EAP-NOOB : Nimble Out-of-Band Authentication for EAP

— Bootstrapping security for smart appliances

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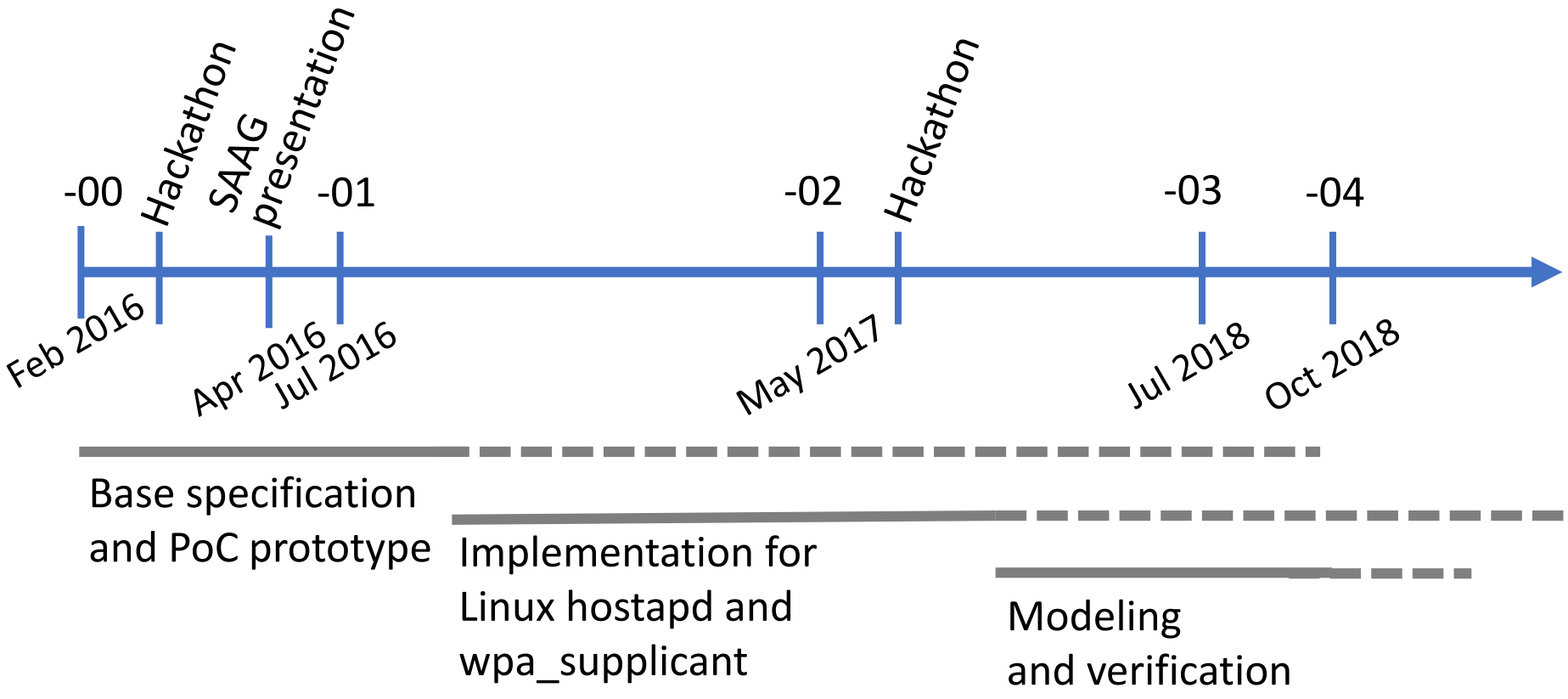
EAP-NOOB: Nimble Out-of-Band Authentication for EAP

