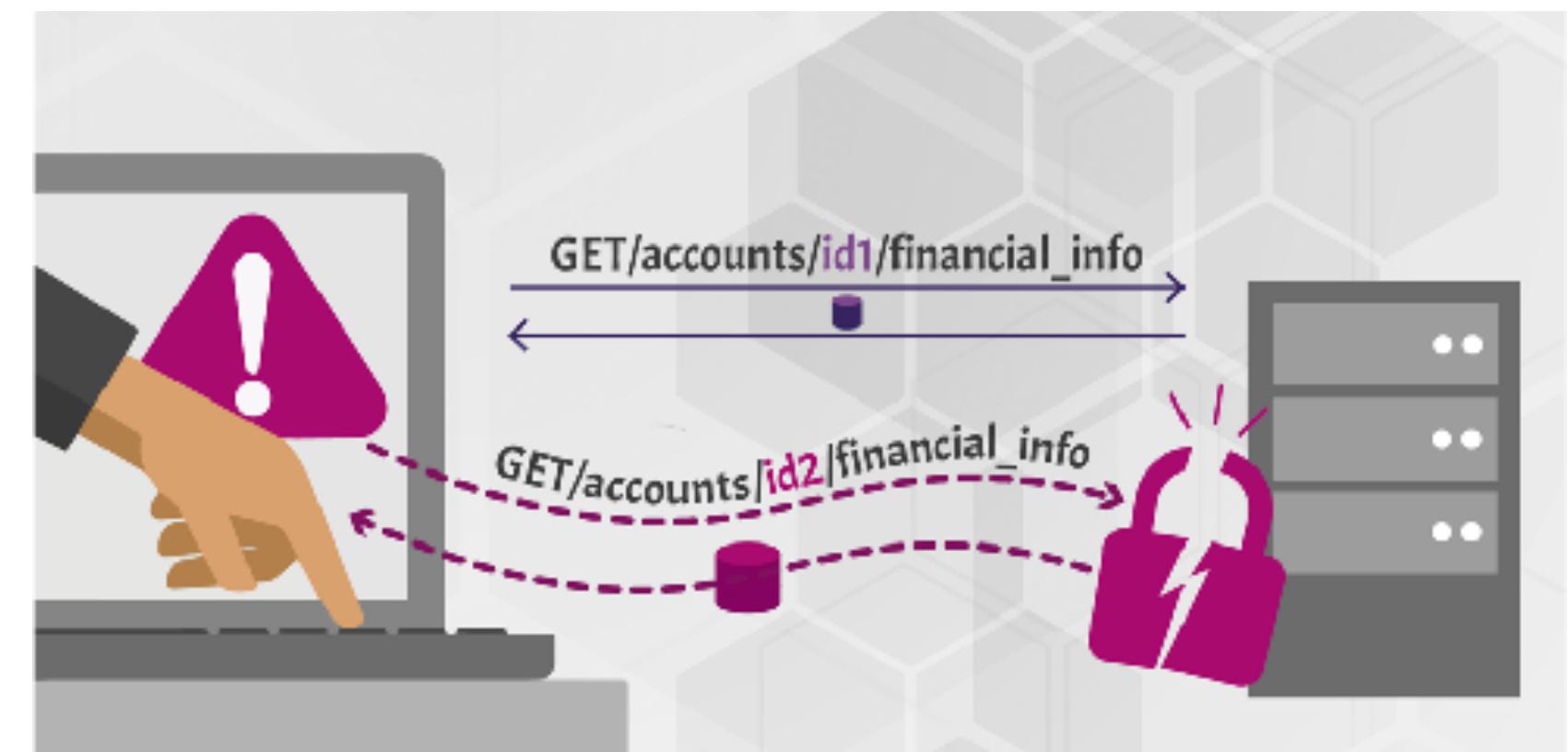
```
curl -X GET SERVER_URL+"/get-admin-users?"
```

```
90 "usersCount": 100,
91 "adminId": null,
92 "allowExcelUpload": false,
93 "active": true,
94 "dataEncrypted": false
95 },
96 {
97 "oid": 86,
98 "name": "הילכוד לכתבת",
99 "password": "1234567890",
100 "email": "",
101 "campaignName": "כנתת 23 ליכת",
102 "maxUsers": 10000,
103 "businessId": "",
104 "businessName": "",
105 "expirationDate": "19-01-2024",
106 "mainOfficeAddress": "",
107 "cost": null,
108 "purchasedSms": 710000,
109 "remainingSms": 340788,
110 "phone": "052-1234567",
111 "creationTime": "2020-01-19",
112 "usersCount": 100,
113 "adminId": null,
114 "allowExcelUpload": false,
115 "active": true,
116 "dataEncrypted": false
117 }
118 }
```

API1: Broken Object Level Access Control aka *BOLA*

APIs tend to expose endpoints that handle object identifiers, creating a wide attack surface Level Access Control issue.

Object level authorization checks should be considered in every function that accesses a data source using an input from the user.



Large Telco

- The Attack
 - Attackers have been able to gather details from millions of users through their phone number.
- Core Issues
 - GET mytelco.com/user_profile/1883456789
 - No rate limiting
 - Guessable/known IDs (phone numbers)
 - No authorization validation



DEMO TIME



Addressing BFLA Issues

- Design properly your authorization policies and test them !
 - OAuth scopes can be used to restrict the access to operations.
- Avoid mixing admin and non-admin operations in the same API
 - Easy to discover via dictionary attacks
- Restrict access to admin APIs, for example:
 - by Mutual TLS
 - by (validated!) IP Range
 - **Do not** rely on the client to do that!

