SeaCat: an SDN End-to-end Application Containment ArchitecTure

Enabling Secure Role Based Access To Sensitive Healthcare Data

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Motivation

- "Everything" is networked
  - Nearly all business applications assume network availability
- Also true in healthcare
  - Accessing patient records
  - Remote diagnoses and consultation
  - In-home monitoring
  - Healthcare analytics
  - Plus "regular" vocational applications
    - HR/payroll functions, accessing domain specific literature
  - Plus non vocational use
    - Browsing the web, social networking etc.

Motivation cont.

- Problem:
  - Same individual, using same device potentially using several of these applications simultaneously
  - Applications have very different security and performance constraints:
    - Healthcare records: stringent regulatory privacy and security requirements
    - In-home patient monitoring: different privacy and security needs + reliability and soft real time guarantees
    - Web use: no impact on core healthcare applications
  - Devices are increasingly mobile (tablets, laptops, smartphones)
    - Often not part of managed and trusted enterprise environment

Motivation cont.

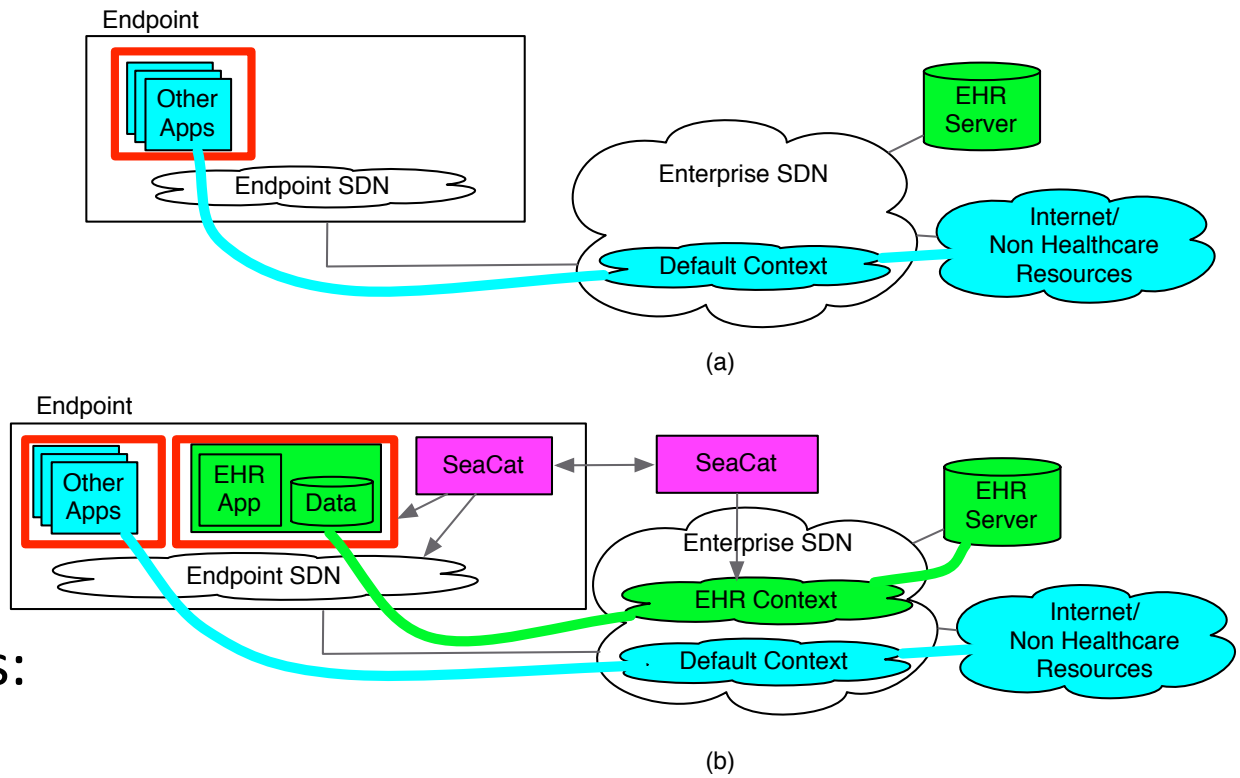
- Current approaches, combinations of:
  - Device scans when new devices attach to network
  - Run applications on application servers with thin clients on devices
  - Complex network and server access control polices
- Inadequate:
  - Device with up-to-date patch levels might still contain malware
  - Application servers with thin clients constrain the type of applications that can be used
  - Access control policies only deal with access. Provide no protection once data is accessed

Motivation cont.

