Secure VM Migration in Tactical Cloudlets

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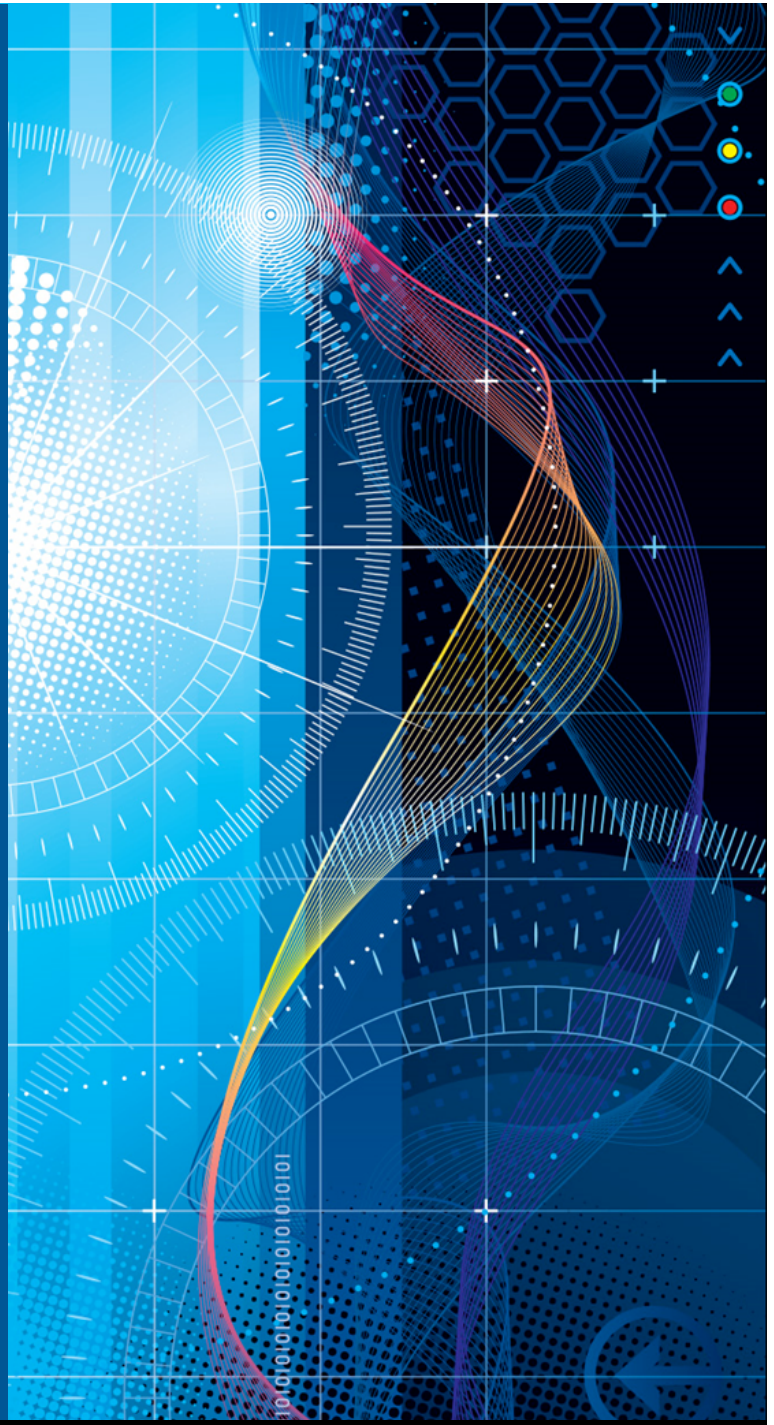