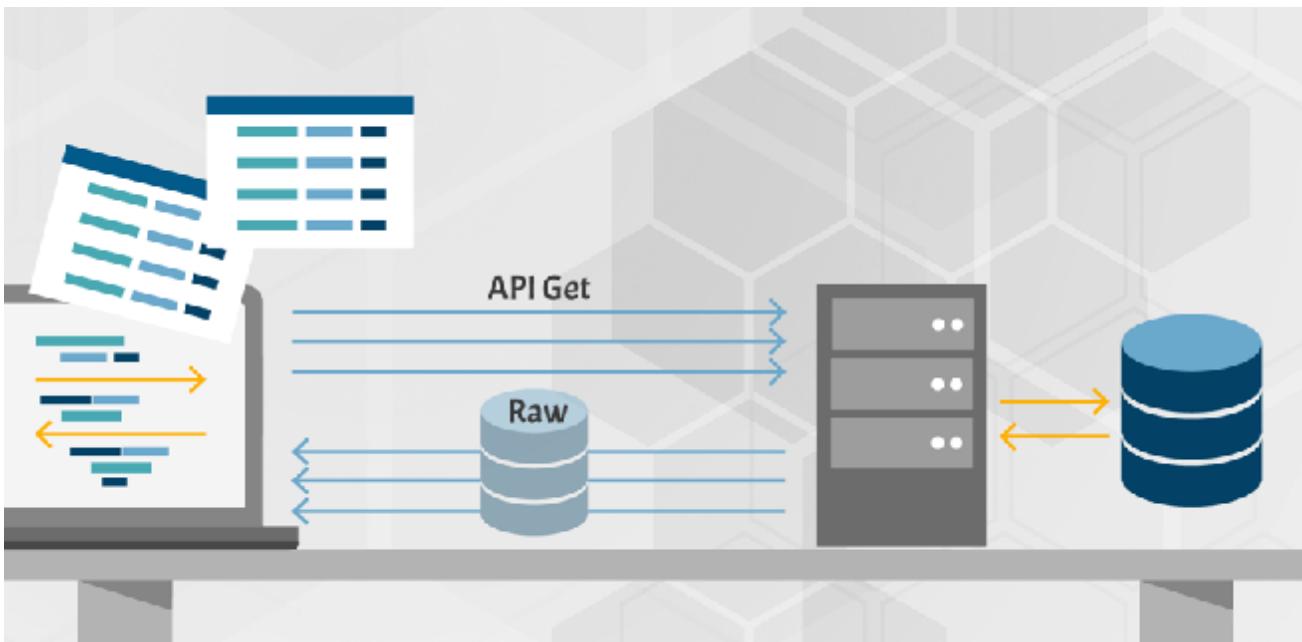
Addressing BOLA Issues

- **True fix : Fine-grained authorisation to resources in every controller layer**
 - Decision engine is required, preferably externally to the code.
 - Need to be able to enforce something like :
 - *Jean is allowed to access account 123, but cannot edit or delete it.*
 - *Peter is not allowed to access account 123*
- Potential *mitigation* approaches
 - Avoid using IDs when possible: GET <https://myapis.com/phone/me>
 - Avoid iterative IDs (123, 124, 125...)
 - Avoid exposing internal IDs through your APIs (for example internal database IDs)
 - Mitigate potential data scrapping by putting **rate limiting** in place (and alerting!)
- **OAuth scopes are not helping here, as they limit access to a function and not to a resource.**

