Introduction to SOA and Microservices Security

Oxford University
Software Engineering
Programme
April 2021

Security Aims

- Confidentiality
- Integrity
- Availability
- Authenticity
- Non-Repudiation
- Authorization

In Real Life

- The **opacity** of the envelope provides confidentiality
- The **seal** on the envelope provides integrity
- Royal Mail hopefully provides availability
- The **signature** provides authenticity
- The **proof of posting** and "**signed-for**" provide non-repudiation

None of these match up to the standards of electronic security

Confidentiality

- Provided by Encryption
- On the web, 99% of the time using TLS
- TLS is the successor to SSL
  - And often referred to as SSL!
- If you want to understand TLS well, this is about the best resource I've seen:
- http://www.moserware.com/2009/06/first-few-milliseconds-of-https.html

Encryption is pointless without authenticity/identity

- If I encrypt the message aimed at the wrong person, I have failed
- Encryption key distribution was the biggest issue until
  - 1973: Ellis, Cocks and Williamson of GCHQ created first “non-secret crypto”
    - Only made public in 1997
  - 1976: Diffie Helman key exchange
  - 1977: Rivest Shamir Adleman (RSA) public key cryptography

A simple analogy

- Padlocks which cannot be explored, re-engineered or re-used
- Keys which cannot be reverse-engineered into a padlock

Public Key Encryption

1. You send out as many padlocks as you like, but you keep the key secret

2. I lock the message in a box with YOUR padlock and send it to you

3. Only you have the key, so only you can read the message

Authenticity

- Need to Sign the message
- Now I send out lots of keys but keep the padlocks secret




- Anything I lock up in a box with my padlock must come from me
- Anyone can unlock it and verify its from me

Hash functions

- Take a message and create a fixed size result
  - E.g. 256 bits of data
- The aim of a hash function is to have no duplicate hits, and a random distribution of responses
  - The only way to find the input from the output is a dictionary attack

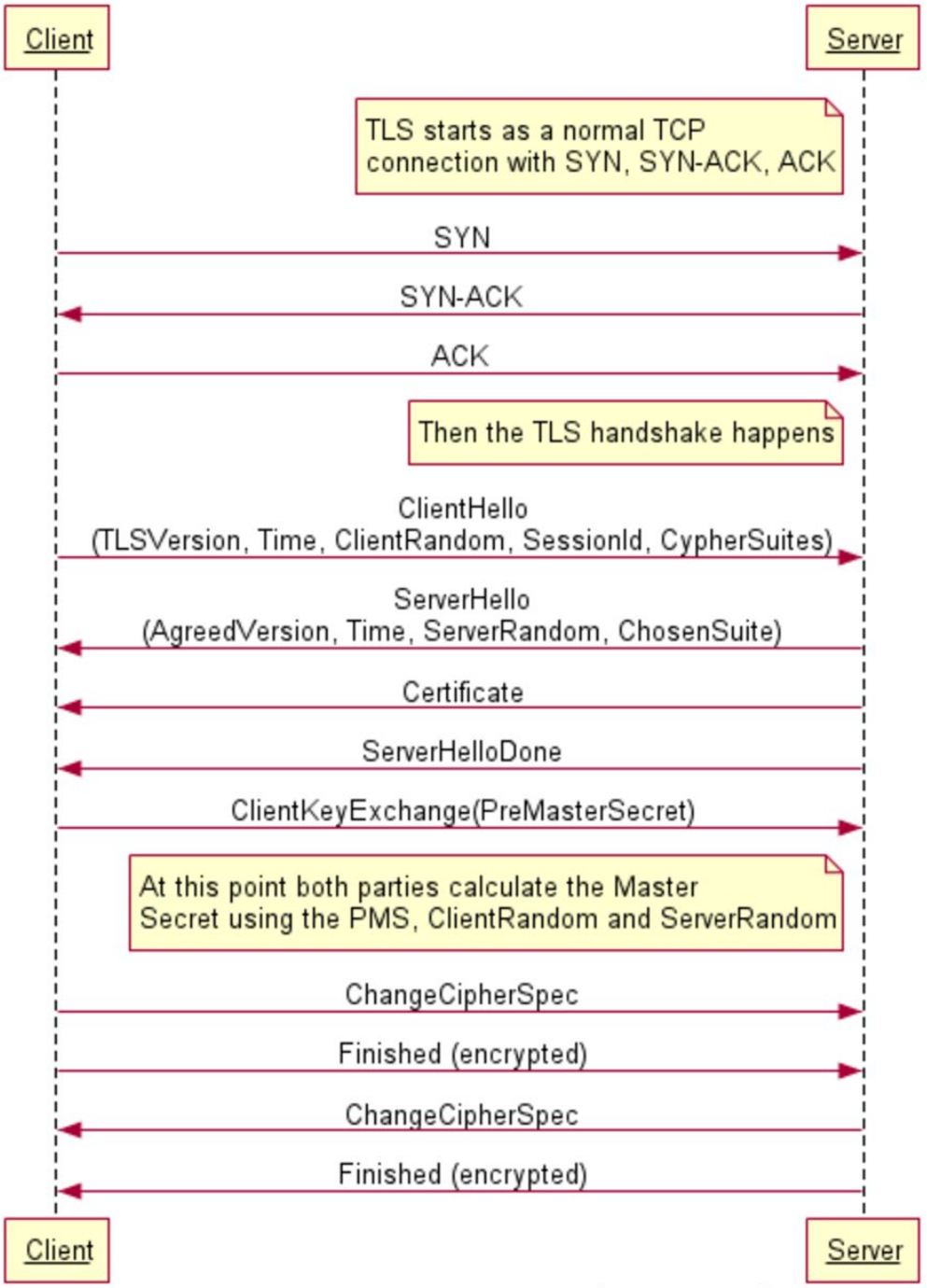
Signatures

- Actually the encrypted hash using the private key to encrypt
  - The validator decrypts the message
  - Applies the same hash function
  - Compares the two

Certificate Authority

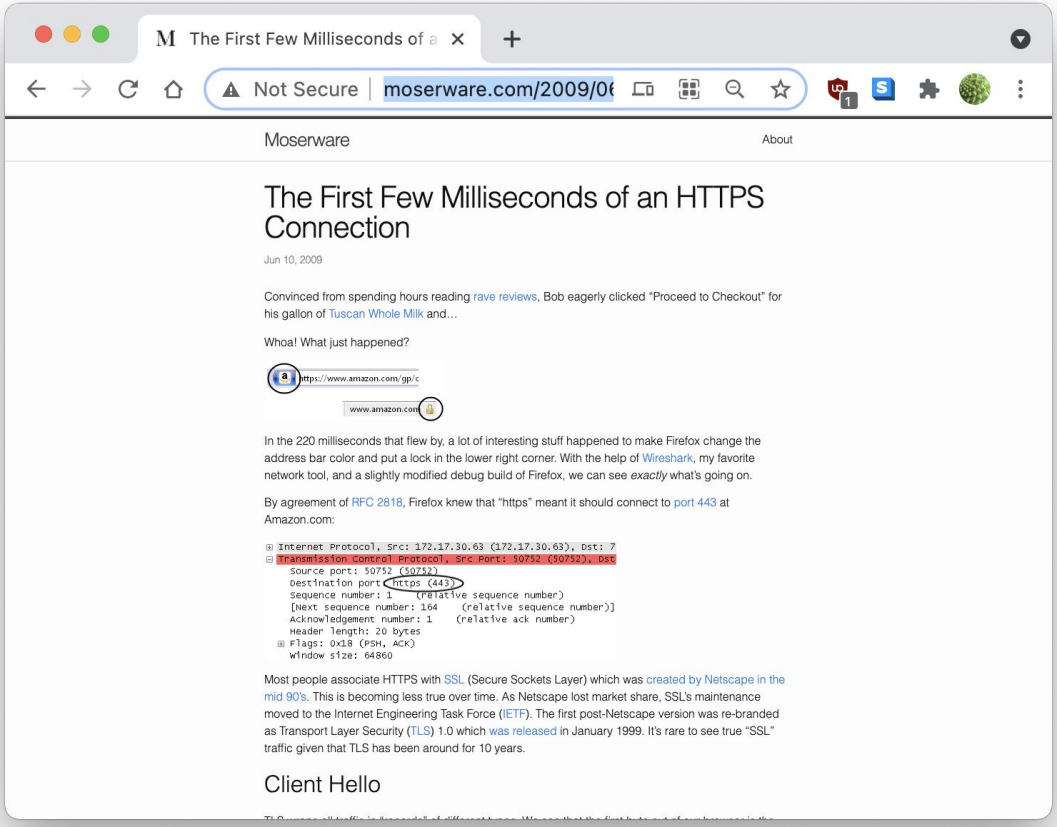
- Instead of everybody needing to know about each other's keys, you have a trust hierarchy:
  - I create a key pair (key + padlock)
  - Export the public key (key)
  - Prove who I am to the CA
  - The CA "signs" the key
    - Locks my key in their padlock
    - Anyone who opens it knows that it is verified by them