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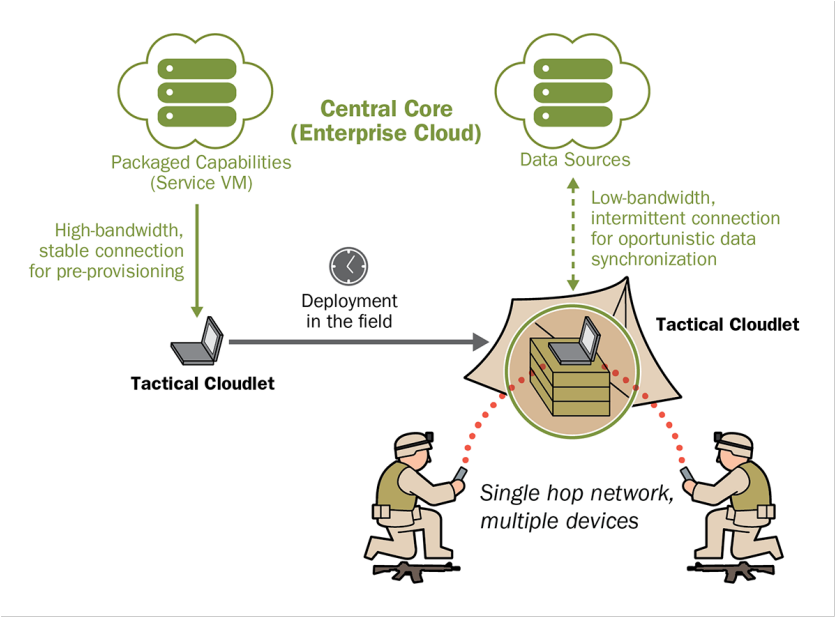
DM17-0829

Background: Tactical Cloudlets

Forward-deployed, discoverable, virtual machine (VM) based cloudlets that can be hosted on vehicles or other platforms to provide

- infrastructure to offload computation
- forward data-staging for a mission
- data filtering to remove unnecessary data from streams intended for dismounted warfighters
- collection points for data heading for enterprise repositories



Features

- Pre-Provisioned Cloudlets with App Store
- Standard Packaging of Service VMs
- Optimal Cloudlet Selection
- Cloudlet Management Component
- Cloudlet Handoff/Migration
- Secure Key Generation and Exchange

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Background: Security Requirements

1. Does not require network connectivity to a third party such as the Internet, an enterprise or wide-area network (WAN), or a Certificate Authority (CA)
2. Does not place any specific security requirements on hardware, such as a Trusted Platform Module (TPM) processor
3. Does not require pre-provisioning of credentials on nodes
4. Addresses the threats of a tactical environment

In previous work we developed a solution for establishing trust between mobile devices and tactical cloudlets based on Identity-Based Encryption (IBE) and the use of out-of-band (OOB) channels (i.e., physical proximity and visual confirmation)

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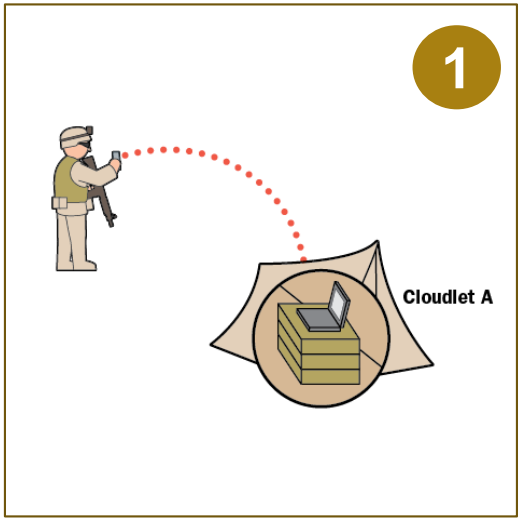
Secure VM Migration

