PKC

API-Induced SSRF

How Apple Pay Scattered Vulnerabilities Across the Web

About me

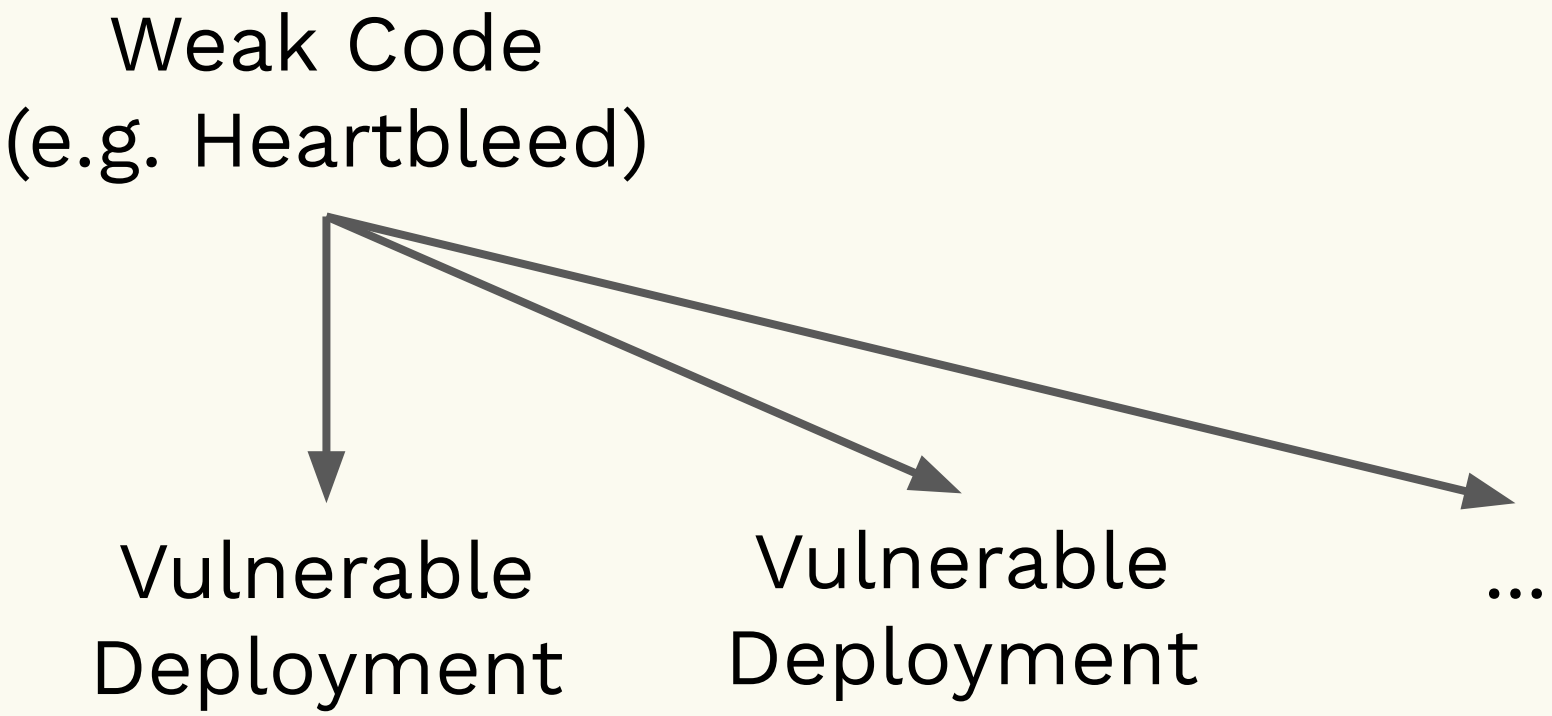
- Math degree
- Web developer, ~5 years
- Bounties
- At PKC ~1 year, web dev and code audits for clients - pkc.io