Transport Layer Security (TLS)

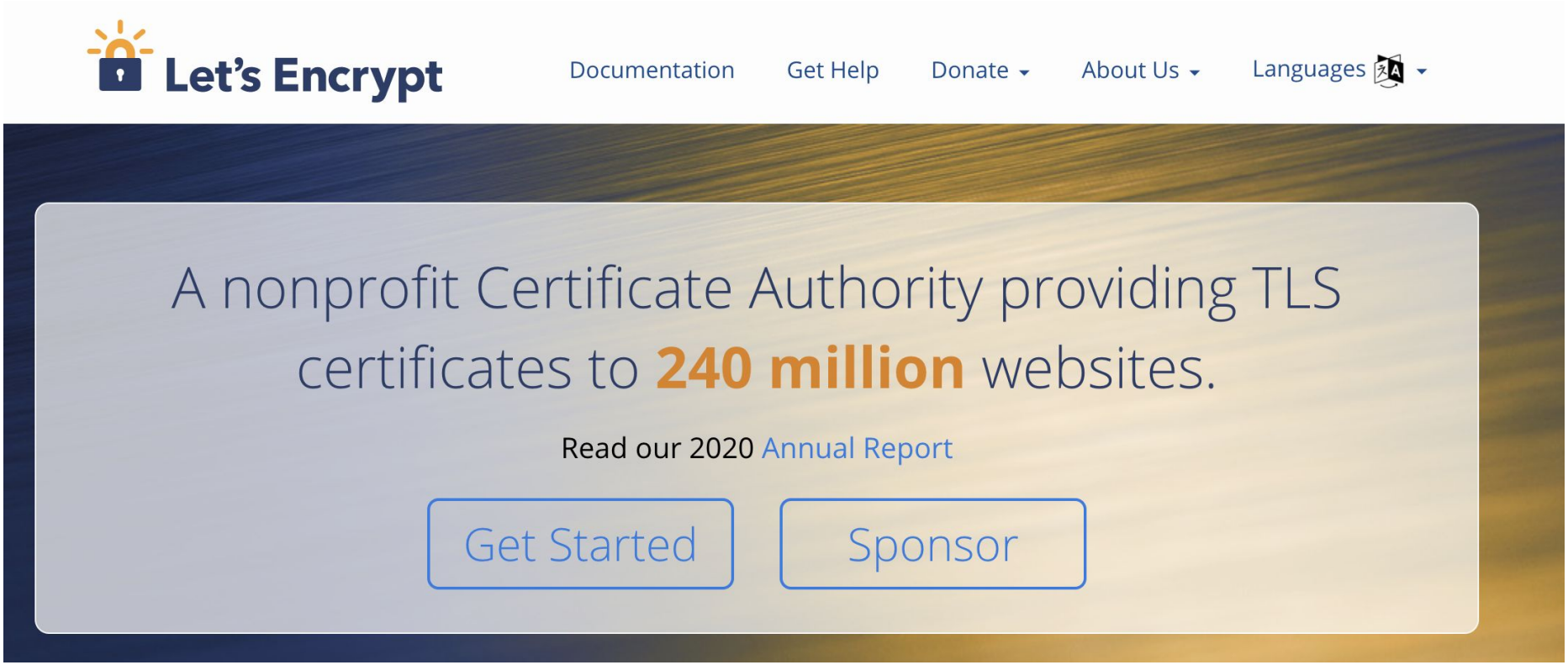


More details

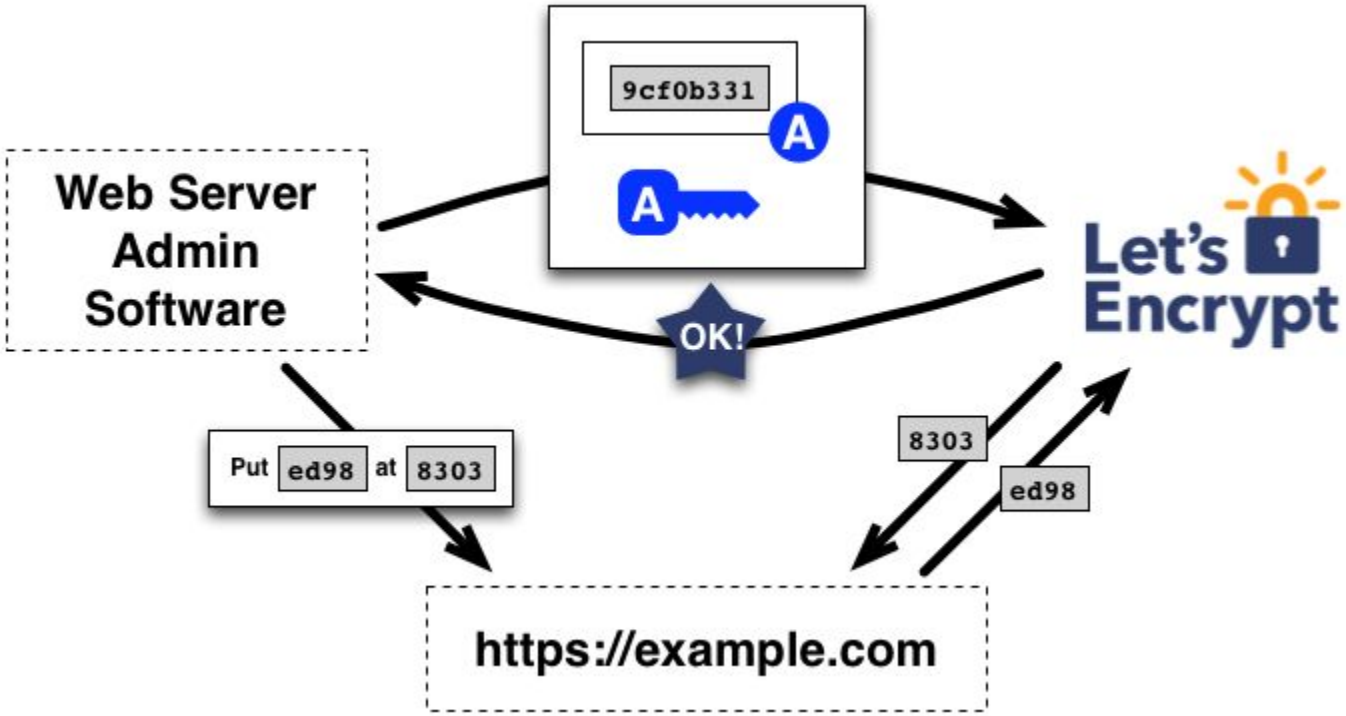
http://www.moserware.com/2009/06/first-few-milliseconds-of-https.html
https://tlseminar.github.io/first-few-milliseconds



LetsEncrypt



Automatic Certificate Management Environment (ACME)



ACME

Internet Engineering Task Force (IETF)
Request for Comments: 8555
Category: Standards Track
ISSN: 2070-1721

R. Barnes
Cisco
J. Hoffman-Andrews
EFF
D. McCarney
Let's Encrypt
J. Kasten
University of Michigan

March 2019

Automatic Certificate Management Environment (ACME)

Abstract

Public Key Infrastructure using X.509 (PKIX) certificates are used for a number of purposes, the most significant of which is the authentication of domain names. Thus, certification authorities (CAs) in the Web PKI are trusted to verify that an applicant for a certificate legitimately represents the domain name(s) in the certificate. As of this writing, this verification is done through a collection of ad hoc mechanisms. This document describes a protocol that a CA and an applicant can use to automate the process of verification and certificate issuance. The protocol also provides facilities for other certificate management functions, such as certificate revocation.

