NAMED DATA NETWORKING

ACM ICN Paris 2021

Tutorial Intro:

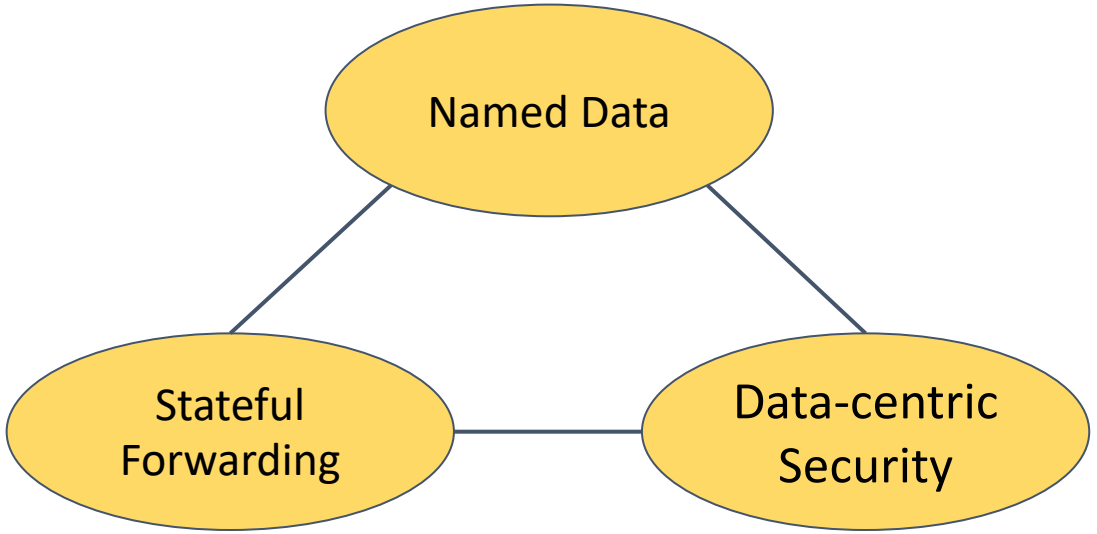
Secure and Friendly Deployment (Plugging) of NDN Apps

Alex Afanasyev (FIU)

Tutorial: Power of Trust Schemas for Easy and Secure Deployment of NDN Applications

Named Data Networking as a New Paradigm

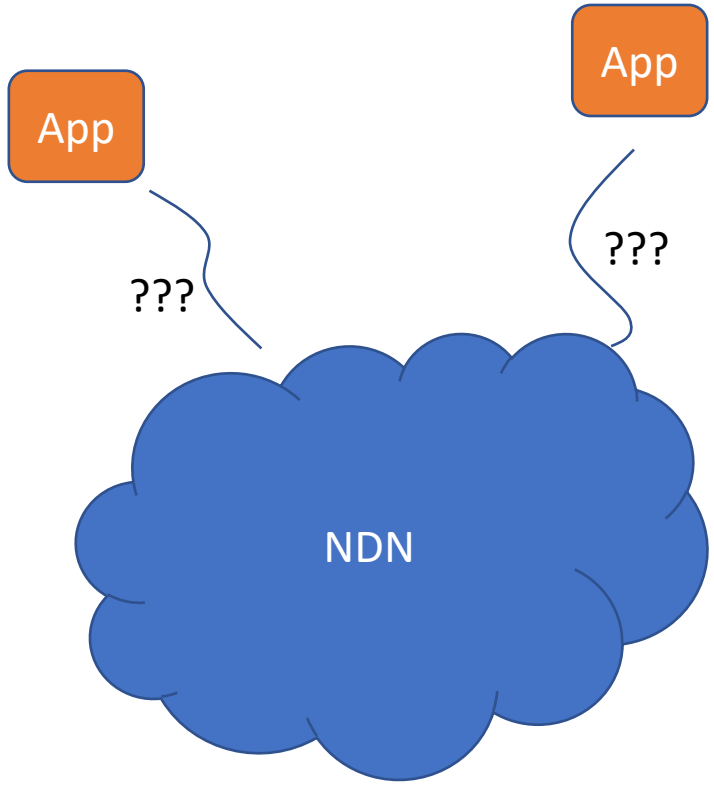
- Named Data Networking (NDN) can bring great benefits to applications
  - Directly using application data names to communicate
  - Built-in security support that secures named data directly
  - stateful dataplane with in-network caching: multipath forwarding, multicast delivery



Setting up NDN Apps

- One builds a new app, how to make it function?
  - How to bootstrap an app into the network?
  - What, where, and by whom need to be configured?
  - Putting everything on the same table: what steps to take?