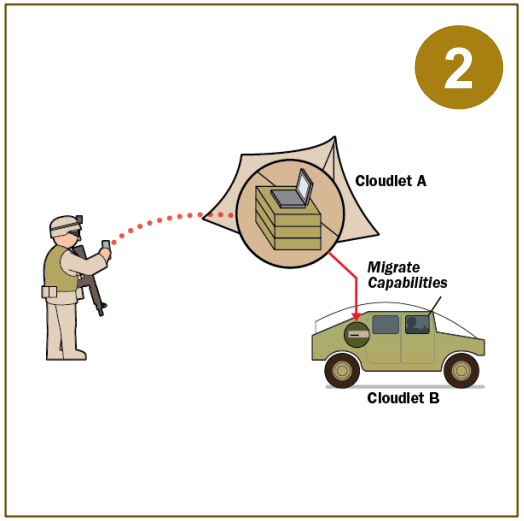
Service VM Migration involves transferring a running service VM on a source cloudlet to a target cloudlet

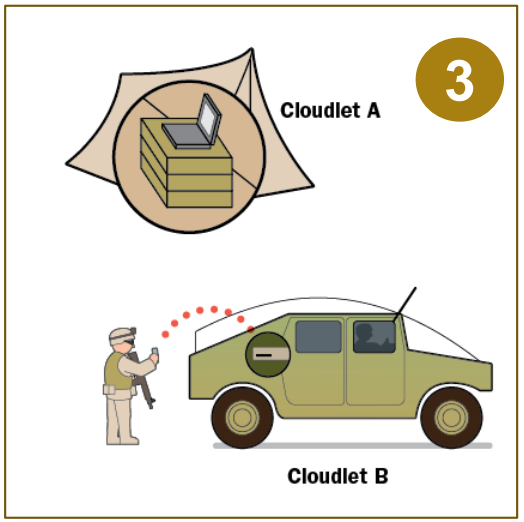
- VM migration
- Device “migration”

Challenges

- Establishing trust between cloudlets for credential exchange
- Transferring device trust from source to target cloudlet







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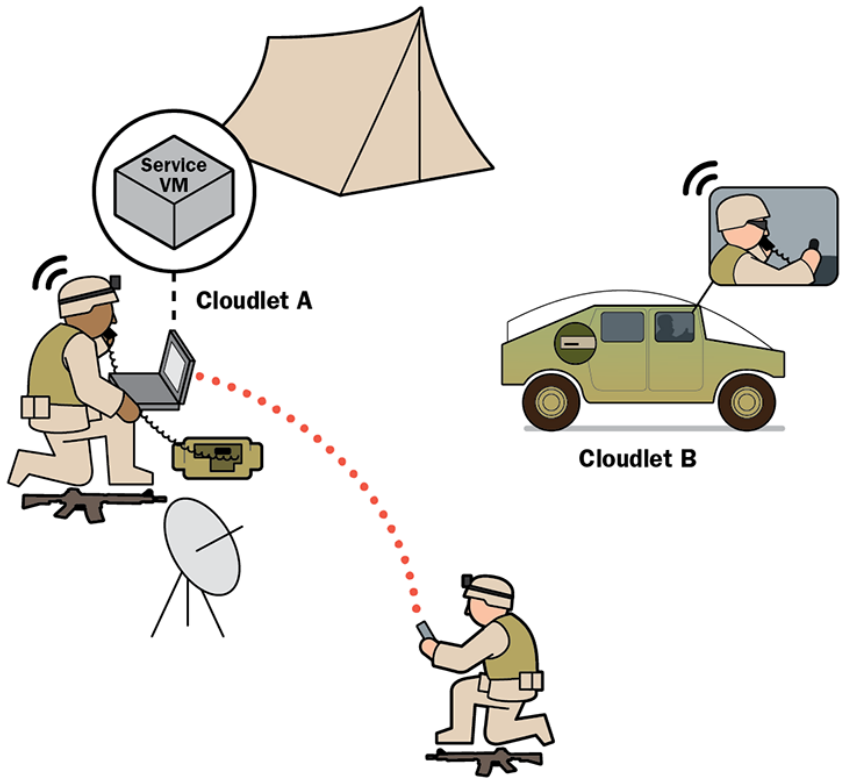
Secure VM Migration
Step 1: Cloudlet Pairing



