On the value of a GNS in Information-Centric Network Architectures

V. Arun

University of Massachusetts Amherst

What is ICN?

- ICN ≡ Named information is a central architectural principle [ICNRG]
  - Often contrasted against TCP/IP's host-to-host IP-address-centric (location-dependent) communication abstraction

[ICNRG] https://irtf.org/icnrg

Location-independence

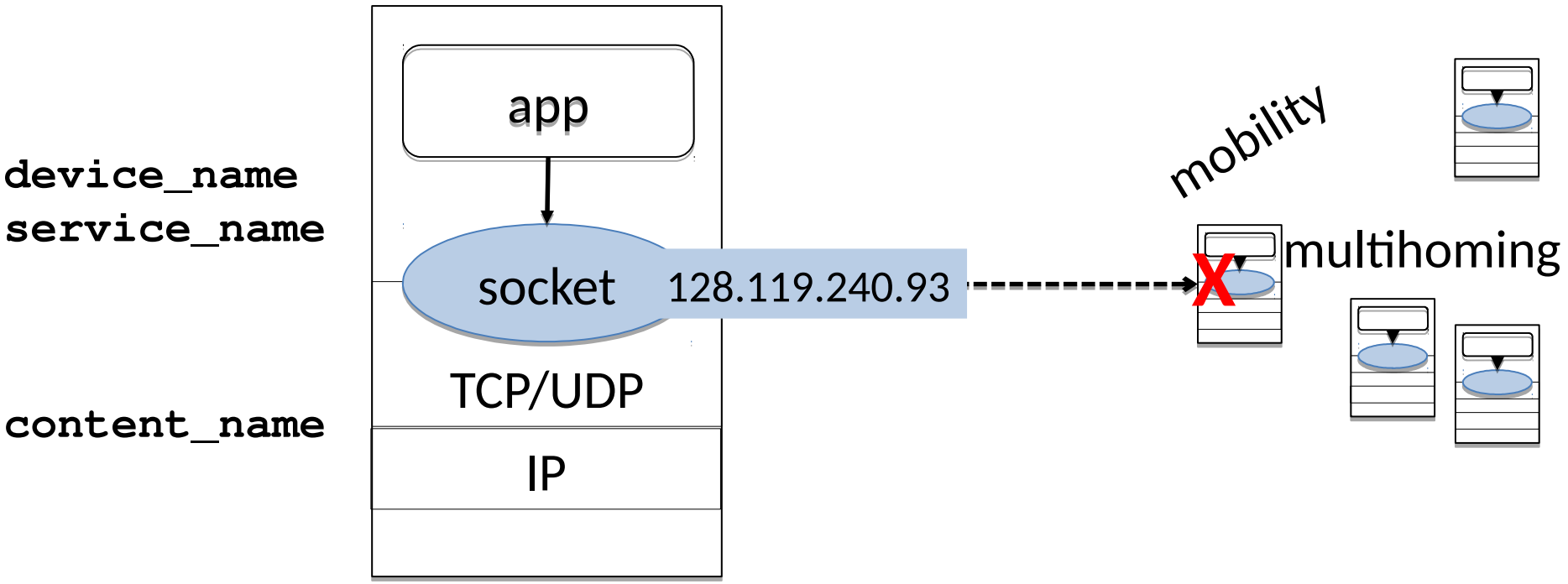
An abstraction to communicate using fixed *names* without worrying about (changing) *locations*.

`get("Alice's webpage")`	HTTP
`send("Bob's phone", msg)`	UDP/SMS
`connect("BofA banking service")`	TCP

Why is today's Internet *not* location-independent?

[ICNRG] https://irtf.org/icnrg *"data becomes independent from location…"*

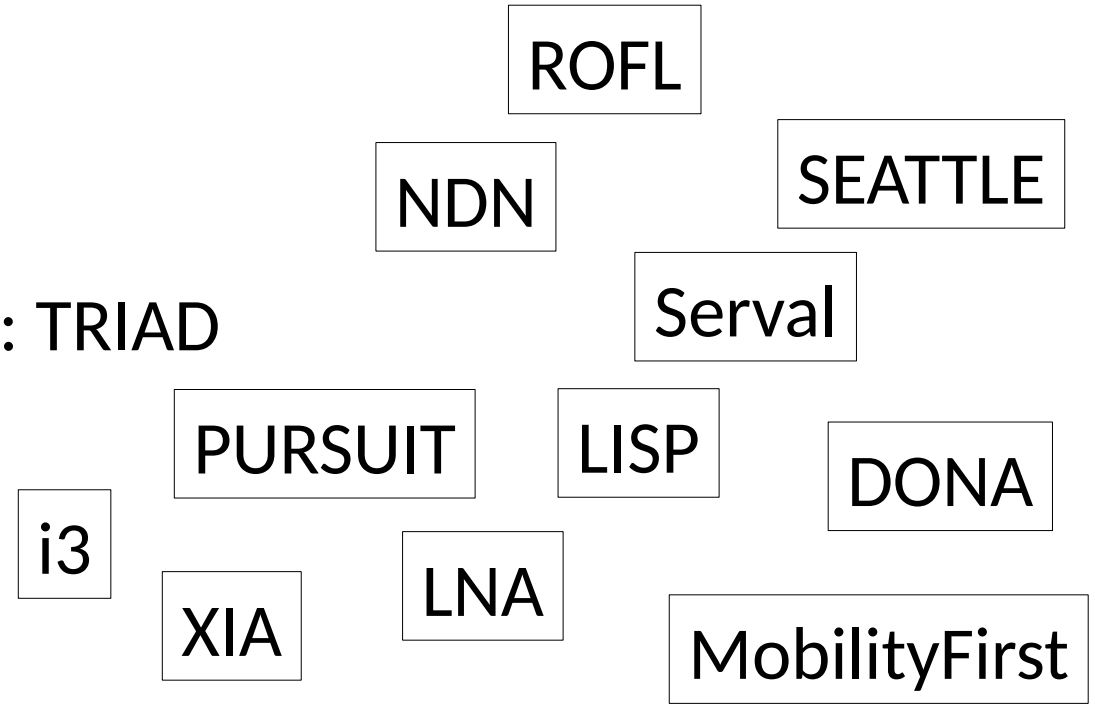
Internet conflates location and identity



