Towards Data-Centric Battlefields: Named Data Networking Services for Tactical Networks

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Tutorial Objectives

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- Identify communication challenges in tactical networks
- Introduce Named Data Networking (NDN)
- Apply NDN to example applications in a notional tactical environment
    - Namespace design
    - Resilient forwarding
    - Data-centric security design
    - Dataset synchronization and support for pub-sub paradigm
    - Integration challenges

Plan for this afternoon

2:00pm Lixia: NDN overview

2:40pm Alex: naming, security in tactical networks

3:30pm: 15min break

3:45pm Lixia: pub-sub, sync

4:00pm Tamer: In-network processing/edge computing

- prioritize caches, forwarding strategies

4:30pm wrapping up

- Alex: Code base and NDN resources available
- Q & A

Named Data Networking (NDN) a new way to communicate

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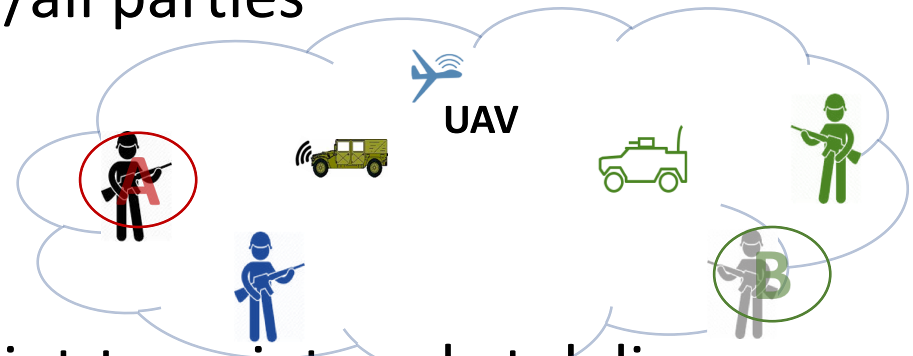
A fresh look at networking

- What a network does: deliver bits → enabling communication between any/all parties



- How IP accomplishes this: point-to-point packet delivery, A—to—B
  - network = collection of links between adjacent nodes
  - find a path by chaining together a set of nodes and links between A—B
  - Packets flow through the pipe while all the nodes between A—B connected and operational
- Issues: nodes move, links fail, connectivity changes

Why a new way


We can't solve problems
by using the same
kind of thinking we used
when we created them.