Cloudlet Admins exchange temporary keys using their radios (voice)

1. Cloudlet Admins exchange temporary keys over voice
2. Keys are used to setup a temporary Wi-Fi ad hoc connection between the two cloudlets
3. Cloudlet credentials are exchanged over the temporary connection
4. WiFi ad hoc connection is terminated after pairing is completed

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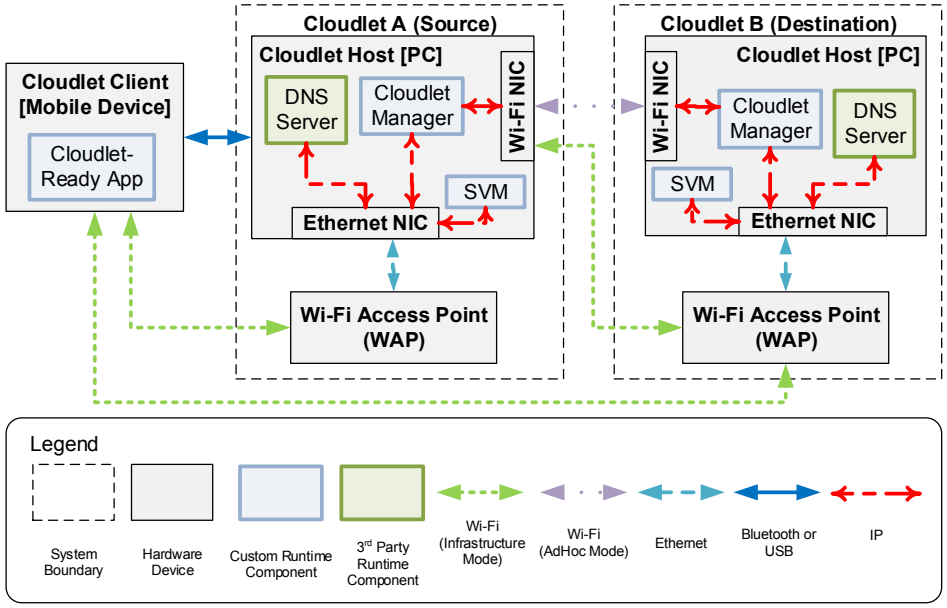
Secure VM Migration
Step 2: Cloudlet Discovery and Connection

2.1. **Cloudlet Network Discovery and Connection**: Cloudlet A connects to Cloudlet Network B using information obtained during pairing

2.2. **Cloudlet Discovery and Connection**: Cloudlet A discovers the IP address and port of the Cloudlet Manager API instance running on Cloudlet B



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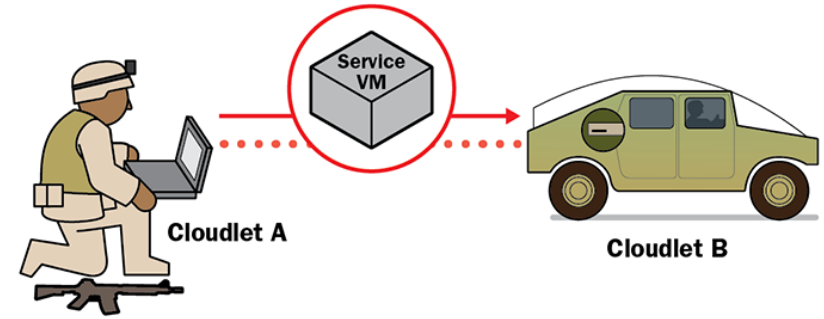
Secure VM Migration
Step 3: Service VM Migration



Service VM is migrated from Cloudlet A to Cloudlet B

1. Service VM Metadata is sent to Cloudlet B so that it can be added to the Service VM Repository.
2. KVM Migration feature is used to perform the actual VM migration