- One builds a distributed app to run over multiple remote computers
  - How to securely configure remote NDN boxes?



The need for plug in order to play

Looking Back on IP Configuration

- Plug in IP networking: establish IP connectivity on a specific IP subnet
  - IP address, subnet mask, default gateway
  - DHCP automates the last step of configuring individual host
    - Network operators manually configure IP address block and subnet mask into DHCP servers

- To enable application communications
  - Need names
    - Network operators also configure DNS resolver address into DHCP servers
  - Need security support
    - PKI “trust” based on OS and browser vendors decisions to trust PKI CAs “on behalf” of users

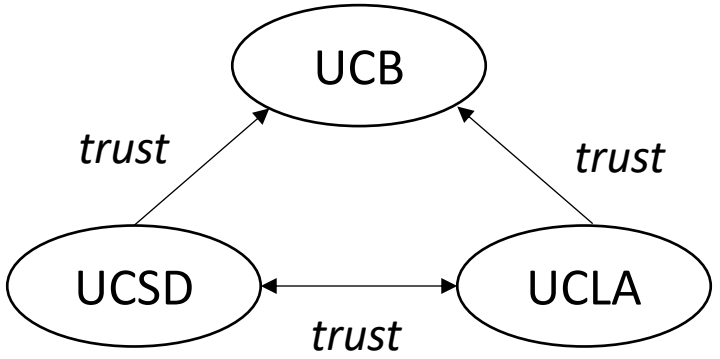
NDN Configuration

- Plug in NDN networking: establish <what>? ~~IP connectivity on a specific IP subnet~~
  - ~~IP address, subnet mask, default gateway~~
  - ~~DHCP automates the last step of configuring individual host~~
    - ~~Network operators manually configure IP address block and subnet mask into DHCP servers~~
  - NDN apps are NDN network entities, so they are need to be bootstrapped / plugged in / (auto) configured !

- To enable application communications
  - Need names
  - Need security support

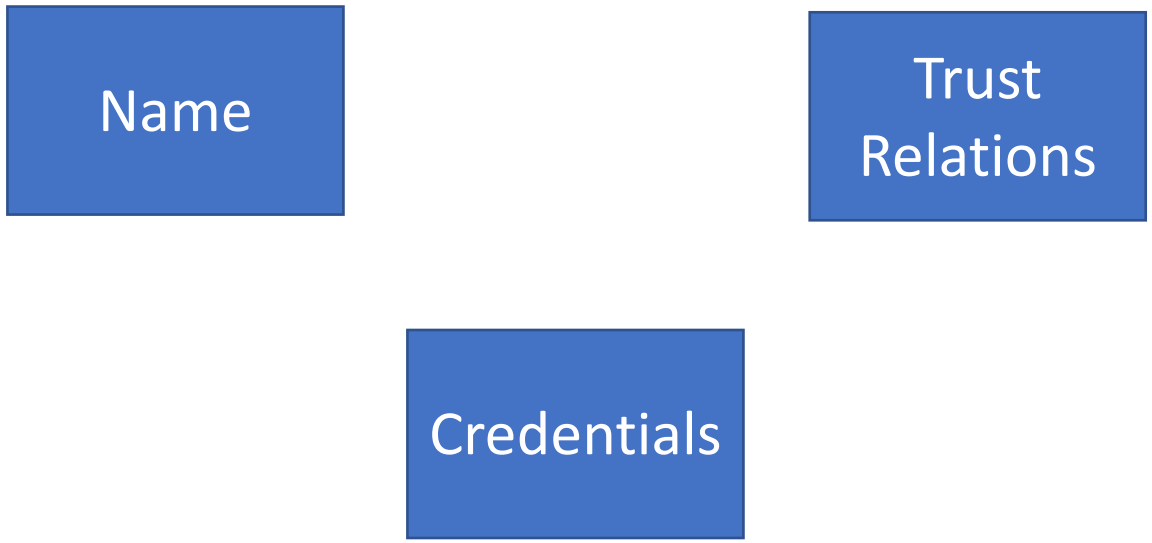
Network Model of NDN

- A networked system is made of named entities
  - Entities are anything produce and/or consume immutable named packets
    - services / application instances
  - Entity names are decoupled from network attachment points
    - Entity can explore available connectivity to communicate on their own
- There exist various trust relations among the named entities
  - Hierarchical
  - Peer-to-peer



NDN Config === NDN App Config

- Where an entity obtains its name and security credentials
- How the initial trust relations are configured into the entity



What About Connectivity?

