MobilityFirst Architecture and Security Analysis

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MobilityFirst architectural components

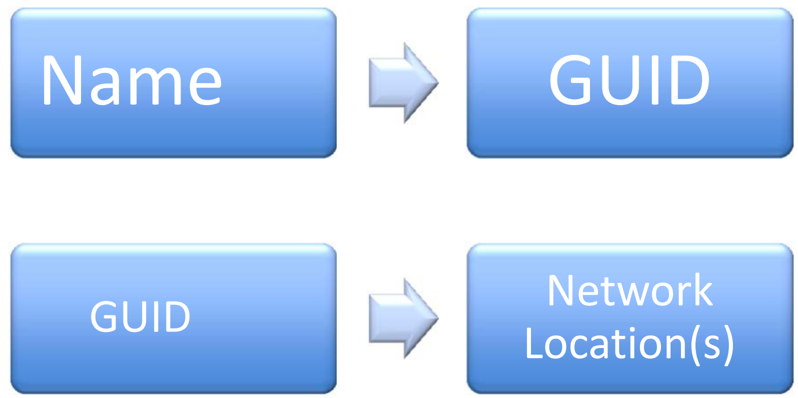
- Name resolution
- Routing
- Transport

Standard components of a network stack, but better refactoring in MobilityFirst

- Context-awareness
- Management plane
- Computing layer

Global name resolution service (GNRS)

- Functions
  - Name certification
  - Location resolution
  - Content retrieval

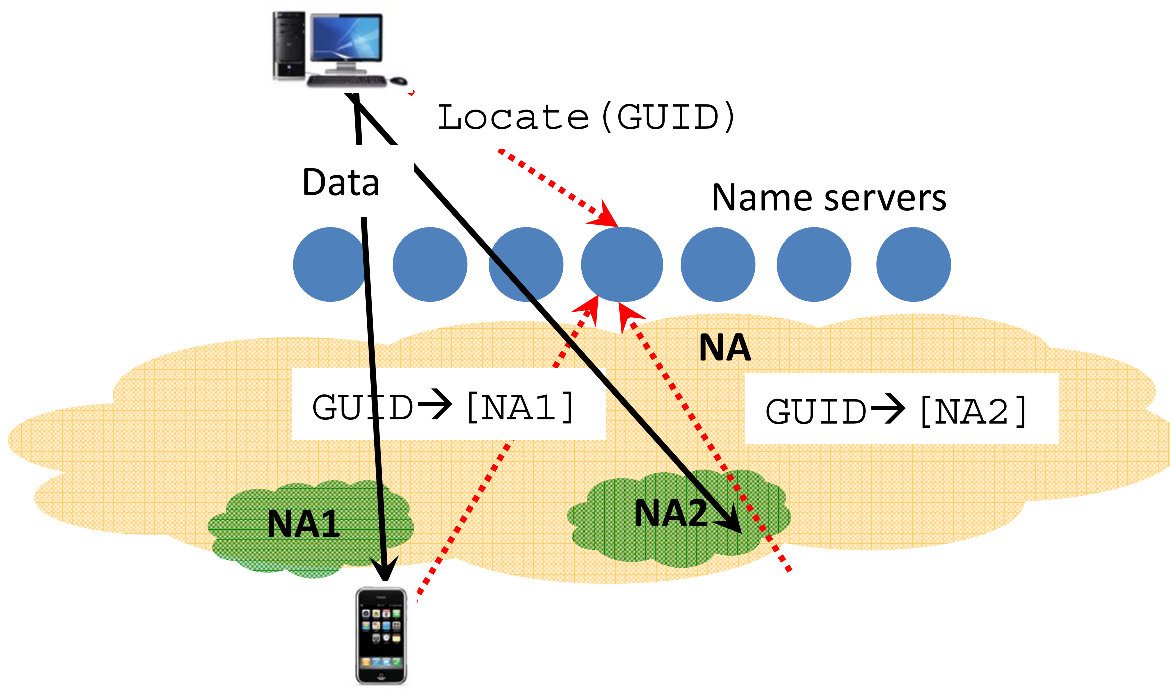


Global name resolution service (GNRS)

- Design metrics
  - Fast
  - Scalable
  - Fault-tolerant
  - Secure
  - Privacy-aware

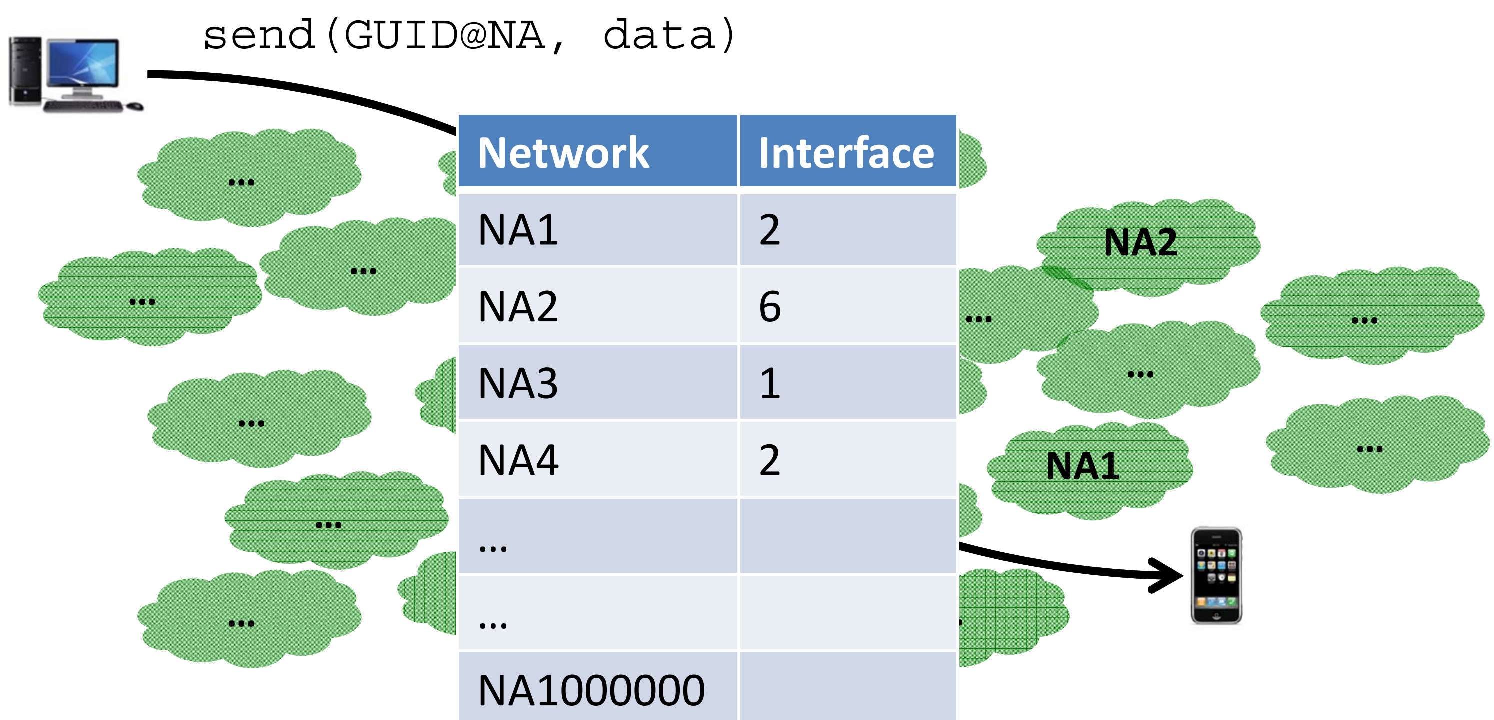
Location Service: Scale to billions of mobiles