Authentication with Client Certificates for humans

- Is rarely used
- Client needs a certificate
  - Hard to prove who you are to the CA
    - Implies costly
  - Some countries have implemented this nationally (e.g. Denmark)

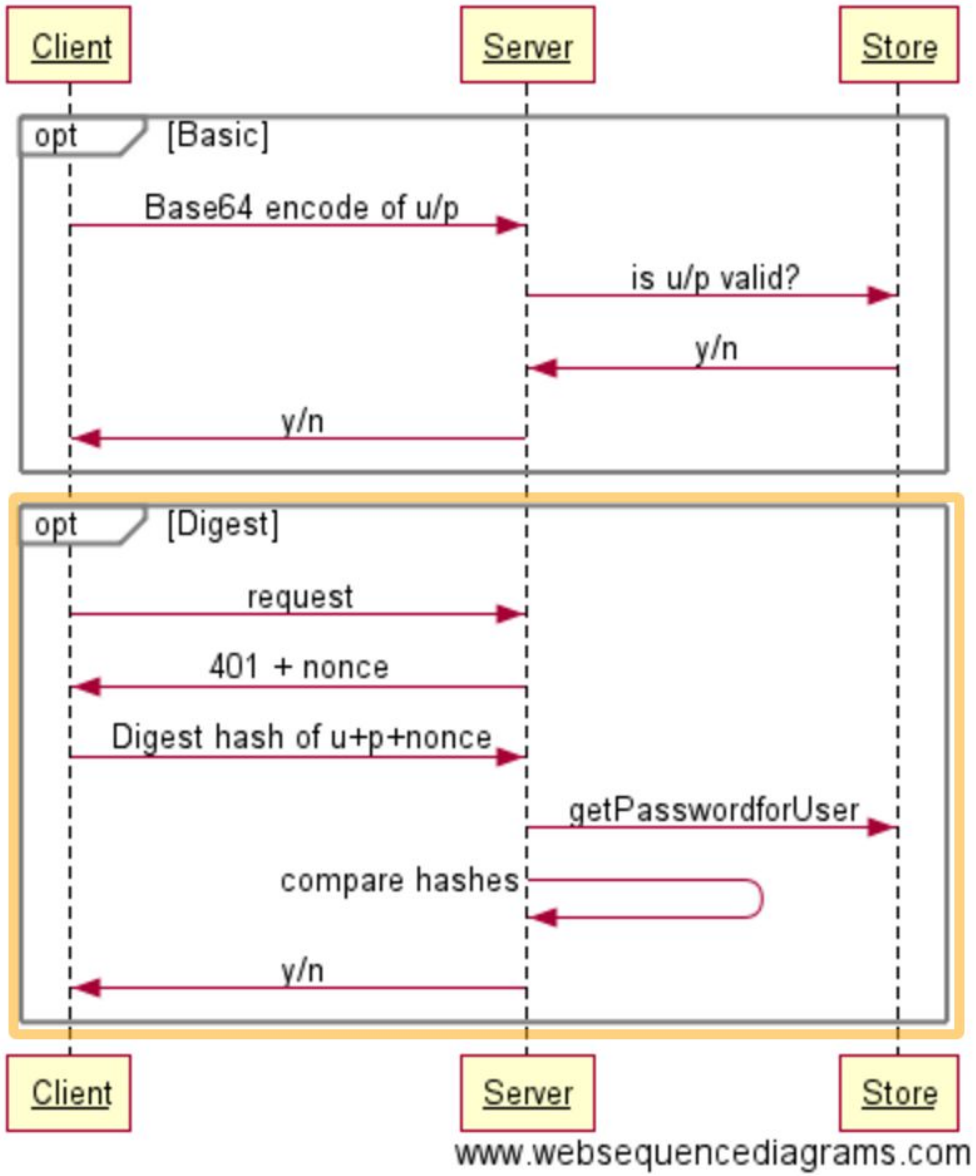
More common authentication

- Server-side TLS
  - Every server is proven
- HTTP level authentication
  - Basic Auth
  - Digest
  - OAuth2 / OpenID Connect (OIDC)

HTTP Authentication

- Basic Auth
  - Easy, fast, effective
  - Completely insecure except over HTTPS
    - base64 encoding
- Digest
  - Hash of the password
- More on OAuth later

Basic vs Digest



Integrity

- Include a signed hash in with the message
- Only the sender could do this
- If the message is modified or manipulated the receiver will calculate a different hash to the sender
- This is used for both integrity AND authenticity
  - The signed hash is equivalent to signing the message

Non-repudiation

- This is done by passing back a signed hash of the signed hash!
- The receiver can prove that the sender sent the message (log the signed hash)
- The receiver then signs this and sends it back
- The sender logs this to prove that the receiver received the message

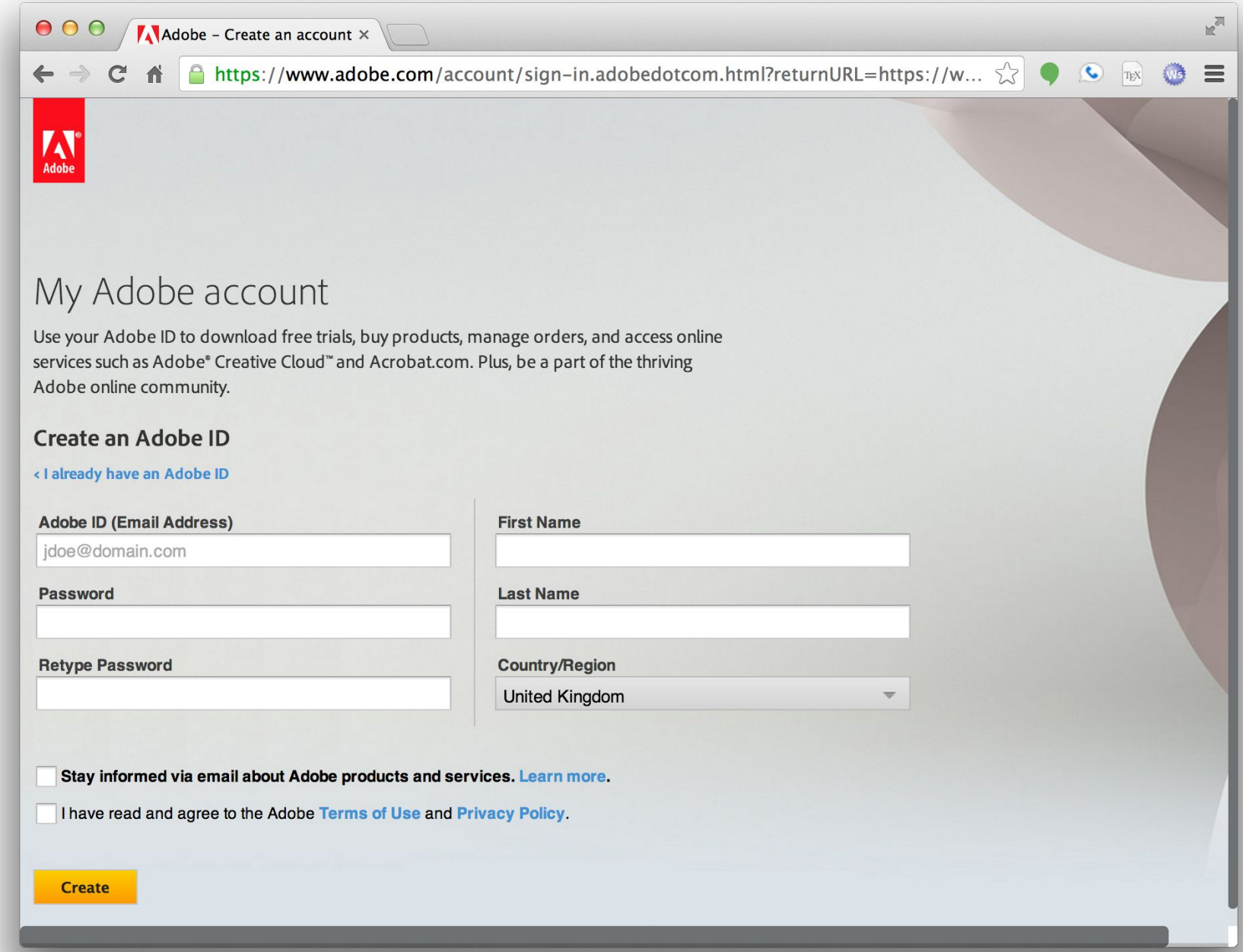
Availability

Performance

- Public Key Cryptography is based on mathematics of very large prime numbers
- The aim is that to break it will take many many years
  - Though Quantum Computing will change that
- It is slow
- Usually PKC is only used for exchange of a secret key that is then used for a session

The problem with passwords

cabbage
Sorry the password must be more than 8 chars
boiled cabbage
Sorry, you must have a numerical character
1 boiled cabbage
Sorry, no blank spaces
50frickingboiledcabbages
Sorry, at least one upper case
50FRICKINGboiledcabbages
Sorry, the password cannot have more than one upper case consecutively
50FrickingBoiledCabbagesShovedSomewhereIfYouDon’tGiveMeAccess
Sorry, no punctuation



BBC News - Adobe hack: A

www.bbc.co.uk/news/technology-24740873

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30 October 2013 Last updated at 11:43

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Adobe hack: At least 38 million accounts breached

Adobe has confirmed that a recent cyber-attack compromised many more customer accounts than first reported.

The software-maker said that it now believed usernames and encrypted passwords had been stolen from about 38 million of its active users.

It added that the attackers had also accessed details from an unspecified number of accounts that had been unused for two or more years.

The firm had originally said 2.9 million accounts had been affected.