- Problem generalizes to broad range of access to sensitive data
- Different sets of regulations/practices
  - Protected health information (PHI)
    - HIPAA regulations
  - Student educational records
    - FERPA regulations
  - Federal government work
    - FISMA regulations
  - Business requirements
    - PCI DSS regulations
  - Institutional requirements
    - IRB regulations

SeaCat Approach

- Combine SDN and application containment:
  - End-to-end application containment
- Treat mobile device as "semi-trusted" SDN domain
  - Inter-domain SDN interaction to tie in
- Non-healthcare apps:
  - default context
- Healthcare app:
  - dynamic app specific context
  - app and data contained in this end-to-end context

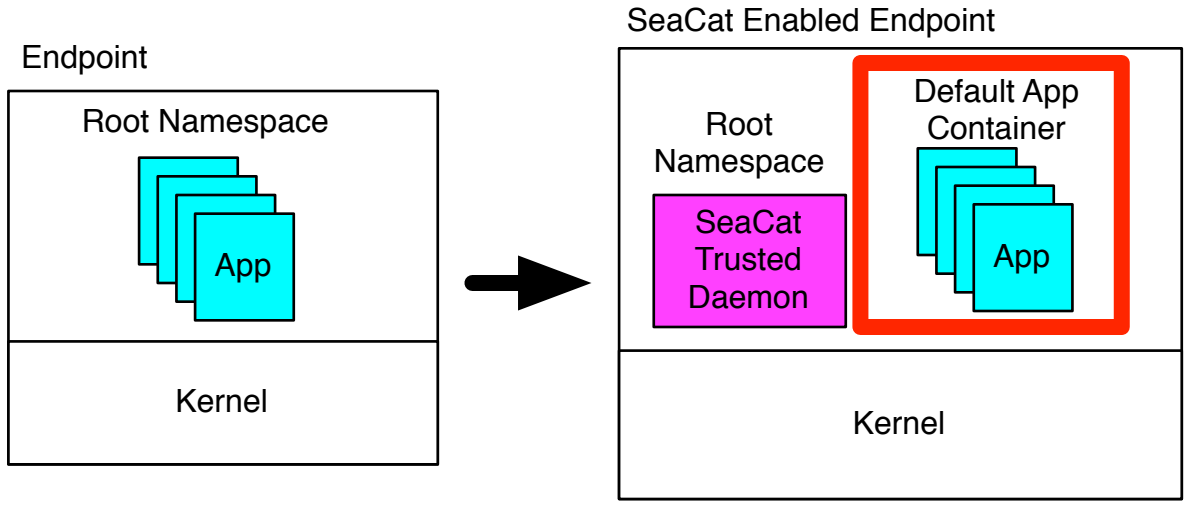


Threat Model

- Concerned with security and performance of health care applications used from variety of devices in a health care environment
- Assume healthcare applications can be trusted
  - different from conventional threat model where device needs to be protected against untrusted applications
- Specific concerns:
  - Unauthorized access
    - role based authentication and policies
  - Data leakage
    - end-to-end application containment
  - Resource guarantees
    - context based resource allocation with preemption
  - Denial of service
    - resource guarantees plus separation of resources

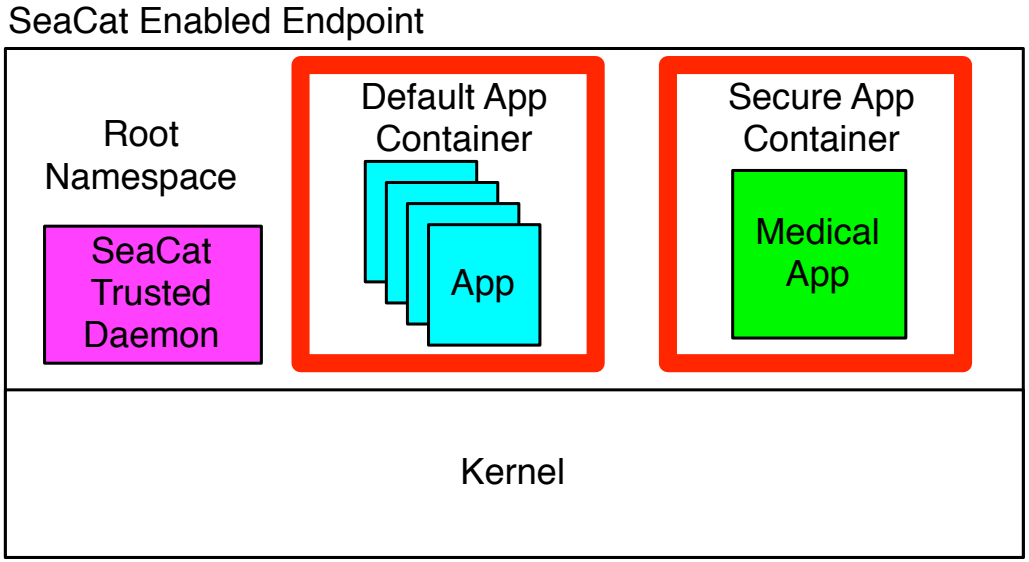
SeaCat Architecture: Endpoint Containment

