ACME-Based Provisioning of IoT Devices

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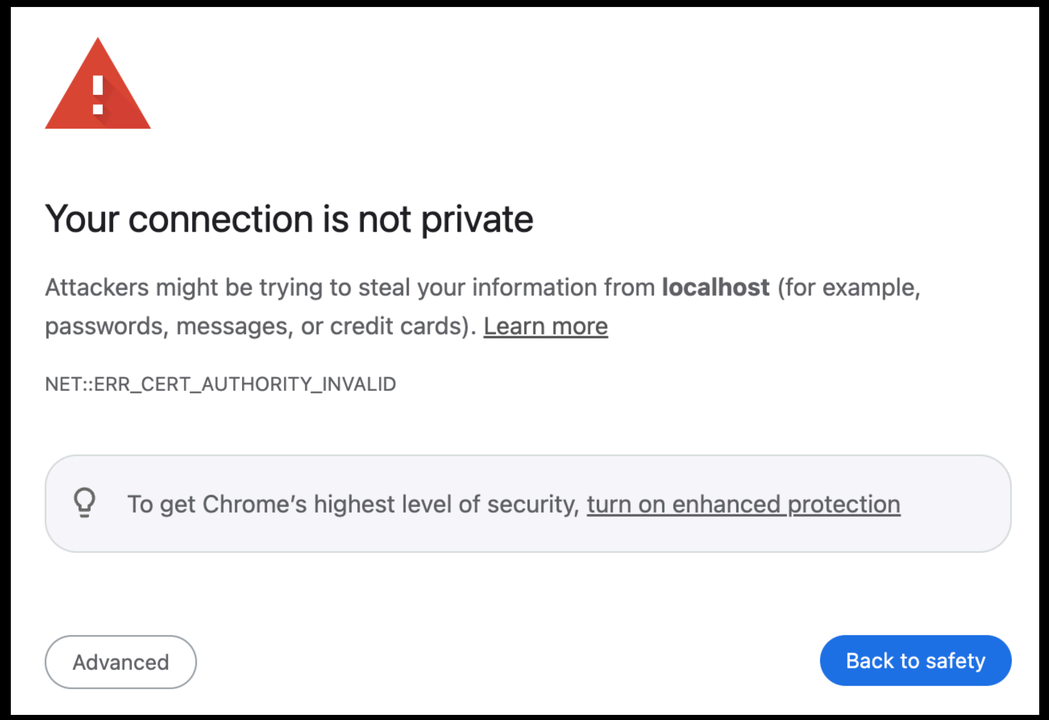
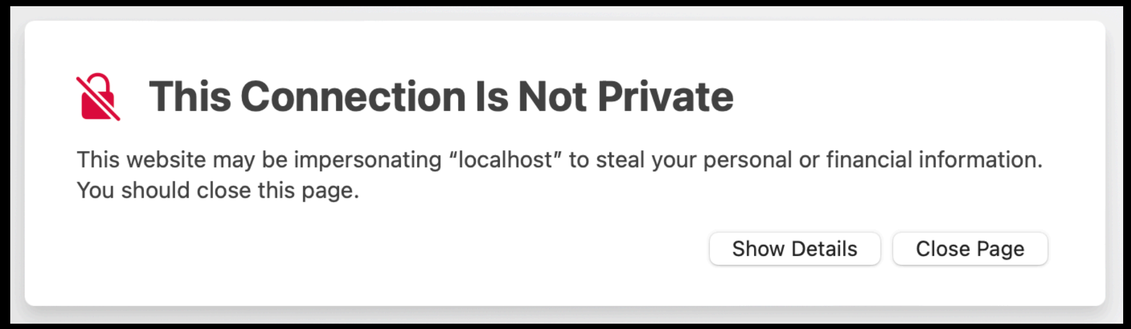
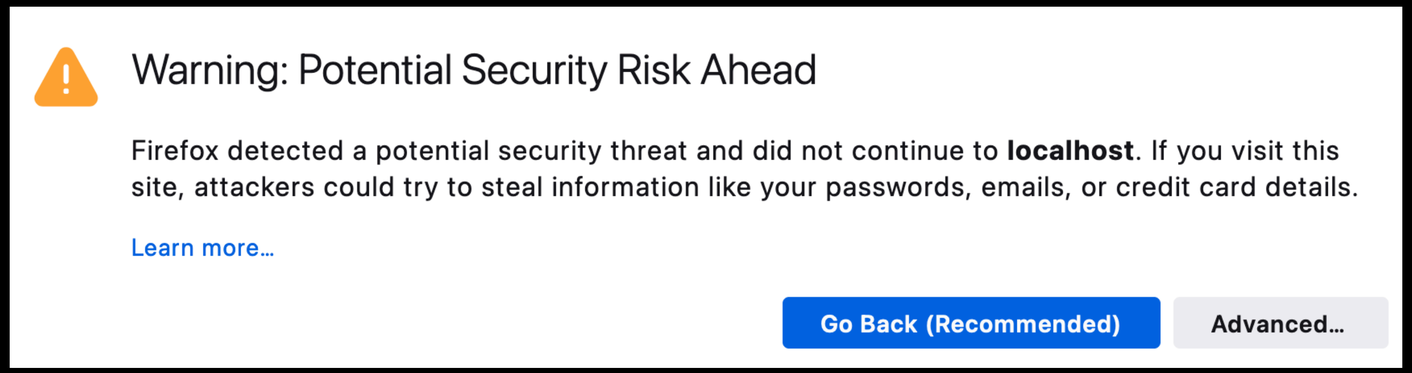
- Current I-D:
  - https://datatracker.ietf.org/doc/draft-sweet-iot-acme/
- Abstract:
  - This document extends the Automatic Certificate Management Environment (ACME) [RFC8555] to provision X.509 certificates for local Internet of Things (IoT) devices that are accepted by existing web browsers and other software running on End User client devices.
- Primary goal is to eliminate scary browser security warnings when accessing embedded web servers on IoT devices
- Secondary goal is to enable a more scalable and trustable local CA infrastructure