What’s the new way

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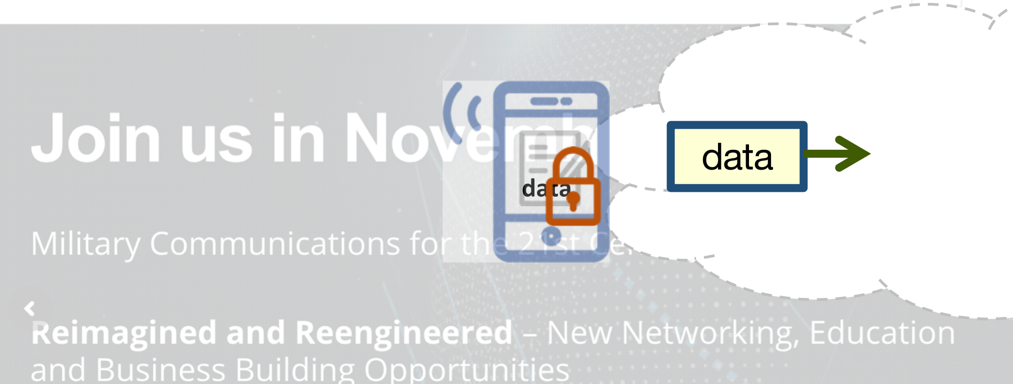
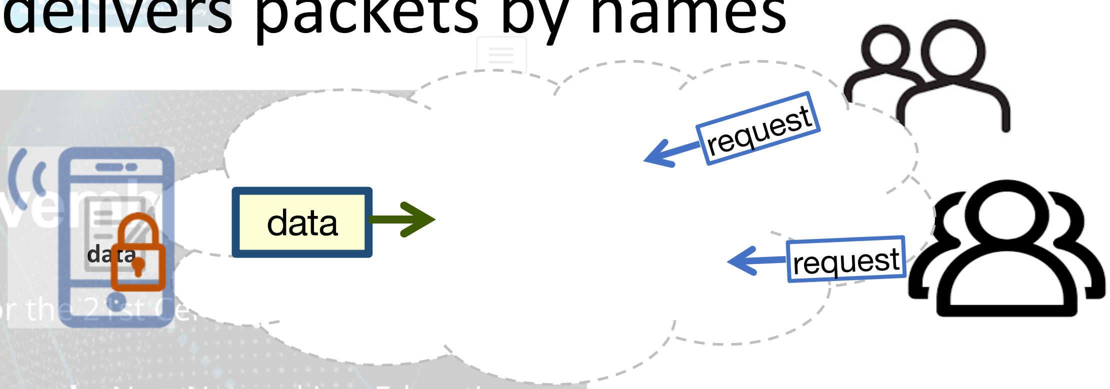
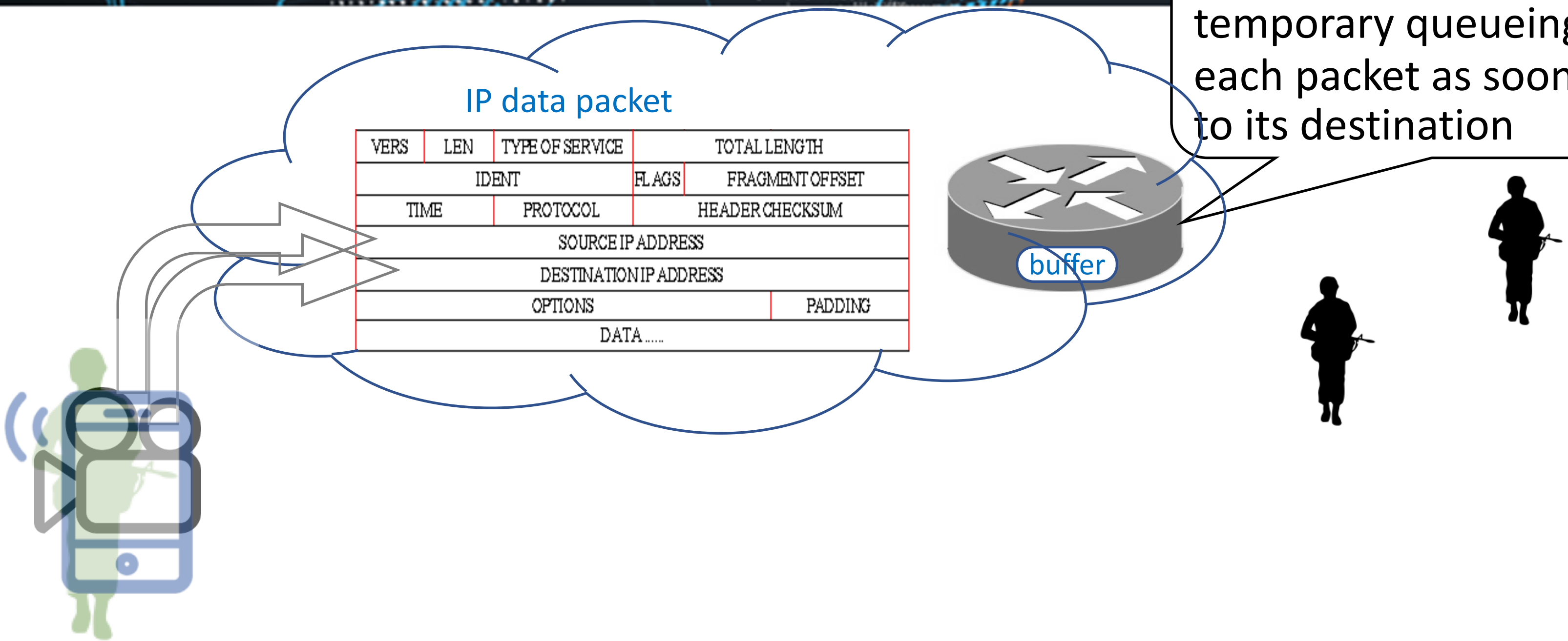
- Delivering desired bags of bits to all the parties who need them – *Named Data Networking*
- Data producers generate named, secured data packets
  - Name data objects by application layer names
    e.g. https://events.afcea.org/MILCOM19/Public/enter.aspx
- Consumers request desired data by names
- Network delivers packets by names