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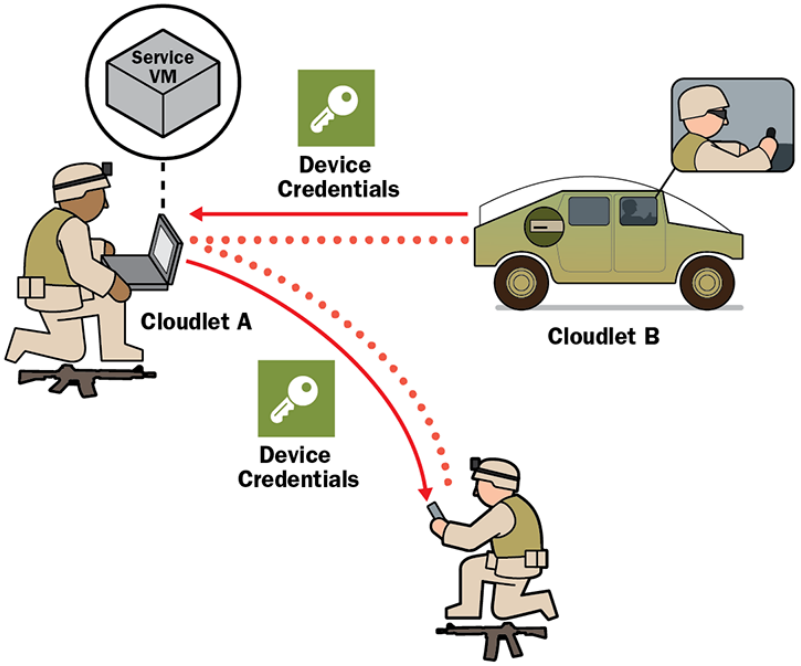
Secure VM Migration
Steps 4 and 5: New Credential Generation for Mobile Device



Cloudlet B generates and sends device credentials to Cloudlet A

1. Cloudlet A requests Cloudlet B to generate credentials for each of the mobile devices that are paired to Cloudlet A and are using the migrated VM
2. Cloudlet A stores new device credentials in a Message Repository
3. Each device receives message from Cloudlet A and retrieves new credentials for Cloudlet B

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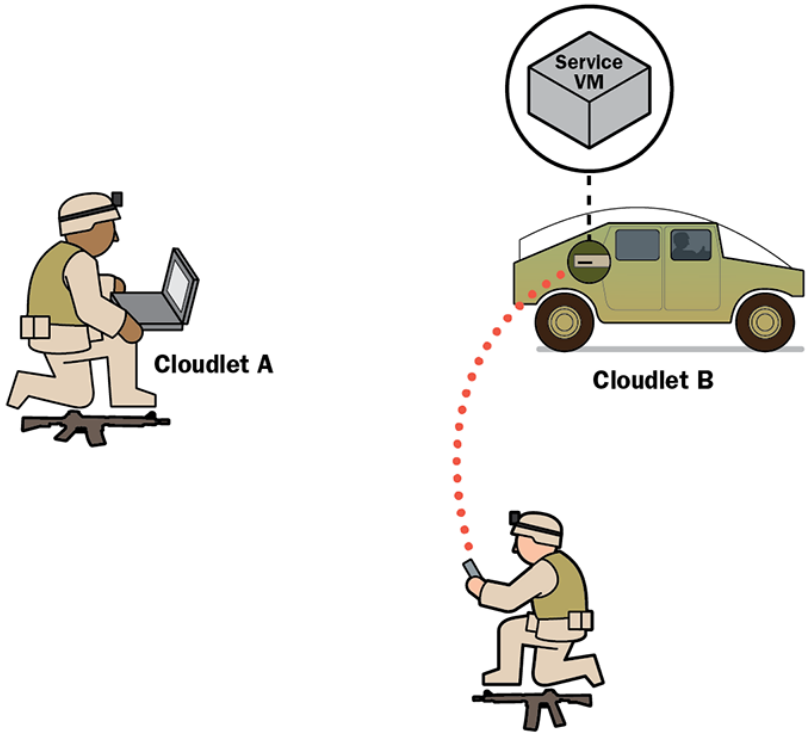
Secure VM Migration
Steps 6 and 7: Device Connection to Destination Cloudlet and Migrated Service VM