DATA AUTHORIZATION

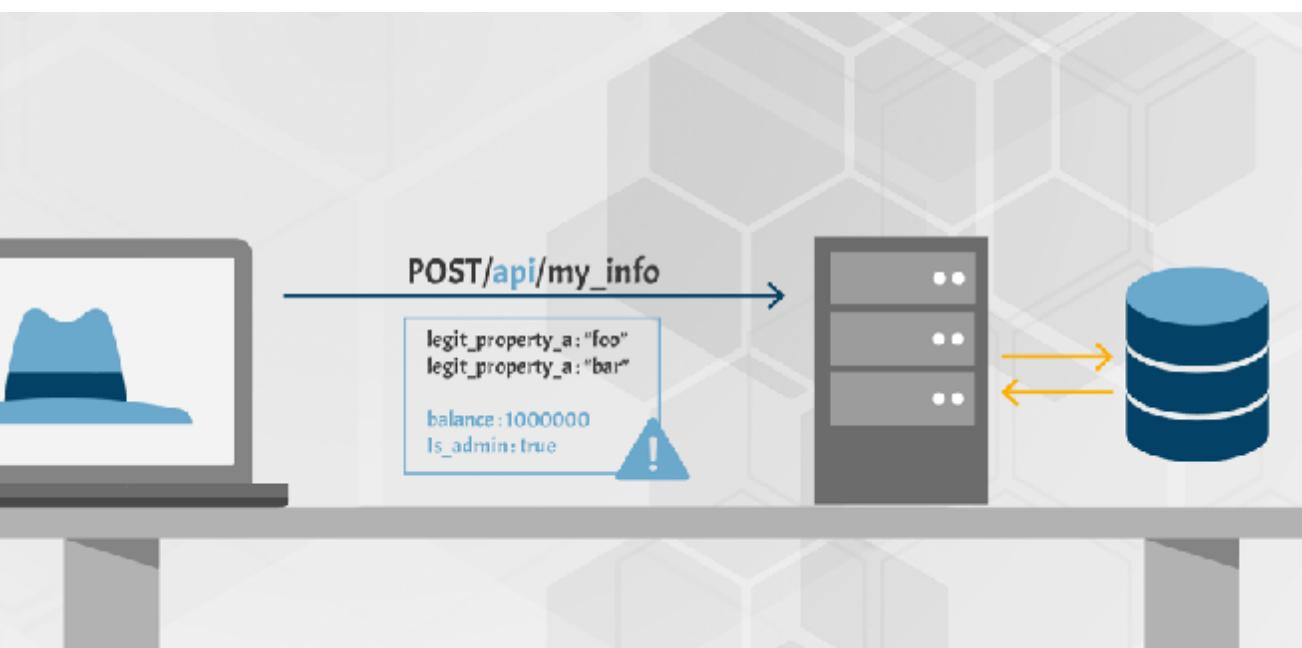


API3: Broken Object Property Level Authorization



Input Data

Binding client provided data (e.g., JSON) to data models, without proper properties filtering based on an allowlist, usually leads to Mass Assignment. Either guessing objects properties, exploring other API endpoints, reading the documentation, or providing additional object properties in request payloads, allows attackers to modify object properties they are not supposed to.



Output Data

Looking forward to generic implementations, developers tend to expose all object properties without considering their individual sensitivity, relying on clients to perform the data filtering before displaying it to the user.

DEMO TIME



Input Data Validation

- **No Trust (even for internal APIs and for East-West traffic)**
- Validation can happen client side, but it must happen server-side!
- Do not blindly update data from input structure
 - Apply caution when using frameworks that map directly database records to JSON objects
- Do not use the same data structures for GET and POST/PUT
- Validate Inputs
 - Only accept information specified in JSON schema (contract-based, whitelist approach) - Reject all others.
 - Also validate Headers
- **How to test**
 - Send bad verbs, bad data, bad formats, out of bounds, etc.

Output Data Validation

- Never rely on client apps to filter data : instead, create various APIs depending on consumer, with just the data they need
- **Take control of your JSON schemas !**
 - Describe the data thoroughly and **enforce the format at runtime**
 - Constraint the amount of data returned by the API
- Review and approve data returned by APIs
- Never expose tokens/sensitive/exploitable data in API responses
- Properly design [error](#) messages - Make sure they are not too verbose!
- Beware of GraphQL queries!
 - Validate fields accessed via query

JWTs transport data too!

- JWT are only **encoded**, they can leak data
- Can be prone to injections (example: [kid sql injection](#))
- Recommended best practice:
 - * Use opaque tokens for external consumption
 - * Use JWTs for internal consumption

Encoded PASTE A TOKEN HERE

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJ1c2VyIjp7Il9pZCI6ODUsImVtYWlsIjoiY3VzdG9tZXJAcGl4aS5jb20iLCJwYXNzd29yZCI6ImhlbGxvcGl4aSIsIm5hbWUiOiJjb3N0ZXhwbgFuYXRpb24iLCJwaWMiOiJodHRwczovL3MzMzLmFtYXpvbmF3cy5jb20vdWlmYWNlcyc9mYWNlcyc90d210dGVyL3NoYW5lSXhELzEyOC5qcGciLCJhY2NvdW50X2JhbGFuY2Ui0jEwMDAsImlzX2FkbWluIjpmYWxzZSwiYWxsX3BpY3R1cmVzIjpbXX0sImlhCI6MTYwMzIxNjIwOX0.DjgTBCev5Kq_DpvBwfKva3K3rLCs4r9hN17S-hh6qMI
```

Decoded EDIT THE PAYLOAD AND SECRET

HEADER: ALGORITHM & TOKEN TYPE

```
{  
  "alg": "HS256",  
  "typ": "JWT"  
}
```

PAYOUT: DATA

```
{  
  "user": {  
    "_id": 85,  
    "email": "customer@pixi.com",  
    "password": "hellopixi",  
    "name": "costexplanation",  
    "pic":  
      "https://s3.amazonaws.com/uifaces/faces/twitter/shaneIx  
      D128.jpg",  
    "account_balance": 1000,  
    "is_admin": false,  
    "all_pictures": []  
  },  
  "iat": 1603216209  
}
```

VERIFY SIGNATURE