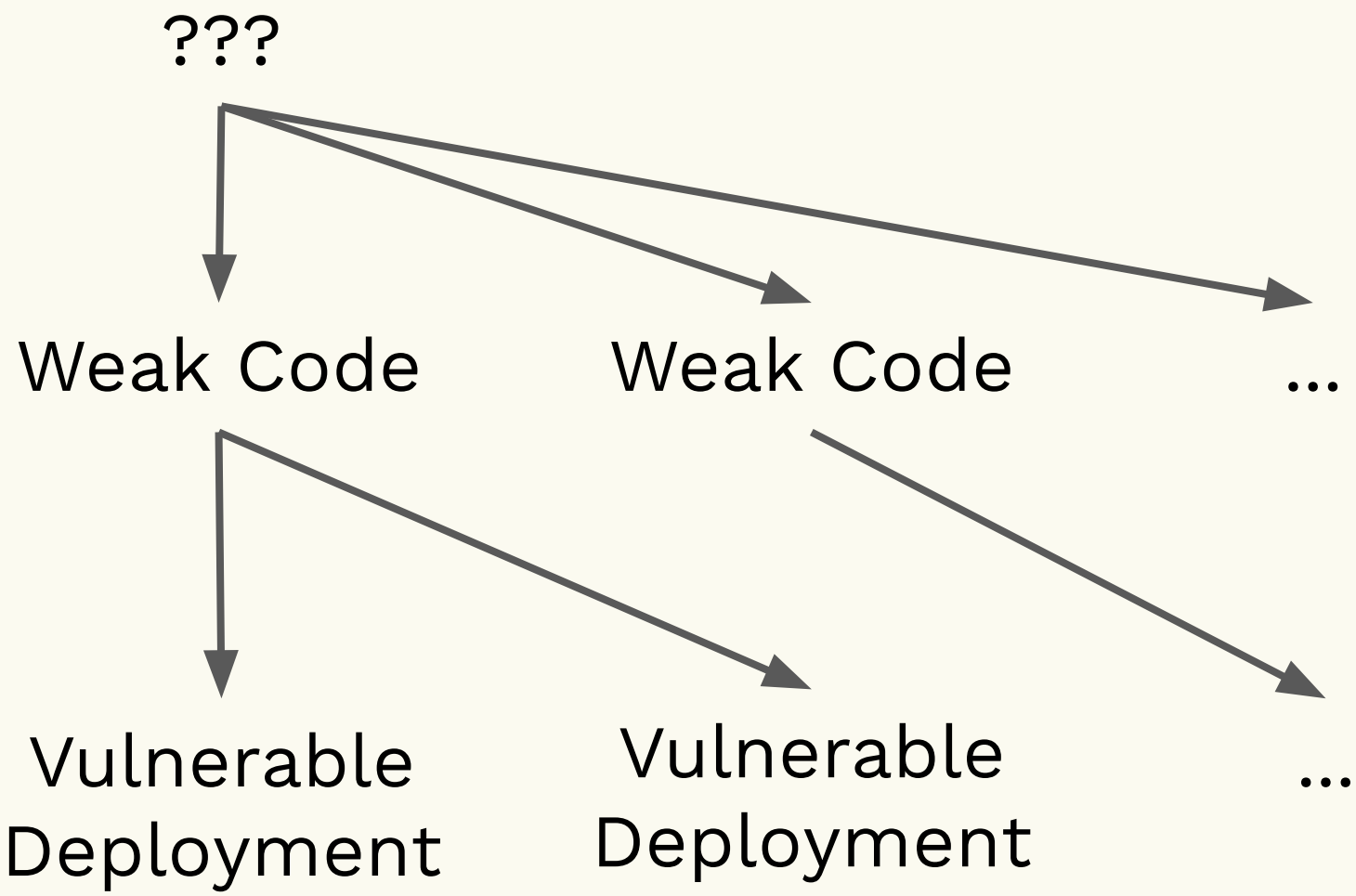
Overview

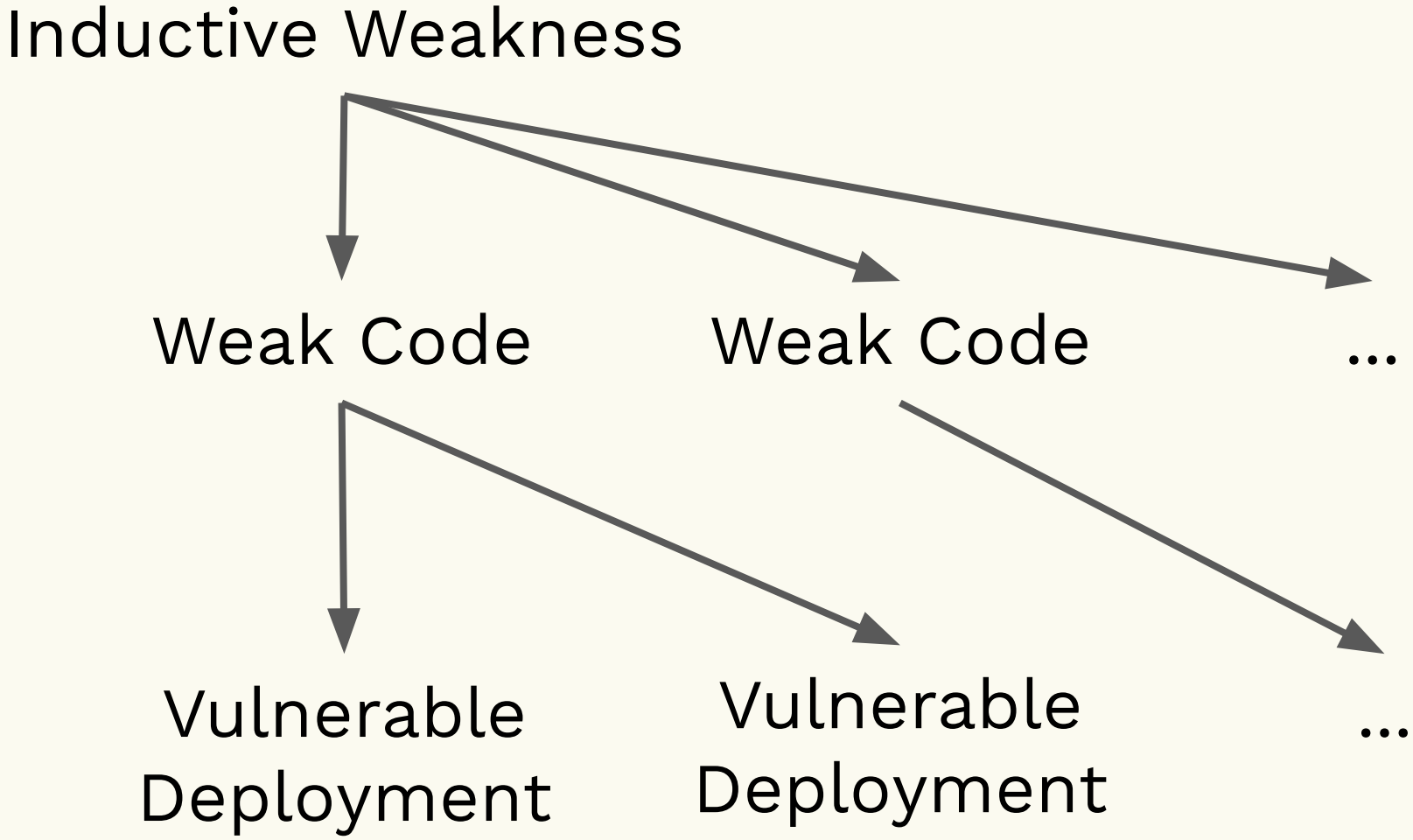
- Definitions
- Demo some mistakes
  - Apple Pay
  - Twilio
  - Others
- How not to be like Apple

Typical Class Breaks

See Schneier's blog post

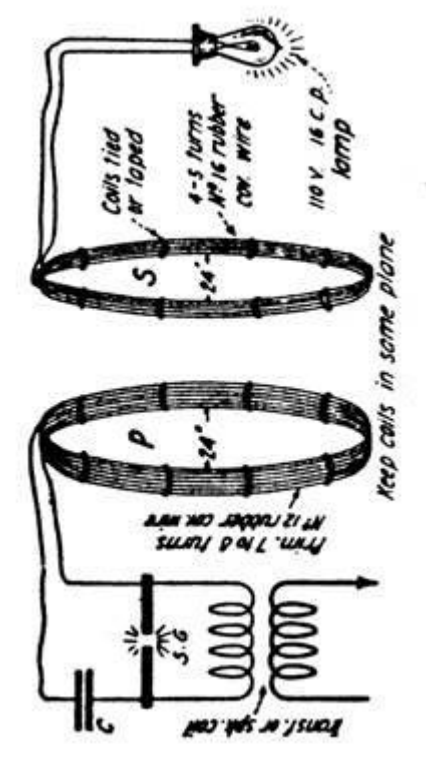



???
Weak Code
Weak Code
...
Vulnerable Deployment
Vulnerable Deployment
...