- Yes, NDN entities also need to establish connectivity among each other to let NDN packets flow
  - an entity can express Interests and they will flow towards the data
  - an entity can attract Interests if it has matching data to publish

- Multiple options to establish NDN connectivity
  - forwarding state
  - forwarding strategy
  - routing state
  - overlay tunnels

Physical links are **necessary** but not sufficient for NDN connectivity (same as with IP)

With Names & Security, Connectivity Can be Setup

A number of tools have been developed to help set up NDN connectivity

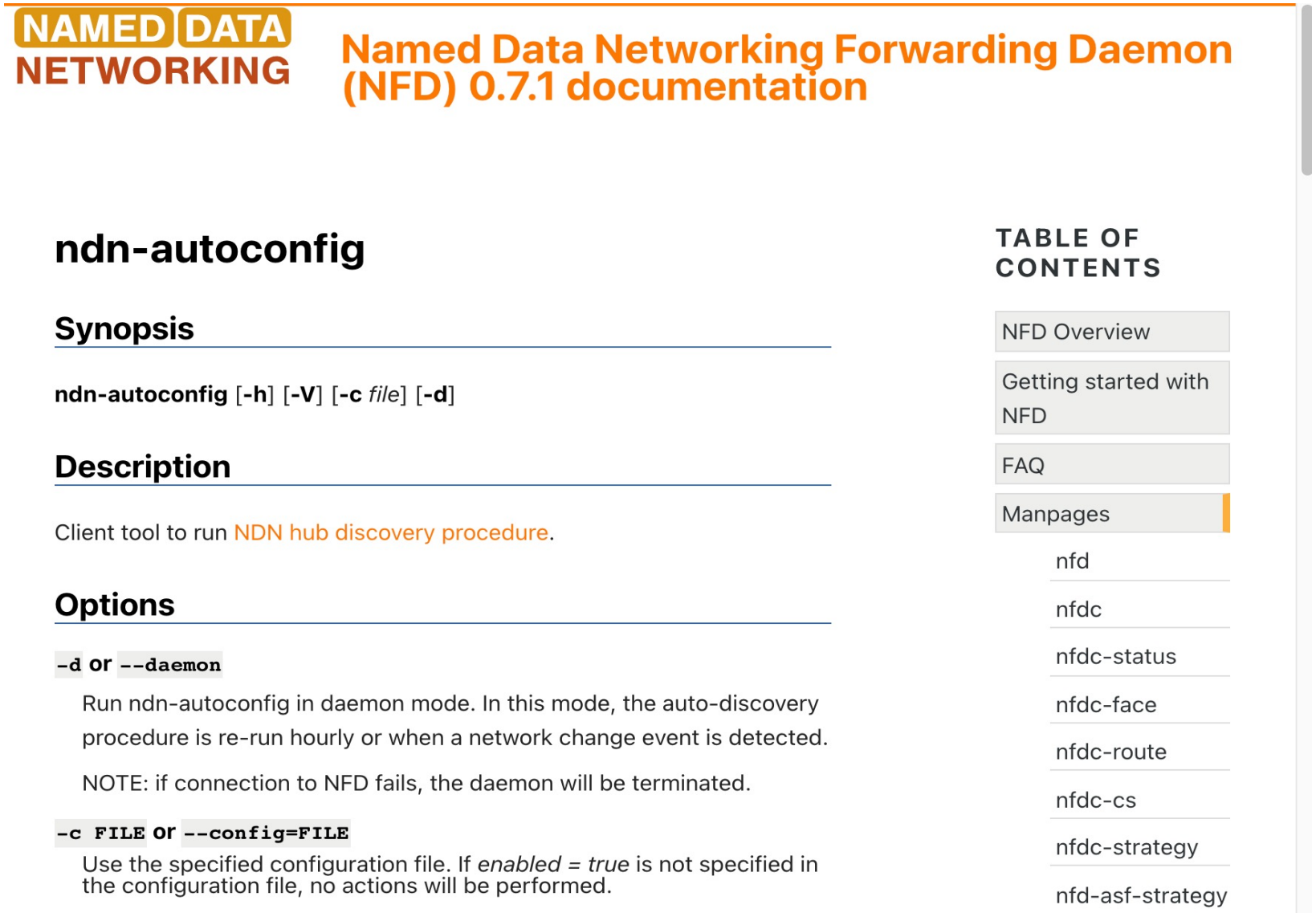
- NDN Routing
  - Exchange **secured name** prefix information and builds routing state (proactively)
- Auto-prefix propagation / prefix readvertise
  - Automated means to push forwarding/routing state to attract interests
- Self-Learning
  - Leverages forwarding strategy to reactively build forwarding state (directions where authentic data can be found)
- NDN Over WiFi Direct
  - Overlay management and **secured name** prefix exchange