```
HMACSHA256(  
  base64UrlEncode(header) + "." +  
  base64UrlEncode(payload),  
  your-256-bit-secret  
)  secret base64 encoded
```

AUTHENTICATION



API2: Broken Authentication

Authentication mechanisms are often implemented incorrectly, allowing attackers to compromise authentication tokens or to exploit implementation flaws to assume other user's identities temporarily or permanently. Compromising system's ability to identify the client/user, compromises API security overall.



Social Network(s)

- Several examples of:
 - No Authentication at all
 - Badly protected auth endpoints (password reset especially)
 - No proper rate limiting



Choosing an Authentication Method

- Choose authentication method balancing **risk and ease of use**:
 - Who are the consumers ?
 - What is the data/operations sensitivity ?
- **Do not use API keys or bearer tokens as proof of identity**
 - Remember a Bearer token is [like a hotel key](#): once you have it, you can open the door. There is no way to validate who you are.

Which options are available ?

Type	Format	Potential Issues	Advantages
Basic Auth	b64 encoded User/password	<ul style="list-style-type: none">• Goes in clear (encoded) over the network• Deprecated.	<ul style="list-style-type: none">• Backward compatibility
API Key	Long string of characters	<ul style="list-style-type: none">• Travels over network• Prone to leaks (Github, hardcoded in apps etc.)• Expiration management	<ul style="list-style-type: none">• Simple to use• Opaque
OAuth Access Token	<ul style="list-style-type: none">• Long string of characters• JWT	<ul style="list-style-type: none">• Used for authentication• Complexity• Carries potentially sensitive data	<ul style="list-style-type: none">• Delegated authorization• Reduced security risks• Expires
OpenID Connect	<ul style="list-style-type: none">• JWT	<ul style="list-style-type: none">• Complexity	<ul style="list-style-type: none">• True Authentication• Session/Logout management• Reduced Security Risks
Signed Requests	Digital signature in header/body	Complex for API consumers	<ul style="list-style-type: none">• Integrity of information• API/Signing keys are not travelling over network.