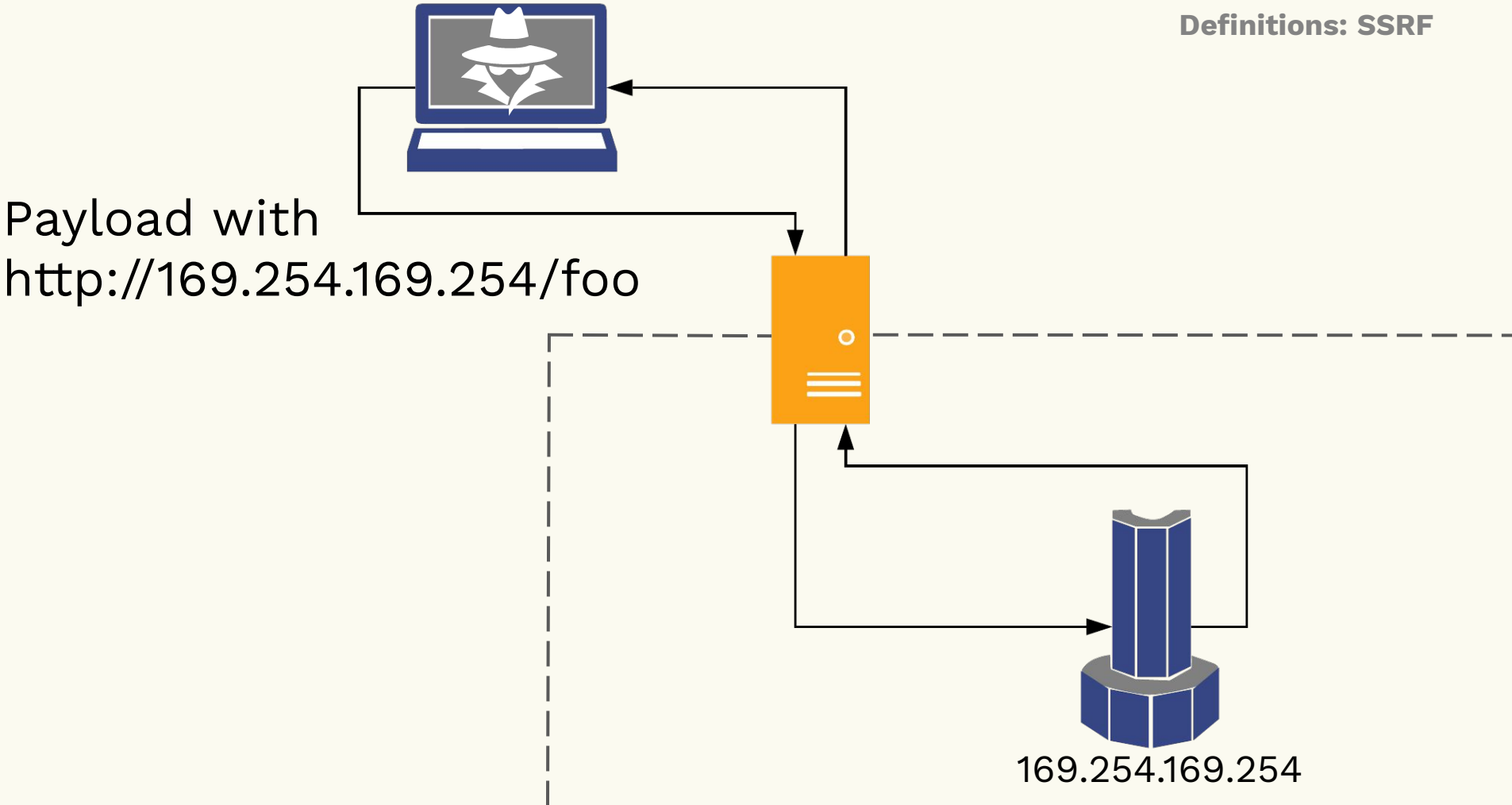

Inductive Weakness
Weak Code
Weak Code
...
Vulnerable Deployment
Vulnerable Deployment
...