- **Function**: Resolve GUID → [NA_1, NA_2,…]
- **Target scale**: 10B devices moving across 100 networks/day ⇔ 10M updates/sec



Routing: Scale to millions of networks (1)

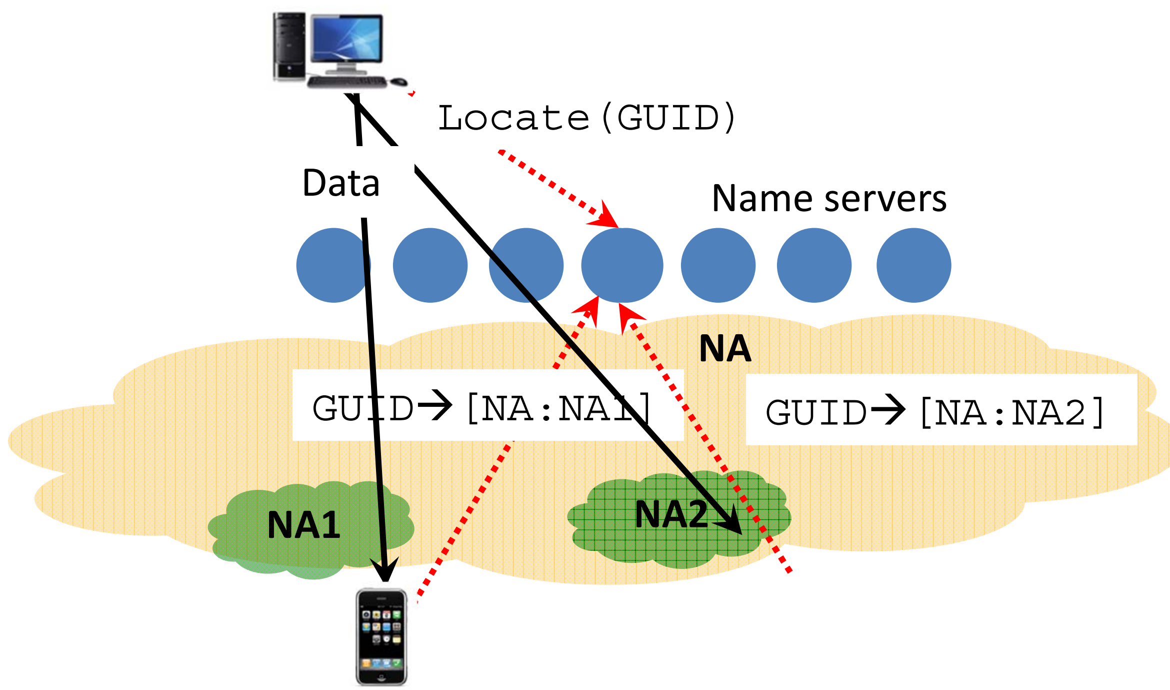
- **Function**: Route to GUID@NA
- **Scale**: Millions of NA's ⇔ huge forwarding tables



Network	Interface
NA1	2
NA2	6
NA3	1
NA4	2
…	
…	
NA1000000	

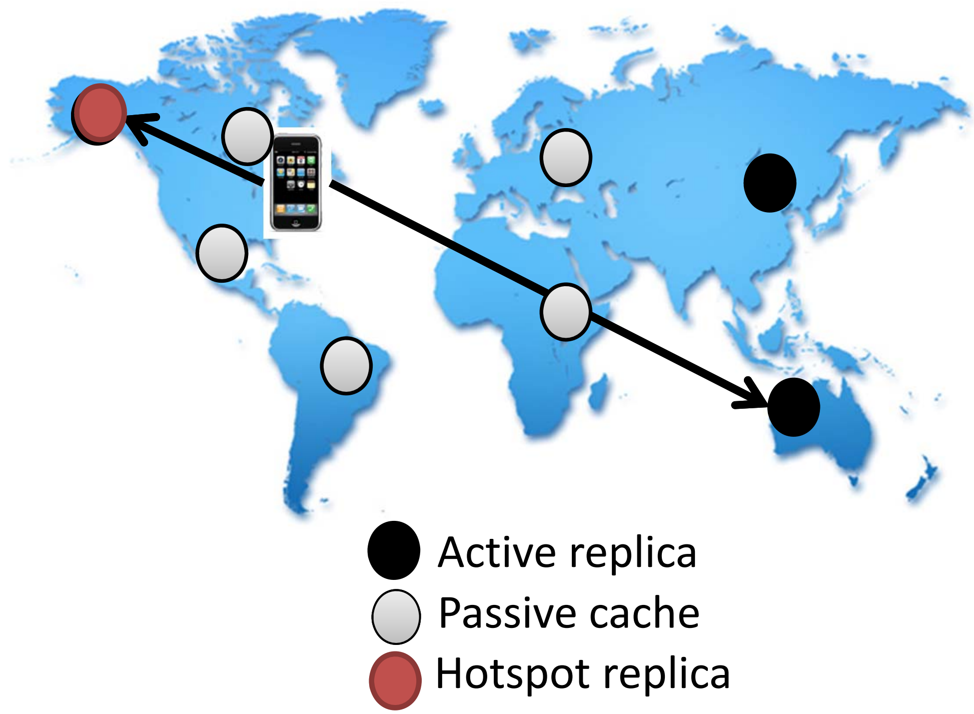
Routing: Scale to millions of networks (2)

- **Function**: Route to GUID@NA scalably
- **Approach:** Leverage natural hierarchy in networks



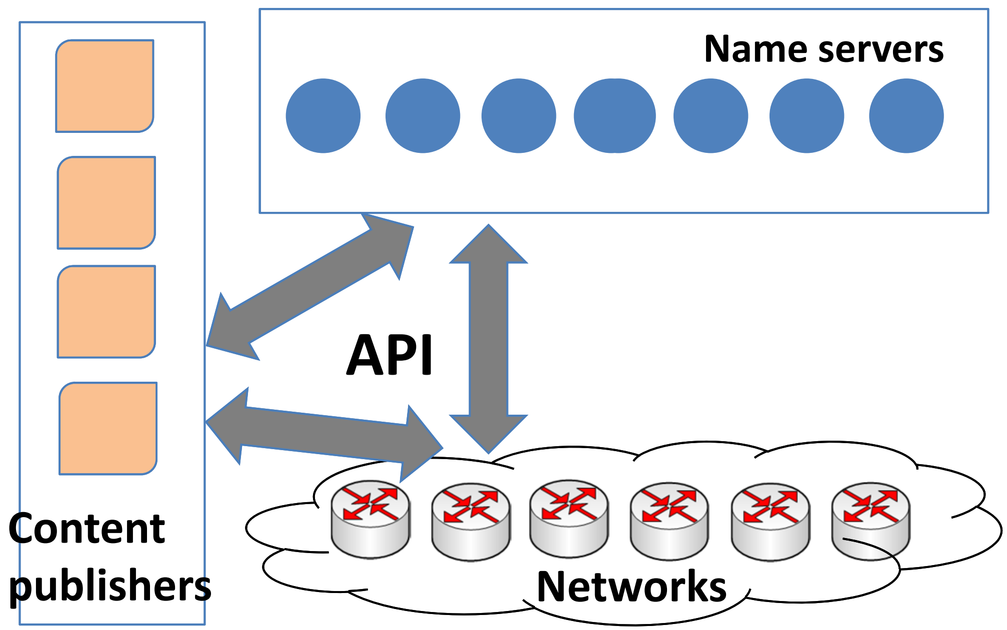
Location Service: Mechanisms and tradeoffs