Your most sensitive endpoints are
authentication and password reset
endpoints.

RESOURCES ABUSE



Rate/Resources Limiting (API 4)

Quite often, APIs do not impose any restrictions on the size or number of resources that can be requested by the client/user. Not only can this impact the API server performance, leading to Denial of Service (DoS), but also leaves the door open to authentication flaws such as brute force.



Rate Limiting Recommendations

- Adjust rate limiting to risk : by API Key/access token/user identity/fingerprint
- IPs are very easy to create/forge - If you are going to use IP, validate it first (reputation, TOR, etc.)
- **Bad example:** 200 attempts per minute per IP for password reset

"In a real attack scenario, the attacker needs 5000 IPs to hack an account. It sounds big but that's actually easy if you use a cloud service provider like Amazon or Google.

It would cost around 150 dollars to perform the complete attack of one million codes"

Further DOS Protection recommendations

- Constrain the data (positive security model) : max value, max size for arrays, string patterns, max size for a file
- Additionally:
 - Set limits in container based environments (memory, CPU, file descriptors, etc.)
 - Good for DOS protection AND for the bill at the end of the month....

Weak Authentication

+

Bad Rate Limiting

=



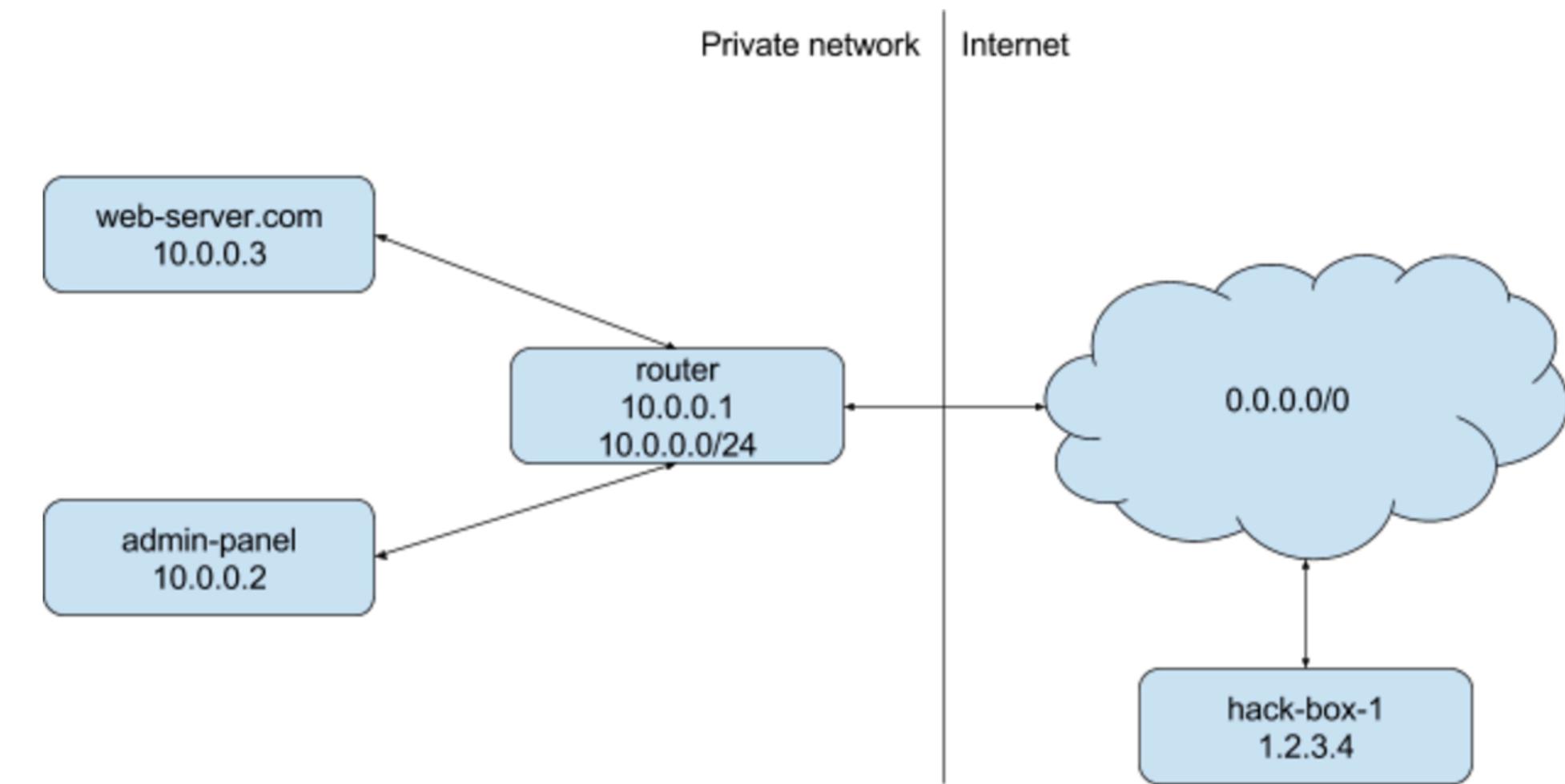


SSRF

SSRF

Server-side request forgery (also known as SSRF) is a web security vulnerability that allows an attacker to **induce the server-side application to make requests to an unintended location.**

<https://portswigger.net/web-security/ssrf>



How to protect yourself from SSRF!

- Getting Started
 - AllowList of websites you want to allow access to (vs. Deny List)
 - Network policies
 - DenyList of protocols (ftp:// , file://)
 - Disable/control redirection
- Did you know ?
 - Blacklisting <http://localhost> or <http://127.0.0.1> is not enough to prevent access to local machine
 - Try : ping 127.0 or ping 2130706433 on your machine or create a DNS entry pointing to localhost..