Bootstrapping security for smart appliances

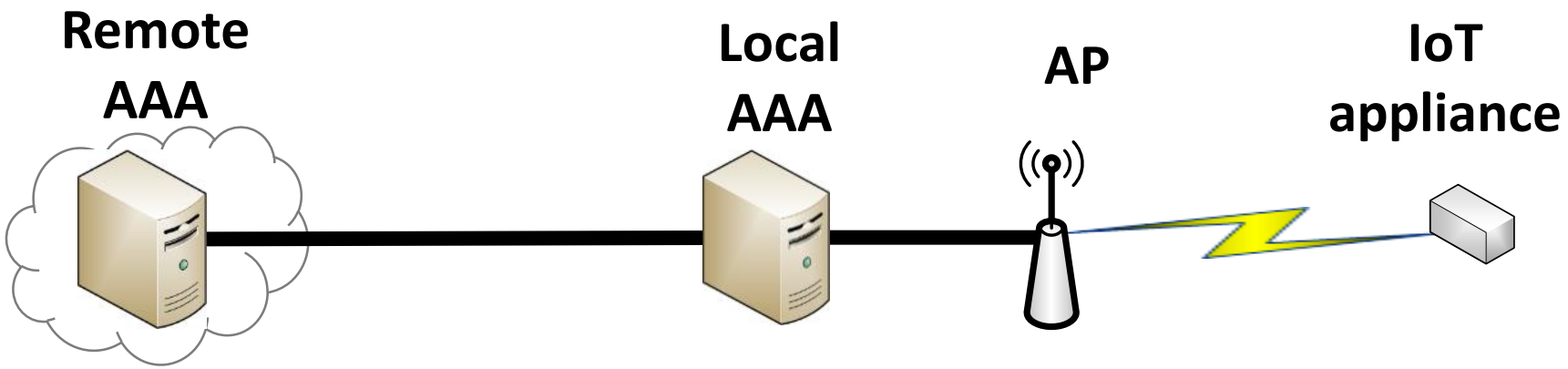
draft-aura-eap-noob



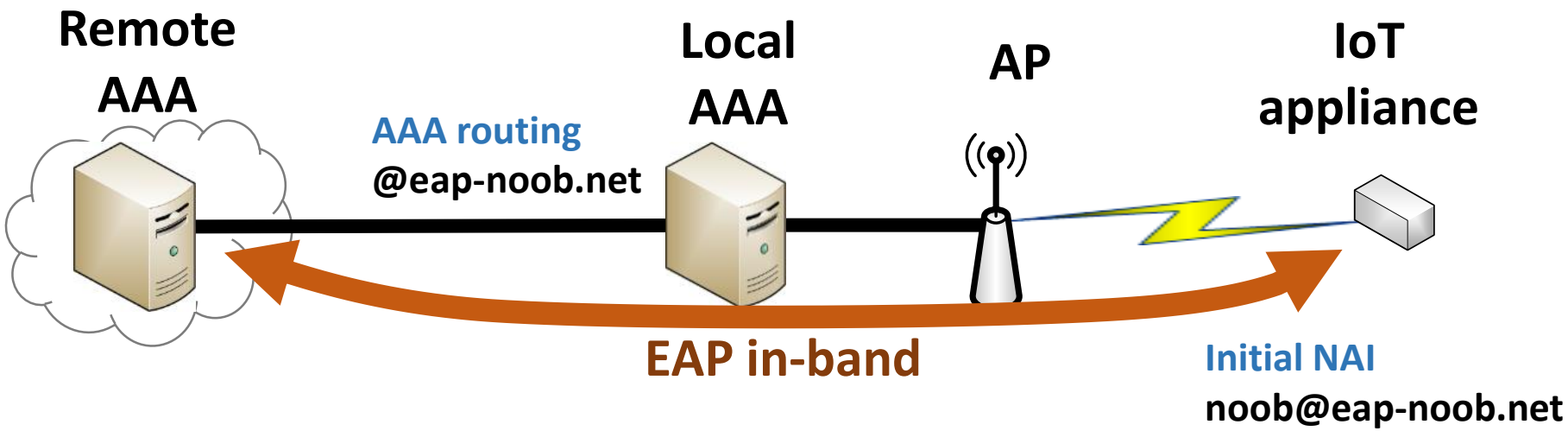
What problems EAP-NOOB solves?

- EAP method for deploying IoT devices out-of-the-box without professional administration
- User-assisted out-of-band (OOB) authentication method for EAP
  - E.g. scanning a dynamic QR code, dynamic NDEF tag
  - No such method currently
- Registration of new peer devices
  - Create persistent association between AAA and device
  - Authorize network connectivity
  - Assign an owner (AAA server) to the device
  - Current EAP methods require peer to be pre-registered