- Uses lightweight containers
  - Linux containers
- All applications execute in containers:
  - move “regular apps” into default container
- Only SeaCat Trusted Daemon left in root namespace



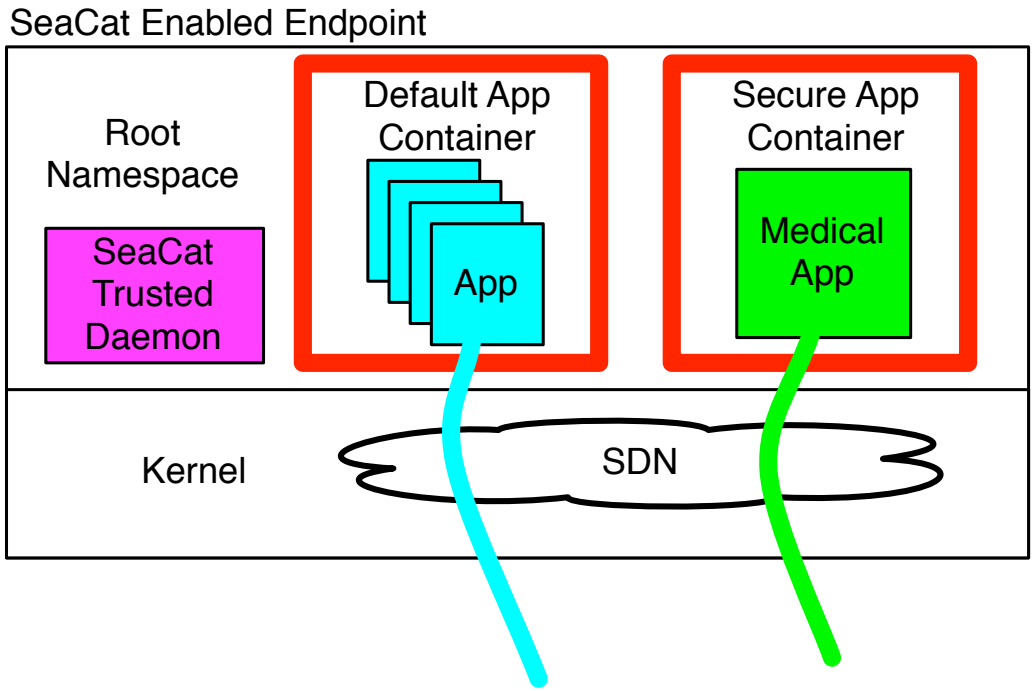
SeaCat Architecture: Endpoint Containment

- SeaCat Trusted Daemon manages containers:
  - Set default container up: apps unaware that anything changed
  - Use Overlay FS to restrict container storage accesses
  - **Dynamically create secure app container(s)**