1. Consistent hashing
   + Load balance, fault-tolerance
   - Proximity
2. Active replication
   + Proximity
   - Update bandwidth
3. Passive Caching
   + Proximity
   - Staleness



Location Service for content retrieval

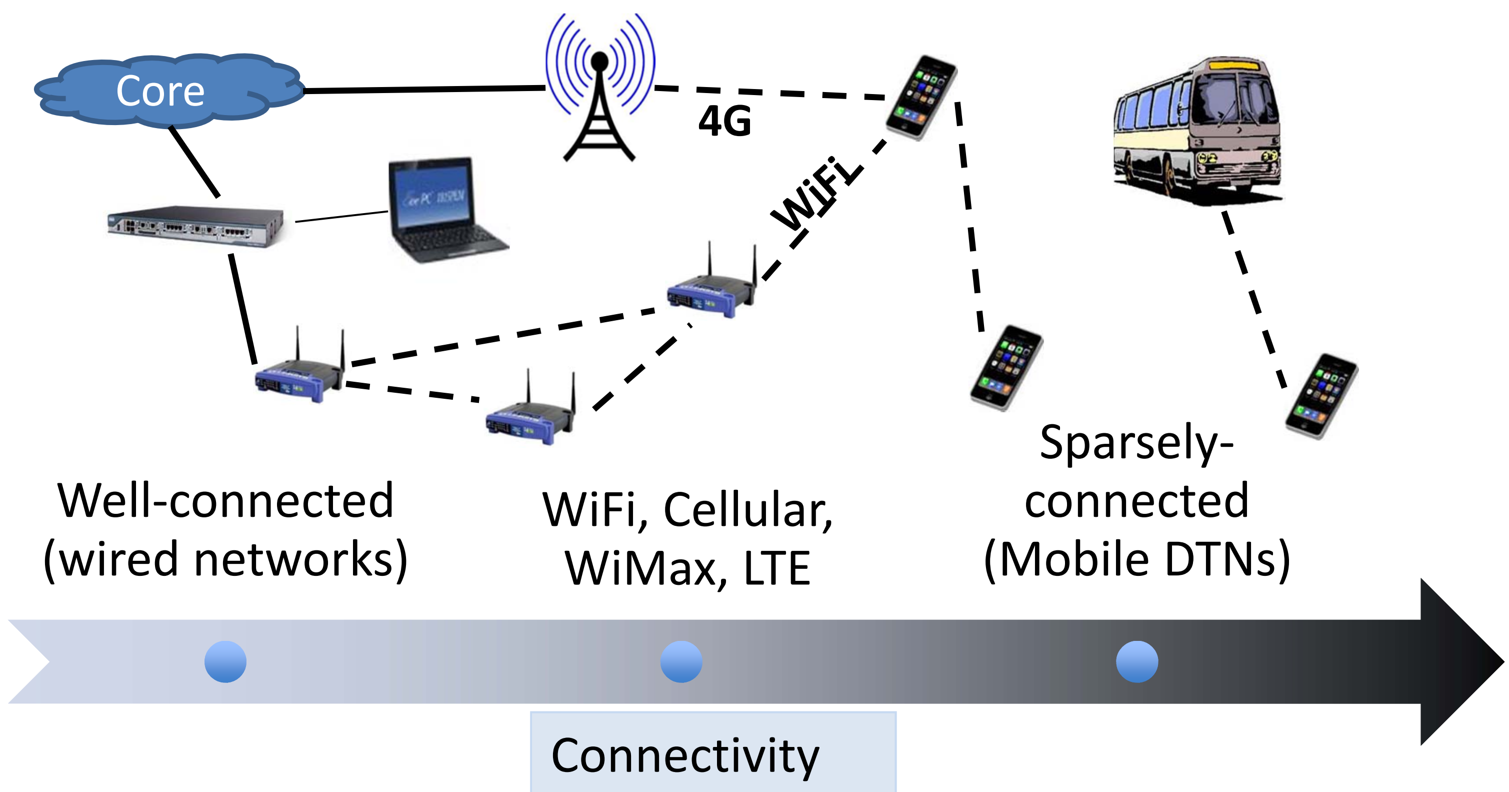
- **Function**: Resolve **GUID → [NA_1, NA_2, ..]**, where NA_i's are locations where GUID is cached or can be authoritatively tracked
- API design challenges:
  1. Proximate content retrieval
  2. Storage-aware routing and traffic engineering
  3. Customizing and tracking consumed content



Routing

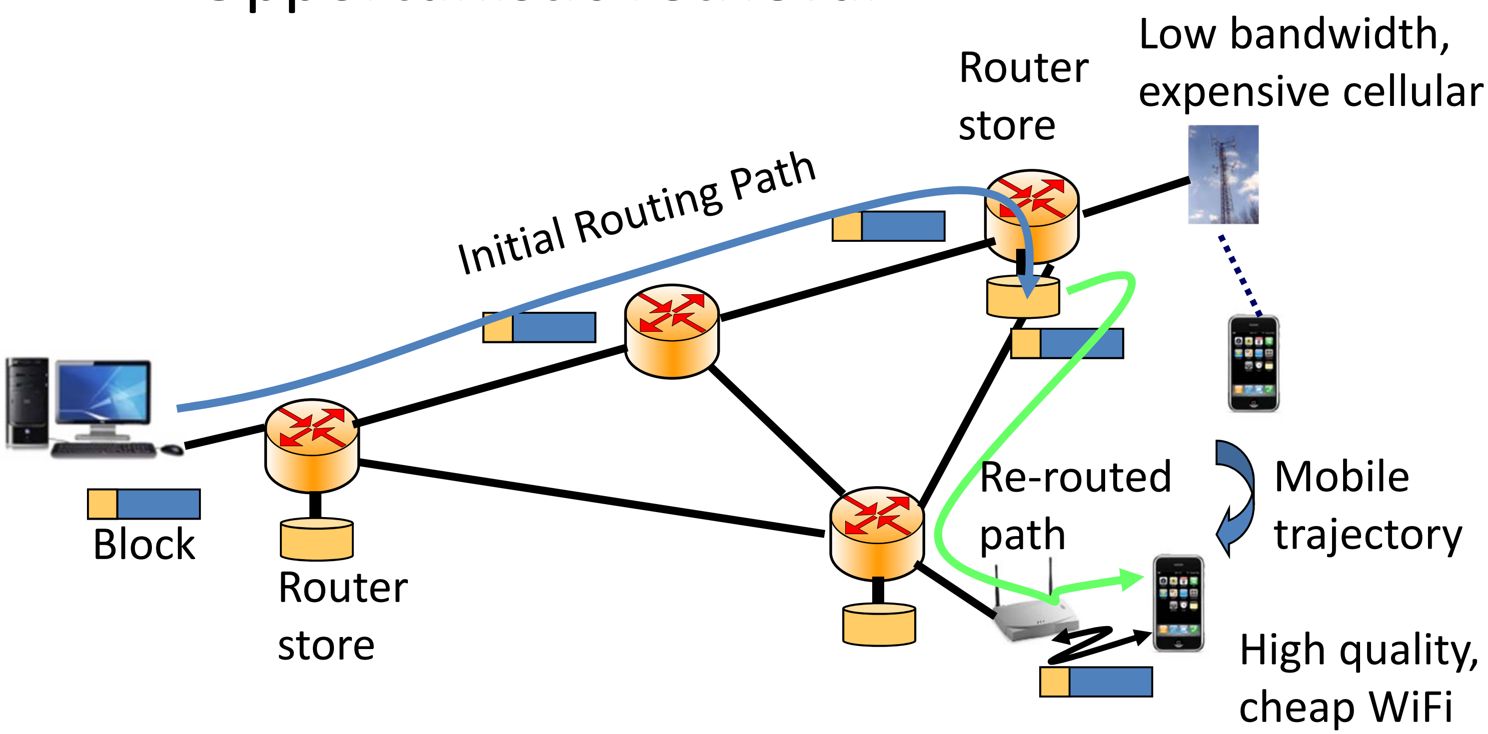
Routing mechanisms (1)