Adobe has also announced that the hackers stole parts of the source code to Photoshop, its popular picture-editing program.

It had previously revealed that the source code for its Acrobat PDF document editing software and ColdFusion web application creation

Adobe said source code for Photoshop had been stolen

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Looking back

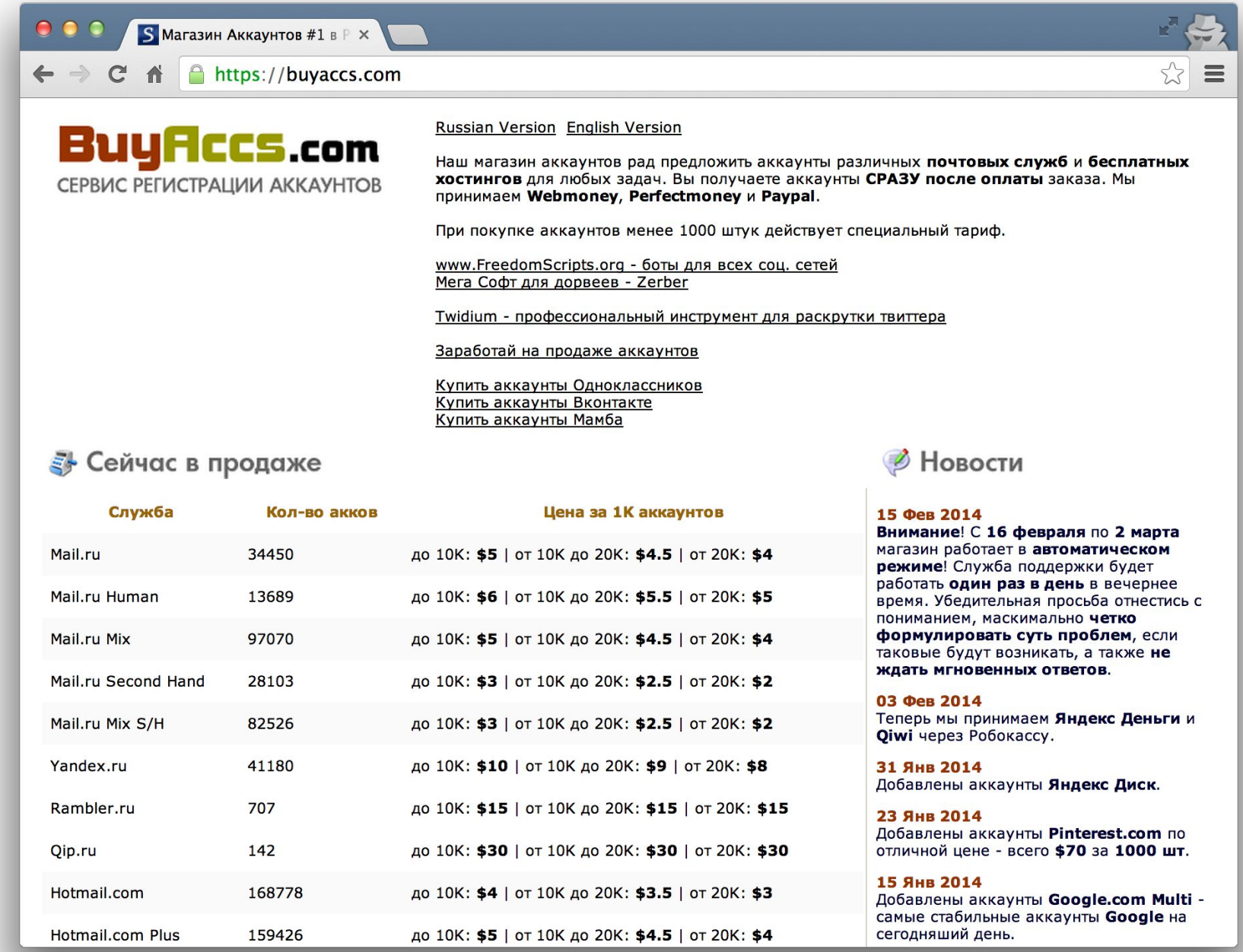
The time when pro-paedo campaigners operated op

Tide of desperation

Picture captures scale of crowd of refugees in Syri

Size matters

Is Gravity too short to wi Picture?



Third hit on Google

“how to add authentication php”

```
CREATE DATABASE todo;

USE todo;

CREATE TABLE IF NOT EXISTS `users` (
  `user_id` bigint(20) unsigned NOT NULL auto_increment,
  `user_login` varchar(100) NOT NULL,
  `user_password` varchar(64) NOT NULL,
  `user_firstname` varchar(50) NOT NULL,
  `user_surname` varchar(50) NOT NULL,
  `user_email` varchar(100) NOT NULL,
  `user_registered` datetime NOT NULL default '0000-00-00 00:00:00',
  PRIMARY KEY (`user_id`),
  KEY `idx_user_login_key` (`user_login`)
) DEFAULT CHARSET=utf8 AUTO_INCREMENT=1;

CREATE TABLE IF NOT EXISTS `tasks` (
  `task_id` bigint(20) unsigned NOT NULL auto_increment,
  `user_id` bigint(20) NOT NULL REFERENCES `users`(`user_id`),
  `task_name` varchar(60) NOT NULL,
  `task_priority` tinyint(2) NOT NULL default '2',
  `task_color` varchar(7) NOT NULL default '#ffffff',
  `task_description` varchar(150) NULL,
  `task_attendees` varchar(4000) NULL,
  `task_date` datetime NOT NULL default '0000-00-00 00:00:00',
  PRIMARY KEY (`task_id`),
  KEY `idx_task_name_key` (`task_name`)
) DEFAULT CHARSET=utf8 AUTO_INCREMENT=1;
```


http://www.developerdrive.com/2013/05/creating-a-simple-to-do-application-%E2%80%93-part-3

Hotel Token

An OAuth 2 access token is like a hotel-room key card.

It gives access, all by itself without further checking, to a particular resource (in this case, room 238 at the Omni Interlocken in Denver.) *Check*.

It's issued to a particular person, who has to be authenticated first (like by showing my driver's license at the check-in.) *Check*.

Nothing on the outside tells you who it's been issued to or what it's for. *Check*.

It's not obscured or encrypted, so you have to take good care of it (if a bad guy got it and knew what it was for, he could get into my hotel room and rob me blind.) *Check*.

You can give it to someone else and have them access the resource for you (like giving a colleague the card and asking them to go up to your room and get the VGA dongle that you stupidly left on the desk.) *Check*.

If you lose it, you can go back to the issuer and get another one which is functionally identical (somehow it wasn't there when you got back from the bar, but the front desk can get you another, assuming you have your wallet and ID.) *Check*.

It expires after a while. (I gave it back to the front desk when I left because I knew it wouldn't be useful any more.) *Check*.

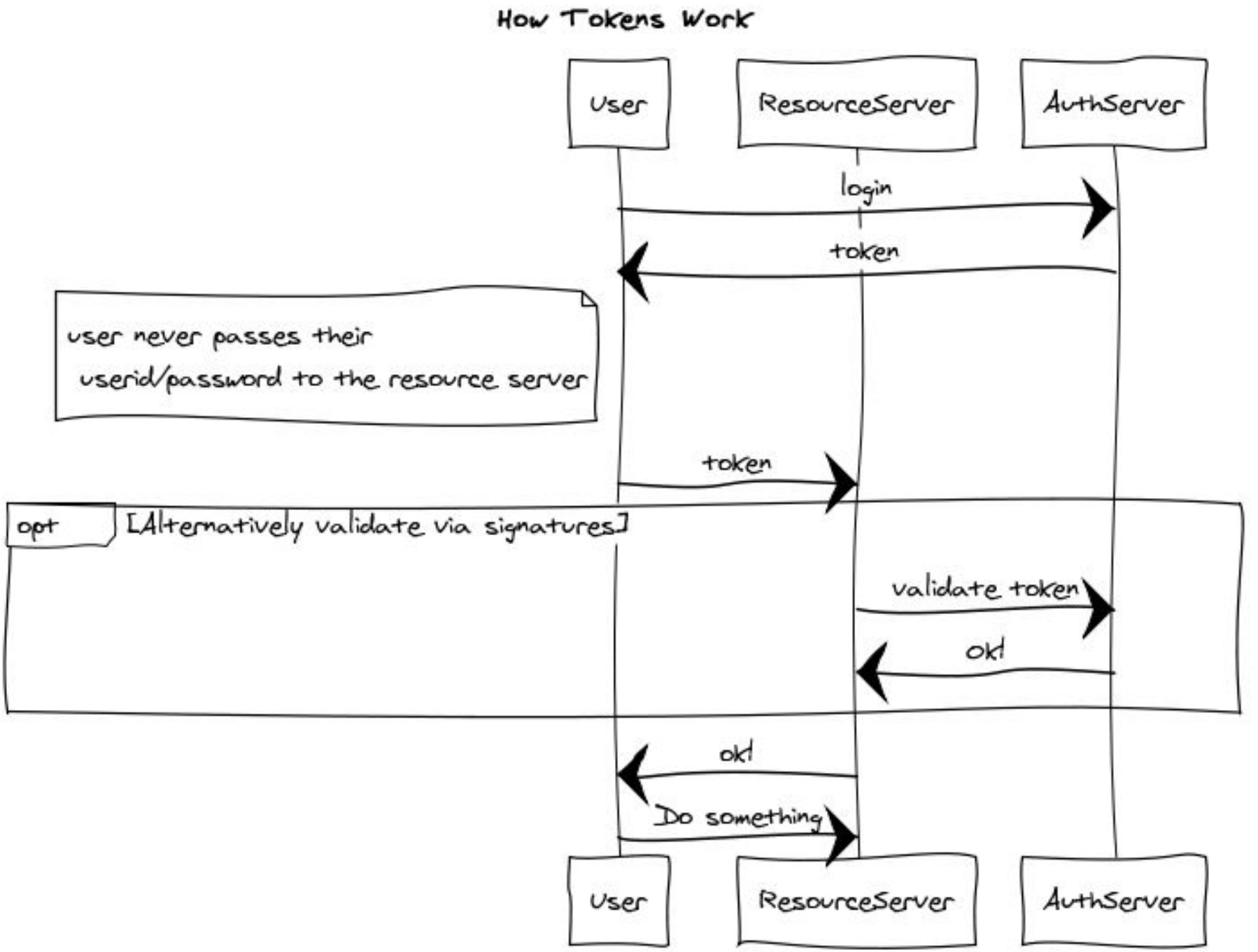
ongoing
What this is ·
Truth · **Biz** · **Tech**
author · **Dad** · **software** ·
colophon · **rights**