- Check references for more data on how attackers can circumvent prevention measures!

ADDITIONAL THREATS



API6:2023 - Unrestricted Access to Sensitive Business Flows

- Using an API in a way in which it was not designed or abusing the underlying business flow or logic
- In other words : BOTS
- Becoming a very common attack vector



How to mitigate bots ?

First a bit of Threat Modelling:

- Identify the business flows that might harm the business if they are excessively used.

Mitigation Approaches:

- **Device fingerprinting:** denying service to unexpected client devices (e.g. headless browsers) tends to make threat actors use more sophisticated solutions, thus more costly for them
- **Human detection:** using either a captcha or more advanced biometric solutions (e.g. typing patterns)
- **Non-human patterns:** analyse the user flow to detect non-human patterns (e.g. the user accessed the "add to cart" and "complete purchase" functions in less than one second)
- Consider blocking IP addresses of Tor exit nodes and well-known proxies

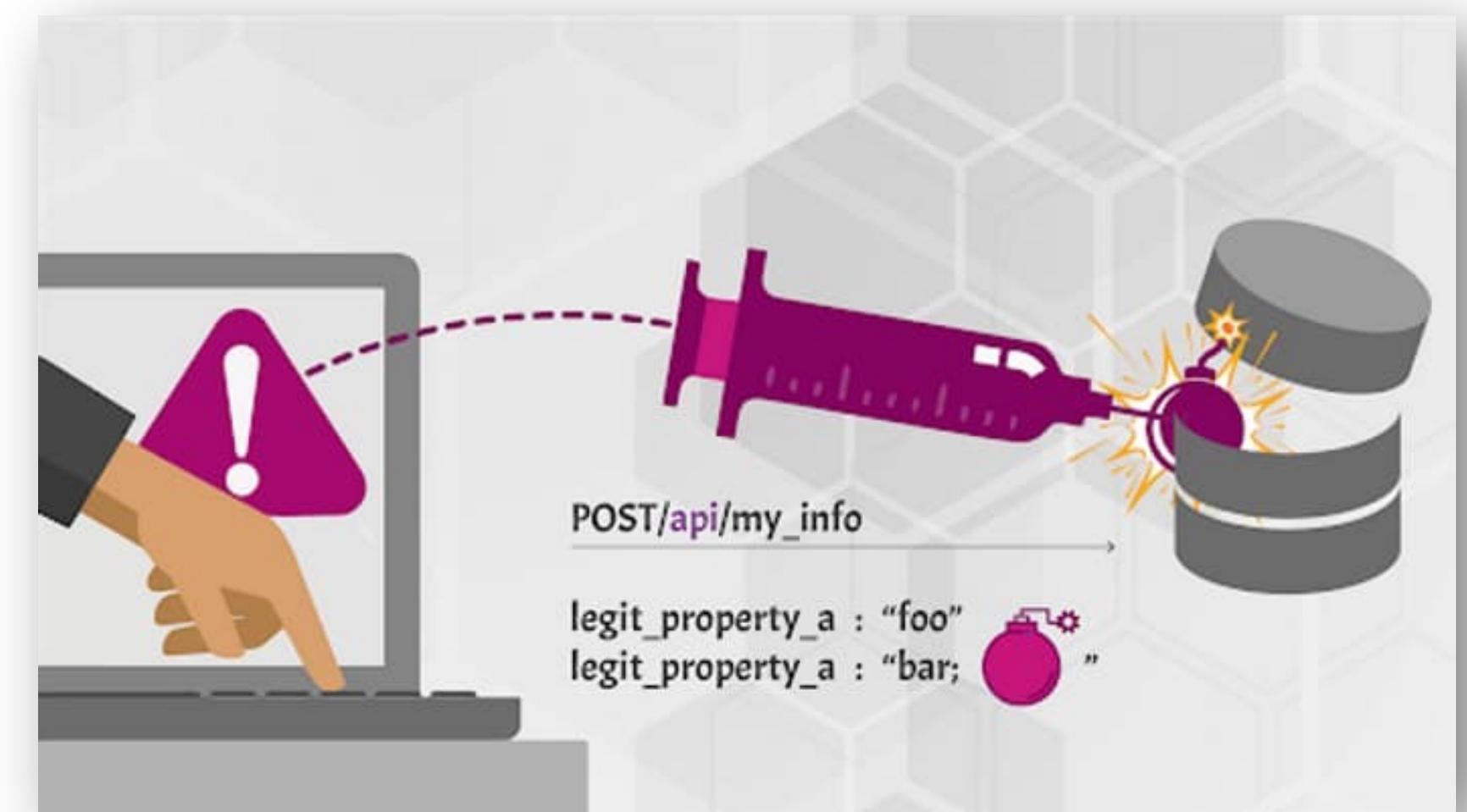
API10:2023 - Unsafe Consumption of APIs

- Developers tend to trust data received from third-party APIs more than user input
- APIs are part of a supply chain and need to be secured at every point
 - When evaluating service providers, assess their API security posture
 - Ensure all API interactions happen over a secure communication channel (TLS)
 - Always validate and properly sanitize data received from integrated APIs before using it.



What about injections?

- Injection attacks affect all software systems, not only APIs
- Injection attacks are still **very prevalent** and affect APIs frequently
- Remediation advice as per OWASP Top 10 still applies (nothing API specific)



Lack of injection in 2023 API10 #86

Open cyn8 opened this issue on Mar 8 · 19 comments

<https://github.com/OWASP/API-Security/issues/86>

<https://apisecurity.io/owasp-api-security-top-10/api8-injection/>

LOGGING



Secure Logging

- **Goals:**
 - Forensics
 - Non-repudiation
- **Need event logs** for anything unusual