Typical Scary Browser Security Warnings







How to Eliminate Scary Security Warnings

- Browser developers do not want to allow self-signed certificates, even for ".local" (mDNS) hostnames
- Only solutions at present are:
  - Obtain (buy) CA-issued X.509 certificates with a trusted root
  - Install a local X.509 root certificate and issue/generate X.509 certificates using it
  - (Manually) use a third-party solution such as Microsoft Active Directory Certificate Services or smallstep's step-ca to generate and install X.509 certificates
- These don't scale to home users and add to the workload of enterprise IT departments

Typical Home Network

- Wi-Fi router/modem provided by ISP
  - Router implements DHCP and DNS (passthrough) services along with NAT and firewall functionality
  - Little to no outbound traffic filtering, may provide inbound port mapping and/or DMZ functionality for a single host
  - Embedded web interface for configuration/status monitoring, speed testing, etc.
- Network clients connect to network and obtain IP address(es), default gateway/route, DNS server, and local domain (usually the ISP's domain name) via DHCP
- Printers, cameras, appliances, etc. provisioned/connected by end users using WPS, captive portal AP web interface, vendor mobile apps, and/or device control panel

Typical Enterprise Network

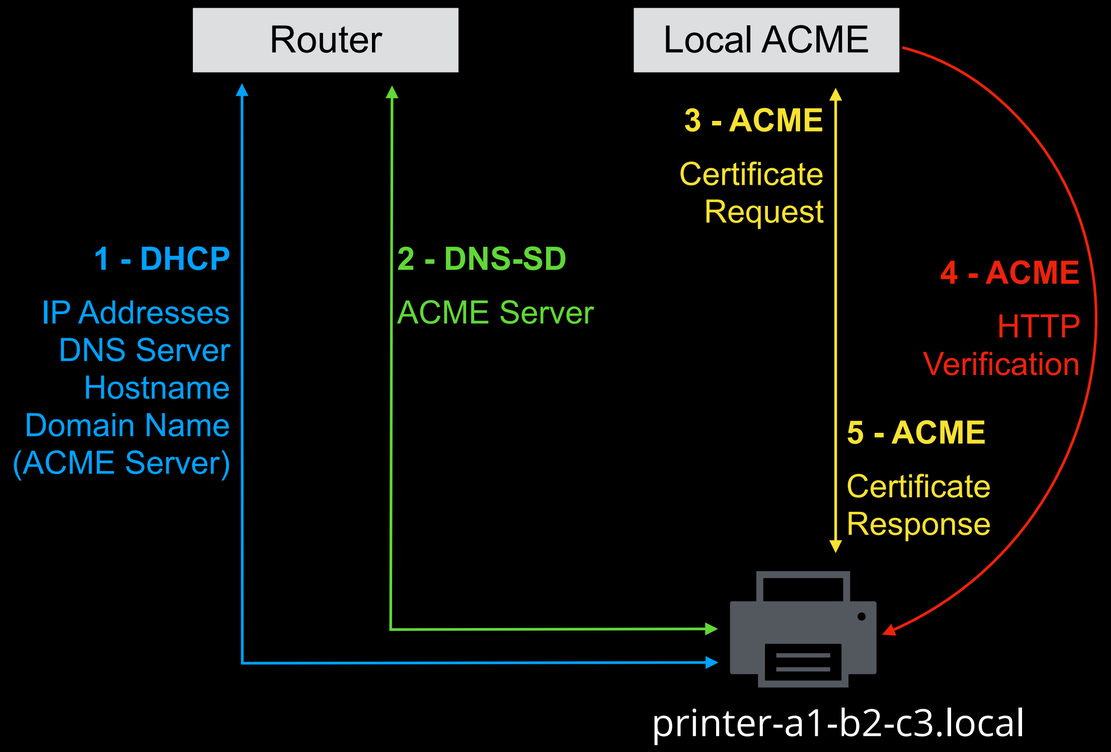
- Managed routers, modems, etc.
  - Multiple subnets/VLANs
  - DHCP service for each subnet
  - DNS service for each site/organization
  - Outbound traffic is filtered/monitored, inbound traffic may be completely blocked or limited to isolated subsets/VLANs, interior traffic is often filtered/monitored
- Dedicated authorization, certificate, etc. services
- Network clients may need to be explicitly provisioned
- Printers, cameras, appliances, etc. are managed by IT department and/or third-party service

ACME

- ACME and Let's Encrypt have enabled the widespread use of HTTPS for public Internet web sites, but:
  - Certificates for ".local" domain names cannot be issued
  - No way to do HTTP or DNS verification of local devices
- A local ACME server can be configured to issue certificates for ".local" domain names (as well as site domains) and can do HTTP and DNS verification with local devices
- Key issues:
  - ACME server discovery
  - Root certificate (trust anchor) for issued certificates
  - Security considerations for local ACME server, clients, and IoT devices