Device connects to the migrated Service VM on Cloudlet B

1. Device automatically connects to Cloudlet B Network with new credentials
2. Cloudlet-Ready App is ready to communicate with the migrated Service VM (using its FQDN – fully-qualified domain name)

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Validation — Threat Modeling

Fully Addressed by Implementation
1: *Impersonating a Client*
2: *Finding an Active Client*
3: *Finding an Inactive Client*
7: Sniffing Wireless
14: *Impersonating a Cloudlet*
Partially Addressed by Implementation
6: Lost Credentials (usability tradeoff)
Not Addressed by Implementation
4: Altered Software
5: *Daisy Chaining (device-device-cloudlet)*

Addressed Outside the Implementation
8: Site Intrusion
9: On the Net (WAP)
10: On the Box
11: Super-User Compromise
12: Application Compromise
13: Seeing Everything
15: On the Net (NIC)
16: Daisy Chaining (device-device-cloudlet)

NOTE: Names of modified threats with respect to our previous work are noted in italics. Names of new threats are noted in bold.

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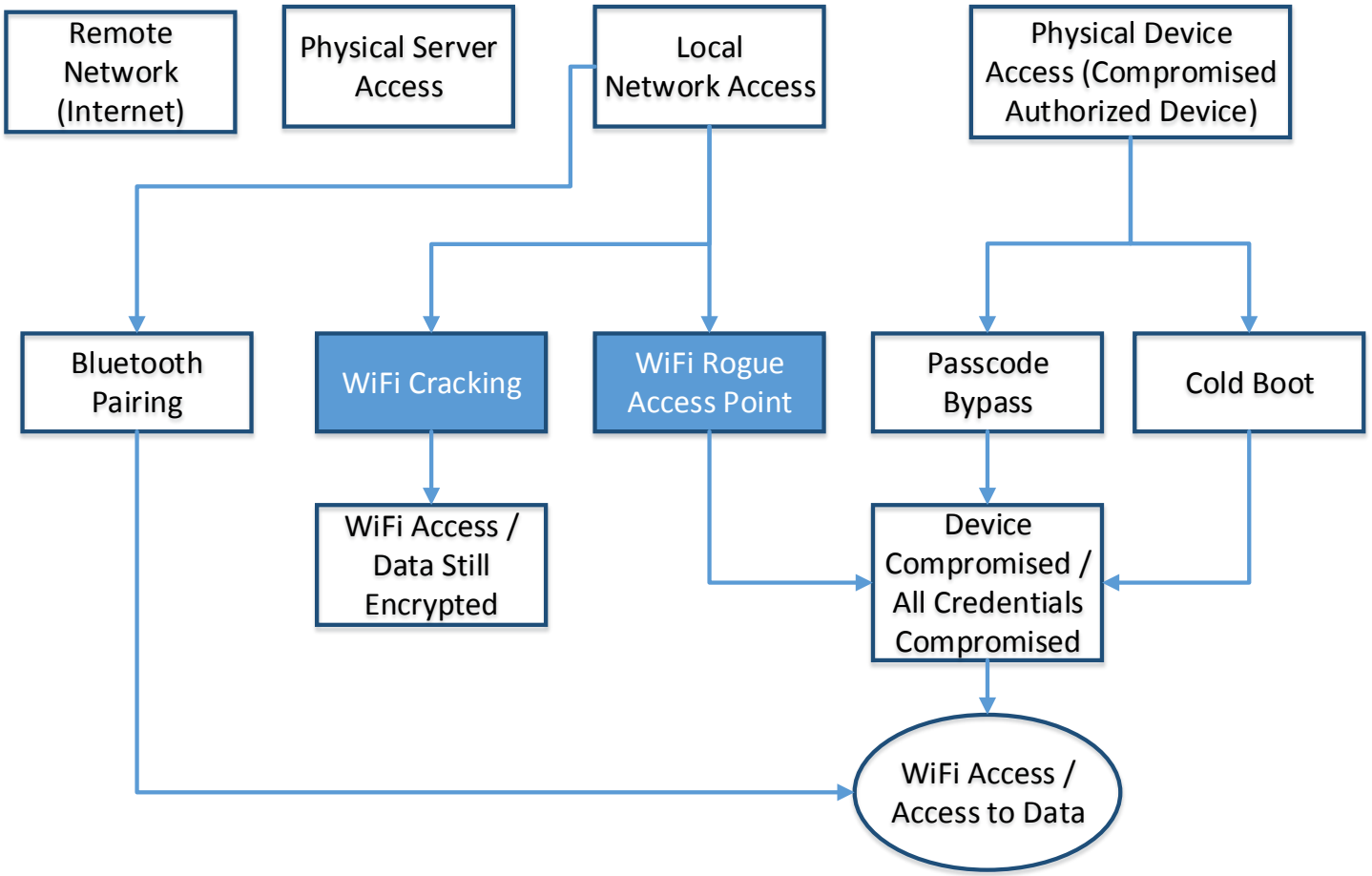
Validation — Vulnerability Analysis