 - Rejected requests (auth issues, authorization issues, data validation, application errors).
 - Critical information needs to be logged at the lowest logging level (i.e. not the debug level)
- **Need to record:** what happened, when, who was the caller, where (app/api details, machine name, pod name, etc.)
- **Recommendations:**
 - Log early - Adding logs once code is written is a nightmare...
 - Invest in a shared framework / custom library that everyone uses and which implements those best practices - will make logging easier and coherent

Secure Logging

- Careful with the data we log:
 - No PII
 - No tokens/API Keys
 - No Encryption keys
 - Anything sensitive for your business
- Sensitive data can be :
 - **Redacted** (replaced with xxxxx for example)
 - **Hashed** : very useful for tokens/IPs for traceability
 - **Encrypted**
- Logs file may need to be signed for non-repudiation purposes

More at : https://cheatsheetseries.owasp.org/cheatsheets/Logging_Cheat_Sheet.html

Tokens/Keys passed as query param!

- Anything in query param end logs in a log somewhere
- ...Then pushed to a central log manager...
- ...Now it's visible in dashboards!
- Always use headers to pass sensitive information (or body in a POST)

More at: <https://www.fullcontact.com/blog/2016/04/29/never-put-secrets-urls-query-parameters/>



IMPLEMENT PROACTIVE SECURITY

An API **must never blindly trust**
anything it receives from the client.

And that includes

- Request payloads
- Headers
- JSON Web Tokens
- IP addresses (X-Forwarded-For)
- And everything else :)



**STAY
PARANOID
AND
TRUST
NO ONE**

Follow the “Hacky Path”

For each happy path test, you should have **10 Hacky Path** tests

And if you automate them, even better!

The way to protect yourself from Human Errors

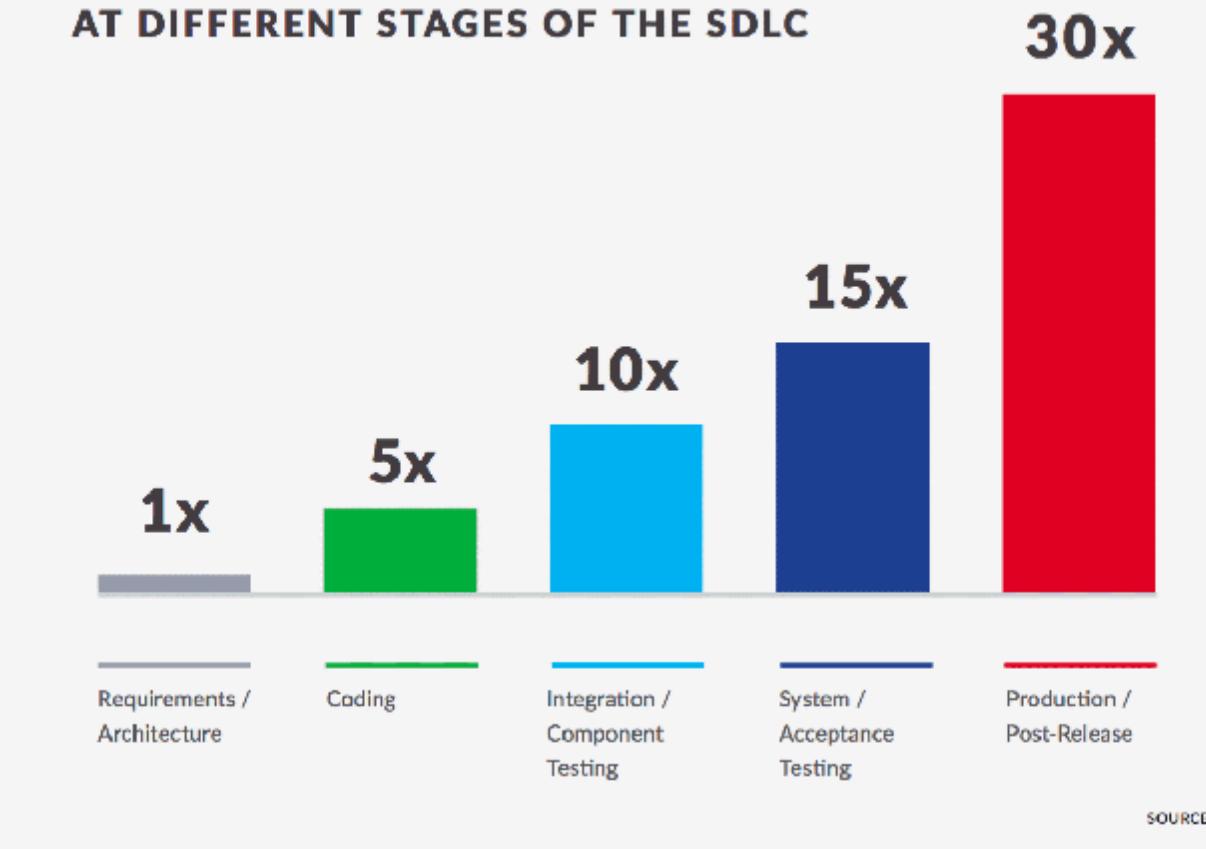


CALL TO ACTION!

- ▶ Use API Top 10 as framework for design and testing
- ▶ Start worrying about API Security at design time
 - ✓ A vulnerability discovered at production time costs up to 30x more to solve
- ▶ Hack yourselves leveraging API contracts
 - ✓ For each functional test, create 10 negative tests