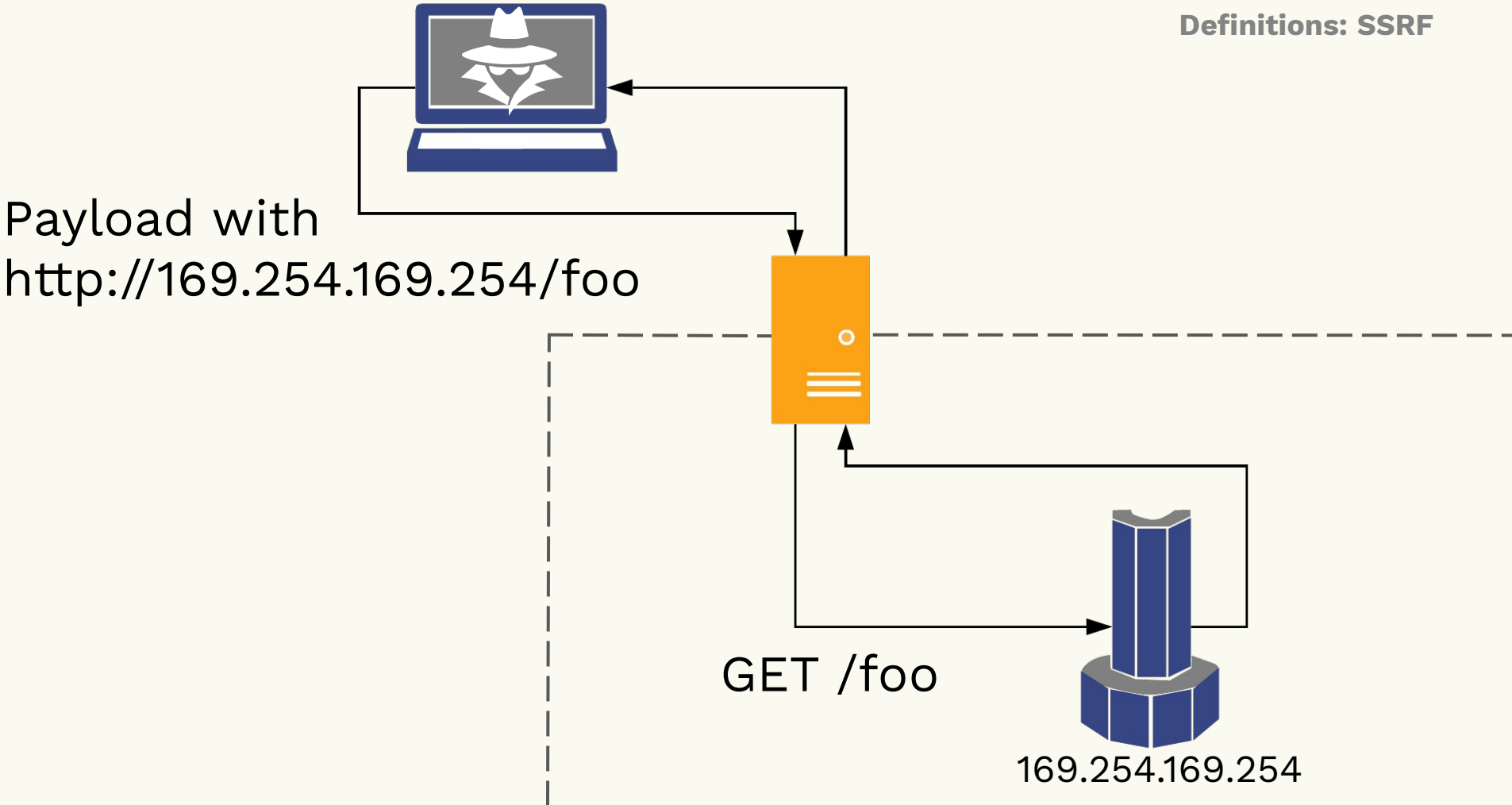
Inductive weakness:

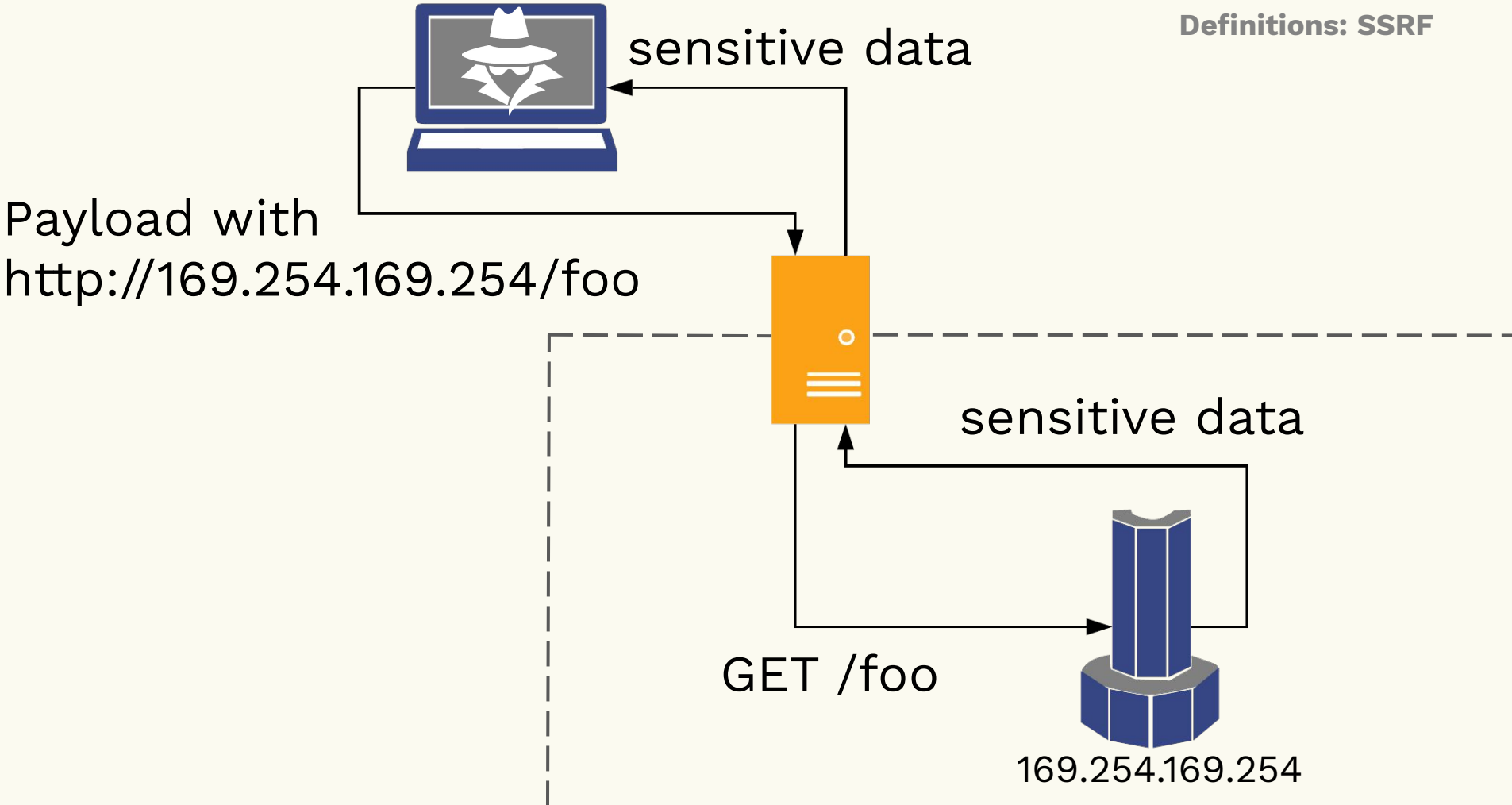
A design flaw that encourages multiple parties to write vulnerable code with a similar exploit pattern across differing software stacks.