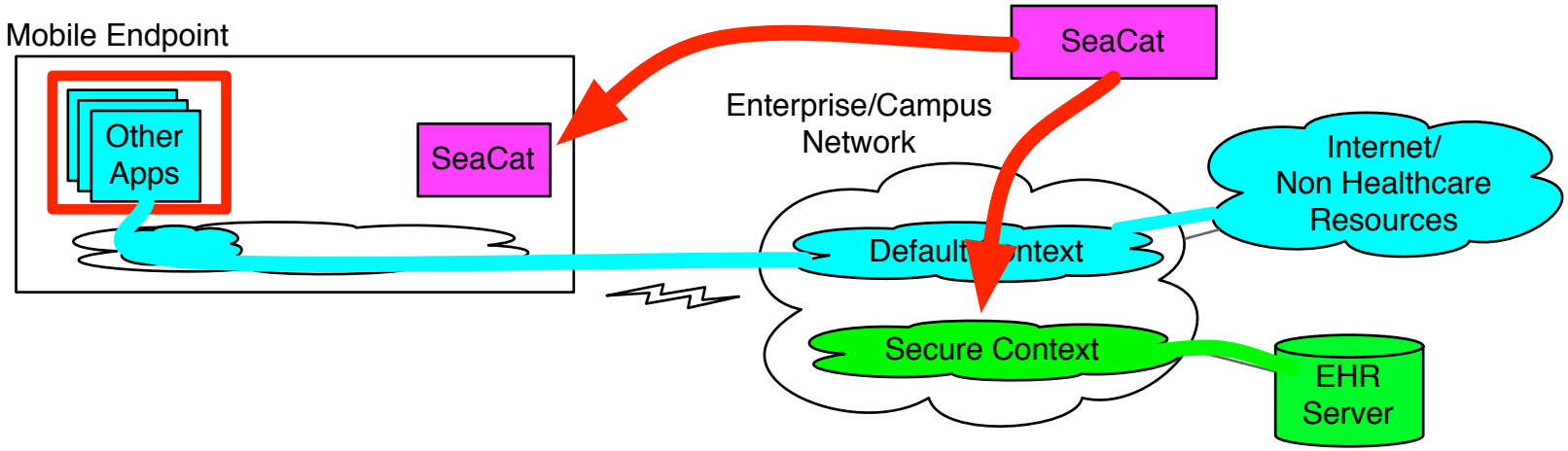


SeaCat Architecture: Endpoint Network Containment

- SeaCat Trusted Daemon:
  - **Manages endpoint SDN domain**
- Single switch domain:
  - Sets up context for default apps
  - Sets up context for secure apps: based on interaction with enterprise SDN



SeaCat Architecture: Enterprise Network Containment

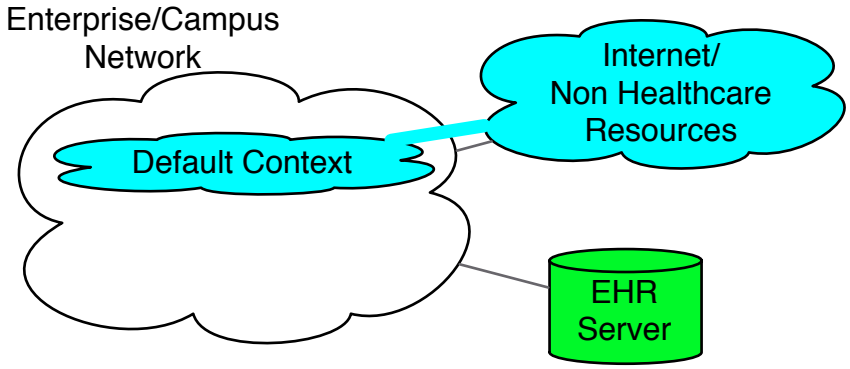


- SeaCat Server:
  - **Manages enterprise SDN domain**
    - Sets up context for secure apps
    - Includes SDN-enabled WiFi
  - **Interacts with SeaCat trusted daemon in endpoint**
    - Instructs trusted daemon to start secure container
    - Coordinates SDN across domains

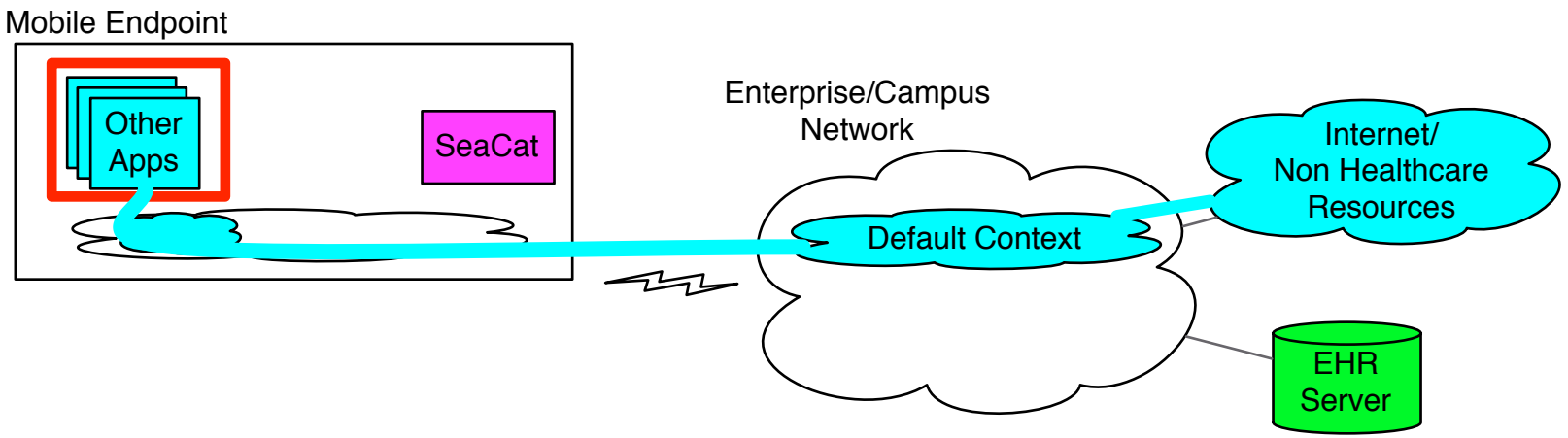
SeaCat Architecture: Putting it all together