All communication must be straitjacketed to an IP-addressable, host-to-host communication primitive

Location-independent network architectures

- Host-centric: HIP
- Information-centric: TRIAD



Location independence (and information centrism?) not incompatible with presence of locator hints

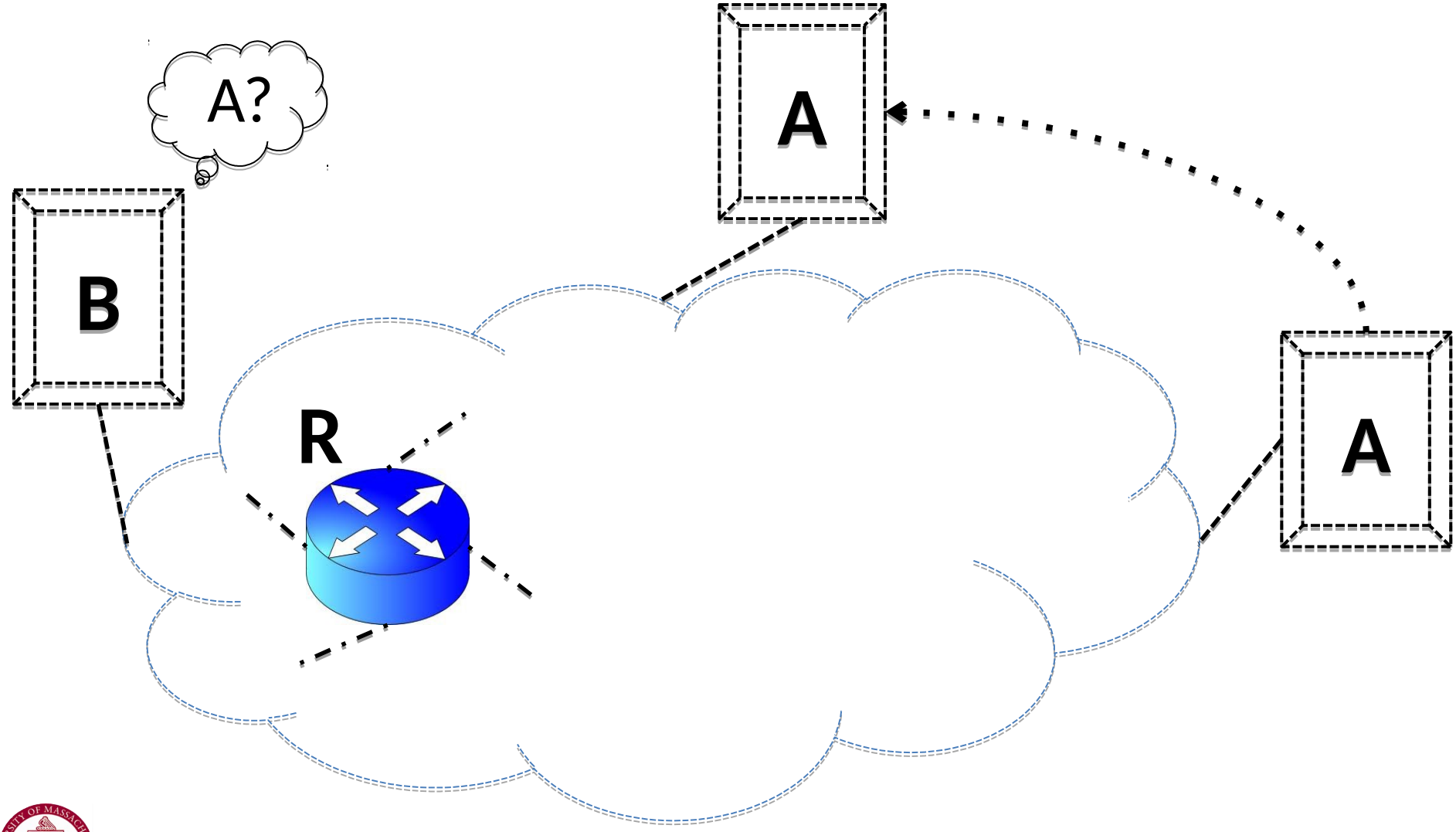
[ICNRG] https://irtf.org/icnrg

FUNDAMENTAL APPROACHES TO LOCATION INDEPENDENCE

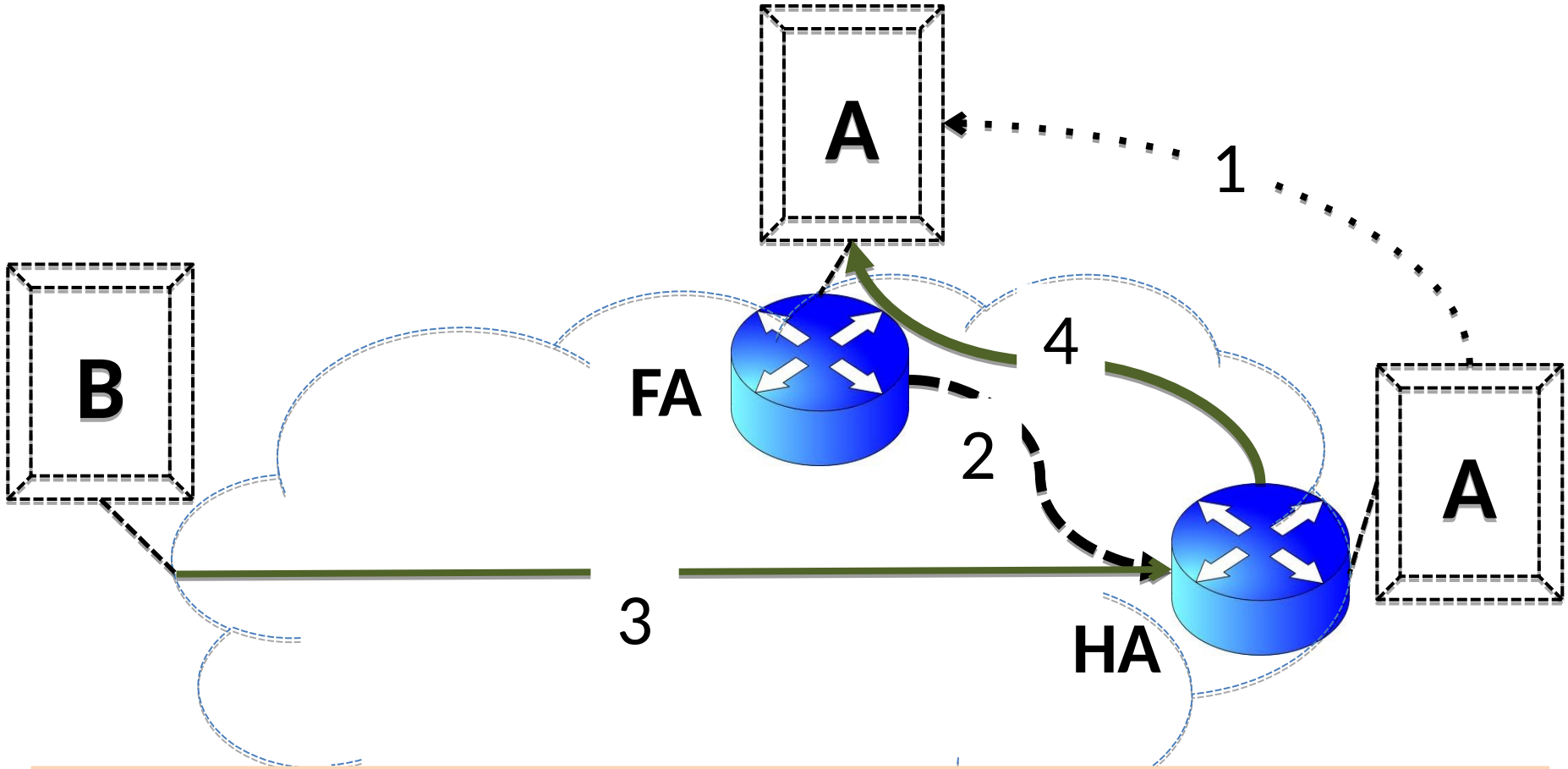
Location independence ⊣ mobility

- Location independence largely matters only when locators change frequently a.k.a. *mobility*