May 24, 2013
· **Technology** (76 fragments)
· · **Identity** (39 more)

By **Tim Bray**.

I work for Google, but the opinions expressed here are my own, and no other party necessarily agrees with them.

A full disclosure of my professional interests is on the **author** page.

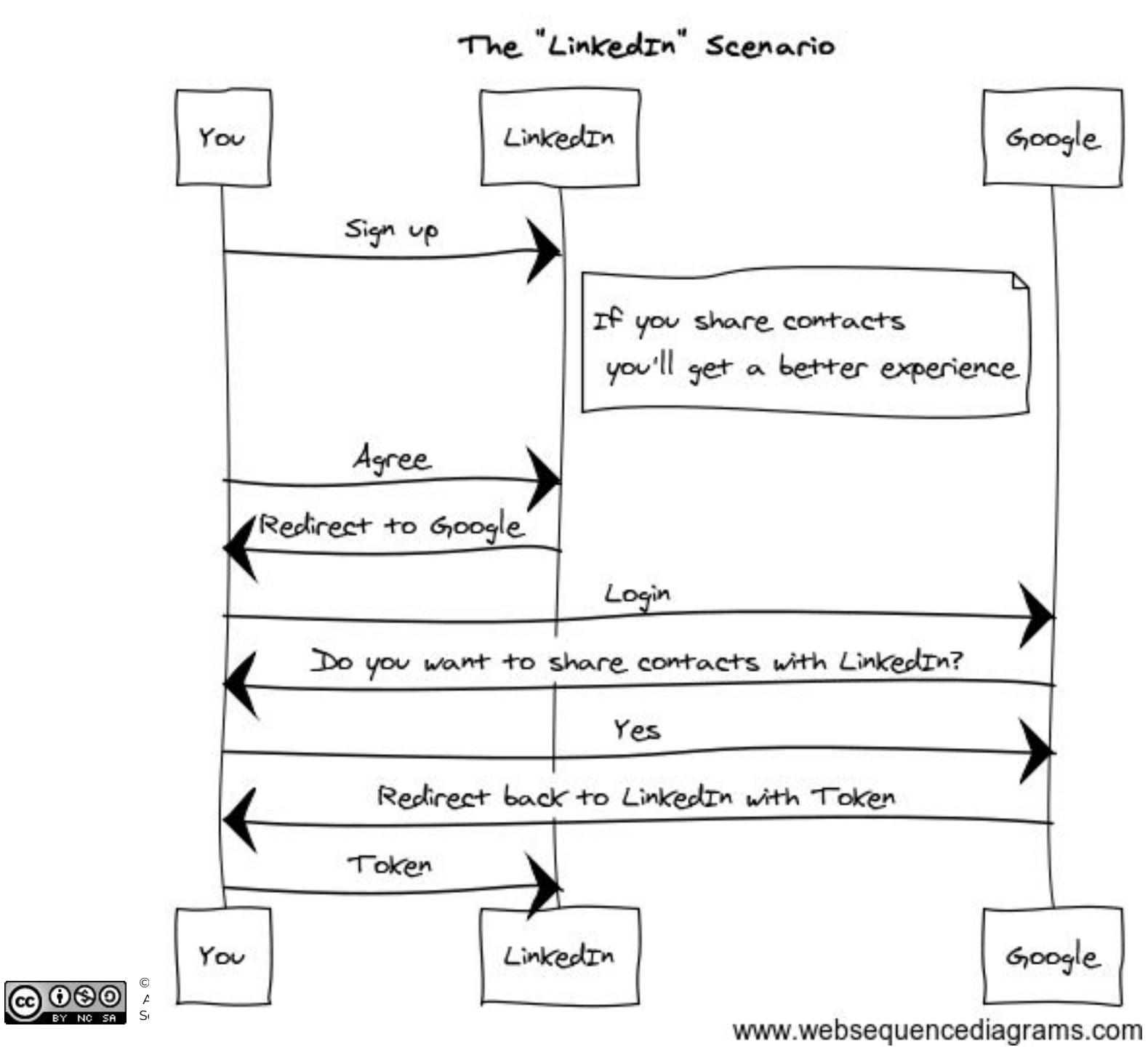

How Tokens Work
User
ResourceServer
AuthServer
login
token
user never passes their
userid/password to the resource server
token
opt
[Alternatively validate via signatures]
validate token
ok!
ok!
Do something
User
ResourceServer
AuthServer
www.websequencediagrams.com

Tokens

- Kerberos Tickets
  - Developed by MIT in the late 80's onwards
  - Designed to allow lots of campus machines to be secured easily (without having local UNIX password files!)
  - Based on Needham-Schroder
- SAML/SAML2
  - An XML version that has become a popular way of doing Single Sign On for the Web
  - Used by Google Apps/Shibboleth/etc

LinkedIn example

- LinkedIn used to ask for your Gmail userid and password
- They said they would only use this to get your contact list for certain purposes and would delete afterwards
- What do you think?