- Robust to connectivity and technology diversity
  - Uncertainty-driven metrics + self-adaptive replication

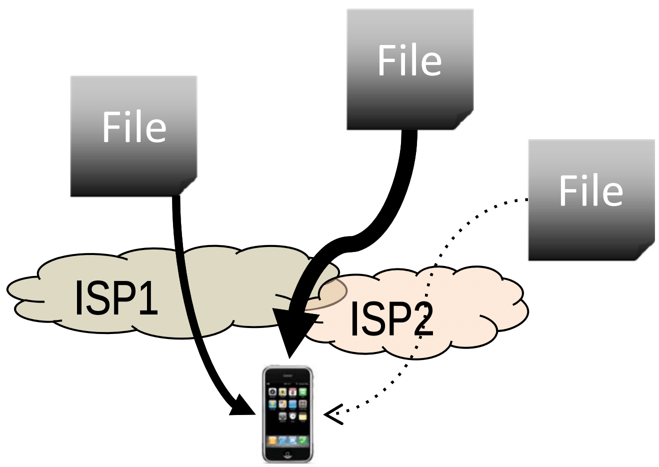


Routing mechanisms (2)

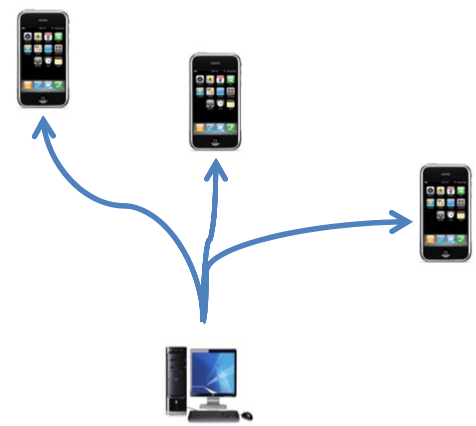
- Storage-aware routing
  - Deferred delivery
  - Opportunistic retrieval



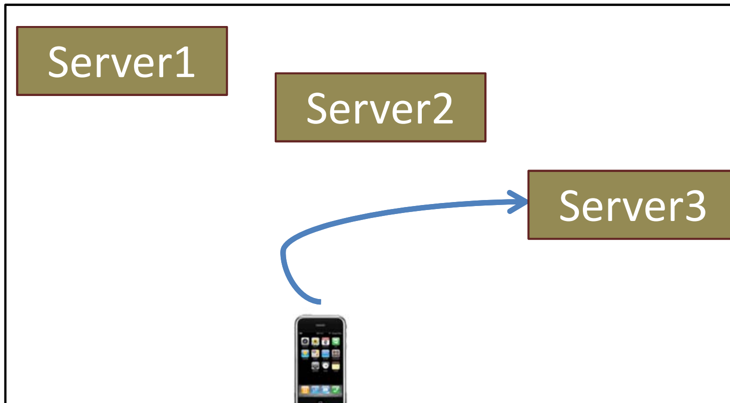
Routing mechanisms (3)



Multihomed multipath



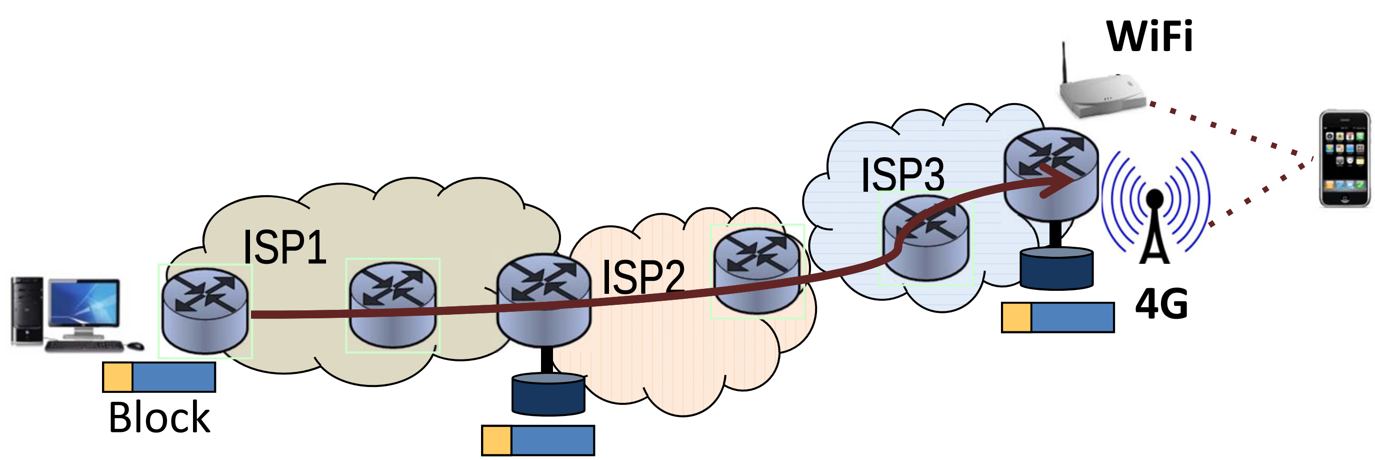
Multicast



Anycast

Segmented transport design

- Storage at segment (contiguous sequence of links) boundaries
- Unit of transmission a large block (instead of small packets in E2E TCP)



Security and Privacy

Verifiable identifiers (unlike IP)