Approaches for handling mobility

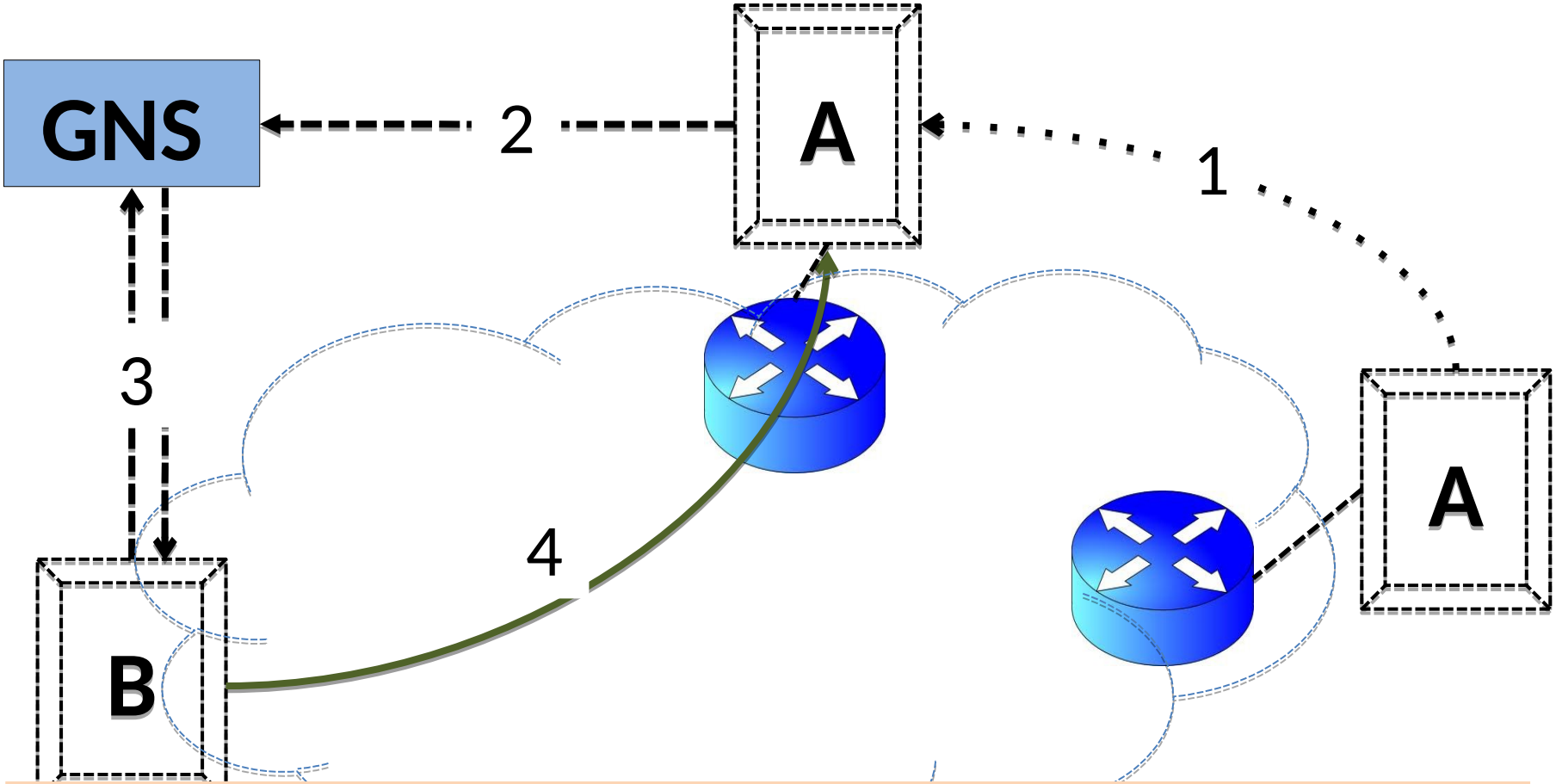


Indirection routing



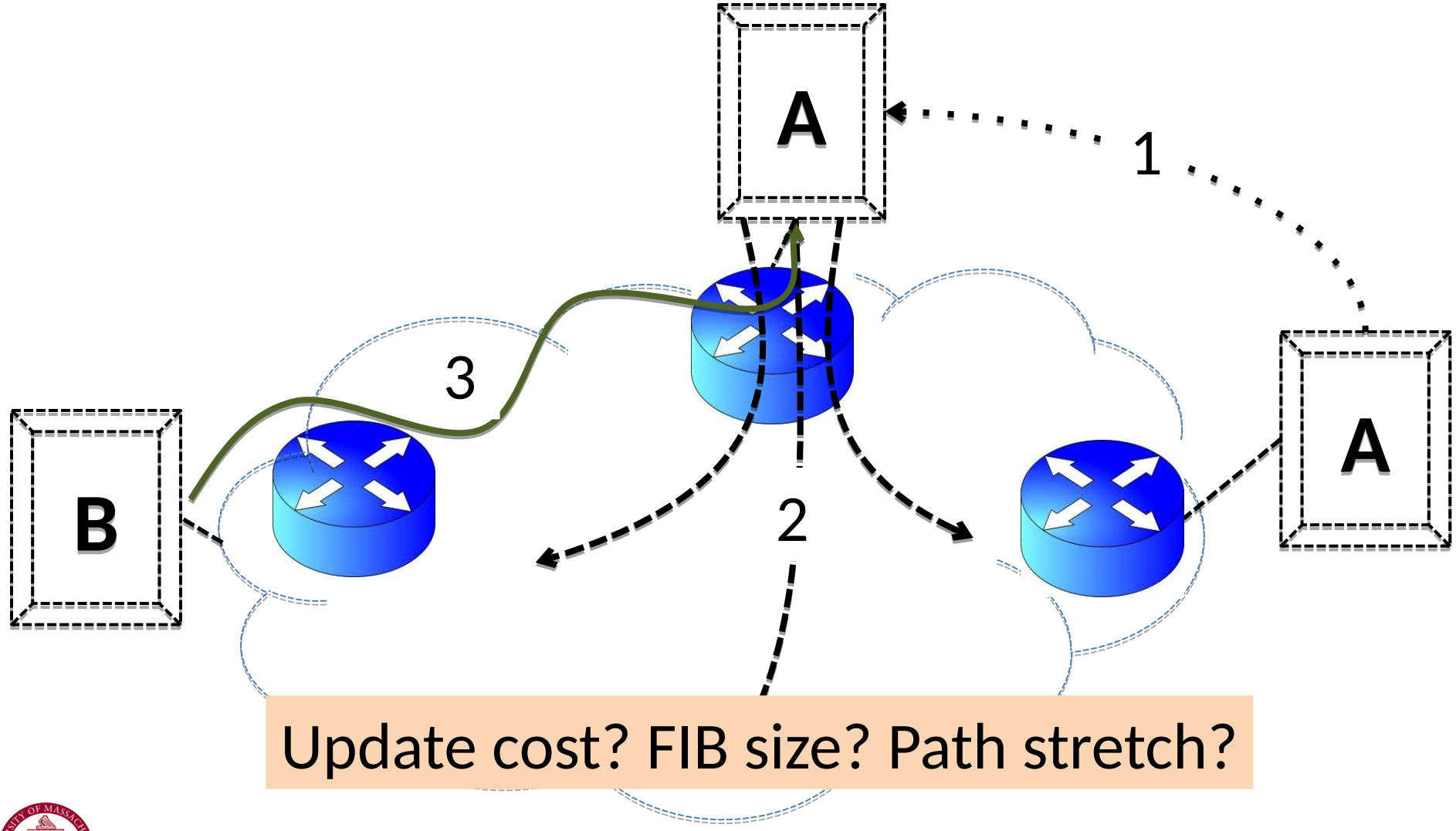
Indirection entails data path stretch (steps 3 and 4)

Name-to-address resolution



Lookup/update overhead but no data path stretch

Name-based routing



Update cost? FIB size? Path stretch?

Research findings

- A logically centralized GNS can significantly enhance mobility support for any network architecture
  - Empirical analysis [GVKH14]
  - Modeling-driven analysis [CKV18]

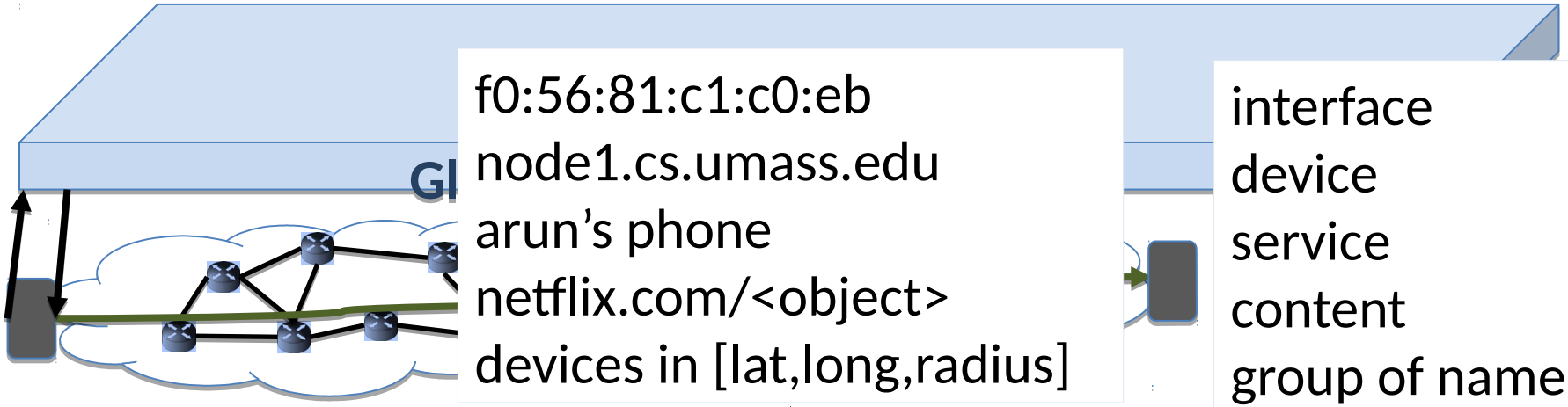
- [**GVKH14**] Z. Gao. A. Venkataramani, J. Kurose, S. Hiemlicher, A Quantitative Comparison of Location-Independent Network Architectures, ACM SIGCOMM 2014
- [**CKV18**] V. Chaganti, J. Kurose, A. Venkataramani, A cross-architectural quantitative evaluation of mobility approaches, IEEE INFOCOM 2018

MOBILITYFIRST GNS

MobilityFirst: Mobility-Centric + Trustworthy

- **Key insight**: A logically centralized global name service can dramatically enhance seamless mobility, security, and rich network functionality
  - Name-based communication abstraction enabled by self-certifying GUIDs (globally unique identifiers)

Scalable global name service (GNS)



A massively scalable, logically centralized GNS to enable secure, name-based communication with flexible endpoint principals with arbitrary (fixed) names despite high mobility.