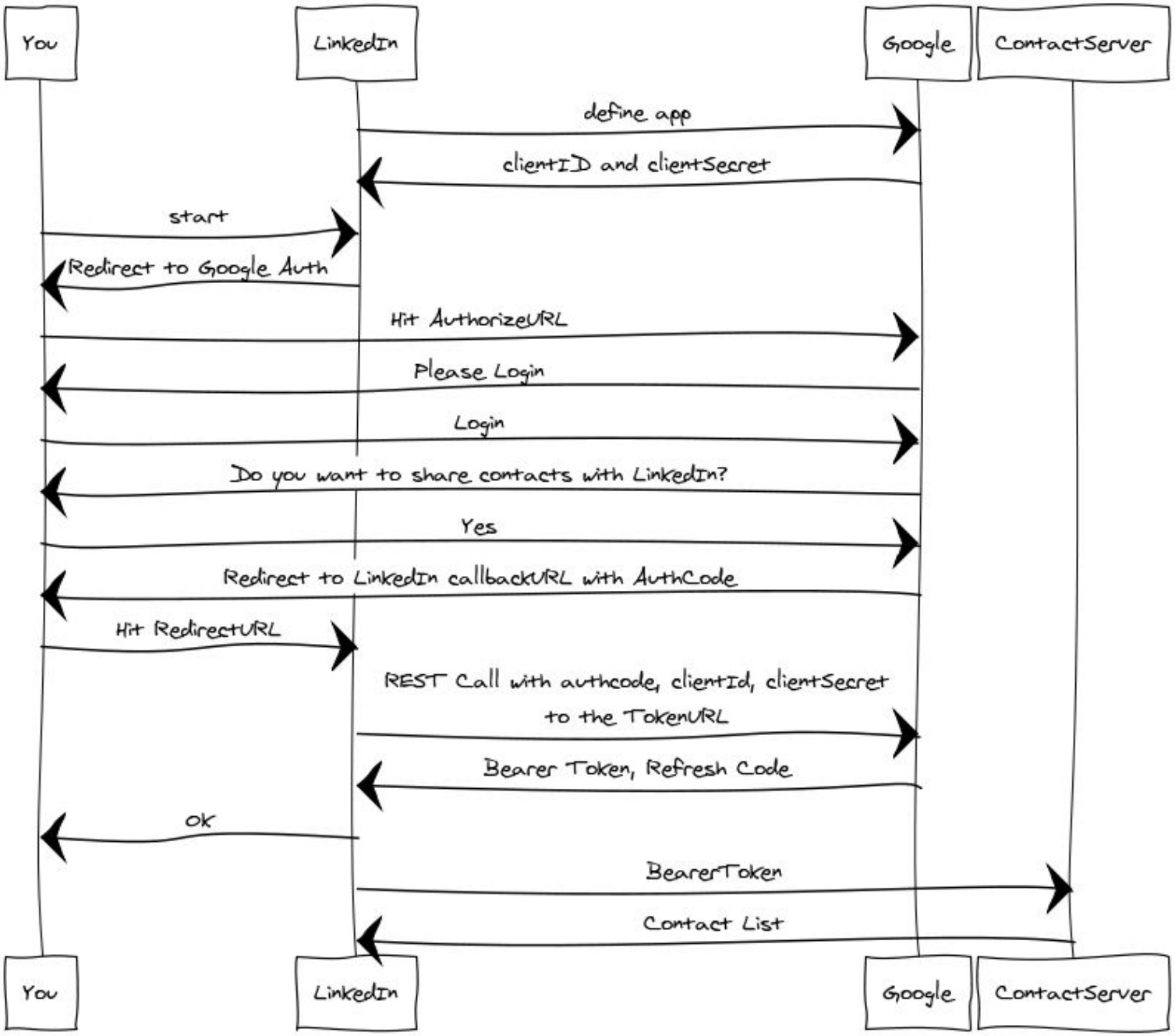


OAuth Terminology

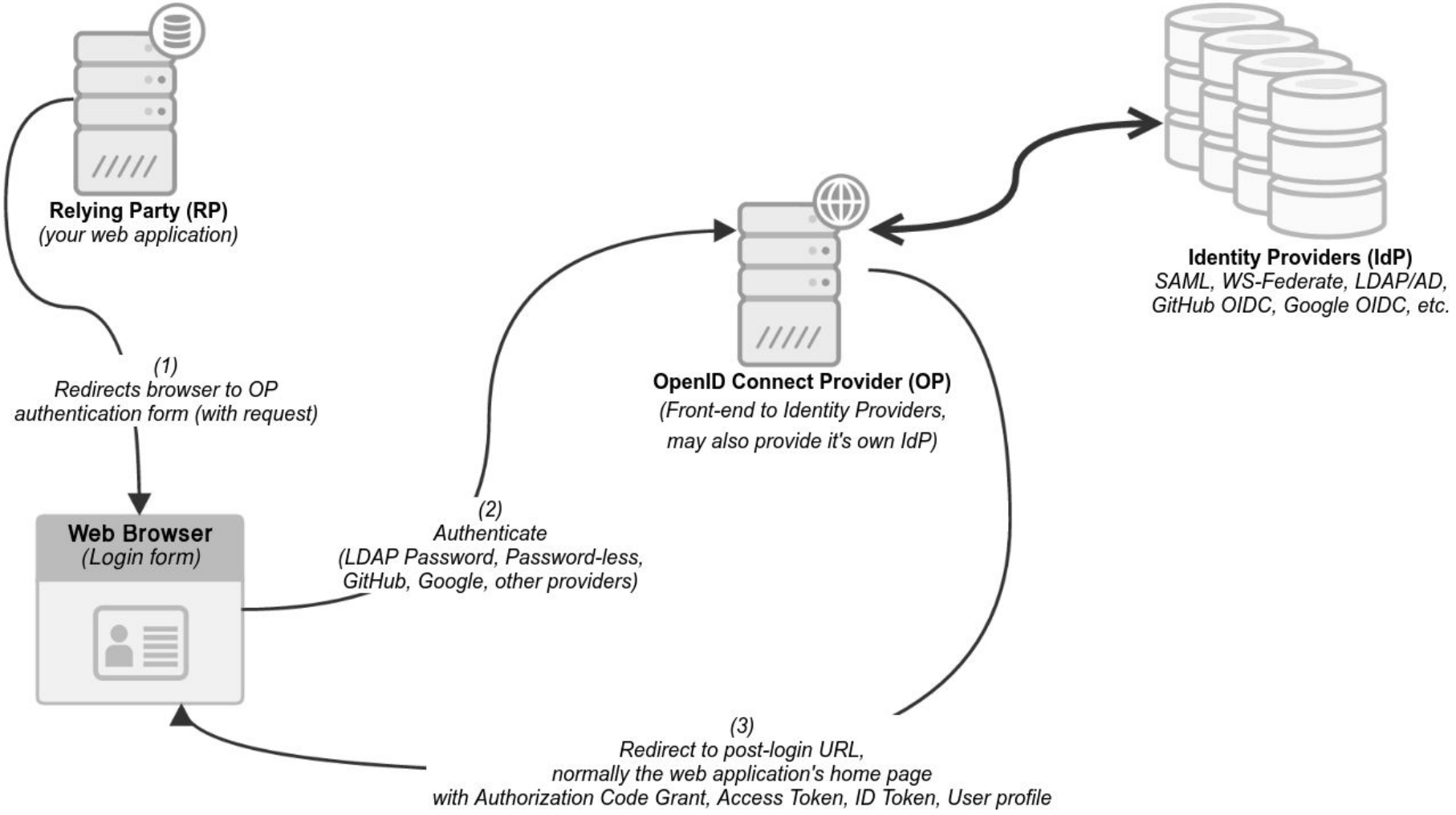
- Resource Owner
  - The end user or logical owner of the resource
  - *The gmail user*
- Resource Server
  - The server that contains or controls access to the resource
  - *The contact list*
- Client
  - The system looking for access to the resource
  - *LinkedIn*
- Authorization Server
  - The system that maintains the user identity and issuing tokens
  - *Google identity*

The more detailed version!

The "LinkedIn" Scenario the details



OpenID Connect (OIDC)



Open Source OIDC systems

- Keycloak
  - Fully featured OIDC/OAuth2/SAML server from Redhat
- WSO2 Identity Server
  - OAuth2/OIDC/SAML IdP and broker
- dex
  - A Kubernetes OIDC provider that only does federated login

Criticisms of OAuth2

- http://hueniverse.com/2012/07/oauth-2-0-and-the-road-to-hell/

"When compared with OAuth 1.0, the 2.0 specification is more complex, less interoperable, less useful, more incomplete, and most importantly, less secure."

Main concern:

Bearer tokens+TLS vs client signature

A retrospective reasoning for OAuth

- Two significant factors:
  - Billions of users do not fit well into traditional hierarchical models
    - Graph-based, user directed approaches work better – Facebook Friends, Google Circles
  - The Web and REST architecture inherently promotes linked websites, ecosystems, federation
- At the same time the web protocols make this easier to do in a standard, interoperable way

JSON Web Tokens

Encoded PASTE A TOKEN HERE

```
eyJhbGciOiJIUzI1NiIsInR5cCI6IkpXVCJ9.eyJzdWIiOiIxMjM0NTY3ODkwIiwibmFtZSI6IkpvaG4gRG9lIiwiaWF0IjoxNTE2MjM5MDIyfQ.SflKxwRJSMeKKF2QT4fwpMeJf36POk6yJV_adQssw5c
```