- Enterprise network treats each mobile endpoint as semi-trusted SDN domain
- Secure app user: authenticates using “normal” single-sign-on (SSO) technology
  - **SeaCat server integrated with SSO**
  - Successful authentication triggers:
    - Creation of app specific SDN context in enterprise
    - Signaling to endpoint SDN to:
      - Create secure container
      - Create endpoint app specific SDN context
      - Ties to enterprise SDN context
- App and data remains in this secure end-to-end context
- When app exits:
  - Complete context is destroyed

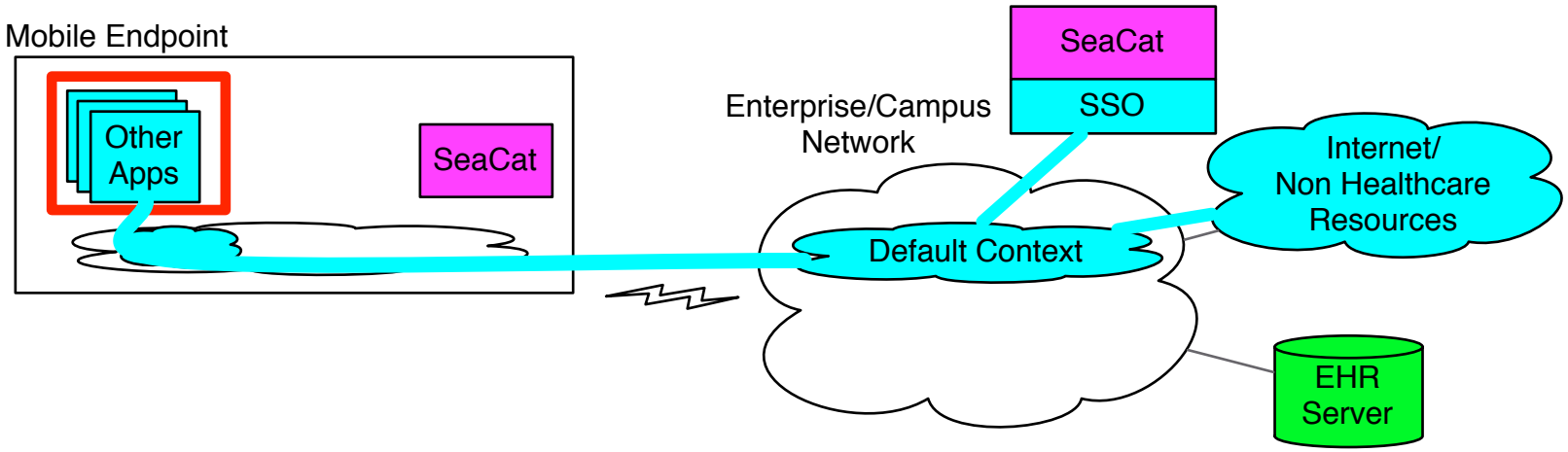
SeaCat Workflow/Interaction