Data consumers verify

IP data delivery by addresses



Named, secured data → in-network caching

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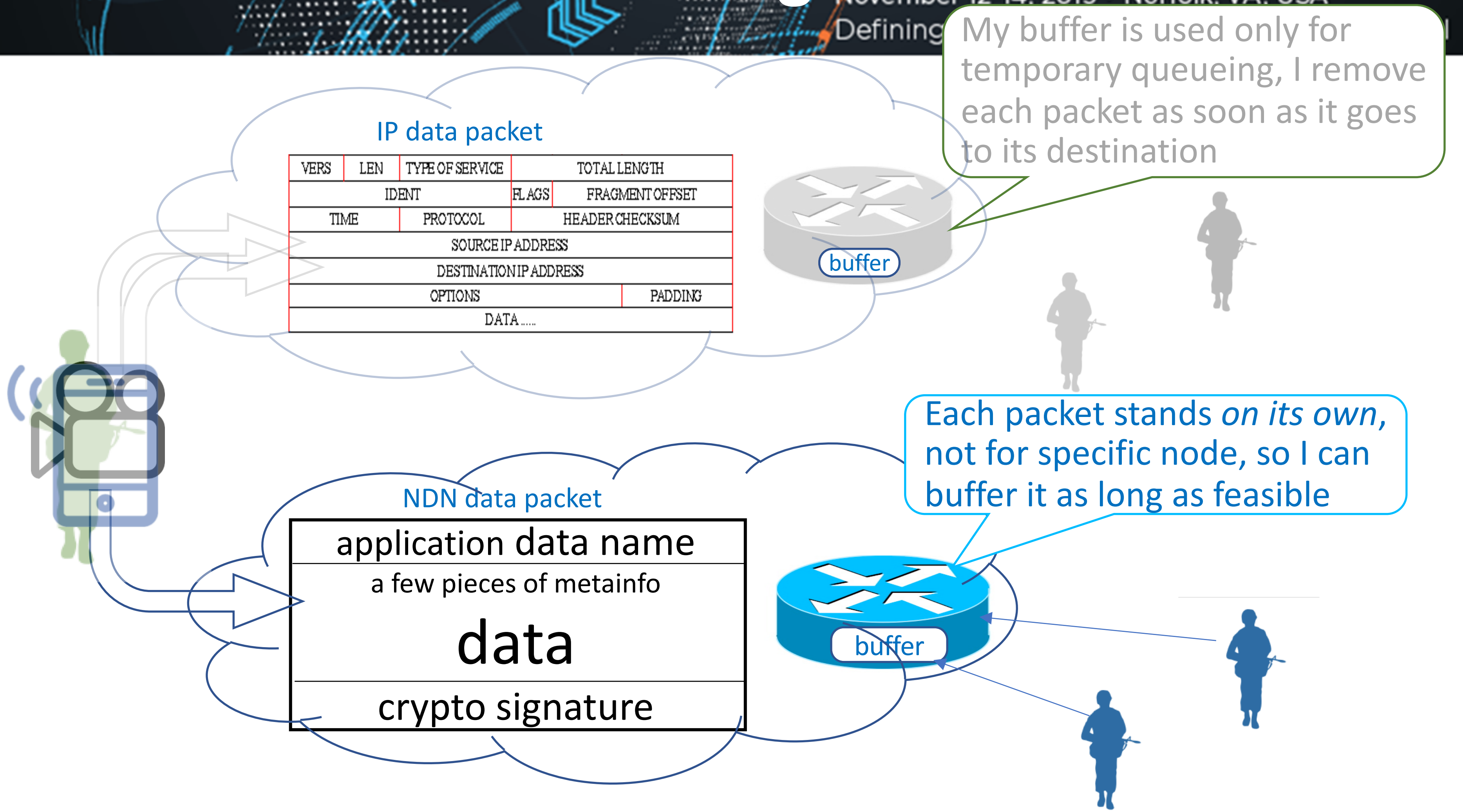
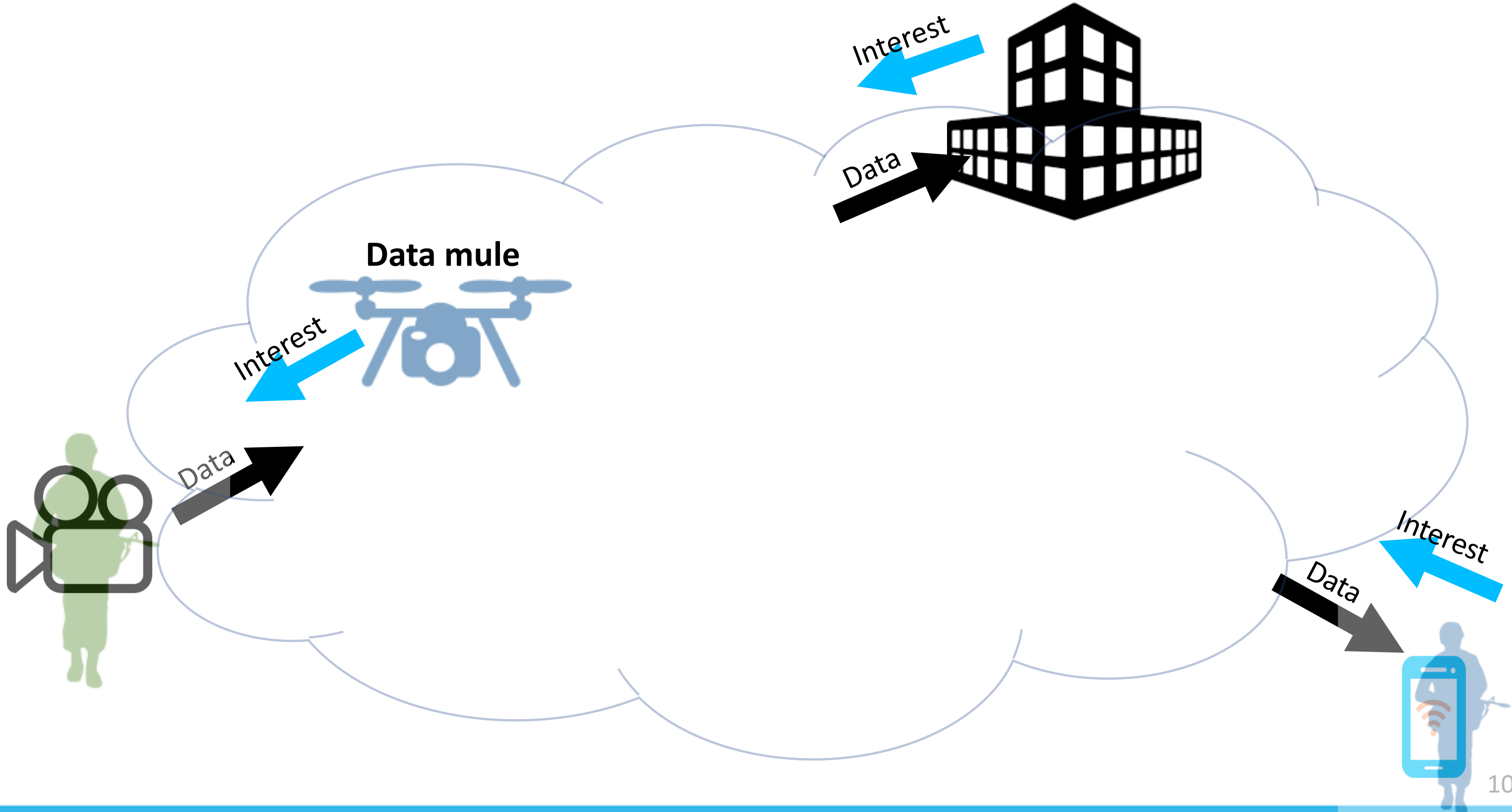