- ndn-autoconfig
  - Constructs/maintains overlay tunnels to closest NDN hub
- NDN-FCH
  - Constructs/maintains overlay tunnels to closest NDN hub
- NDN Neighbor Discovery
  - Constructs/maintains overlay tunnels to neighbors

Virtual physical links, not a complete NDN connectivity solution

https://named-data.net/doc/NFD/current/manpages/ndn-autoconfig.html

Showed our own lack of understanding on what kind of config NDN needs



Plugging NDN Entities into NDN Networks

- NDN's network model requires one named entity to establish trust relations with others
  - **Name**
    - carrying application semantics
  - **Certificate**
    - enabling one to produce authenticatable data and verify received data
  - **Trust anchor**
    - establishing the trust relations of entities under a namespace
  - **Trust policies**
    - limiting the power of signing key to data with specific names

Configuring a Trust Anchor and Trust Policies

- Deployment/application parameters
  - Trust schema defining data/key name relations
  - Which key can sign what data / privilege separation
- Determine the local trust zone (and its scope)
  - Trusted microcosm “boss” (of the local trust zone)

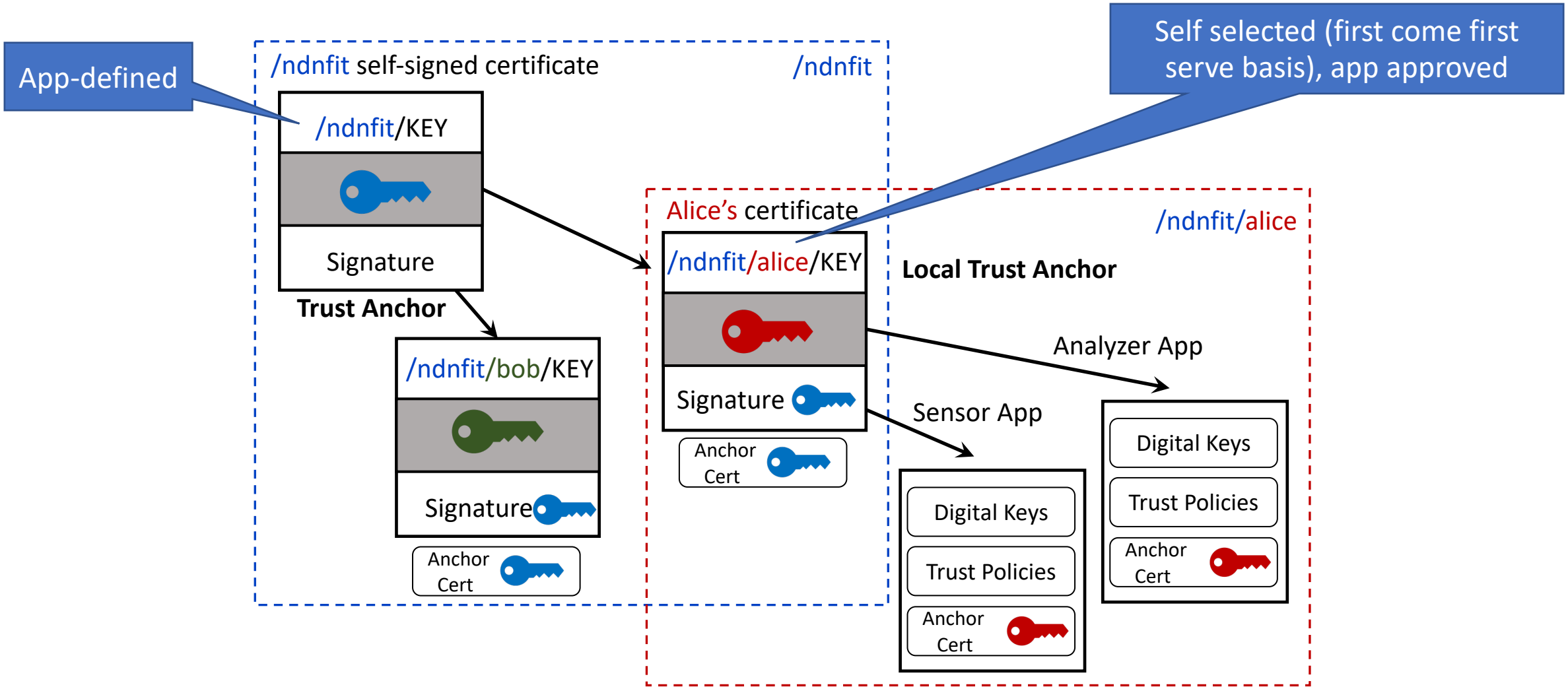
- **After trust anchor and trust policies bootstrapping**
  - **App can receive and authenticate data from trust zone entities**