GNS DEEPER DIVE

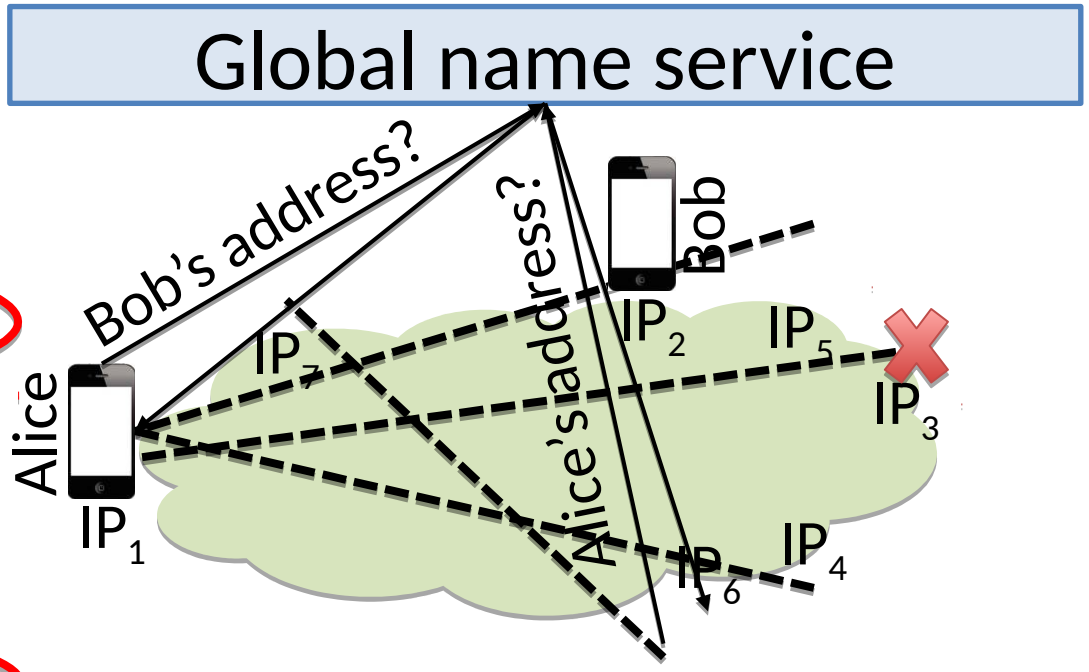
Why GNS critical to handle mobility

Pre-lookup mobility

Connect-time mobility

Individual mobility

Simultaneous mobility



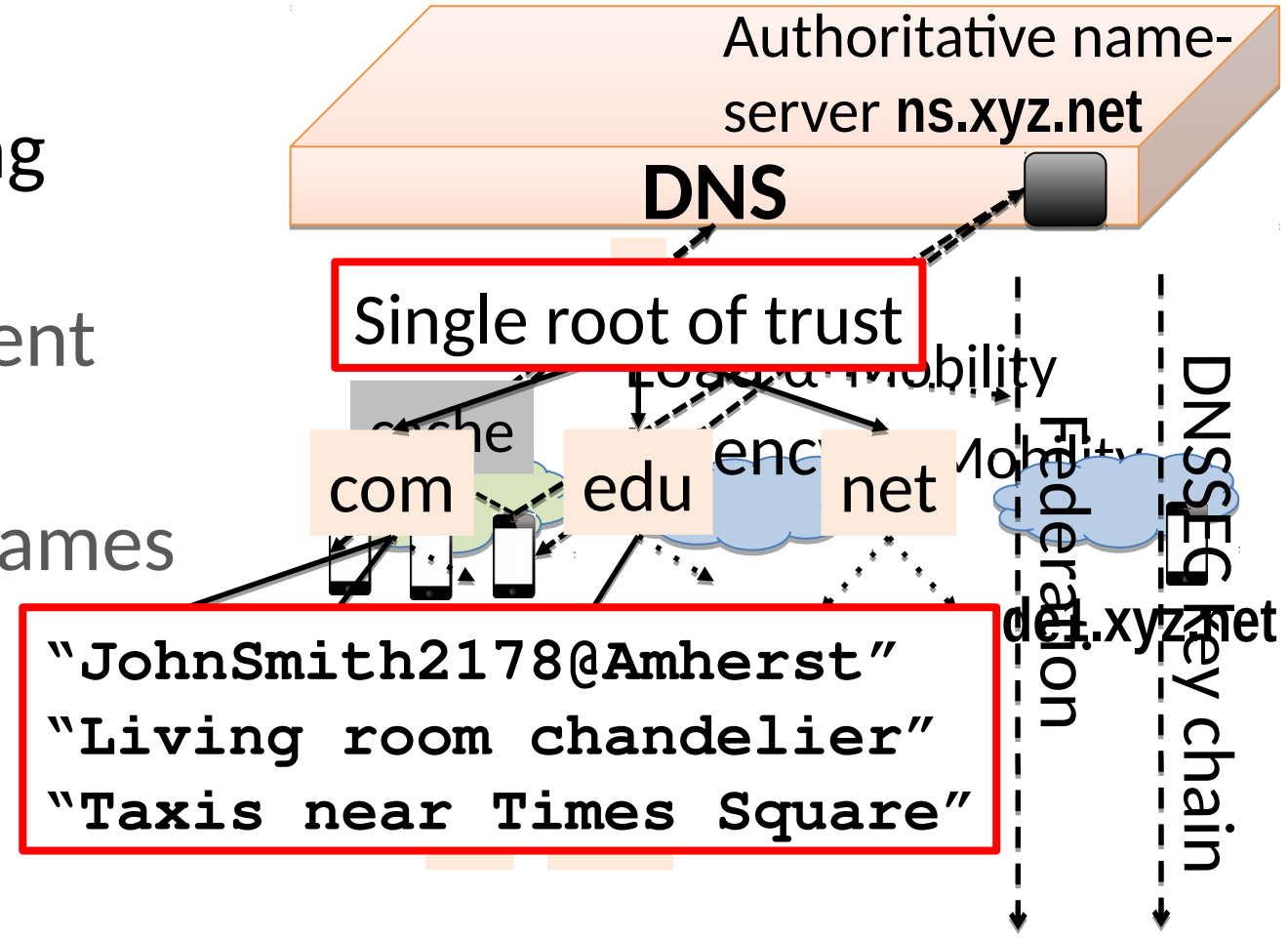
GNS critical or can significantly benefit mobility handling in any network architecture