Named, secured data enables data muling

Effective communication in face of intermittent connectivity



NDN’s Stateful Forwarding Plane

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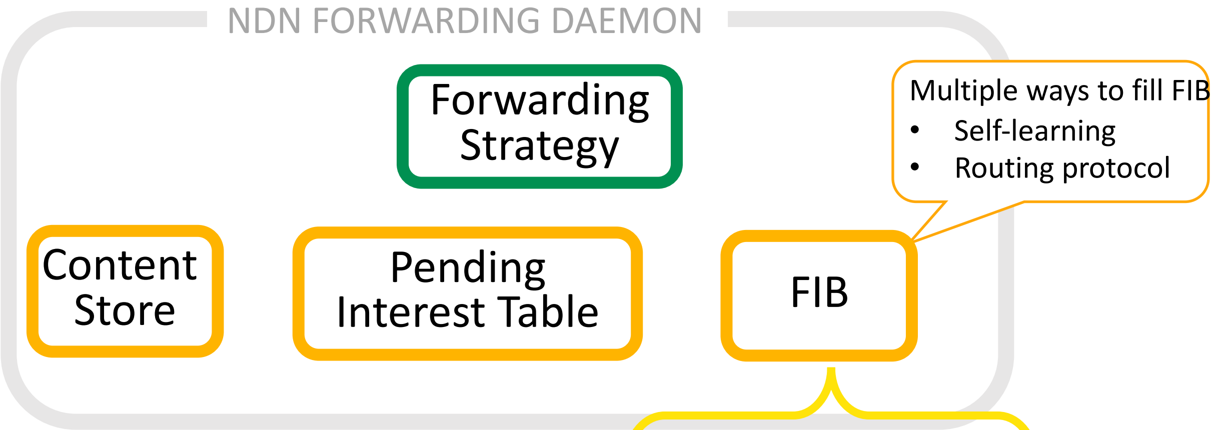
NDN’s node model