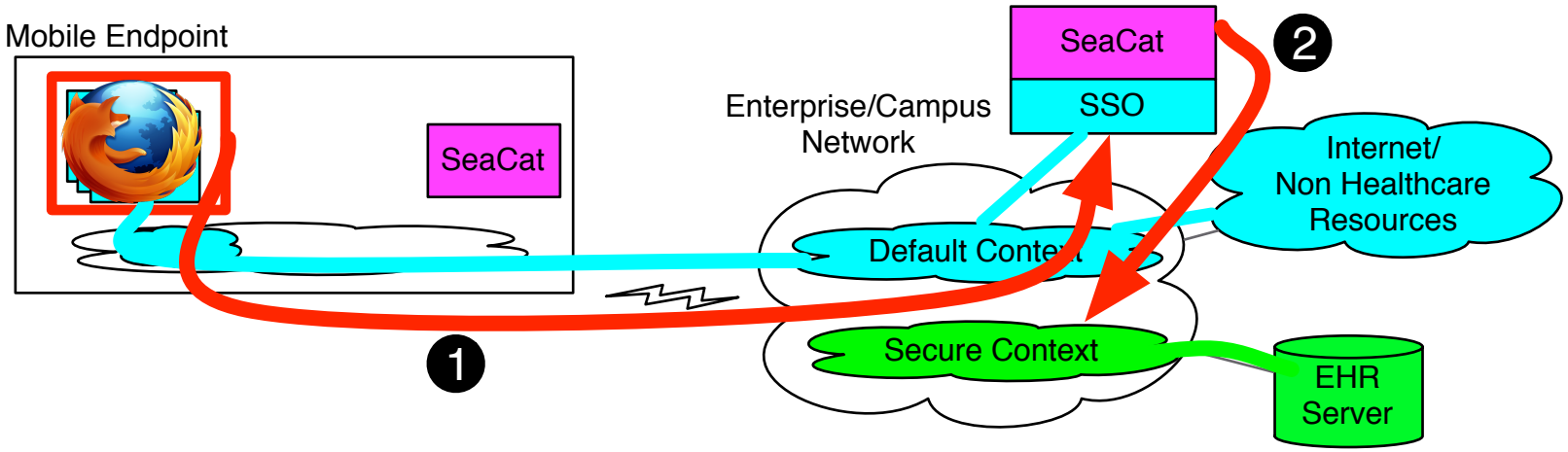
SeaCat Workflow/Interaction



SeaCat Workflow/Interaction



SeaCat Workflow/Interaction



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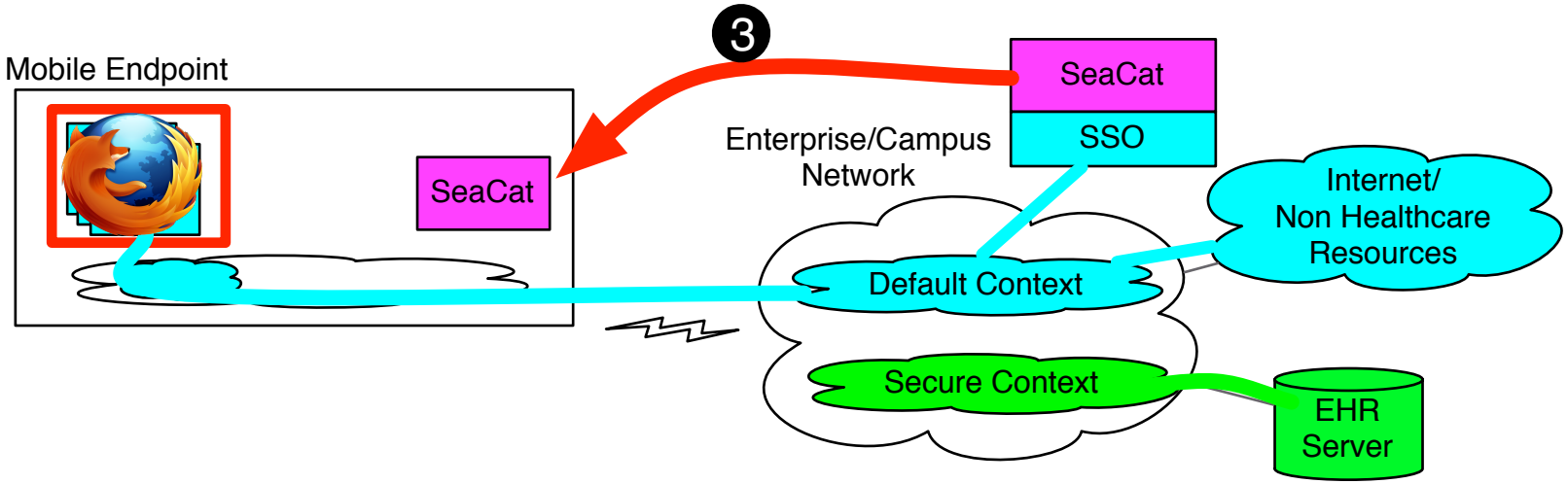
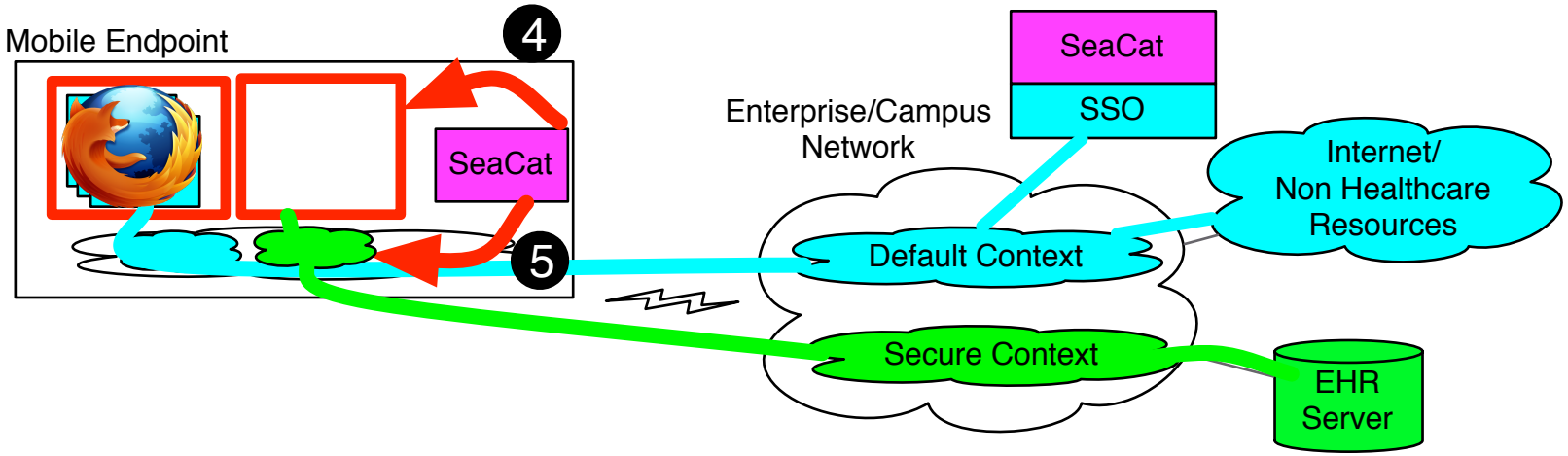
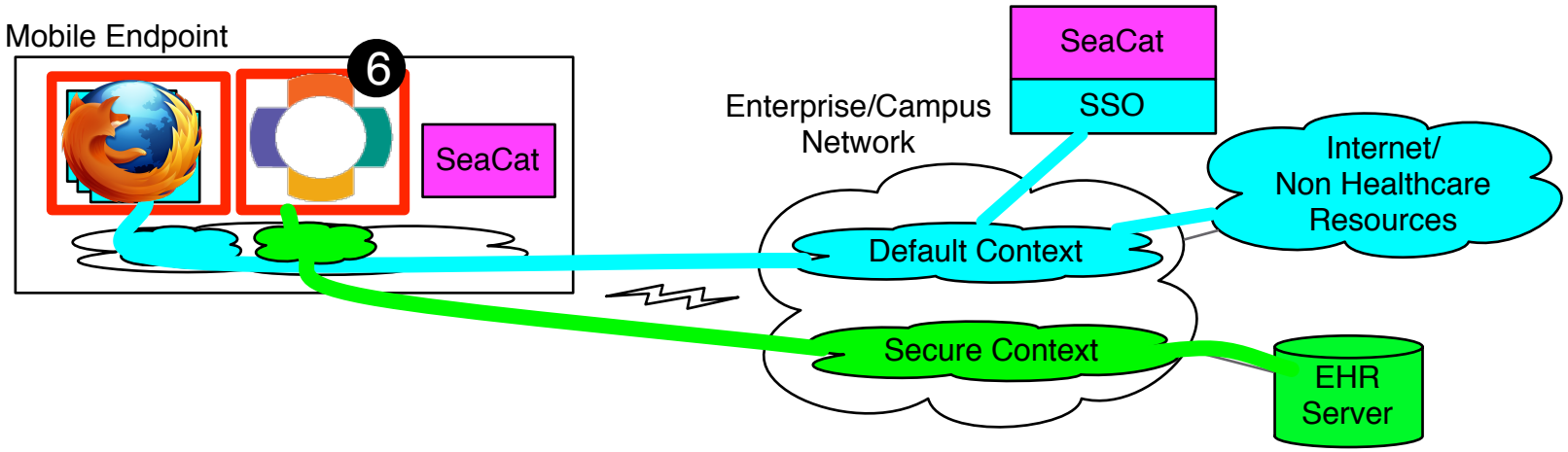