 - ✓ Hammer your APIs with bad data, bad tokens, bad users
- ▶ Automate Security
 - ✓ Inject Security into DevOps practices and don't rely on manual testing of APIs.
 - ✓ Only solution to scale and have avoid human errors

<https://www.helpnetsecurity.com/2020/05/20/devops-software-development-teams/>

THE RELATIVE COST OF FIXING A FLAW
AT DIFFERENT STAGES OF THE SDLC

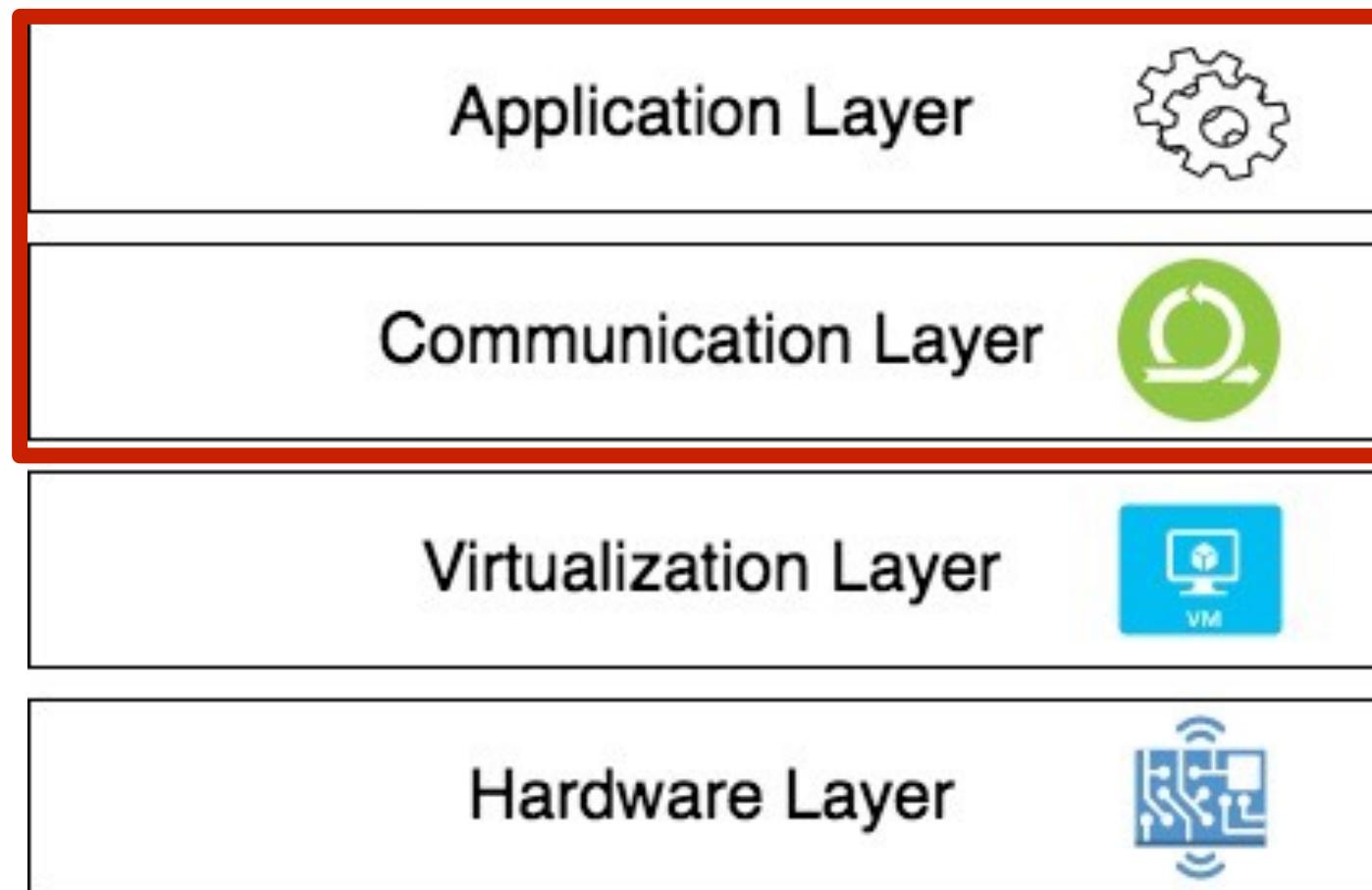


"I think security, in most cases, is not a single person's specialization. Security must be a practice of every member of the team from the frontend developer to the system administrator (also non tech roles)."

From: [Gitlab DevSecOps report](#) - 2021

ARCHITECTURE AND TOOLS

API Security Applies at Multiple Levels



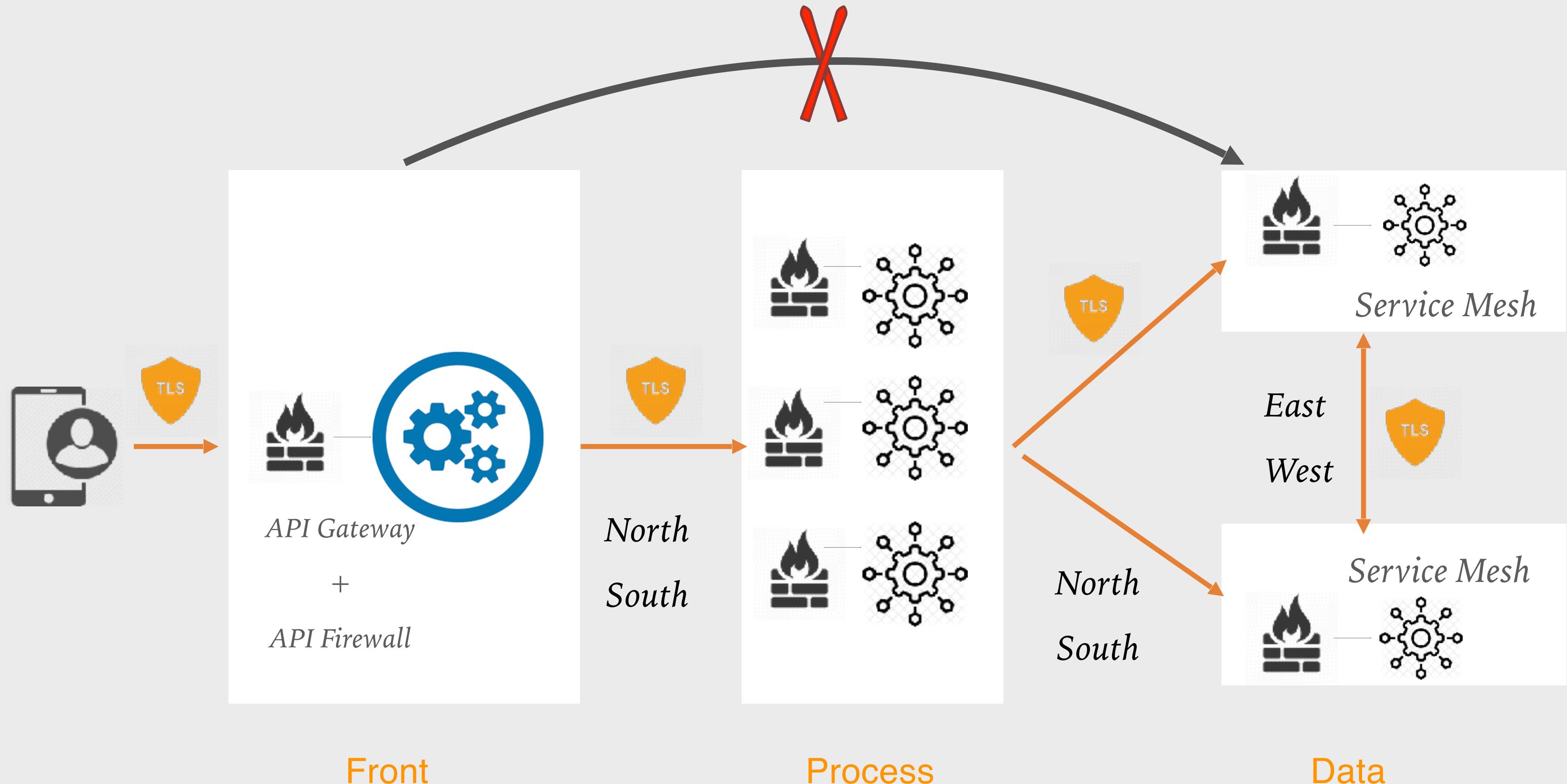
App level security (Auth, Azn, libs, code, images, data)

Intra-services communication (Auth, Azn, TLS)

Hypervisor, Kubernetes

OS / Network / Physical Access

DEPLOYMENT ARCHITECTURE



Further learning

- **42Crunch webinars with Jim Manico on SSRF/CSRF**
 - <https://42crunch.com/defending-apis-with-jim-manico-episode-1/>
- **42Crunch webinars with Philippe De Ryck on OWASP Top 10 :**
 - <https://42crunch.com/owasp-api-security-top-10-webinar-series-recordings-3/>
 - <https://42crunch.com/webinar-top-things-you-need-to-know-about-api-security/>
- **42Crunch webinar on JWTs**
 - <https://42crunch.com/webinar-json-web-tokens-api-security/>
- **OWASP Input Validation Cheat Sheet**
 - https://cheatsheetseries.owasp.org/cheatsheets/Input_Validation_Cheat_Sheet.html
- **OWASP REST Security Cheat Sheet**
 - https://www.owasp.org/index.php/REST_Security_Cheat_Sheet
- **OWASP Transport Layer Security Cheat Sheet**
 - https://www.owasp.org/index.php/HTTP_Strict_Transport_Security_Cheat_Sheet
 - https://www.owasp.org/index.php/Transport_Layer_Protection_Cheat_Sheet
- **OWASP HTML5 Security Cheat Sheet**
 - https://www.owasp.org/index.php/HTML5_Security_Cheat_Sheet#Local_Storage
- **Mitigate OWASP Top10 with API Management**
 - <https://learn.microsoft.com/en-us/azure/api-management/mitigate-owasp-api-threats>

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