Architectural and technical analysis of possible vulnerabilities using a simple attack tree based on the threat model



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Validation — Ceremony Analysis

Ceremonies include all protocols, applications with a user interface, and security provisioning workflows — nothing is out of band

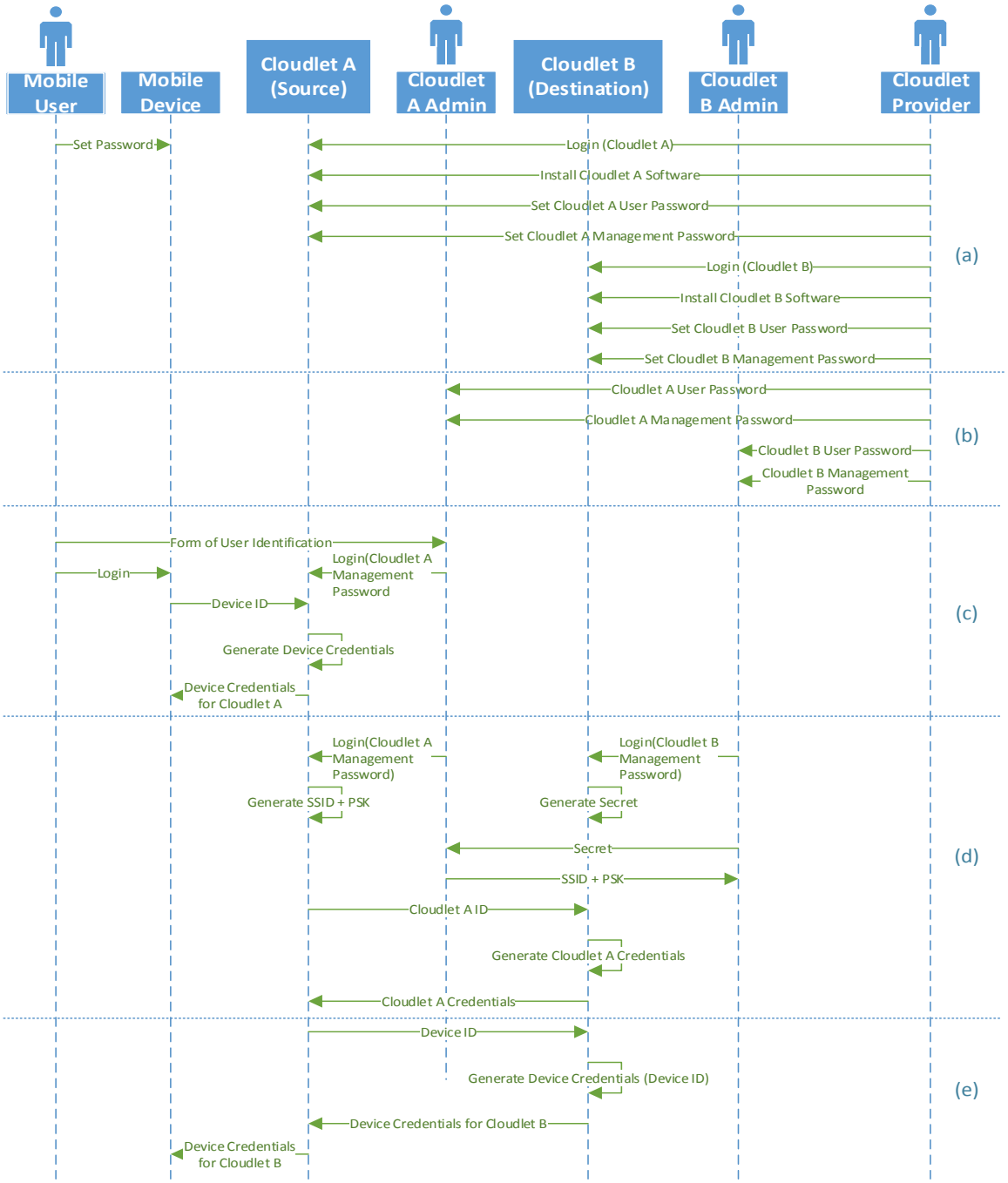
a) Cloudlet Setup

b) Cloudlet Delivery

c) Device Credential Generation (for pairing with Cloudlet A)

d) Cloudlet Credential Exchange

e) Device Credential Generation (for pairing with Cloudlet B)



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Summary and Conclusions

Presented a solution for secure VM migration in tactical cloudlets that combines Identity-Based Encryption (IBE) with mechanisms for Secure Key Exchange without a Trusted Third Party.