Configuring a Name and Certificate

- Application semantics
  - Depends on specific app what name is and how it is structured
- Assigned or selected
  - Depends on out-of-band (outside bootstrapping) knowledge of what it is
  - By admin, app owner, app developer, etc.
- Certificate issued based on proof-of-control over the namespace within a “trust zone”
  - ”Security challenges”, physical challenges (for proximity proof), or predefined knowledge (codes)

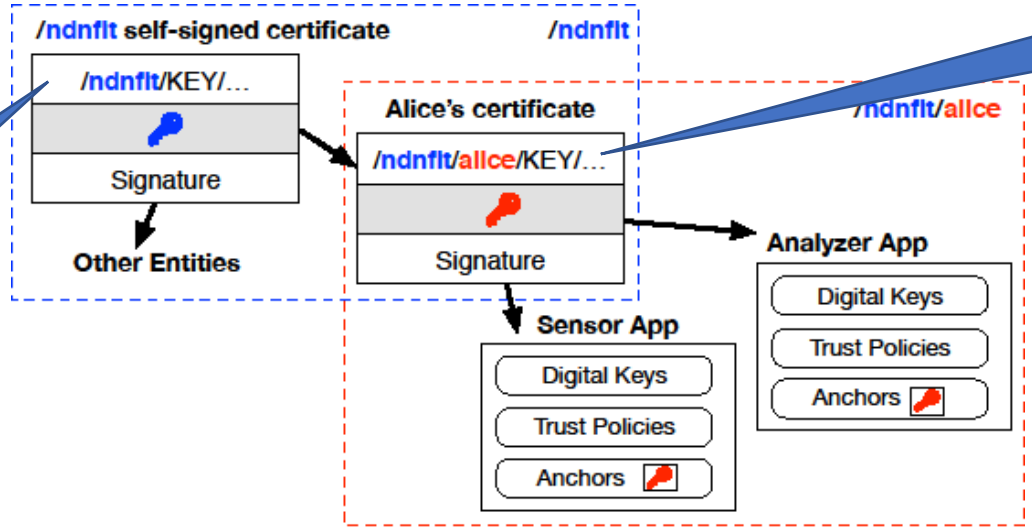
- **After trust anchor and trust policies bootstrapping**
  - **App can publish authenticatable data for other trust zone entities**

An Example of NDN Entities



Terminology for the Rest of Tutorial

- Any NDN entity can become a (local) trust anchor $\boldsymbol{T}$
- All NDN entities under the same trust anchor make a $\boldsymbol{Trust\ Zone}$
- Owner of the trust anchor T is the $\boldsymbol{Controller}$ of this trust zone