EAP-NOOB architecture

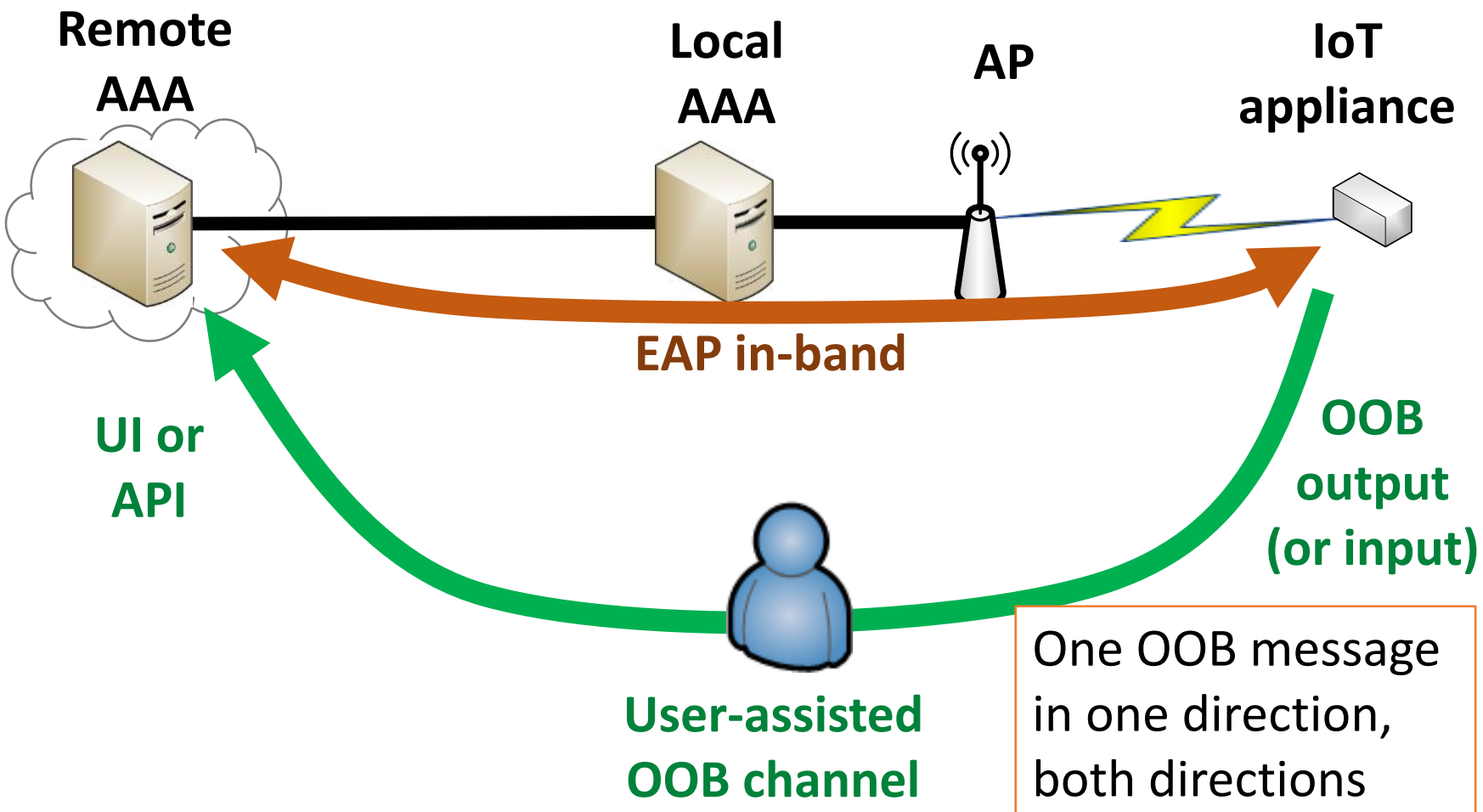


EAP-NOOB architecture



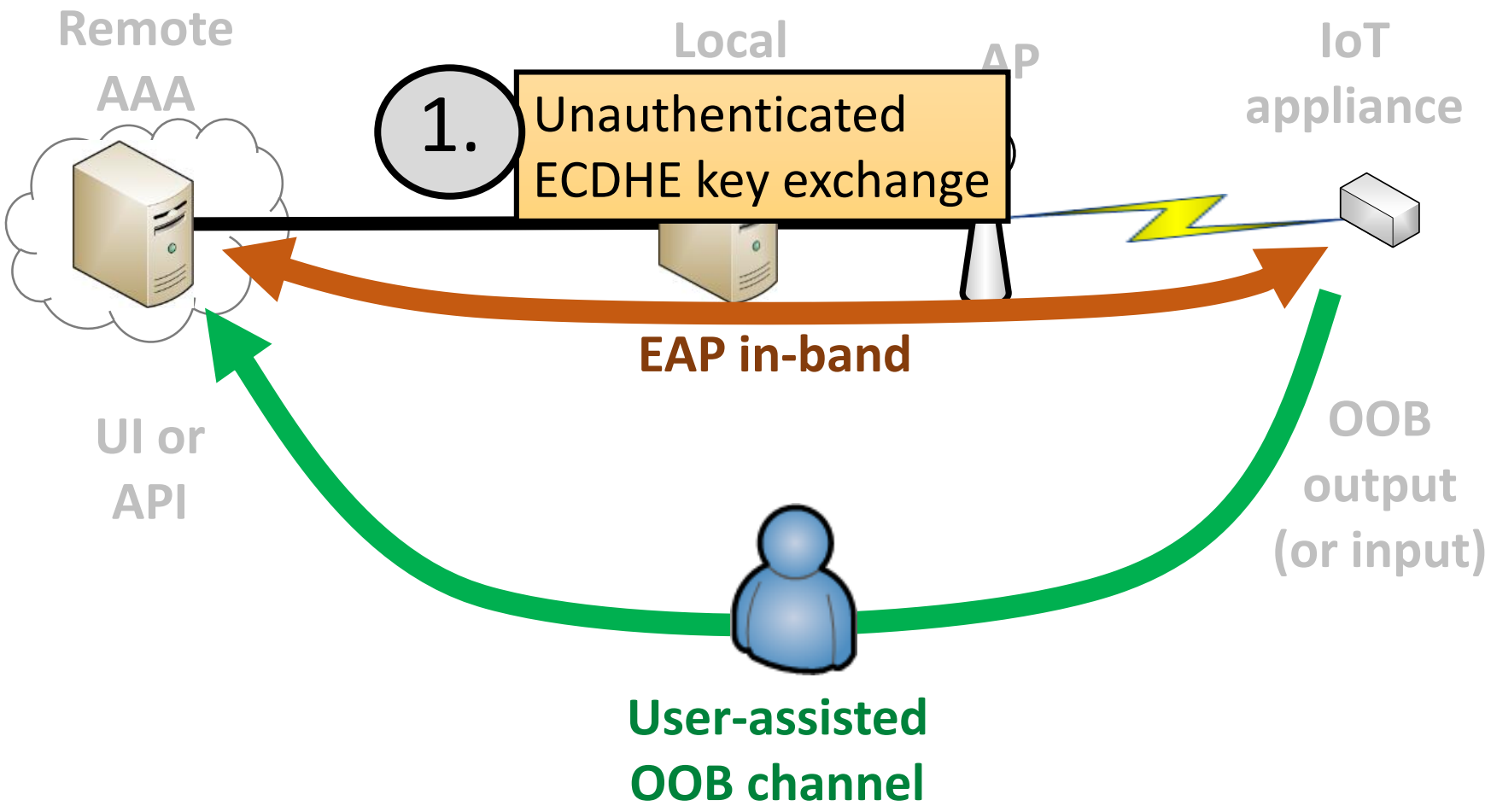
EAP tunnel and AAA routing enable in-band communication with the authentication server *before* the device is registered