SSRF Refresher


Payload with
http://169.254.169.254/foo
169.254.169.254


Payload with
http://169.254.169.254/foo
GET /foo
169.254.169.254


sensitive data
Payload with
http://169.254.169.254/foo
sensitive data
GET /foo
169.254.169.254

If you can relay requests through a GCP or AWS box...

```
$ curl -s http://169.254.169.254/computeMetadata/v1beta1/instance/service-accounts/default/token | jq
{
  "access_token": "ya29.c.[redacted]",
  "expires_in": 3511,
  "token_type": "Bearer"
}
```

Easy things to do with SSRF

- AWS, GCP have a gooey center
  - People have already criticized AWS/GCP for this
- `file:///` urls
- Reflected XSS
  - Technically not SSRF

SSRF: Hard mode

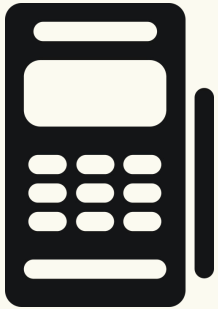
- Cross-protocol stuff
  - SMTP through `gopher://` URLs
  - HTTP->memcached->RCE
    - See A New Era of SSRF
  - ???

Apple Pay Web

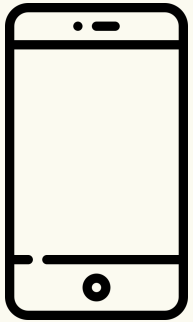
Inductive SSRF

Apple Pay: 3 forms

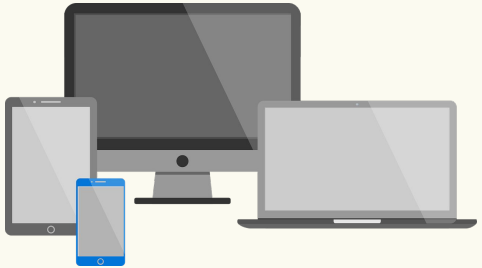
In-store



In-app



Web

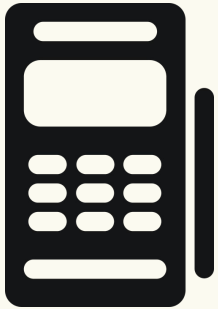


Buy with Pay

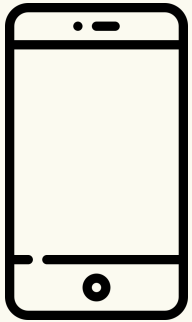
Apple Pay

criticising this

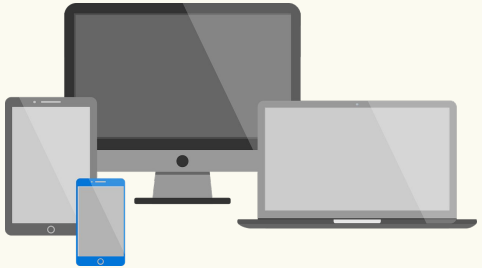
In-store



In-app



Web



these are unaffected

The intended flow

- Safari generates a `validationURL` (https://apple-pay-gateway-*.apple.com)