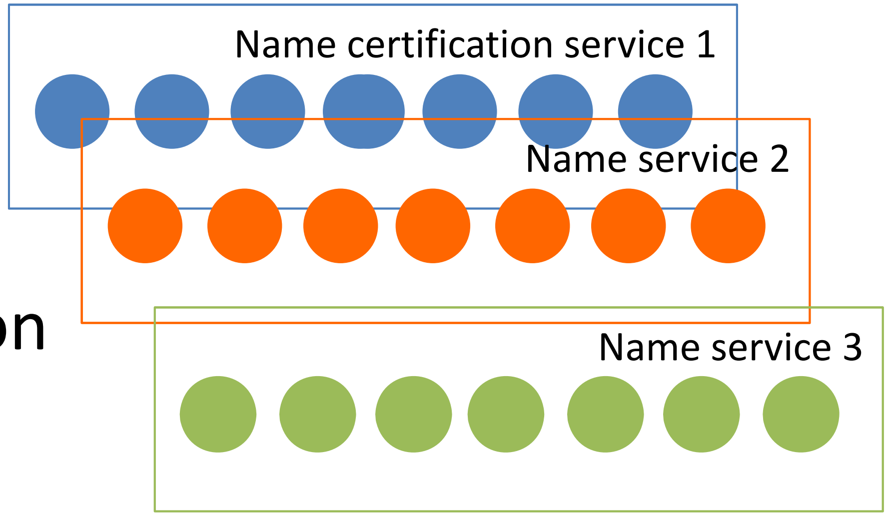
- Name certification service
  - human_readable_name → public_key
  - contextual_keywords → public_key
  - network_name → public_key

Verifiable identifiers are robust to hijacking or spoofing unlike location-encoding IP addresses

- Network operations
  - send(GUID, <data>) or send(NA:GUID, <data>)
  - get(GUID) or get(NA:GUID)

Decentralizing trust in naming

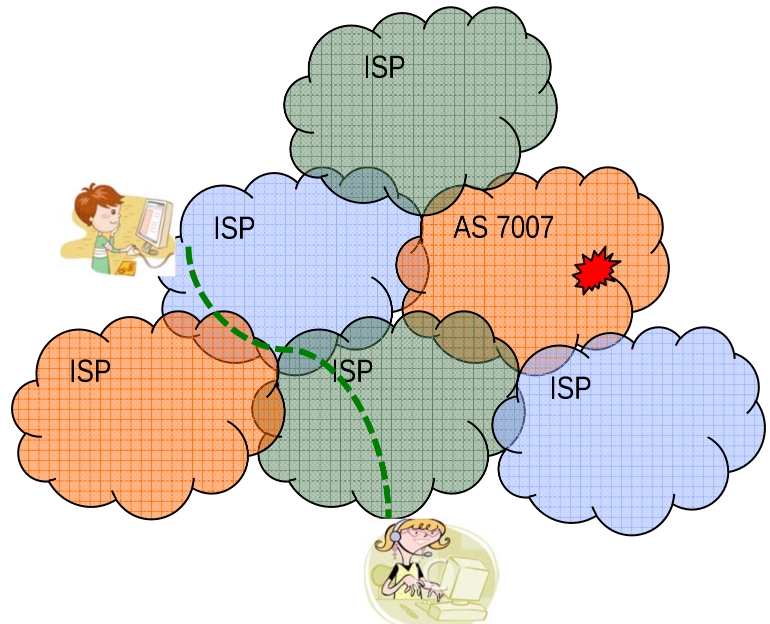
- **Goal**: No single root of trust in name certification
- **Approach**:
  - Multiple name certification service (NCS) providers
  - Many-to-many mapping from namespaces to NCSs
  - Quorum-based certification



Proportional robustness

Goal: A small number of malicious nodes must not be able to disproportionately impact network performance/availability

- Byzantine fault-tolerant name service
- Routing
  - Multihomed multipath
  - Disruption-tolerant
  - Storage-aware
  - Logically centralized intradomain decisions

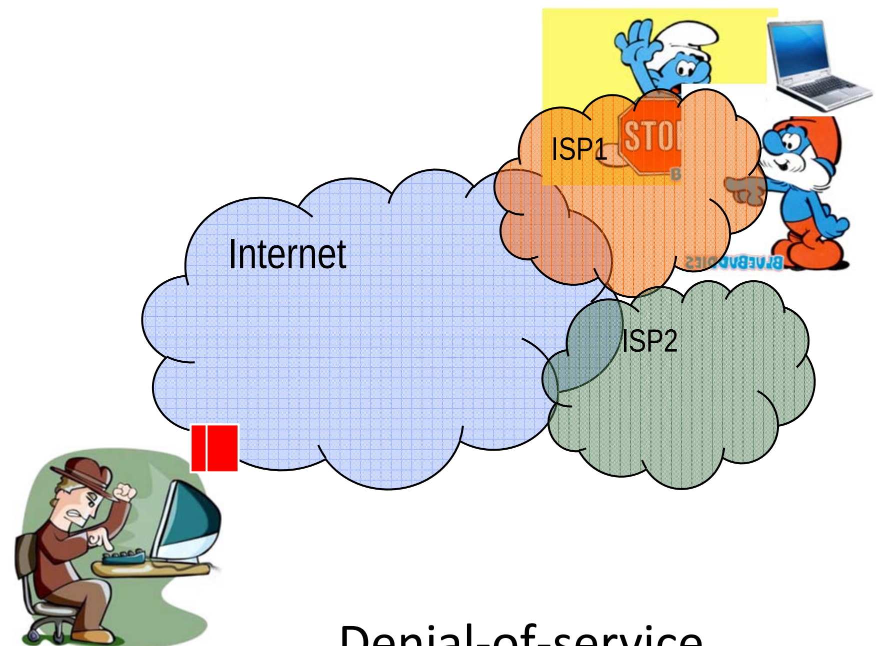


Today, a single faulty router can render most of Internet unavailable.

Intentional data receipt

An end-host must be contactable only if the transmission is consistent with its receipt policy.

Little receiver control in IP



Denial-of-service

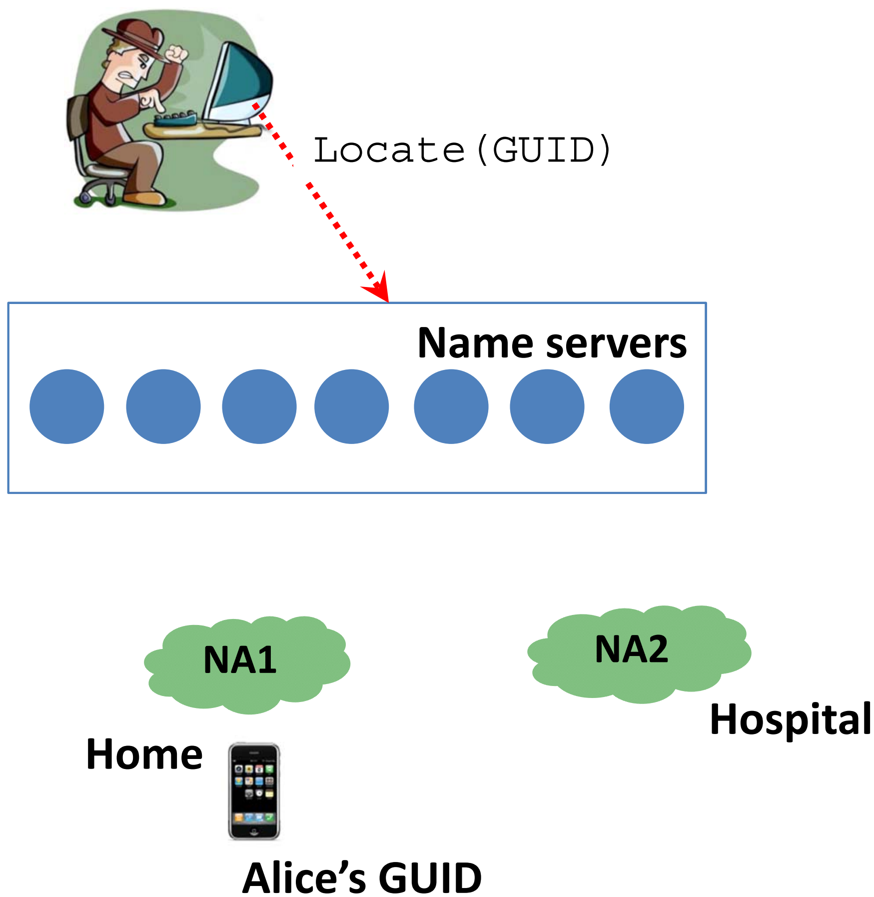
Sender-driven IP

Intentional data receipt for security + privacy

Goal: Controlling access to network location

Approaches:

- Blacklist known bad senders
- Whitelist known good senders
- Switch GUID pseudonyms



Pseudonym switching can help both security and privacy.

Other threats and mitigations

- **Dynamic peering with unknown mobile network**
  - **Trust management service**
- Ensuring fair resource allocation with multicast
- Balancing utility and privacy in context-aware services

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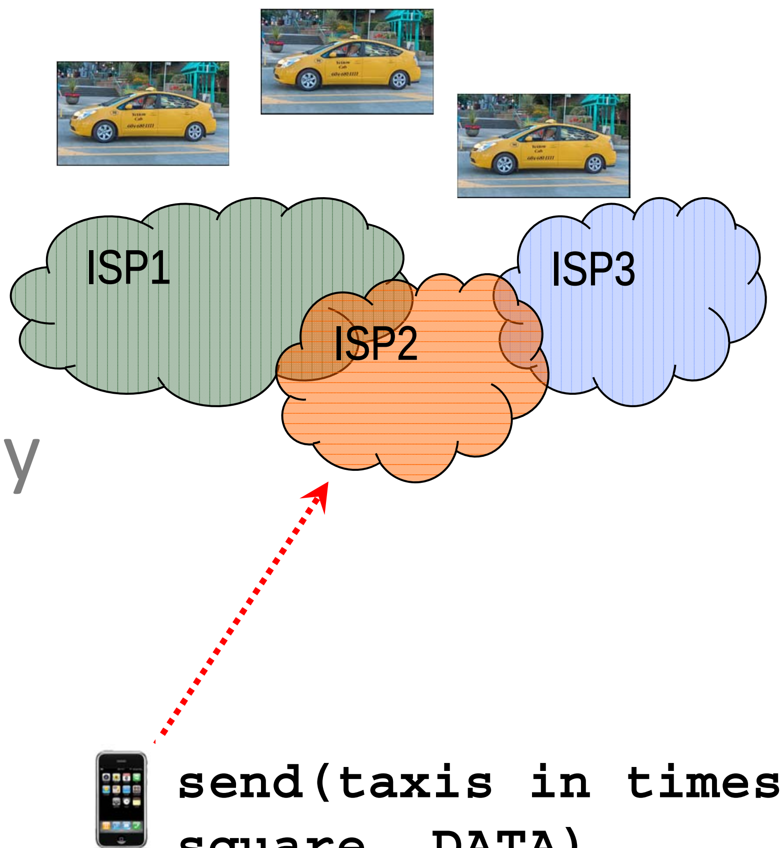
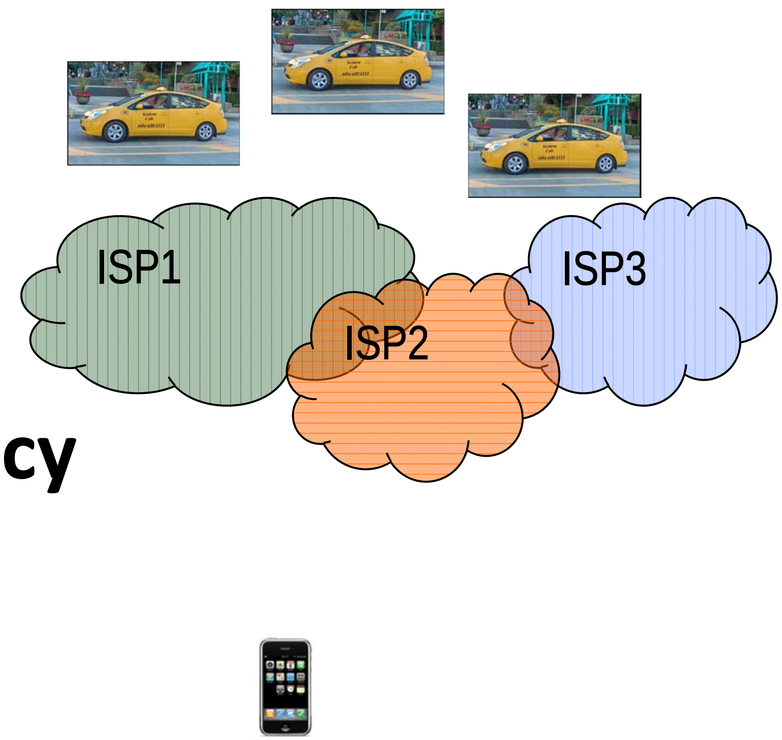
- Dynamic peering with unknown mobile network
- **Ensuring fair resource allocation with multicast**
- Balancing utility and privacy in context-aware services



Other threats and mitigations

- Dynamic peering with unknown mobile network
- Ensuring fair resource allocation with multicast
- **Balancing utility and privacy in context-aware services**