Decoded EDIT THE PAYLOAD AND SECRET

HEADER: ALGORITHM & TOKEN TYPE

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

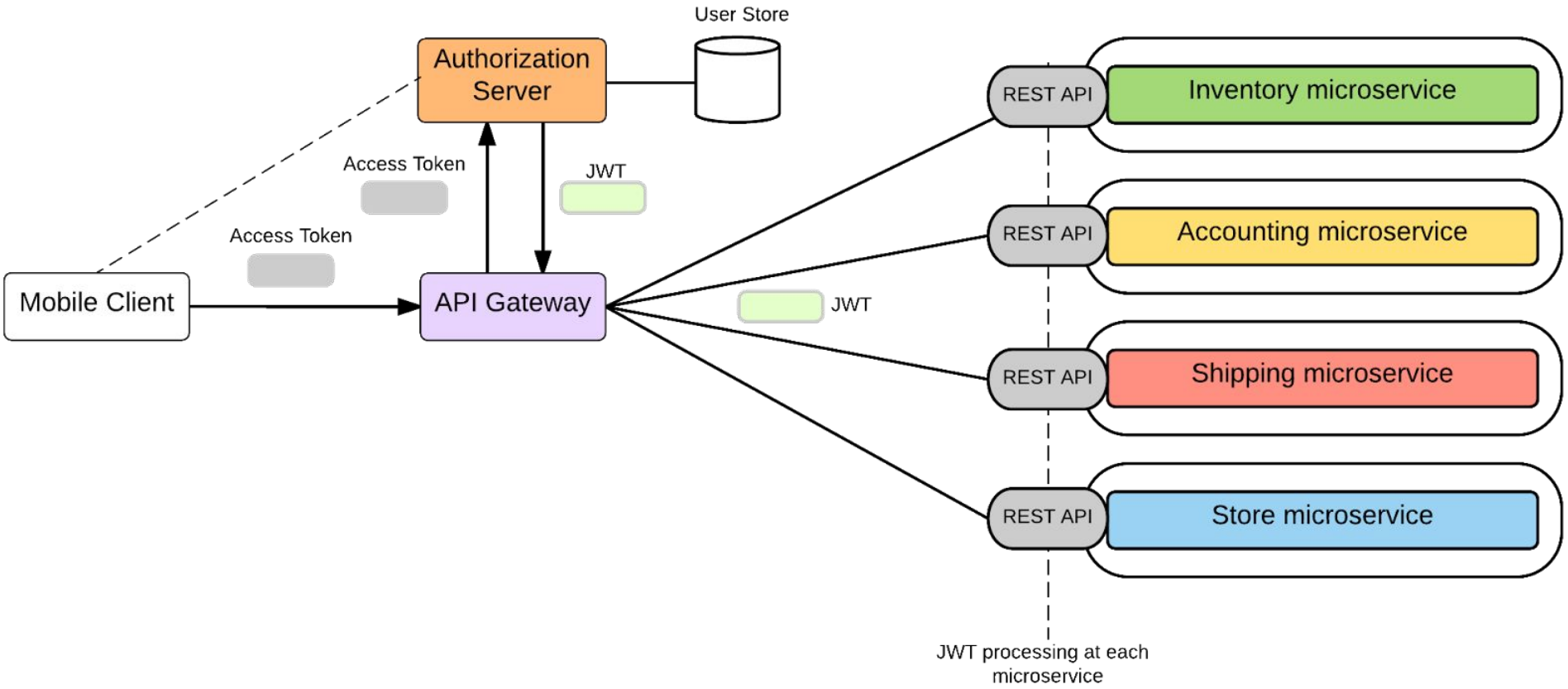
PAYLOAD: DATA

```
{
  "sub": "1234567890",
  "name": "John Doe",
  "iat": 1516239022
}
```

VERIFY SIGNATURE

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

JWT in Microservices



mTLS

mutual TLS is where both sides have a certificate

- Has come back into fashion for microservices
- Built in support from Service Meshes

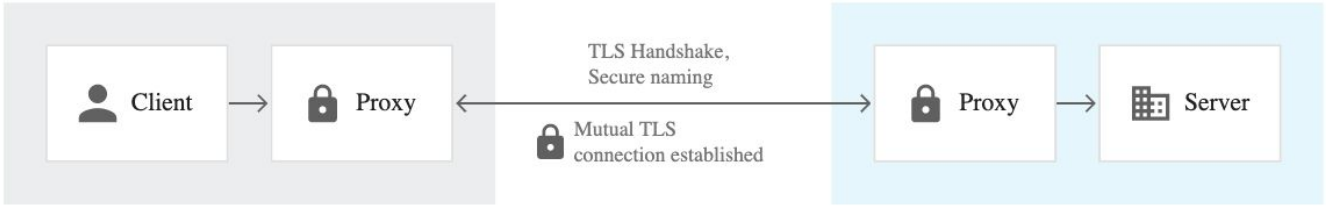
mTLS - mutual TLS by Proxy

Anthos Service Mesh by example: mTLS

Send feedback

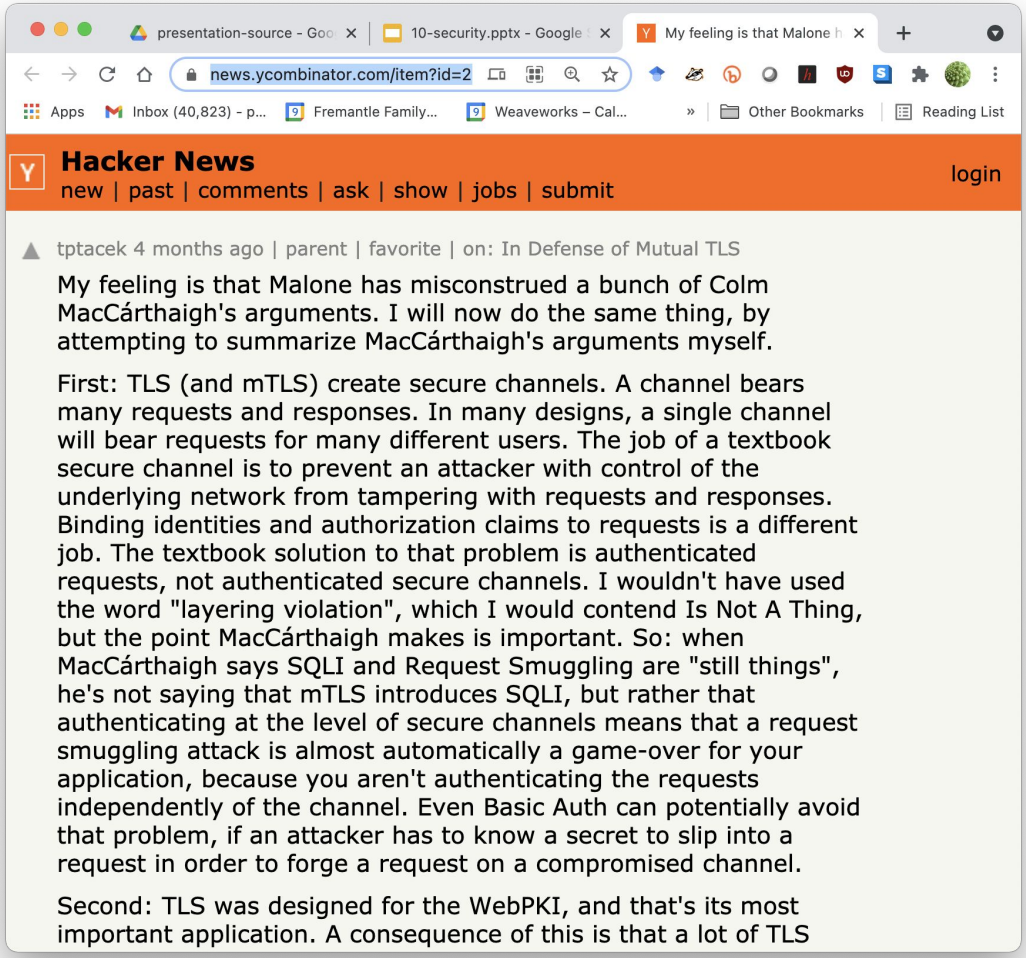
In Anthos Service Mesh 1.5 and later, auto mutual TLS (auto mTLS) is enabled by default. With auto mTLS, a client sidecar proxy automatically detects if the server has a sidecar. The client sidecar sends mTLS to workloads with sidecars and sends plaintext to workloads without sidecars. Note, however, services *accept* both plaintext and mTLS traffic. As you inject sidecar proxies to your Pods, we recommend that you also configure your services to only accept mTLS traffic.

With Anthos Service Mesh, you can enforce mTLS, outside of your application code, by applying a single YAML file. Anthos Service Mesh gives you the flexibility to apply an authentication policy to the entire service mesh, to a namespace, or to an individual workload.



An interesting thread on mTLS

https://news.ycombinator.com/item?id=25380301



Welcome to cert-manager | cer

cert-manager.io/docs/

Apps | Inbox (40,823) - p... | Fremantle Family... | Weaveworks – Cal... | Other Bookmarks | Reading List

cert-manager

Search

- **Welcome to cert-manager**
- Concepts
- Installation
- Configuration
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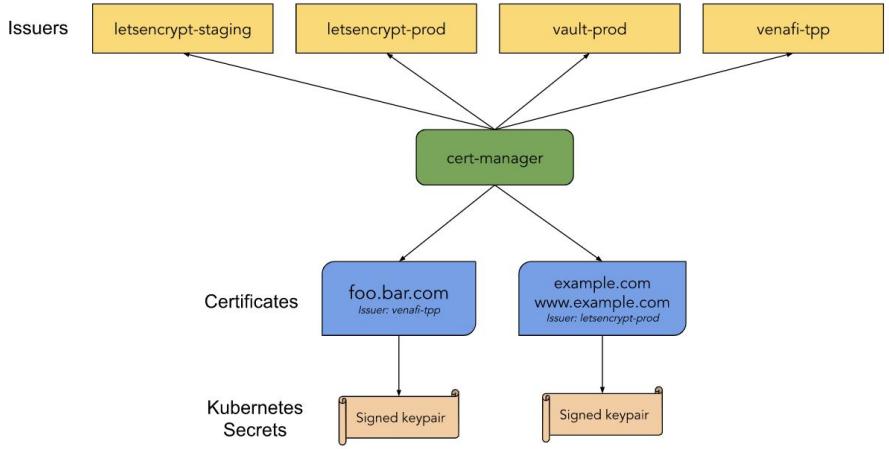
- Release Notes
- About Jetstack
- API reference docs

Welcome to cert-manager

cert-manager is a native Kubernetes certificate management controller. It can help with issuing certificates from a variety of sources, such as Let's Encrypt, HashiCorp Vault, Venafi, a simple signing key pair, or self signed.