The intended flow

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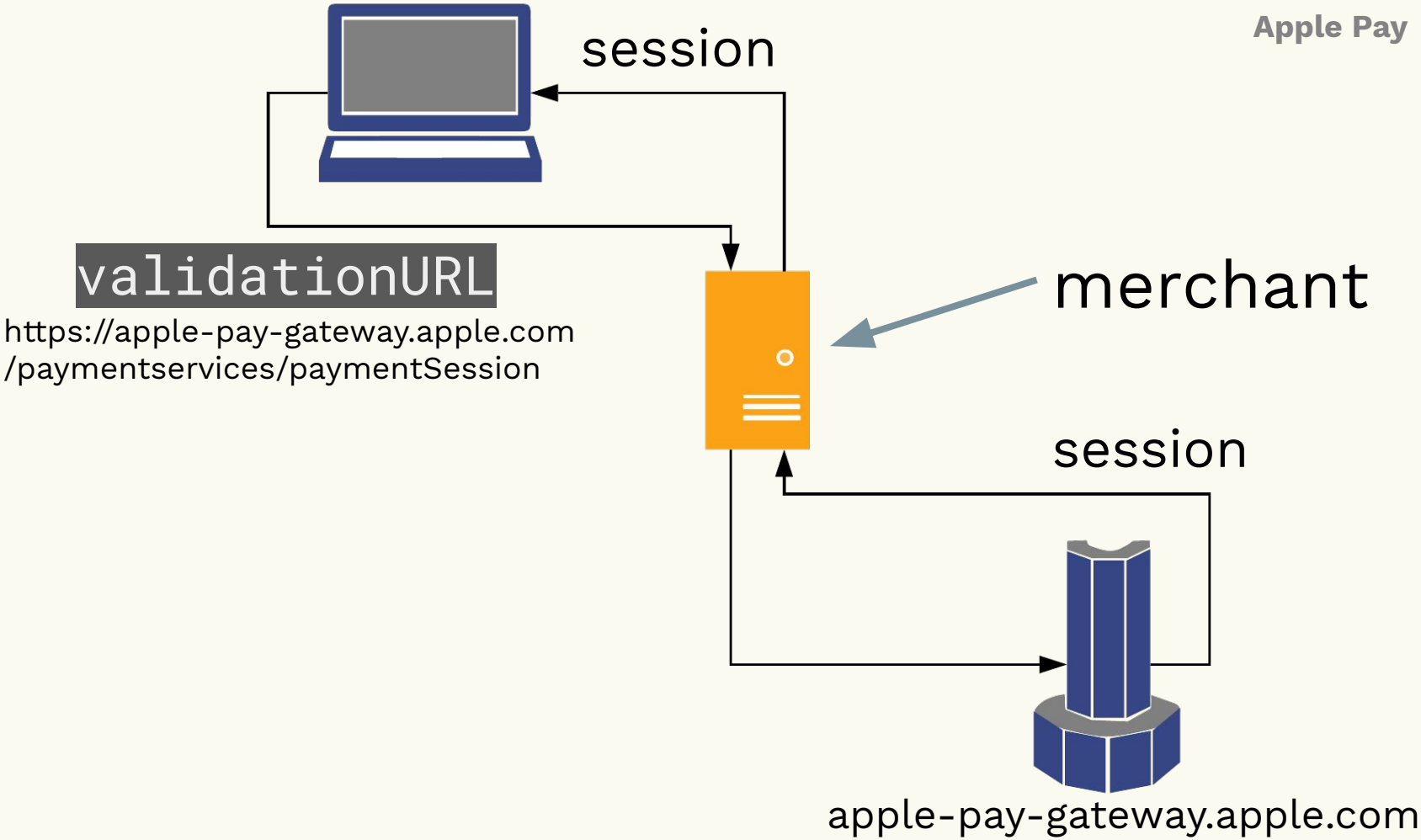
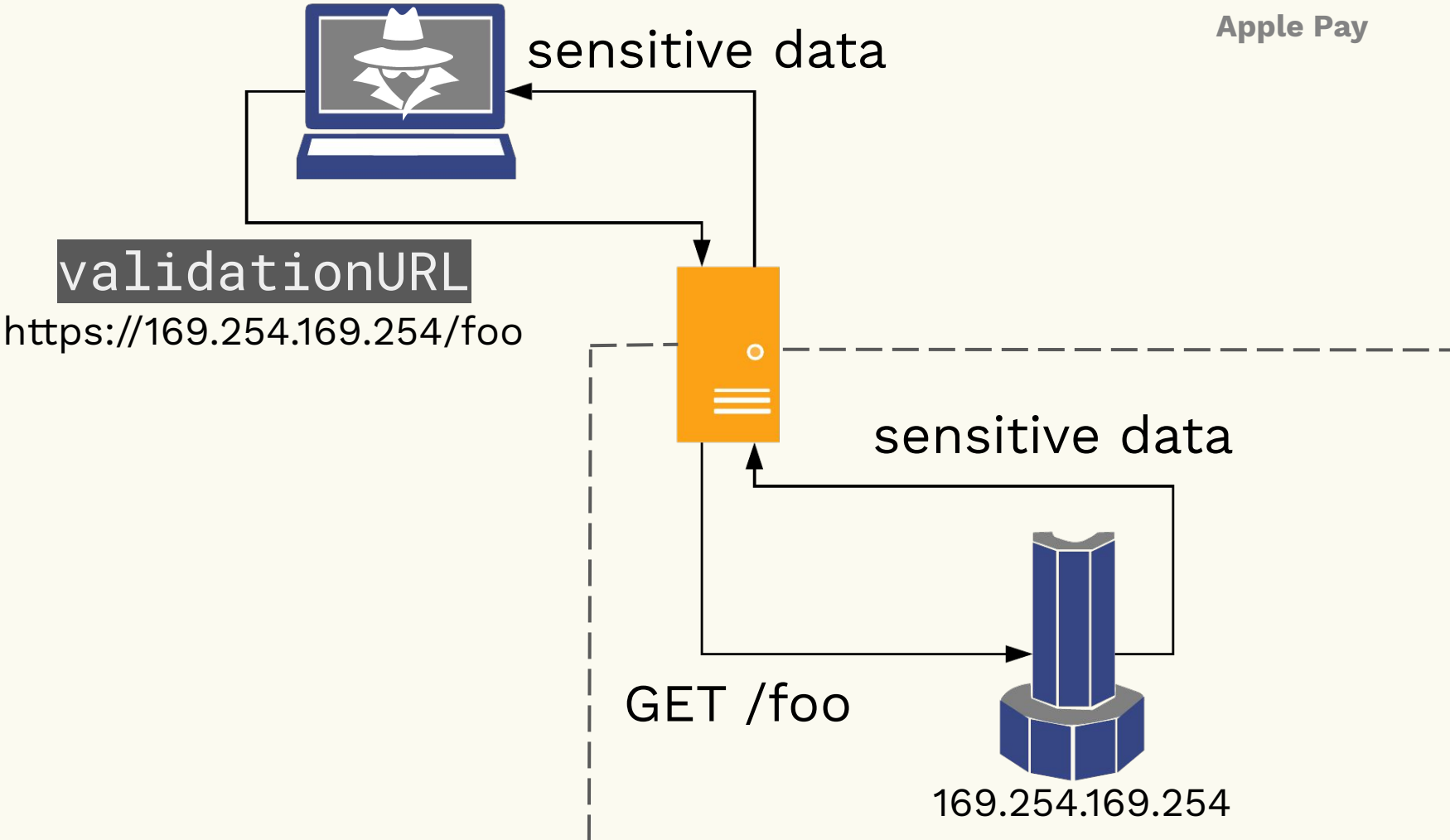
- Your JS sends `validationURL` to **your** backend

The intended flow

- Safari generates a `validationURL` (https://apple-pay-gateway-*.apple.com)
- Your JS sends `validationURL` to **your** backend
- Your backend grabs a session from `validationURL` and forwards it to the client


session
validationURL
https://apple-pay-gateway.apple.com
/paymentservices/paymentSession
merchant
session
apple-pay-gateway.apple.com


sensitive data
validationURL
https://169.254.169.254/foo
sensitive data
GET /foo
169.254.169.254

Demos

appr-wrapper

- Under GoogleChromeLabs on github
- Written, deployed by an @google.com account
- A sort of polyfill between Apple Pay and the PaymentRequest API
- A test deployment, so low severity target

Apple Pay

webkit.org

- Maintained by Apple
- Another demo, but on a higher-severity target

Apple's response

Just added this

Whitelist Apple Pay IP Addresses for Merchant Validation

To enable merchant validation and receive a session object, your server must allow access over HTTPS (TCP over port 443) to the Apple Pay IP addresses and domains provided in Listing 1.