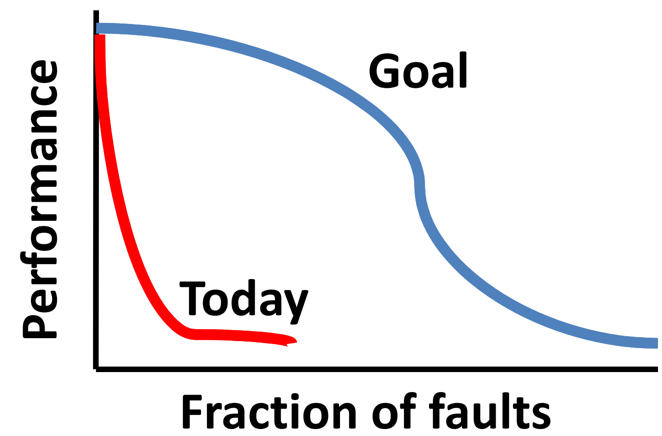


Summary

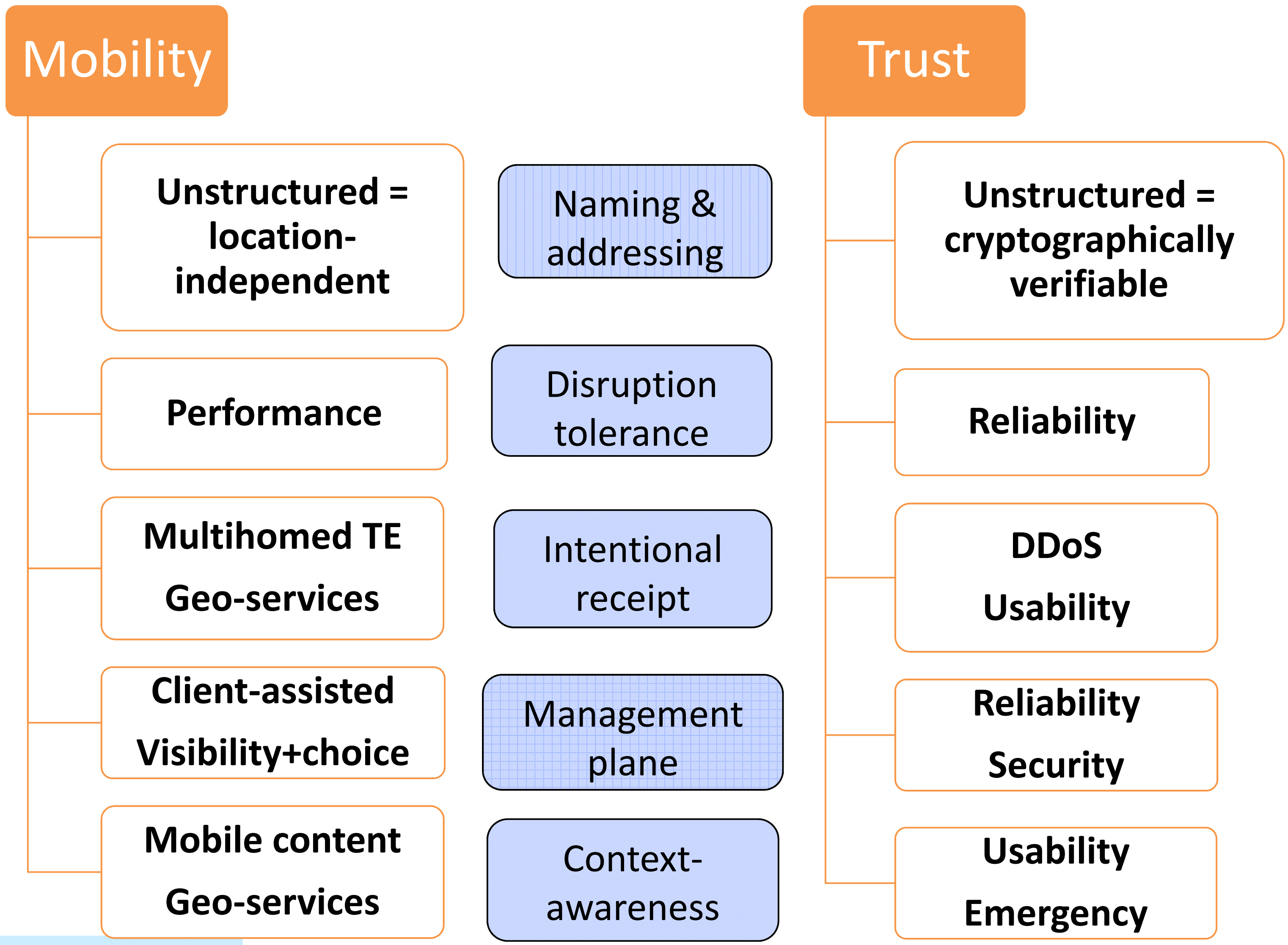
- Mobility and security synergistic – mechanisms for one improve other, e.g.,
  - Unstructured names
  - Disruption-tolerance
  - Intentional/context-aware receipt
  - Management plane
- Design, evaluation, re-design cycle ongoing

Summary

- Designing for mobility also improves trust
- Key challenge is performance security
  - Ensuring graceful performance/availability degradation with malicious node presence
- Logically centralized decision making is easier to secure



Mobility =Trust

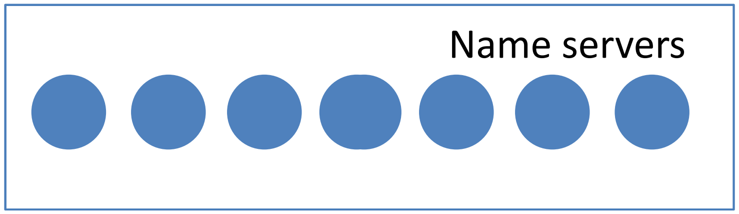


MobilityFirst Design Goals

1. **Host + network mobility**
2. No global root of trust
3. Intentional data receipt
4. Proportional robustness
5. **Content addressability**
6. Evolvable network

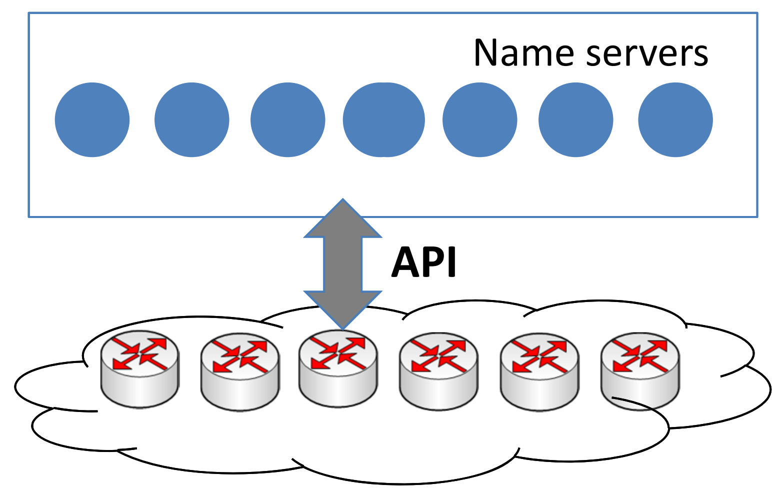
Location Service: Scalability to billions of mobiles

- **Function**: Resolve GUID → [NA_1, NA_2,…]
- **Scale**: 10B devices, 100 networks/day ⇔ 10M/sec
- Metrics:
  1. Query/Update delay (<50ms)
  2. Response staleness (<500ms)
  3. Load balance
  4. Fault tolerance



Location Service: Scalability to billions of mobiles

- **Function**: Resolve Host → [NA_1, NA_2,…]
- **Scale**: 10B devices, 100 networks/day ⇔ 10M/sec
- Design issues:
  1. In-situ routing deflection (?)
  2. Structured local scope IDs (?)
  3. Network anycast to root servers
  4. Context-based addressing



Proportional robustness (1)

Goal: A small number of malicious nodes must not be able to disproportionately impact network performance/availability

Approach for naming:

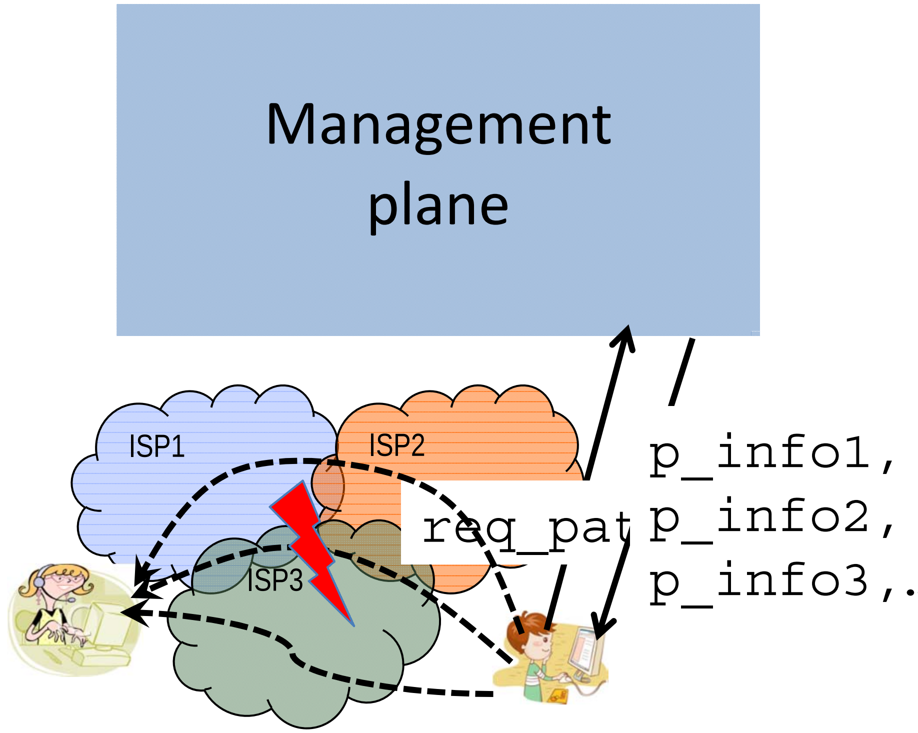
- Byzantine-fault tolerant (BFT) name certification and location service
- BFT both within and across name service providers

Proportional robustness (2)

Goal: A small number of malicious nodes must not be able to disproportionately impact network performance/availability

Approach for routing:

1. **Multipath routing and congestion control**
2. Disruption-tolerance
3. Storage-aware routing
4. Logically centralizing decisions with network-wide impact
   A. Intradomain: Aggregate network-wide information centrally, compute routes, and disseminate to routers
   B. Interdomain: BFT "consensus routing"

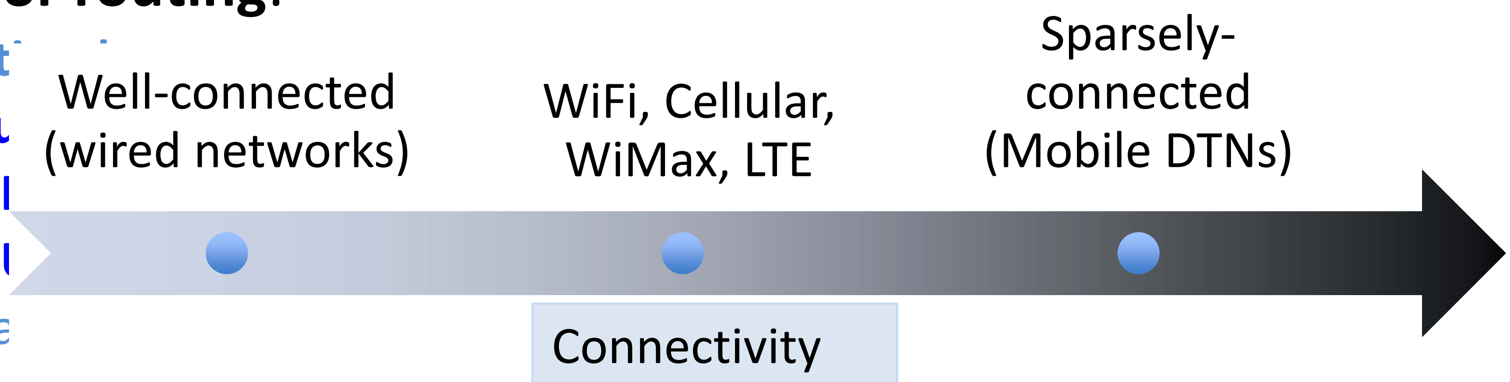


Proportional robustness (2)

Goal: A small number of malicious nodes must not be able to disproportionately impact network performance/availability

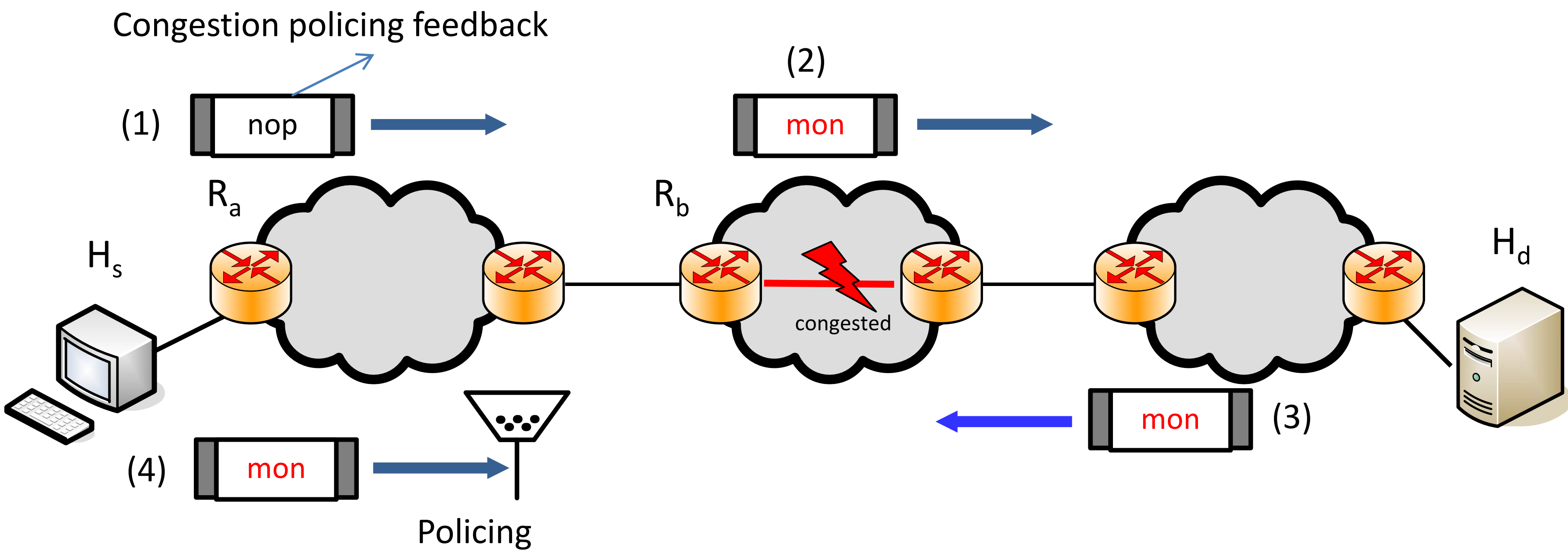
Approach for routing:

1. **Mult**
2. **Disru**
   - A.
   - B.
3. Stora
4. Logic



   - A. Intradomain: Aggregate network-wide information centrally, compute routes, and disseminate to routers
   - B. Interdomain: BFT "consensus routing"

Intentional receipt for DDos



Goal: Scalable fair resource allocation under DDoS

Approach:

- Packets carry unspoofable congestion policing feedback
- Congested routers use pair-wise keys for congestion policing feedback that receivers use as capability tokens
- Access routers police senders' traffic to guarantee per-sender fairness without per-sender queues