It will ensure certificates are valid and up to date, and attempt to renew certificates at a configured time before expiry.

It is loosely based upon the work of kube-lego and has borrowed some wisdom from other similar projects such as kube-cert-manager.



Access Control

- Traditionally Authorization has been
  - Role-based
    - If I am a manager then I can look at salaries
    - Based only on user
  - Hard-coded
    - Authorization rules encapsulated in code and applications

Problems with RBAC

- Problems with this are:
  - Doesn't correctly model the real world
    - I should only be able to see my team's salaries, and only while participating in the salary review process
  - Hard to evolve
  - Hard to manage compliance
    - How do I find out who can make a trade of $30m?

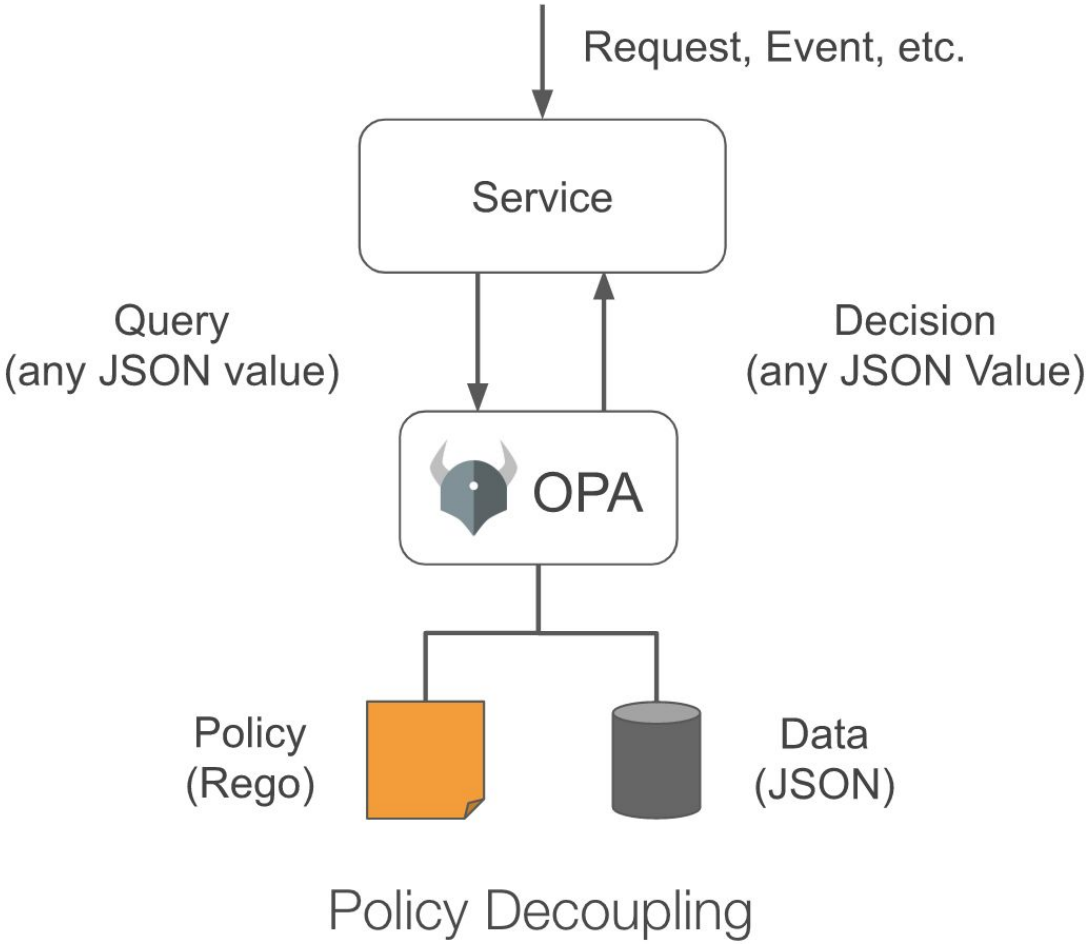
Policy Based Access Control

- Delegate access control decisions to a "Policy Decision Point"
- Utilise more information in the decision
- Externalise the decision from the code

XACML 3.0

- An XML language for capturing authorization and entitlement
- Together with a powerful model
- Terminology
  - Policy Decision Point (PDP)
  - Policy Enforcement Point (PEP)
  - Policy Administration Point (PAP)
  - Policy Information Point (PIP)

Open Policy Agent (OPA)



Policy Decoupling

OPA in Kubernetes

OPA for HTTP APIs

authz.rego — ~/src/policies/httpapi/acmecorp

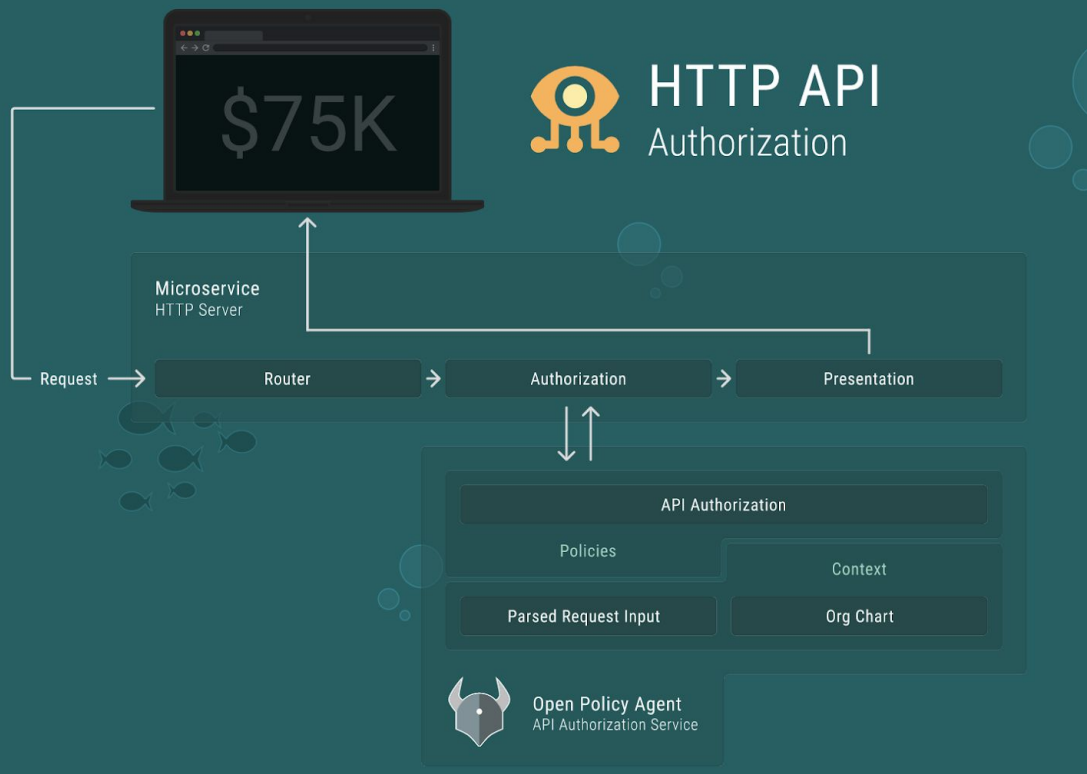
```
# HTTP API Authorization

package acmecorp.authz

default allow = false

# Allow people to read their own salaries.
allow {
    input.method = "GET"
    input.path = ["salaries", employee_id]
    input.user = employee_id
}

# Also allow managers to read the salaries of people they manage.
allow {
    input.method = "GET"
    input.path = ["salaries", employee_id]
    input.user = data.manager_of[employee_id]
}
```



Resources

- Applied Cryptography, Second Edition, Bruce Schneier, John Wiley & Sons, 1996, ISBN 0-471-11709-9
- Web Services Security, Mark O'Neill, 2003, ISBN 0072224711
- Google (sorry but there are too many links!)