SeaCat Workflow/Interaction



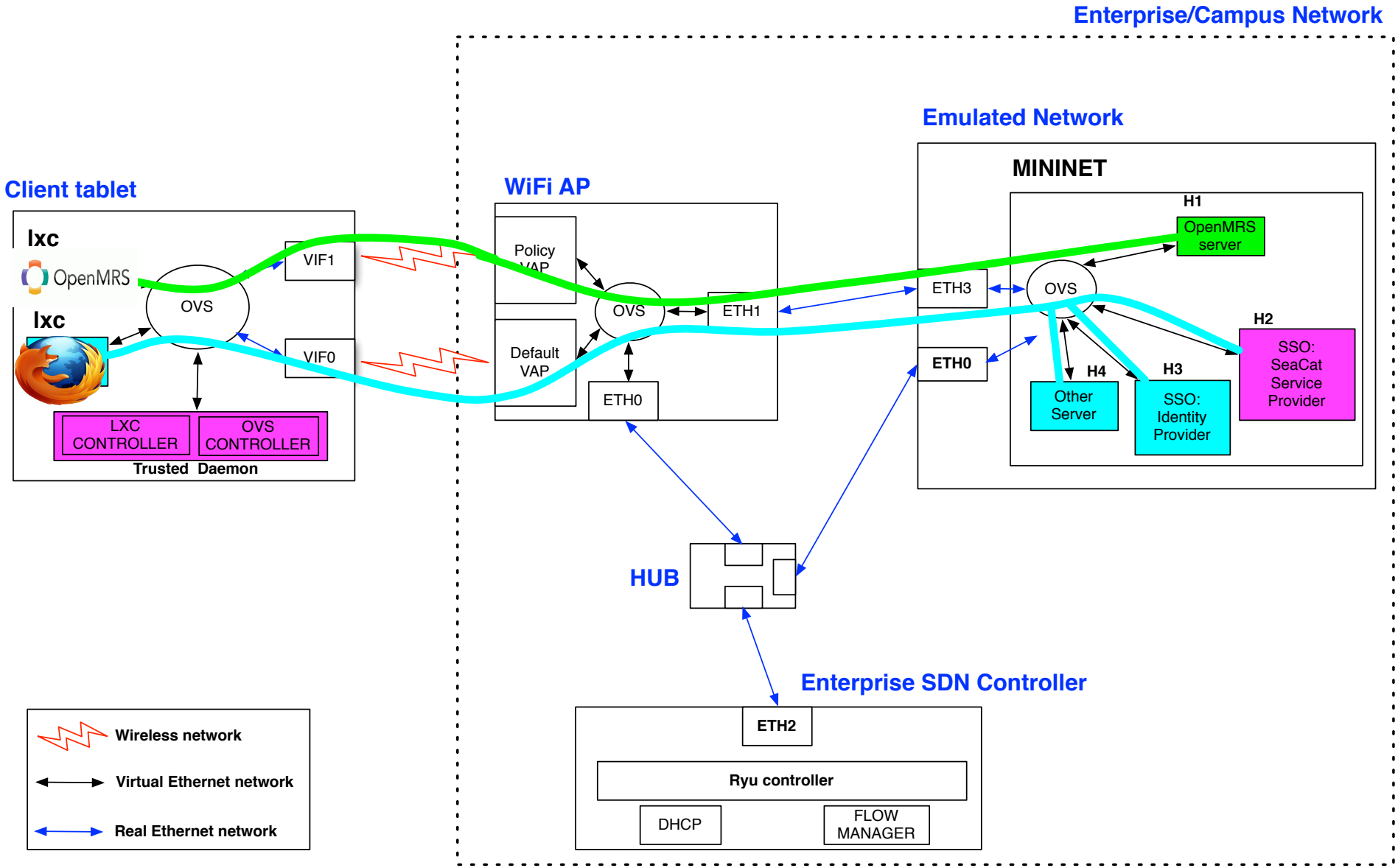
SeaCat Workflow/Interaction



SeaCat Demo

- Mobile endpoint:
  - Linux WiFi-enabled tablet
  - With SeaCat Trusted Daemon:
    - Container and SDN management
- Enterprise network:
  - SDN enabled WiFi access point
    - Tallac Networks
    - Virtual APs
    - Mapped to OpenFlow switch
  - Rest of enterprise SDN emulated in a Mininet instance
- SSO:
  - Uses Shibboleth SSO
  - SeaCat (Service Provider) to realize SeaCat functionality
- Medical application:
  - OpenMRS (Medical Record System)

SeaCat Demo


Enterprise/Campus Network
Client tablet
lxc
OpenMRS
lxc
OVS
VIF1
VIF0
LXC CONTROLLER
OVS CONTROLLER
Trusted Daemon
WiFi AP
Policy VAP
Default VAP
OVS
ETH1
ETH0
Emulated Network
MININET
H1
OpenMRS server
ETH3
OVS
ETH0
H2
SSO: SeaCat Service Provider
H4
Other Server
H3
SSO: Identity Provider
HUB
Enterprise SDN Controller
ETH2
Ryu controller
DHCP
FLOW MANAGER
Wireless network
Virtual Ethernet network
Real Ethernet network

Status

- Have working prototype…
- Looking for partners to do a trial deployment…