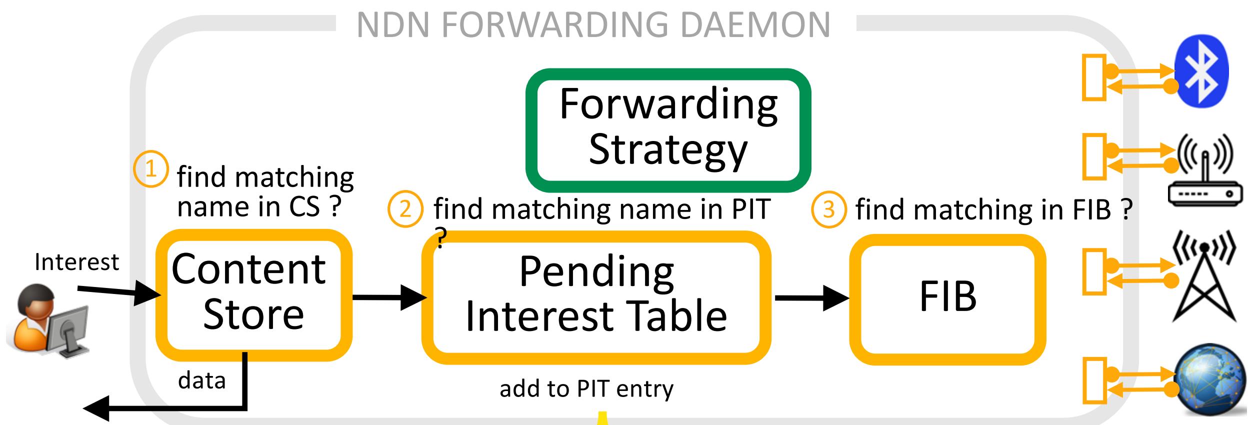


A NFD module resides in every NDN node

name prefix	***next hop***
google.com	A, B
ucla.edu	B,C, D
ucla.edu/cs/lixia	A, B, D,