Important

Use a strict whitelist for the merchant validation URLs provided by Apple, in Listing 1. Do not allow your server to access any other URLs for merchant validation.

Disclosure timeline

- Feb 11, Initial email to Apple
- March 26, Apple updated docs
- May 14, Apple concluded investigation. I replied with follow-up questions.
- ... Then Apple ghosted for 2 months :(

One mitigation...

[redacted]

Watch [redacted] Star [redacted] Fork [redacted]

Code | Issues 0 | Pull requests 1 | Projects 0 | Wiki | Security | Insights

[redacted] Remove apple pay endpoint to remove security vulnerability #72

Merged [redacted] merged 1 commit into develop from [redacted] 3 hours ago

Conversation 0 | Commits 1 | Checks 0 | Files changed 1 | +0 −16

Changes from all commits | File filter... | Jump to... | Review changes

[redacted] Remove apple pay endpoint to remove security vulnerability

develop (#72)

[redacted] committed 3 hours ago commit [redacted]

General mitigations

Apple Pay

- Check `validationURL` against Apple's list
- Stripe and Braintree handle this flow, so you're safe if you use them

General mitigations

SSRF in general

- Whitelist egress traffic
- Protect your metadata like Netflix: Detecting Credential Compromise in AWS
- Be mindful of local, unauthenticated stuff on servers

Ineffective mitigations

Do <u>not:</u>

- Use a regex to validate the domain
  - Sometimes people try a regex like `https?://.*.apple.com/.*`
  - But that matches: `http://localhost/?.apple.com/...`
- Rely on HTTPS to prevent cross-protocol attacks
  - See slide 16 of A New Era of SSRF

Webhooks

Inbound Settings

To receive inbound messages on the phone numbers associated with your Mes

Learn more ↗

PROCESS INBOUND MESSAGES ☑ If enabled, Twilio will make a synchronous HTTP requ

REQUEST URL https://jmaddux.com/sms HTTP POST

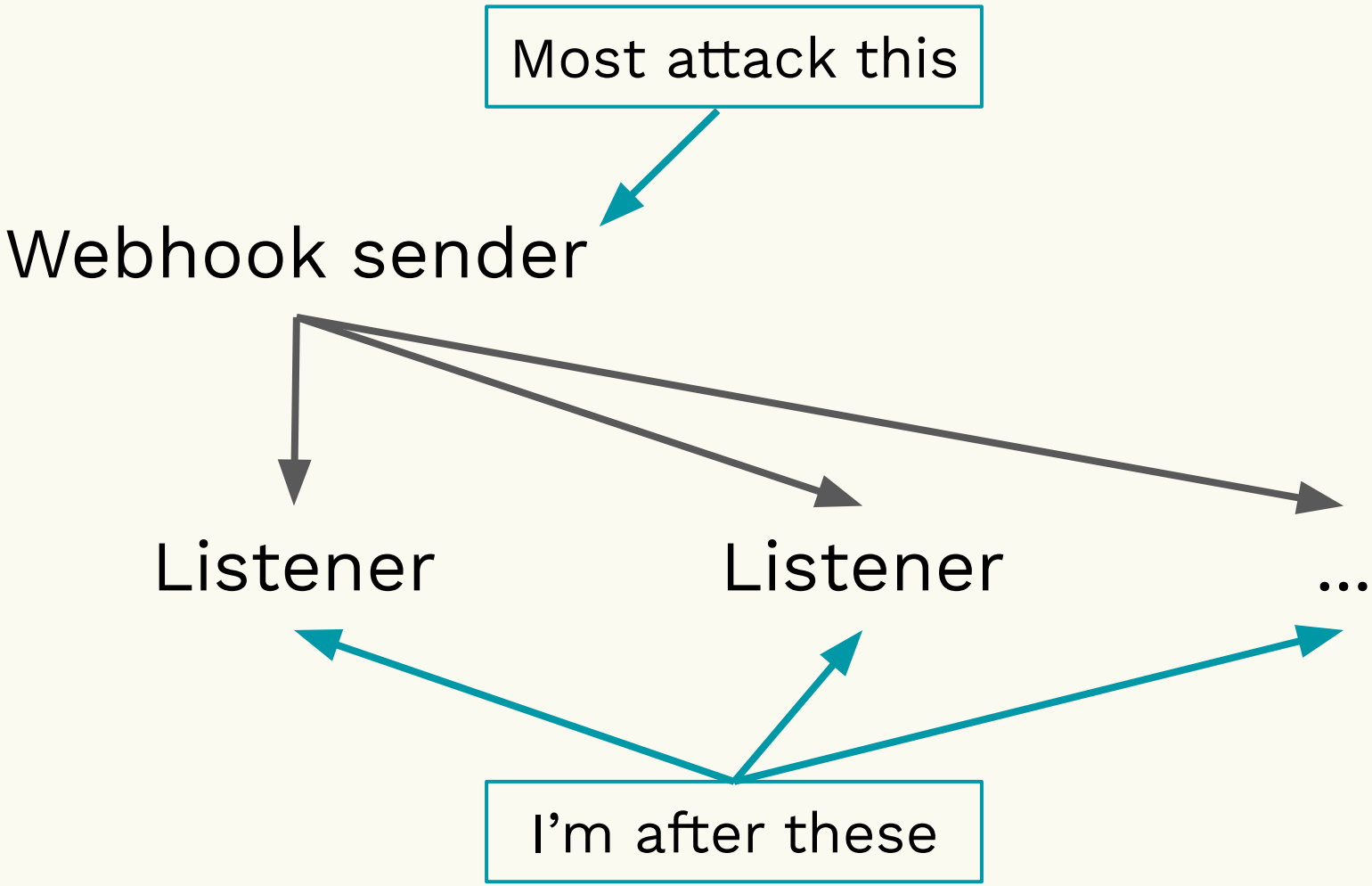
FALLBACK URL HTTP POST

Save Cancel Delete this Messaging Service

Previous webhook exploits

Payload would go here

- http://169.254.169.254
- gopher://localhost:11211/...