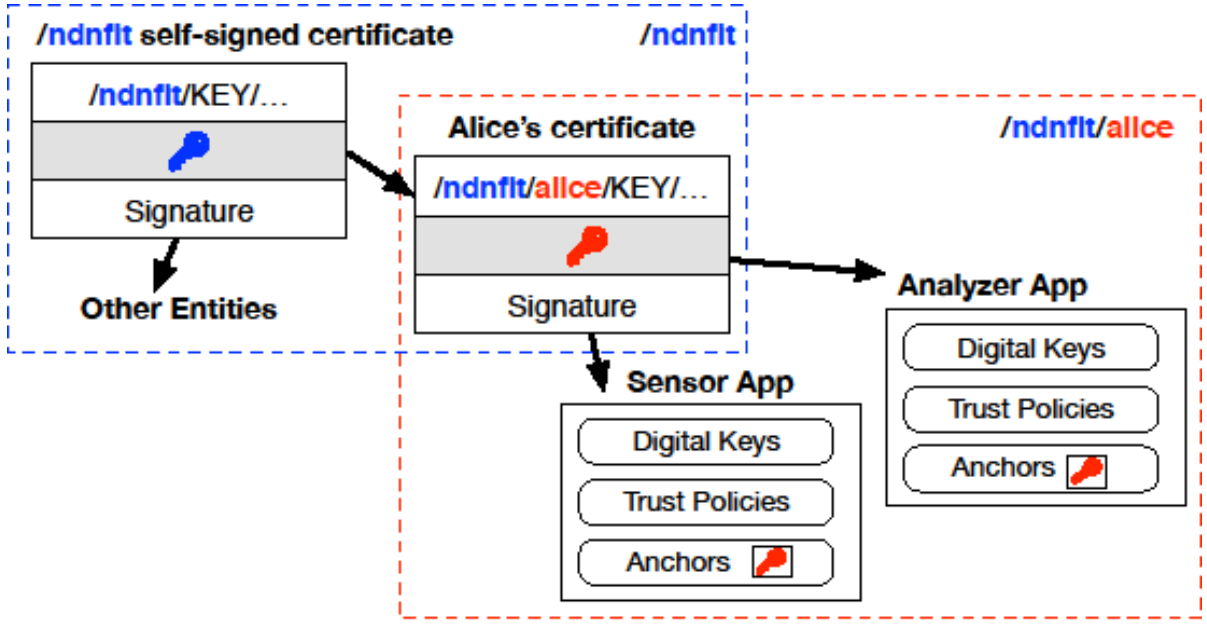
Trust Controller for top-level /ndnfit trust zone

Trust Controller for local /ndnfit/alice trust zone**

** Can be self-signed (may require different logic for name selection)

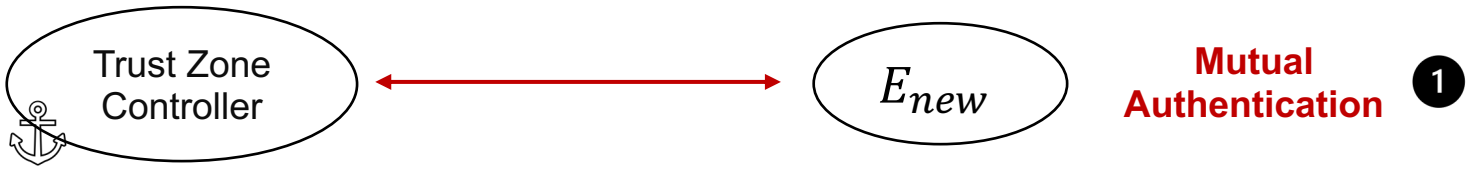
Definition of NDN Configurations

- Plugging/Configuring a new entity E_{new} is
  - Configuring E_{new} into a trust zone
    - E_{new} must have a name, obtained on its own, or otherwise assigned by the Trust Zone Controller
    - E_{new} must have its trust anchor, certificate and trust policies installed



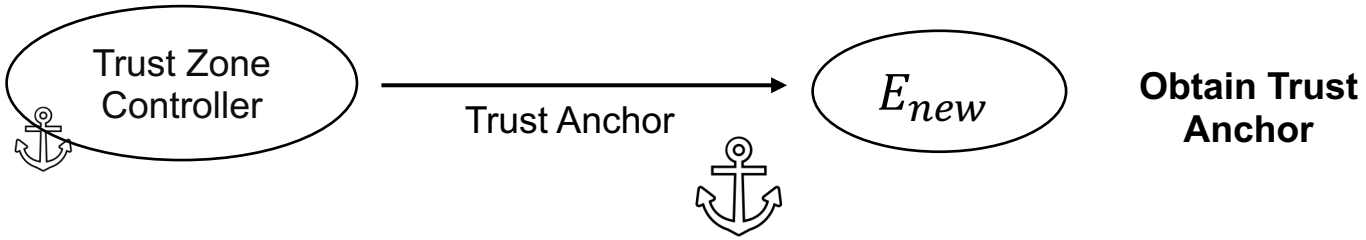
Logical steps of security bootstrapping: Step 1

- Mutual authentication between Trust Zone Controller and E_{new}
  - Trust Zone Controller authenticates E_{new} to confirm its trustworthiness
  - E_{new} authenticates Trust Zone Controller to be its authority
    - In order to accept the Trust Zone Controller's self-signed certificate as trust anchor