Breaks Interest looping, can freely use any/all paths

NDN Interest Forwarding

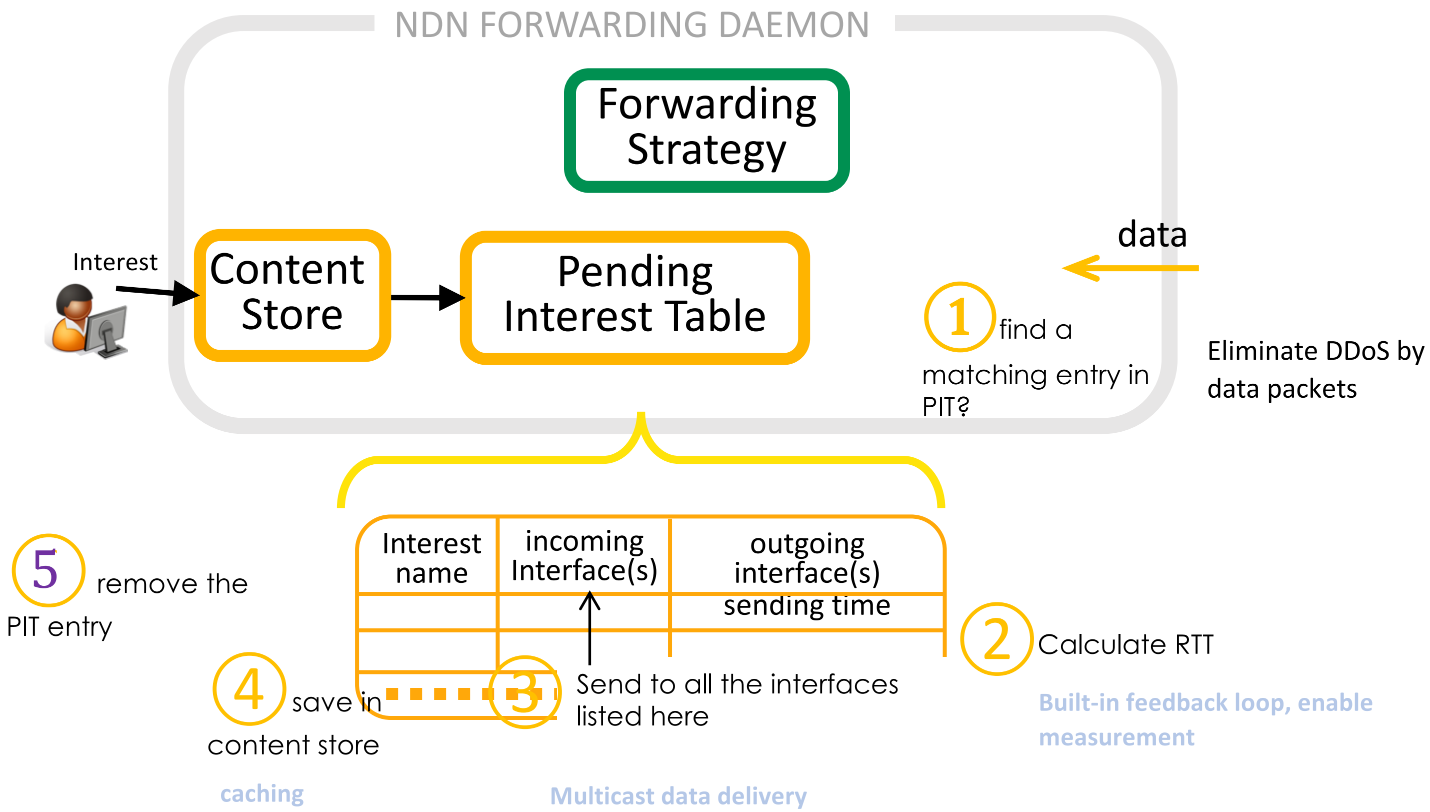


For each PIT entry:

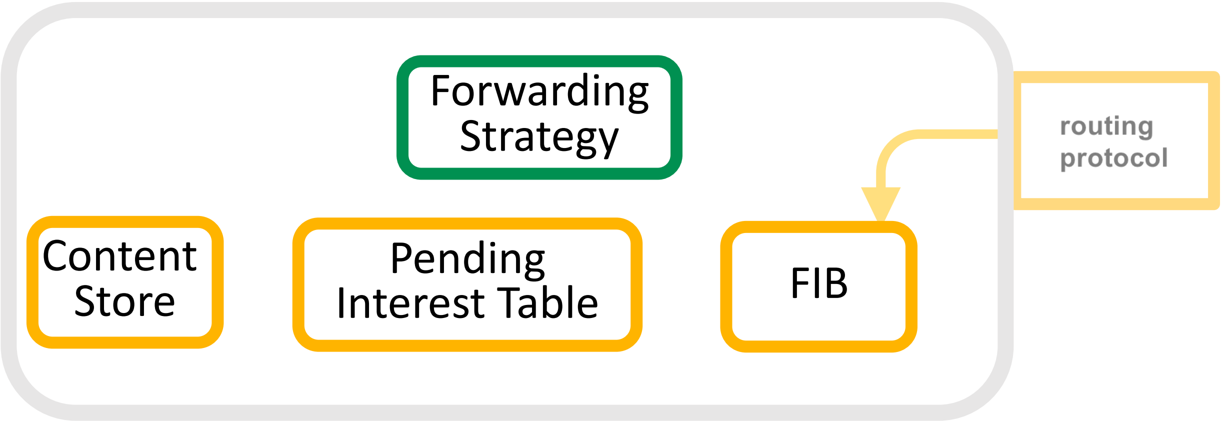
Interest name	incoming Interface(s)	outgoing interface(s) sending time
...		

May forward an interest packet out through one or multiple interfaces

NDN Data Packet forwarding



Forwarding Strategy



- Forwarding Strategy makes interest forwarding decisions by taking input from
  - FIB
  - measurement from Interest-data exchange (and any other local resource information)
  - Per-namespace forwarding policies

Resilient data availability means

- Host multihoming
- Multicast delivery
- Pervasive in-network storage
- Delay/disruption tolerance
- Multipath forwarding

- Can be addressed by IP-based solutions
- Solving each in isolation by amending TCP/IP with special tweaks