EAP-NOOB architecture

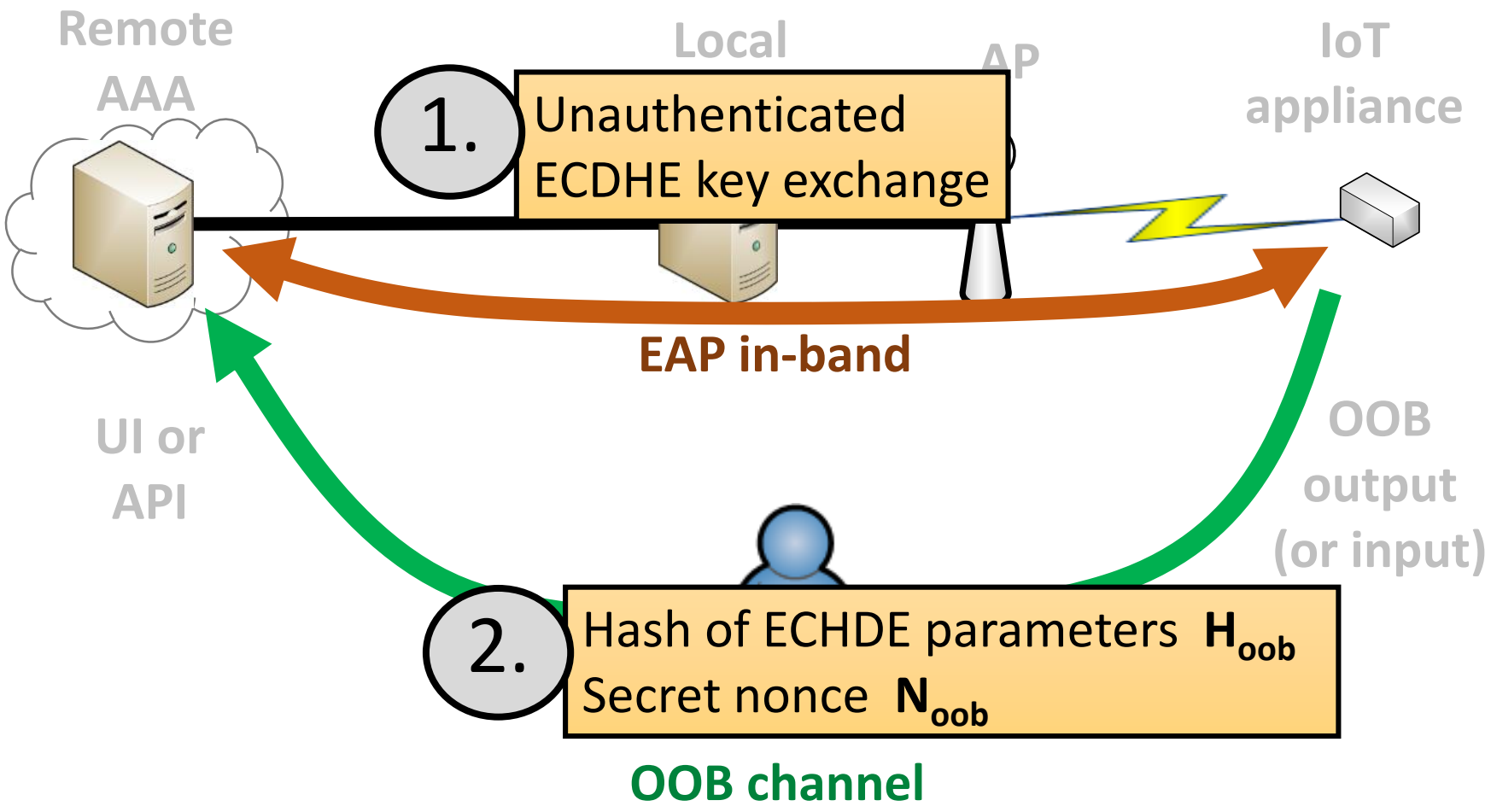


One OOB message in one direction, both directions supported

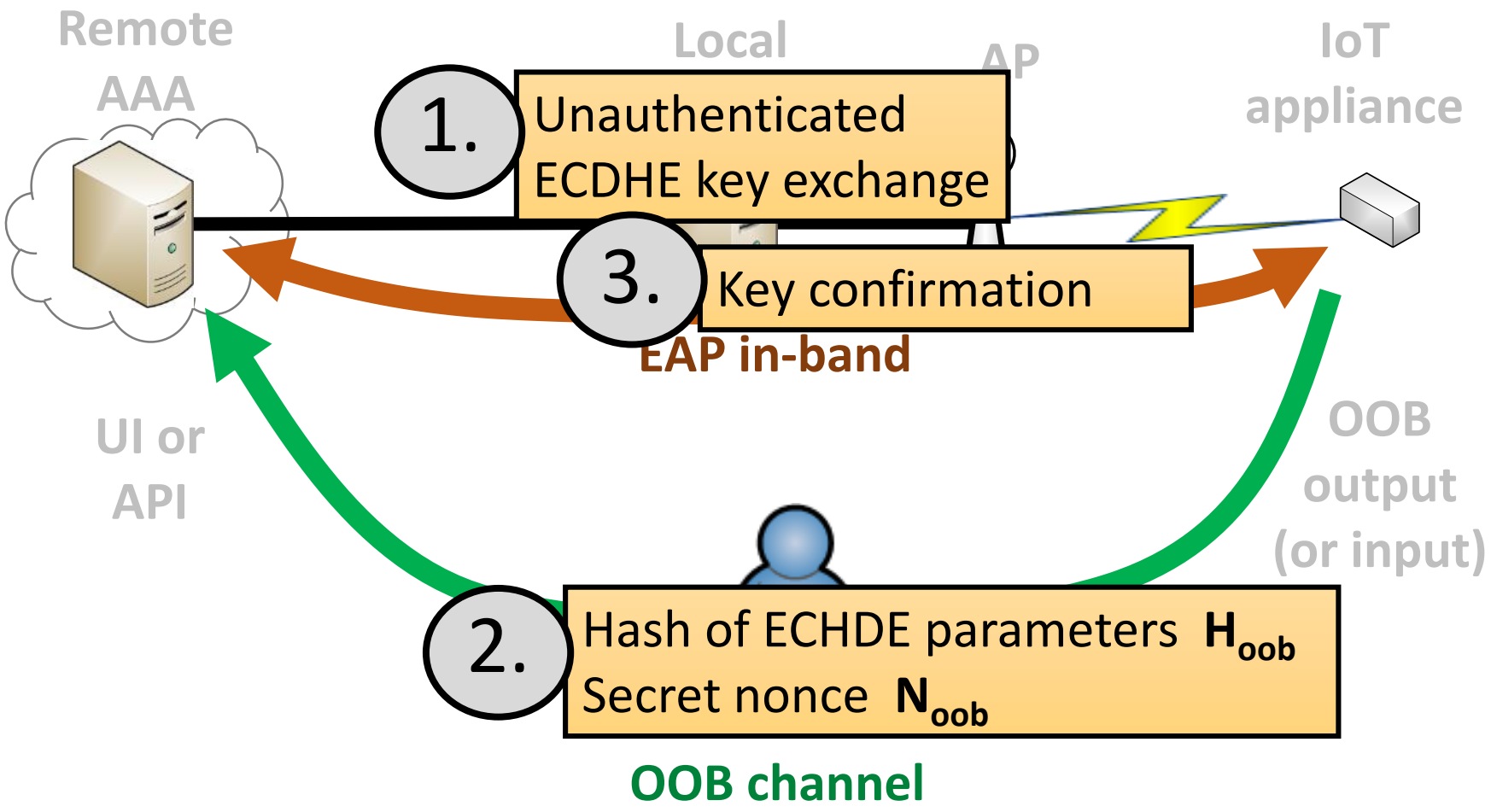
EAP-NOOB protocol



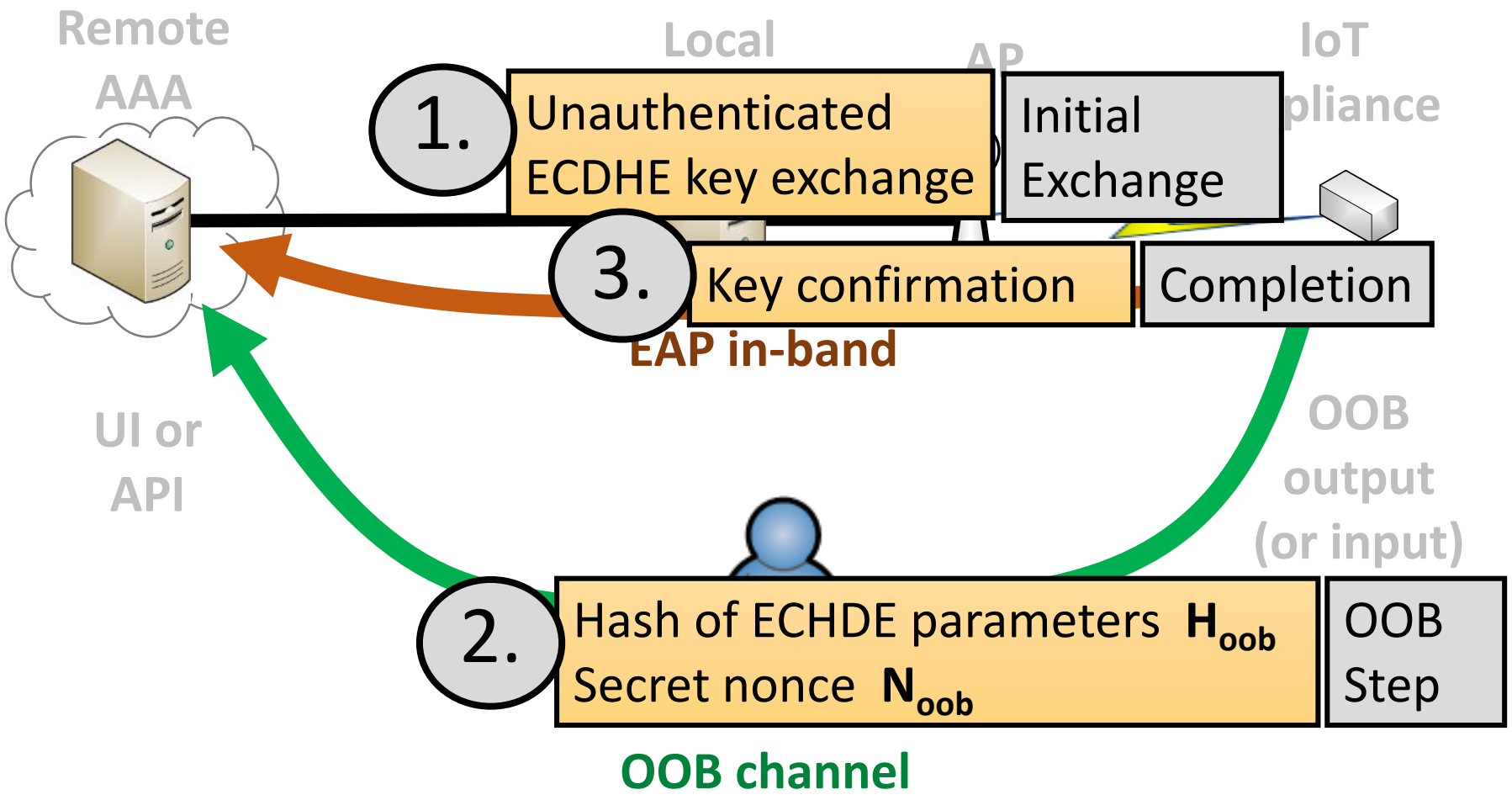
EAP-NOOB protocol



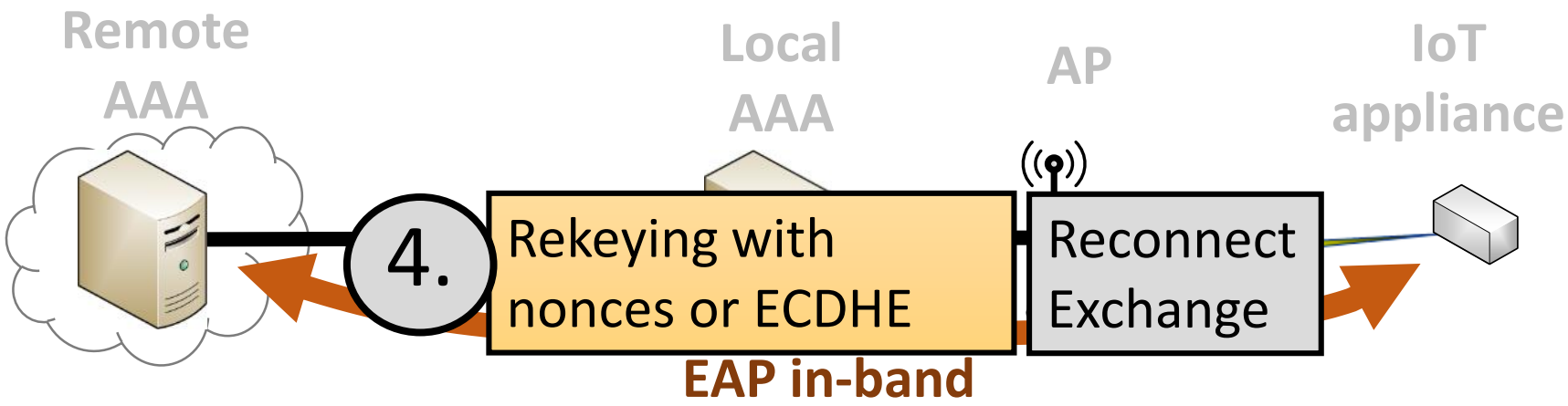