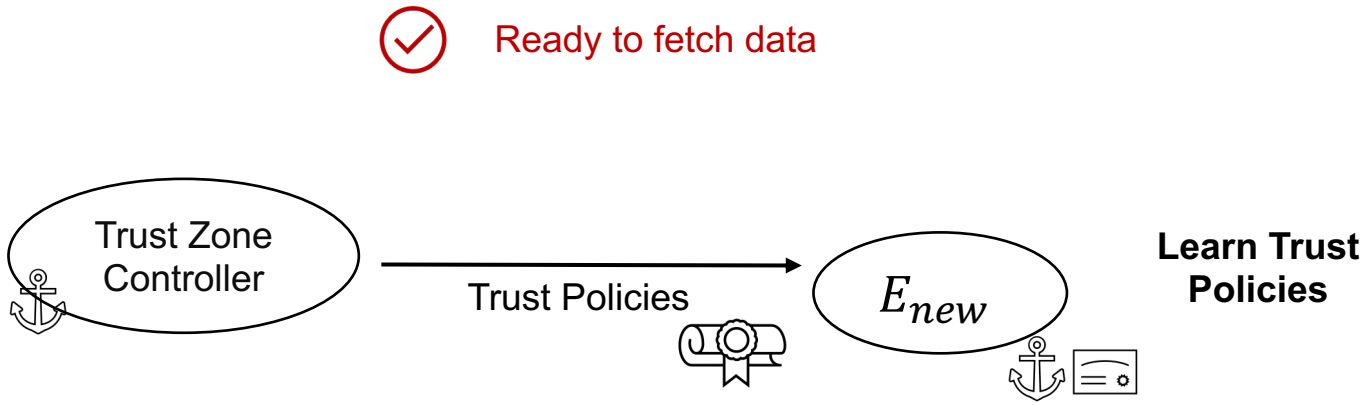
Steps 2: Obtain Trust Anchor and Policies

- After mutual authentication, E_{new} can obtain trust anchor
- Trust anchor establishes the trust relation between E_{new} and Trust Zone Controller



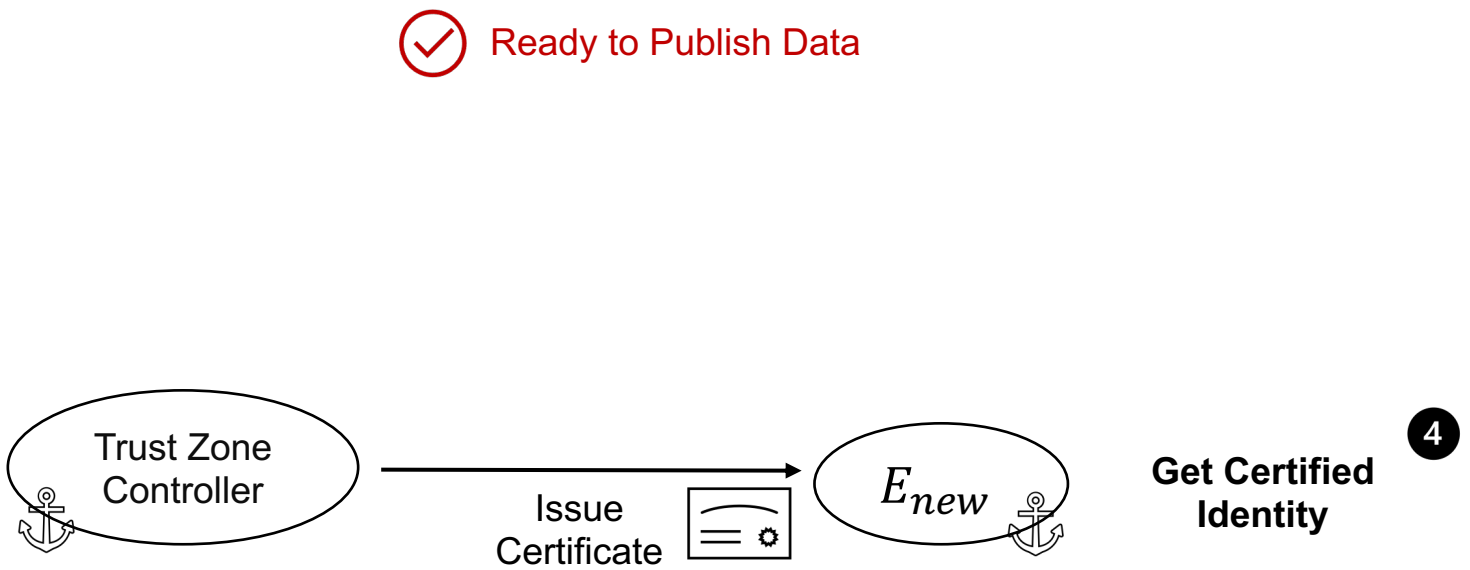
Step 3: Obtain/Update Trust Policies

- E_{new} fetches trust policies that Trust Zone Controller has defined for it
- Trust Zone Controller may change trust policies from time to time
- E_{new} can fetch new trust policies securely in the same way as fetching other named data