Evaluation of the implementation was done against the threat model and using vulnerability and ceremony analysis

- Results show that it is a resilient solution that addresses most of the threats and characteristics of disconnected environments if combined with proper application-, OS-, network- and site-level controls

Current and future work is focusing on reduced human involvement and use of passive out-of-band channels, especially as tactical systems start to incorporate resource-constrained IoT (Internet of Things) devices such as sensors.

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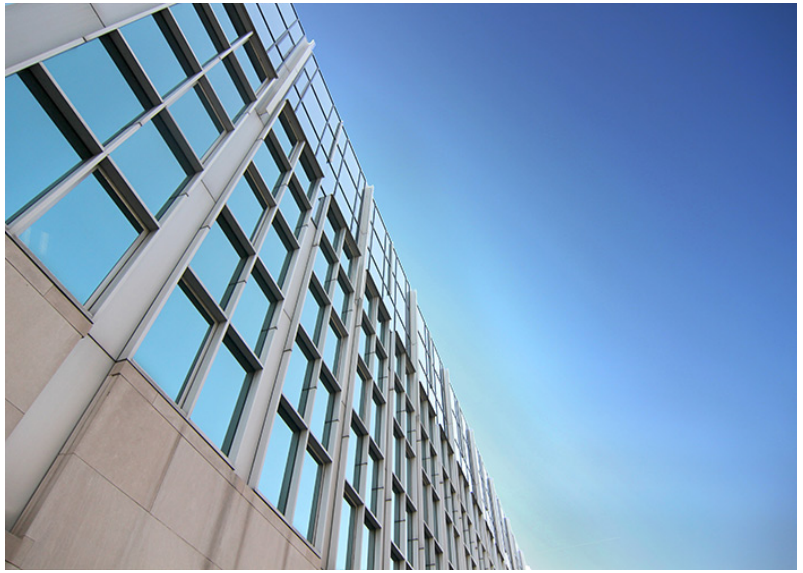

Tactical Cloudlets software available on GitHub as KD-Cloudlet

https://github.com/SEI-AMS/pycloud

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