DNS limitations

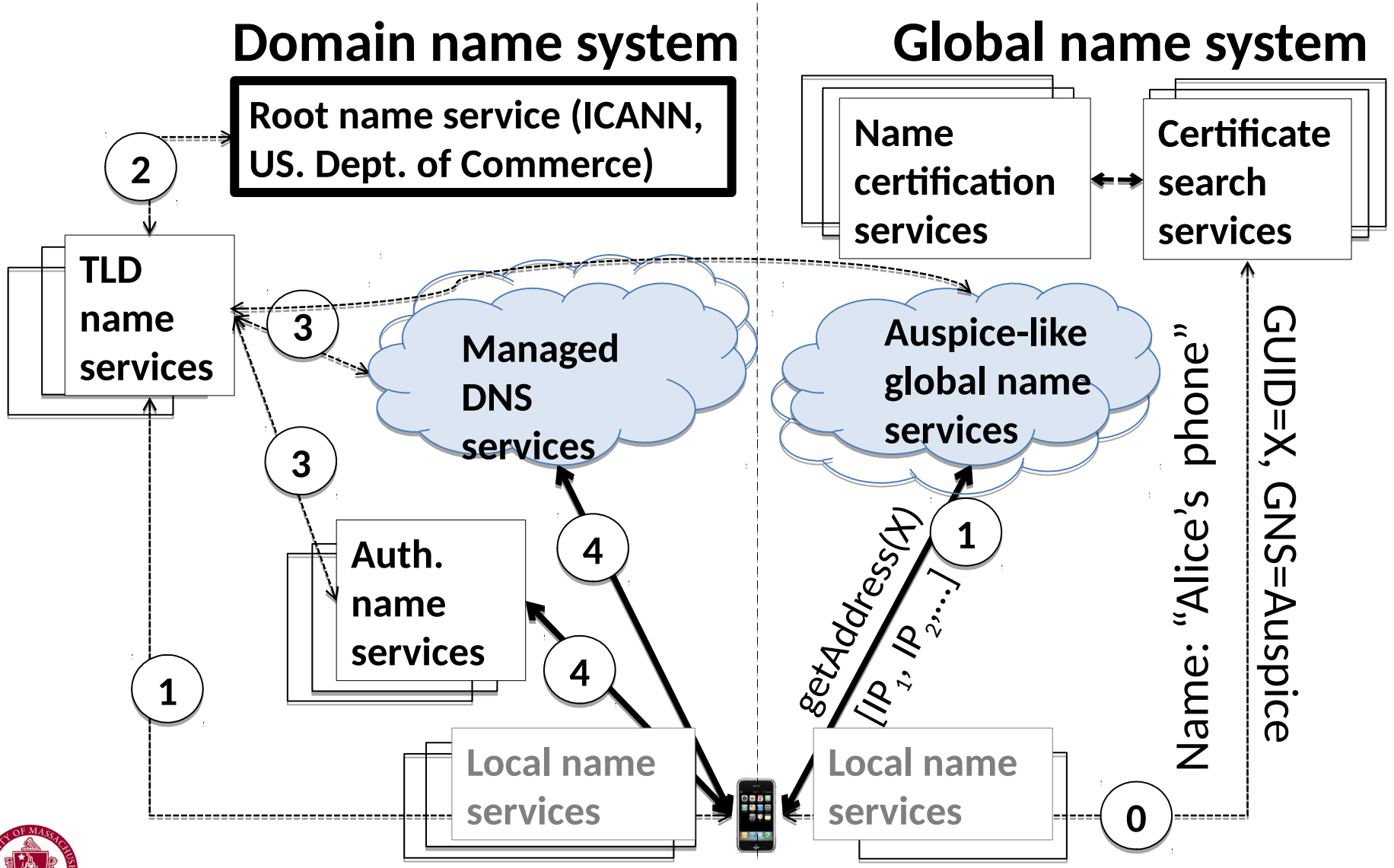
Passive caching

Static placement

Hierarchical names



GNS: Decoupling certification and resolution



Open-source GNS for community use

- https://github.com/MobilityFirst/GNS

Currently being used as a foundation for Light-Speed Networking (LSN) ICN-WEN project and being beta-tested in several pre-production pilot deployments

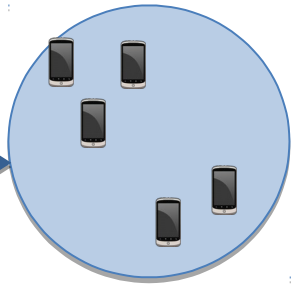
CONTEXTUAL COMMUNICATION DRIVEN BY GNS

Contextual Communication

- Ability to communicate based on (changing) attribute values (or context), e.g.,
  - send(msg, [lat, lon, radius])
  - get(cam_recording, type="4K", building="CSAIL", time=3pm)

Context-based communication

```
msocket.bind([lat, long, radius])
msocket.send(msg)
```