Most attack this
Webhook sender
Listener
Listener
...
I'm after these

How Twilio Authenticates Webhooks

- HMAC and hope the listener checks it
- Lots of webhooks do this, Twilio’s not unique

The problem

- Who failed to check the HMAC?
  - 23 out of 31 open-source projects

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The problem

- Who failed to check the HMAC?
  - 23 out of 31 open-source projects
  - Most of Twilio’s example code
- Contributing factors
  - Bad documentation
  - The easiest receiver implementation is a vulnerability

Demo: Webhooks

Twilio Example Code

- Examples themselves not deployed publicly
- But, did find vulns where it was copied/pasted

Disclosure timeline

- Feb 17, Initial email to Twilio
- March 6, Twilio updated some of the docs
  - Rejected all architectural changes due to “unforeseen issues”

What about nexmo?

Validate the signature on incoming messages

In order to verify the origin of incoming webhooks to your SMS endpoint, you can enable message signing for incoming messages - contact support@nexmo.com to request incoming messages be accompanied by a signature. With this setting enabled, the webhooks for both incoming SMS and delivery receipts will include a `sig` parameter. Use the other parameters in the request with your signature secret to generate the signature and compare it to the signature that was sent. If the two match, the request is valid.

Contact support to enable message signing on your account: support@nexmo.com

Source

What about nexmo?

Validate the signature on incoming messages

Contact support to enable message signing

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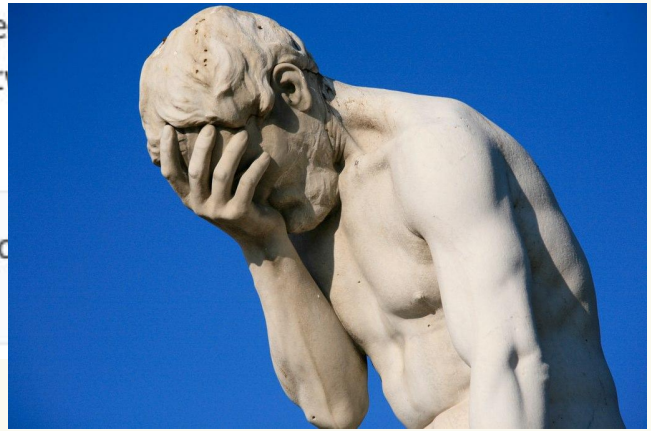

Source

Gitlab webhooks: the happy path


```
{
  "object_kind": "push",
  "commits": [{
    "message": "Initial commit of foo project",
    "url": "https://...",
     ...
  }],
  "repository": {
    "url": "git@your.git.url/something.git", ...
  }, ...
}
```

What did I do?

- Found a server that was receiving gitlab webhooks
  - On the open internet
  - Was the trigger of build pipelines for multiple tenants...

Gitlab webhooks: what I did


```
{
  "object_kind": "push",
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    "url": "https://...",
     ...
  }],
  "repository": {
    "url": "git@your.git.url/something.git", ...
  }, ...
}
```

Put the tenant's gitlab url here

Gitlab webhooks: what I did


```
{
  "object_kind": "push",
  "commits": [{
    "message": "Click here to do something! :D",
    "url": "javascript:alert('XSS on: ' + window.origin);",
     ...
  }],
  "repository": {
    "url": "git@your.git.url/something.git", ...
  }, ...
}
```

What are some better ways to send webhooks?

- For crypto nerds: authenticated cipher
  - E.g. AES-GCM
  - Still symmetrical like an HMAC
  - Forces webhook consumers to decrypt, so they'll accidentally verify the GCM tag you send them

What are some better ways to send webhooks?

- More practical: only send high-entropy, cryptographically random event IDs
  - Webhook consumer has to fetch `/items/?id=<id>` with their API token
  - Plaid does roughly this

What are some better ways to send webhooks?

- For existing webhooks: test & warn
  - During registration, do 2 test requests:
    - 1 valid MAC
    - 1 invalid MAC
  - Warn if they get the same response code

What else?

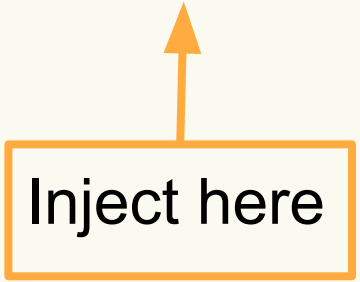
Salesforce Objects vs Dynamodb

Both:

- NoSQL-like object storage
- REST APIs with custom SQL-like queries

Salesforce SOQL

```
/?q=SELECT+id+from+Foo+WHERE+name+LIKE+'...'
```



Salesforce SOQL

Prevent SOQL Injection in Your Code

Learning Objectives

After completing this unit, you'll be able to:

- Learn the different patterns of SOQL injection prevention.
- Prevent SOQL Injection using string.escapeSingleQuotes().
- List the cases where the use of string.escapeSingleQuotes isn't sufficient.

Source

Dynamodb: Better

```
POST / HTTP/1.1
{
    "TableName": "ProductCatalog",
    "KeyConditionExpression": "Price <= :p",
    "ExpressionAttributeValues": {
        ":p": {"N": "500"},
    },
}
```

Enforced Parametrization

Closing Thoughts

From Apple after two months of silence

“Developers are responsible for implementing whatever security and networking best practices make the most sense for their environment.”

“If you’ve built a chaos factory, you can’t dodge responsibility for the chaos.”

Tim Cook, Apple CEO

Source

Financial

- Low-hanging bounty fruit
- Embarrassment
- High-interest tech debt

Designing defensive APIs

- Audit your example code
- Be careful about passing around URLs
- If “Do this or you’re vulnerable!” is in your documentation, try to make the warning unnecessary

Takeaways

- You can find a lot of vulnerabilities by looking at an API, finding a flaw, and seeing who integrates with it.
- We need to place more scrutiny on security weaknesses that induce others to write vulnerable code.
- While there has been a lot of recent work on SSRF, the software development world has a long way to go in defensively coding around URLs.

Acknowledgments

- Jonathan Ming at PKC - asked the initial questions about Apple Pay
- Arte Ebrahimi at PKC - pointed me to the Nexmo stuff
- Ken Kantzer at PKC - helped with the presentation
- Andrew Crocker at EFF - legal assistance

PKC

Thank you!

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