EAP-NOOB protocol



EAP-NOOB protocol



EAP-NOOB protocol: Reconnect



After successful OOB step,
persistent association is created.
OOB step is *not* repeated

EAP-NOOB security

Minimal assumptions on OOB channel:

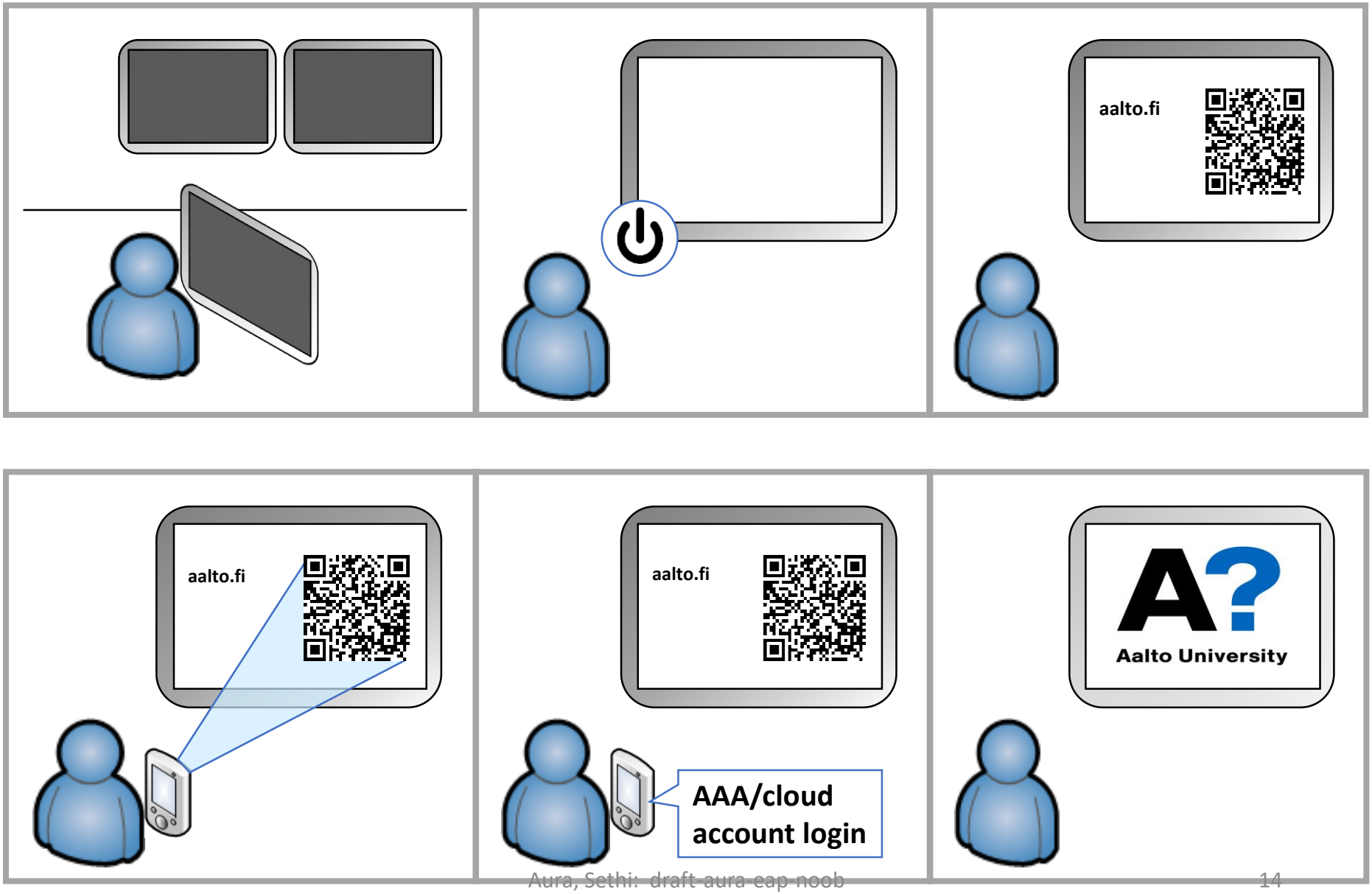
- One OOB message in either direction
- OOB channel may provide only integrity or secrecy
- Tricky case: peer-to-server OOB with no secrecy
  - In this case, one-directional OOB message not enough
  - User must note failure of server to register peer and, in that case, reset the peer