Step 4: Obtain Certificate

- E_{new} obtains certificate issued by Trust Zone Controller
  - E_{new} validating certificate issued by Trust Zone Controller



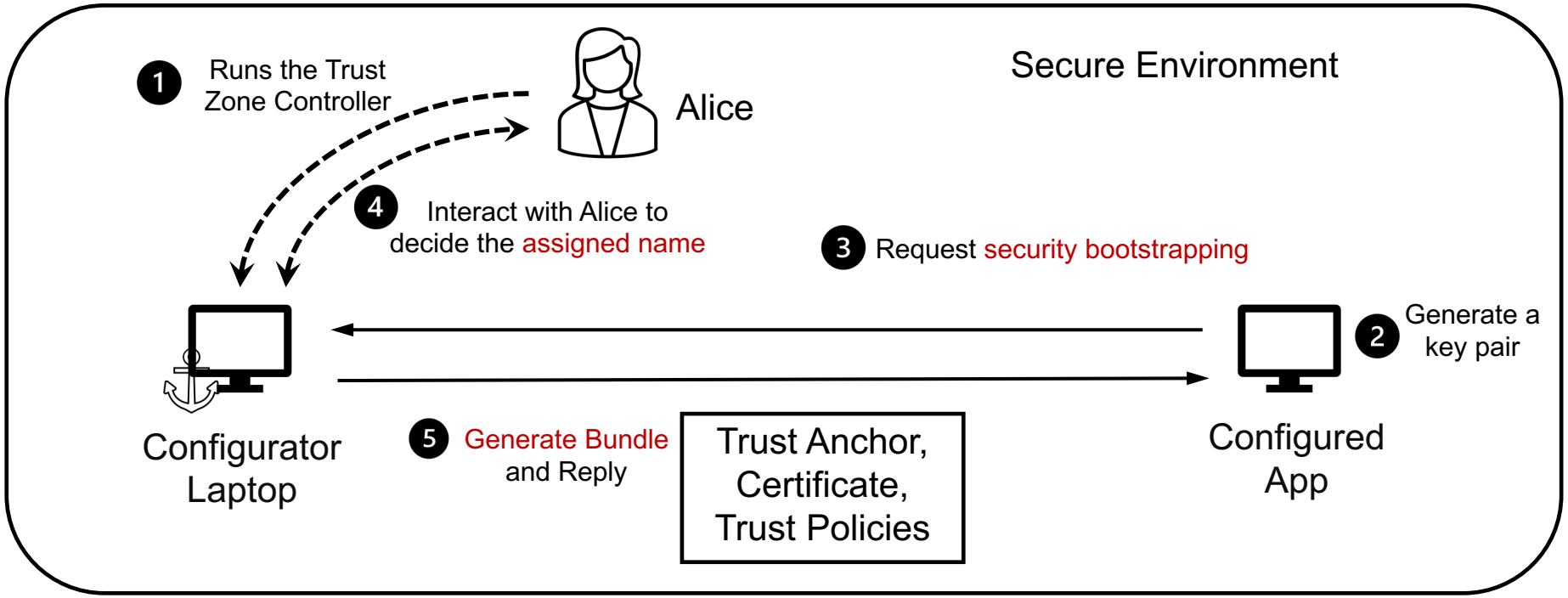
Bootstrapping Mechanics

- Use-case specific mutual authentication process
- Manual or protocol-specific trust anchor and policies (schema) installation
- Manual or protocol-specific obtaining a certificate
  - Manual
  - NDN-CERT

Trust Zone Controller Returning Identity Bundle

- Trust Zone Controller can bundle *<trust anchor, certificate, trust policies>* in one data object as the reply to the configuration request
- Chatroom app installs the components inside bundle

more in the next part of tutorial



Exploring Problem Space in Security Bootstrapping

- How to accomplish mutual authentication
  - Solutions depend on use case scenarios

- Generalized used case scenarios

next part

  - **Bootstrapping E_{new} in secured local environment**
    - **Physically secured environment:**
    - **No third party can communicate with either Trust Zone Controller and E_new**
    - **mutual authentication: the only party that can communicate with E_new is the controller, and vise versa**
  - Bootstrapping E_{new} in unsecured local environment
  - Bootstrapping remote E_{new}

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Moving on to part 2 of the tutorial

Creating and Using Trust Schemas in 1st Use Case