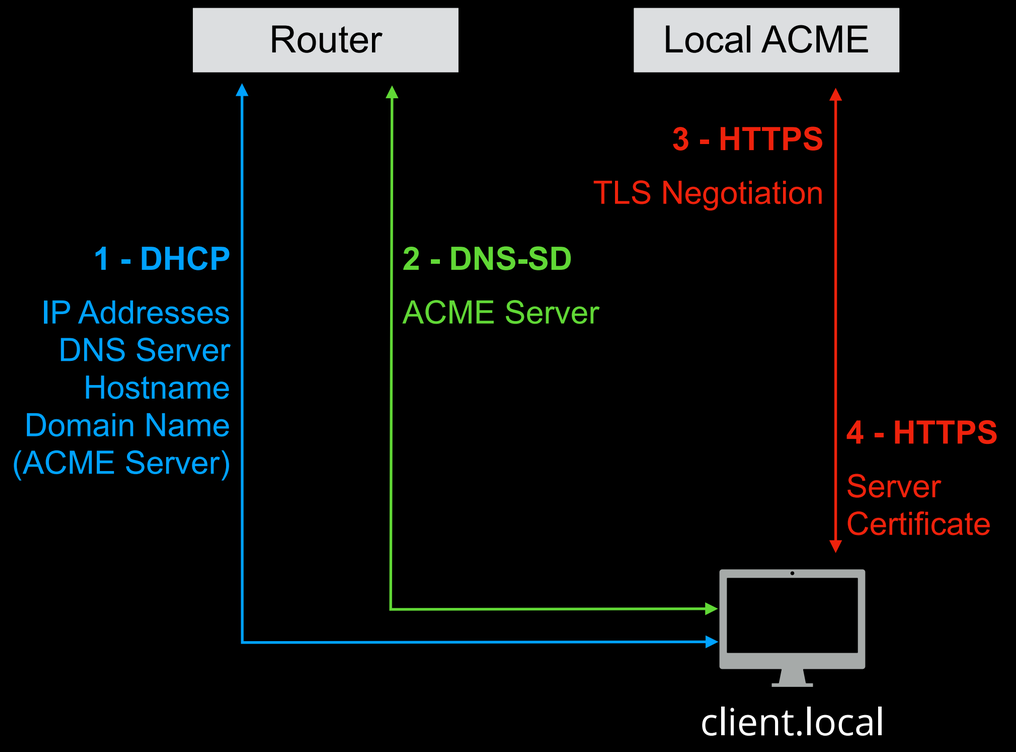
ACME Server Discovery

- Use DHCP option and/or DNS-SD with local DNS service
  - DHCP is both commonly used and trusted for local device access/connection
  - DHCP option provides simpler way for home networks
  - DNS-SD easily integrates with enterprise infrastructure
  - *Cannot use mDNS for security reasons*
- Nominally one ACME server per network
  - Failover/load-balancing is possible via DNS but from the network device perspective there is a single service



Network Root Certificate ("Trust Anchor")

- CA-signed root certificate will work with existing CA infrastructure/ support
- Self-signed root certificate requires some special handling
  - Trust On First Use (TOFU) when connecting to network
  - Only valid while connected to that network
  - Only valid for ".local" and local/site-specific domain



Security Considerations

- Local ACME server:
  - Only issue certificates for approved domains - ".local" and site-specific domain ("examplecorp.com")
  - Protect root certificate and private key
  - Support revocation/re-issue as needed
  - Long-duration self-signed root cert or CA-signed root cert to minimize time-of-use/MITM attacks
  - Short-duration issued certs to minimize exposure of compromised credentials
  - **One proposed addition:** provide a way for the network owner to manually approve issuance of new certificates

Security Considerations

- Client devices:
  - Limit trust of local root certificate to current network/domains
    - Challenge is network identification - SSID isn't unique, MAC address should be but isn't authenticated, TLS negotiation establishes ownership of private key but anybody can make a self-signed certificate
    - **One proposed solution:** use the local root certificate as the network identity
  - TOFU for "self-signed" root certificates, possibly with UI to confirm on network connection
- IoT devices:
  - Protect ACME-issued certificate and generated private key
  - Do not reuse private keys
  - Must have ability to wipe/"factory reset" the device

Level of Trust

- With self-signed root certificates, the level of trust is necessarily reduced
  - Browsers could choose to indicate this somehow, but based on prior research with "EV" certs that might not be useful/effective
  - Might also simply change the wording of the scary error message to something more like the SSH TOFU prompt
- Need to be comfortable with "less than perfect" security
  - Encrypting potentially sensitive communications is always a good thing
  - Providing a network-specific trust anchor provides better control and local validation of certificates and protects against MITM attacks
  - Using a common protocol such as ACME allows the same certificate infrastructure to be used in both enterprise and home networks, which is especially important as more people have hybrid work scenarios

Q&A