Resist denial-of-service by man-in-the middle:

- Avoid persistent failure caused by limited number of dropped or tampered messages

Use case: secure bootstrapping of cloud-managed displays

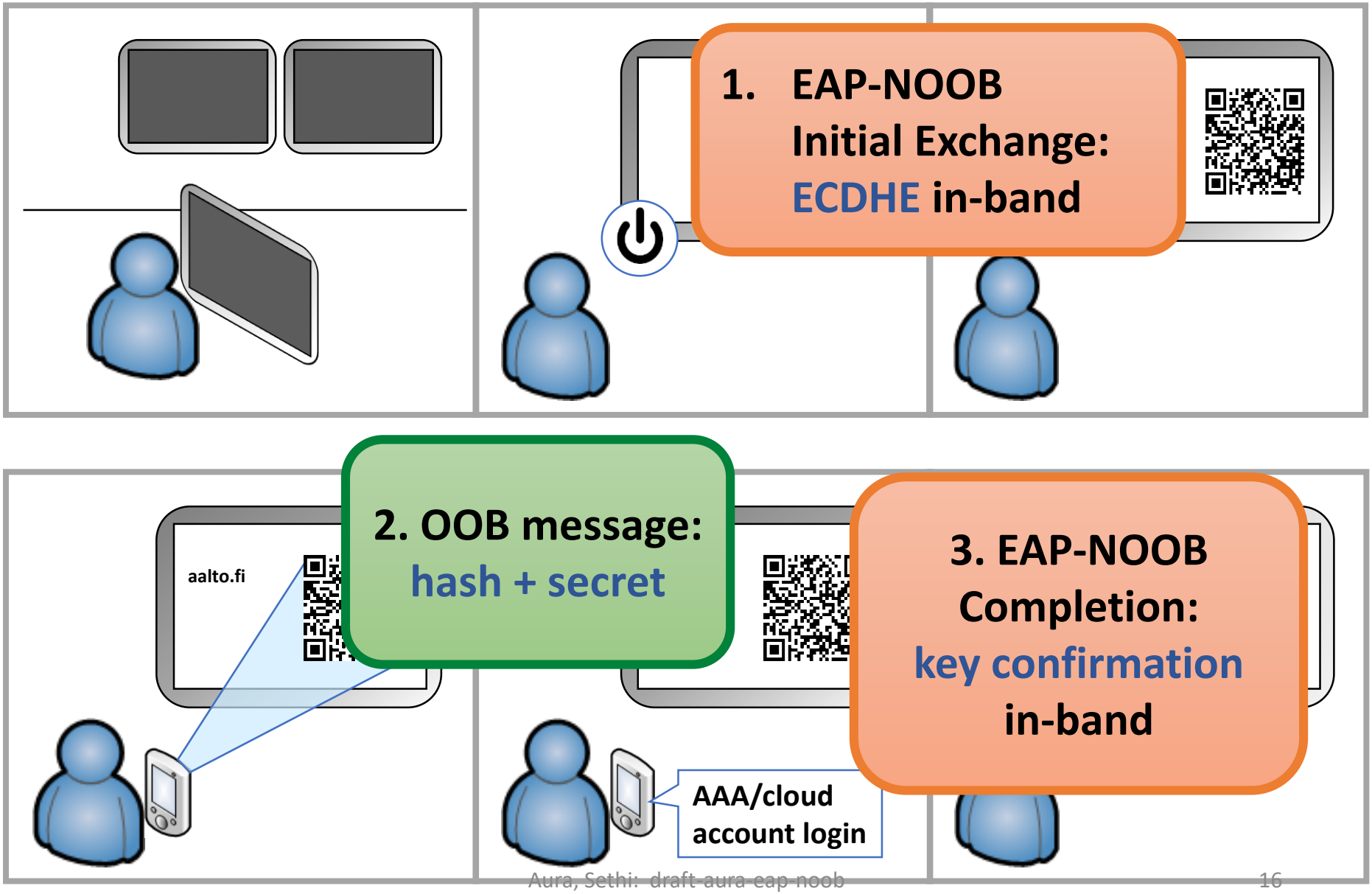
EAP-NOOB user experience example



Use case: bootstrapping cloud-connected display

- New display device has no owner or domain, no credentials for cloud or Wi-Fi
- One-step process to:
  - register display device to cloud + get Wi-Fi access
  - link device to a user account (ownership)
  - export URL and key for application-layer device management
- Display device can output OOB message is URL as QR code, but has no input, except reset button
- User has a smart phone (app optional)
- Remote AAA server integrated to display-management service in cloud

EAP-NOOB in the background



Resolved and open issues in EAP-NOOB design

OOB message details

- Short and convenient OOB message format
- OOB message contents:

  PeerId = server-allocated peer identifier

  Noob = secret nonce (16 bytes)

  Hoob = hash of ECDHE parameters (16 bytes)
- OOB message can be encoded as URL:

  `https://example.com/Noob?P=ZrD7qkczNoHGbGcN2bN0&N=rMinS04F4EfCU8D9ljxX_A&H=QvnMp4UGxuQVFaXPW_14UW`
- URL output e.g. in dynamic QR code or NDEF tag
- OOB security requirements:
  - Noob confidentiality must be protected, **or**
  - Hoob integrity must be protected

Persistent association

- Must avoid rerun of user-assisted authentication (OOB step) at all cost
- EAP-NOOB solution:
  - After OOB message delivered and Completion takes place, peer and server create persistent association
  - Future authentication requires no user interaction
  - User reset is the only way to move back to initial state

Identifier allocation

- Must not rely on unauthenticated identifiers
- Need to avoid identifier squatting
- EAP-NOOB solution:
  - Peer is initially anonymous noob@eap-noob.net
  - Server allocates new PeerId for every Initial Exchange
  - User may name devices at server UI
- Device can send app-layer identifiers and capabilities to server in PeerInfo field
  - Cryptographic assertions about the peer device could be added as protocol extension

Bootstrapping application security

- Network connectivity and association with application server in one step
- AAA server may be integrated with application-layer device management
  - Can export keys to application layer
  - Can convey initial app-layer configuration to peer
- Compare with entering wireless credentials and then application-layer cloud credentials

Roaming support

- Devices may need to roam like personal computers, e.g. in Eduroam
  - Feature requested by Josh Howlett (Jisc.ac.uk)
- EAP-NOOB solution:
  - Server sends to peer a list of SSIDs where the persistent association is valid
  - Peer uses server-allocated PeerId@Realm for future authentications

Wireless network selection

- Out-of-the-box peer does not know the current wireless network or AAA server – how to disccover?
- EAP-NOOB solution 1:
  - Peer device scans all wireless networks for EAP-NOOB support, performs Initial Exchange with all
  - Peer device outputs multiple OOB messages (e.g. alternative QR codes)
  - User typically only knows one AAA server and delivers the OOB message to/from it
- EAP-NOOB solution 2:
  - User selects SSID on peer device

Multiple OOB messages

- Peer device may have multiple OOB messages in flight, by the same or different user
- Peer may support both peer-to-server and server-to-peer directions for the OOB message
  - not encouraged for usability reasons
- If peer tries to connect to multiple wireless networks in parallel, multiple users may deliver OOB messages to different servers
- EAP-NOOB solution:
  - The first delivered OOB message wins
  - If two OOB messages delivered at the same time in different directions, server-to-peer message wins
  - The first server to complete wins
  - Deadlock freedom verified in mCRL2 model

Cryptosuite upgrade

- Common solution: Upgrade of long-term credentials (e.g. certificate) requires admin action
- EAP-NOOB solution:
  - Avoid user action (new OOB step) at all cost
  - Reconnect Exchange may negotiate a new cryptosuite and update the persistent association keys

Dropped last messages

- If last message of the Reconnect is dropped, peer moves to new cryptosuite while server keeps old one → Synchronization failure between peer and server
  - Man-in-the-middle attacker can cause DoS
- Unavoidable problem in distributed systems
  - EAP retransmission does not help
  - Adding another ack message would not help
- EAP-NOOB solution:
  - Peer willing to roll back to old cryptosuite until it received confirmation that server has upgraded in the next attempted rekeying
  - Server never rolls back
  - Cryptosuite upgrade completes when the packet-dropping attacker goes away

Isolating devices on access network

- In typical use of EAP-NOOB:
  - users can register new peer devices to network
  - remote AAA trusted to register new devices for wireless access
  - corrupt IoT device could share its access credentials
- These devices probably should be isolated to a VLAN and isolated from local network hosts
  - Local AAA can signal APs to do this
- Isolation of devices from each other on VLAN possible but not supported on most Wi-Fi networks
- Not for us to solve, but something to keep in mind

Software requirements

- Peer device and AAA server need to support EAP-NOOB
  - We implemented the EAP method for Linux hostapd and wpa_supplicant
  - Integrating EAP method and user interaction for OOB delivery can be a bit tricky
- AP does not need any changes
- Local AAA at the access network typically requires only minor configuration changes
  - Forward authentication for @eap-noob.net and server-assigned Realm to remote AAA that supports EAP-NOOB

Other issues on our TODO list:

- Thorough modeling and analysis of error message handling
- Timeouts in the protocol need modeling and user testing
- Should add separate message field for application-layer bootstrapping info
- API for exporting application-layer keys and bootstrapping info
- Update the security considerations section

Summary

What is the trick?

- Tricks in EAP-NOOB
  - Thanks to inband communication over EAP, we only need one short OOB message, in either peer-to-server or server-to-peer direction
  - OOB message designed so that either secrecy or integrity is sufficient for security
- Is there a catch?
  - Requires AAA, e.g. Wi-Fi with WPAx-Enterprise
  - Network admin has to choose one AAA server for device bootstrapping in that network

Comparison to…

- Configuring the peer offline with all it needs
  - Peer UI may have only output and no suitable input
- Simply transferring a secret key to/from the peer?
  - OOB channel may be vulnerable to spying. EAP-NOOB can work with only integrity
- Static QR code with hash of device public key
  - EAP-NOOB establishes two-way trust
  - EAP-NOOB assigns a network and owner to the device
- Reading and writing configuration data over NFC
  - EAP-NOOB only requires one OOB message in one direction
  - EAP-NOOB supports a variety of OOB channels incl. NFC
- Home networks with shared passphrase
  - Devices need to be managed and revoked individually; WPA-Enterprise is better

EAP-NOOB Summary

- EAP method with user-assisted OOB authentication for bootstrapping security of smart appliances
- Current version: draft-aura-eap-noob-04

Requests to the EMU WG:

- If the WG is rechartered, consider including EAP-NOOB
- Can we use the EMU git for the draft and issue tracker?