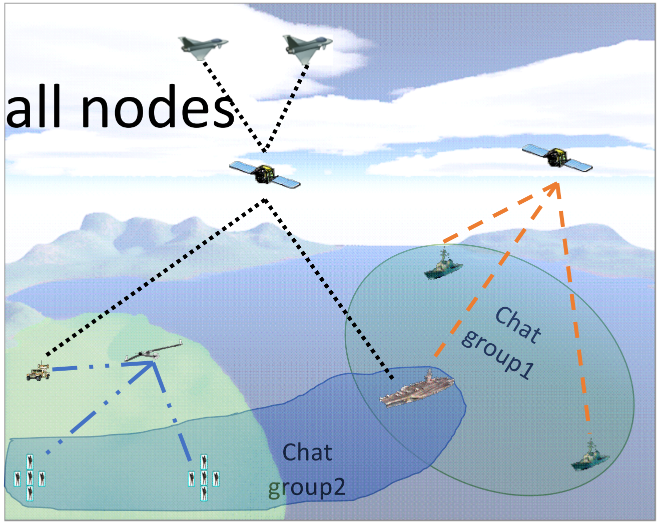
All the above lead to *redundant* means to get data

NDN: making data itself identifiable, independent from its containers or channels

- this requires that data be secured directly

How we secure communication today

- Encrypting point-to-point channels
  - TLS
  - QUIC
- Assumptions
  - synchronized connectivity between two communicating ends
  - All CAs' crypto keys configured into all nodes
- Battlefields need support for delay *and* disruption tolerant (asynchronous) communications
  - No centralized CAs



How NDN secures communications

- The NDN design mandates that all Data packets are secured at the time of production
  - Signed
  - Encrypted as needed
  - Interest packets can be secured as needed
- Enabling secure communication *independent* from data containers or underlying communication channels

NDN enables end-to-end data security

Data producers sign

Data consumers verify

End-to-end data authenticity

independent from intermediate communication channels, middle boxes, intermittent connectivity

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End-to-end data authenticity

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Security bootstrapping:

- installing trust anchor(s) into all entities
- All data producing entities receive crypto certificates

Network security is conceptually simple

- Data authenticity → Signing (verifying) produced (received) data
  - NDN mandates data authentication
- Data confidentiality → Encrypting data
  - NDN supports name & attribute-based encryption
- Data availability → via redundancy
  - Maintaining multiple copies
  - Trying multiple paths

} native properties built into the NDN forwarding plane

The real security challenges

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- **Trust management**
  - Today: through centralized commercial ce
    services
  - NDN's approach to trust management
    - Start with local trust anchors
      - UCLA as the trust anchor for all UCLA controlled business
    - Establish relations among trust anchors

    (adopted from "SDSI - A Simple Distributed Security Infrastructure")
    https://people.csail.mit.edu/rivest/sdsi10.html

- **Usability**
  - Comprehensive trust policy configurations
  - *Automated* crypto key management

Addressing crypto usability challenges

- **Easy access to crypto keys and trust policies**: they are all *named, secured data packets*
  - Can be fetched by anyone as needed
- **Establishing naming conventions for keys and policies**
- **Naming keys in a way to simplify the definition of security policies** via the relations between names of keys and their permitted actions
  - *trust schema*, see reference 3
  - Automated key generation and distribution for content encryption/decryption
    - *name-based access control*, with attribute-based encryption, reference 4

Takeaway

- **A new way to communicate**: requesting named data
  - *without needing network addresses*
- **Fetching named data at network layer** is
  - Demanded by new apps and network scenarios
  - enabled by technology advances
- Networking by app defined data names enables NDN
  - **Securing data directly** →remove dependency on intermediaries
  - **Using semantic names of data & keys to reason security policies**, automate crypto management and operations
  - **Increasing data availability** via
    - host multihoming, multipath forwarding, multicast delivery, in-network storage to support delay/disruption tolerance

Further readings

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1. An Overview of Security Support in Named Data Networking, IEEE Communications Magazine, November 2018.

2. Opportunities and Challenges for Named Data Networking to Increase the Agility of Military Coalitions *Proceedings of Workshop on Distributed Analytics Infrastructure and Algorithms for Multi-Organization Federations (DAIS)*, 2017.

3. Schematizing Trust in Named Data Networking, ACM Information Centric Networking Conference 2015

4. NAC: Automating Access Control via Named Data, IEEE MILCOM 2018