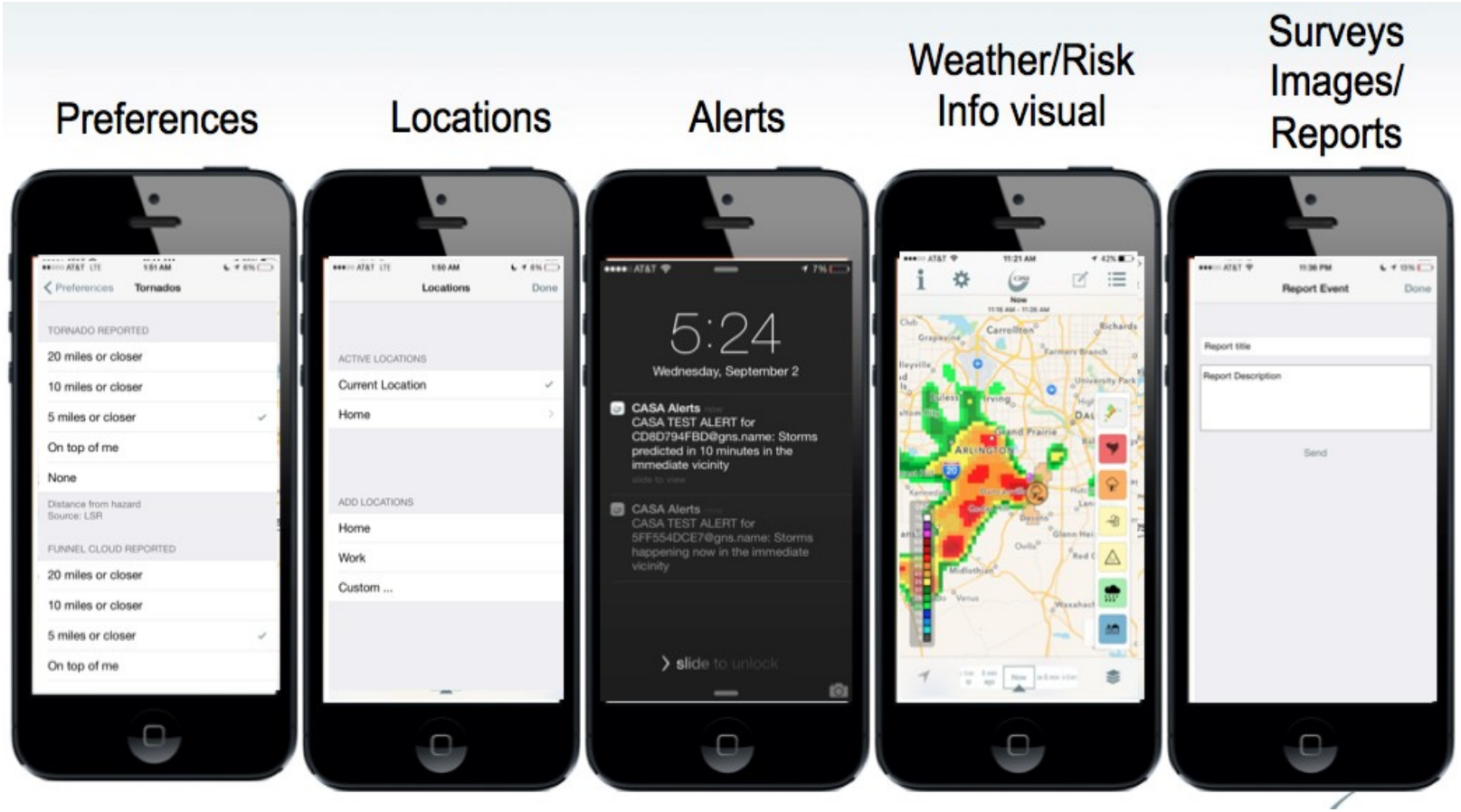


CAID ␣ members(CAID) ␣ $\{T_1, T_2, ..., T_k\}$

Why GNS for contextual communication

- **Key insight**: "Solving" the problem of high mobility in a network location space naturally generalizes to mobility in any attribute space

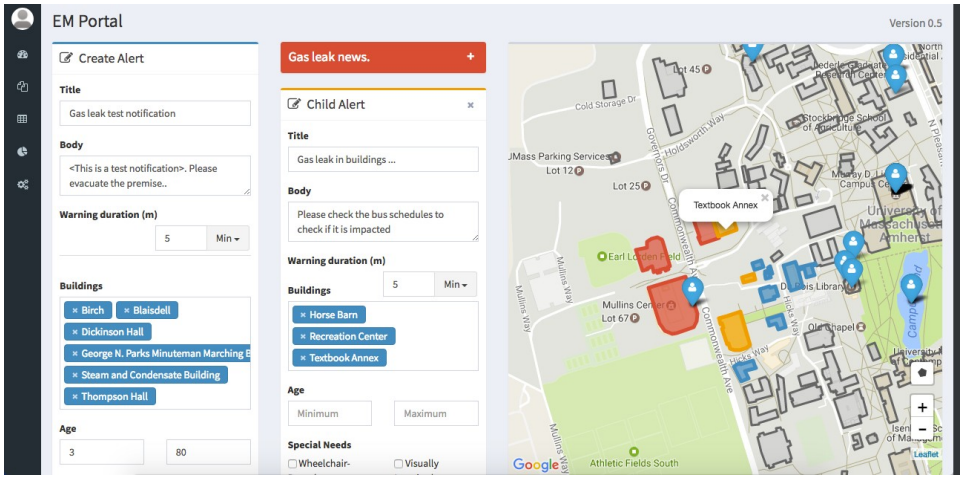
Apps: Hazardous weather warning

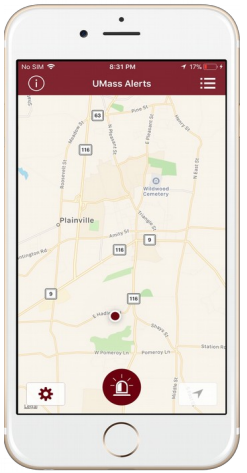


CASA Alerts: Collaborative Adaptive Sensing of the Atmosphere

Apps: Campus emergency management

EM web dashboard





Alerting app

Functional prototype being pilot-trialed at UMass; followed by UCSD

(open-source)
Contextual cloud engine

Research challenges

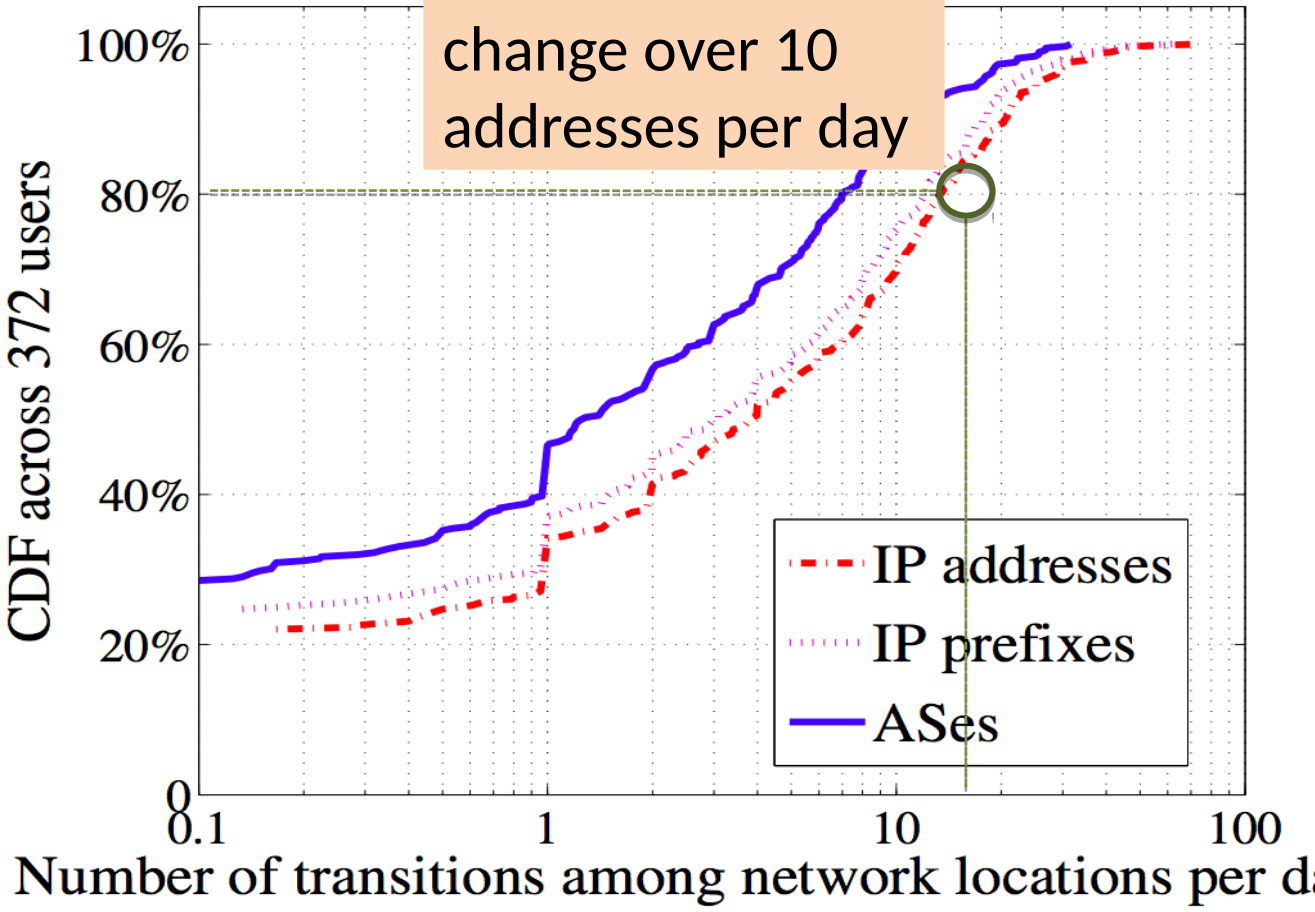
- **Scalability**: Balancing frequent updates and distributed search in a scalable manner
- **Privacy**: Ensure provider privacy, i.e., even GNS service provider must not be able to access or infer ACL-protected sensitive contextual attributes
- **Programmable APIs**: Simple robust APIs for app developers to build contextual applocations

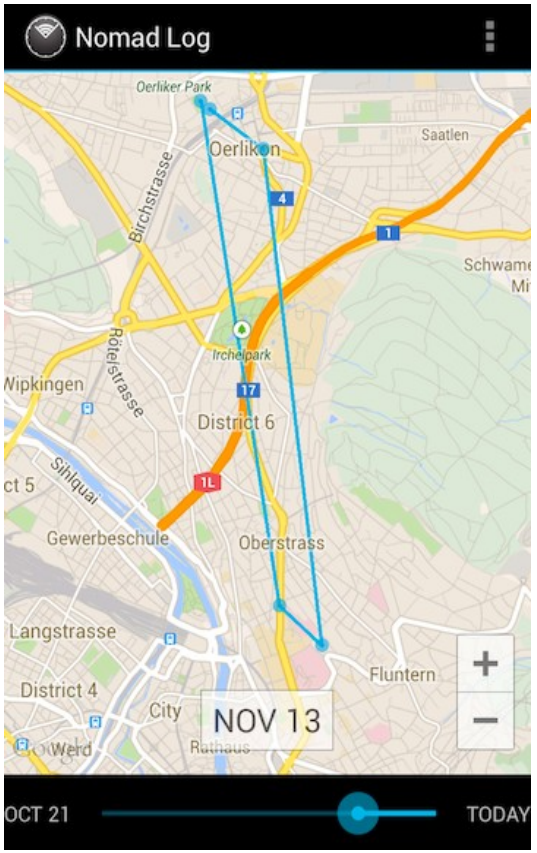
Discussion

BACKUP

High device mobility norm, not exception

370+ users, 14+ months





Z. Gao, A. Venkataramani, J. Kurose, S. Heimlicher, Towards a Quantitative Comparison of Location-Independent Network Architectures, ACM Sigcomm 2014

Takeaways [GVKH14]

- ***Mobility is the norm***, e.g., 20% of users make well over 10 transitions a day
- ***Update cost of name-based routing high* for devices**, e.g., some routers impacted by 14% of mobility events
- ***Update cost of name-based routing small for content***, especially for the unpopular long tail
  - FIB size? forwarding traffic? path stretch with caching?

[LocInd] A Quantitative Comparison of Location-Independent Network Architectures, ACM SIGCOMM 2014

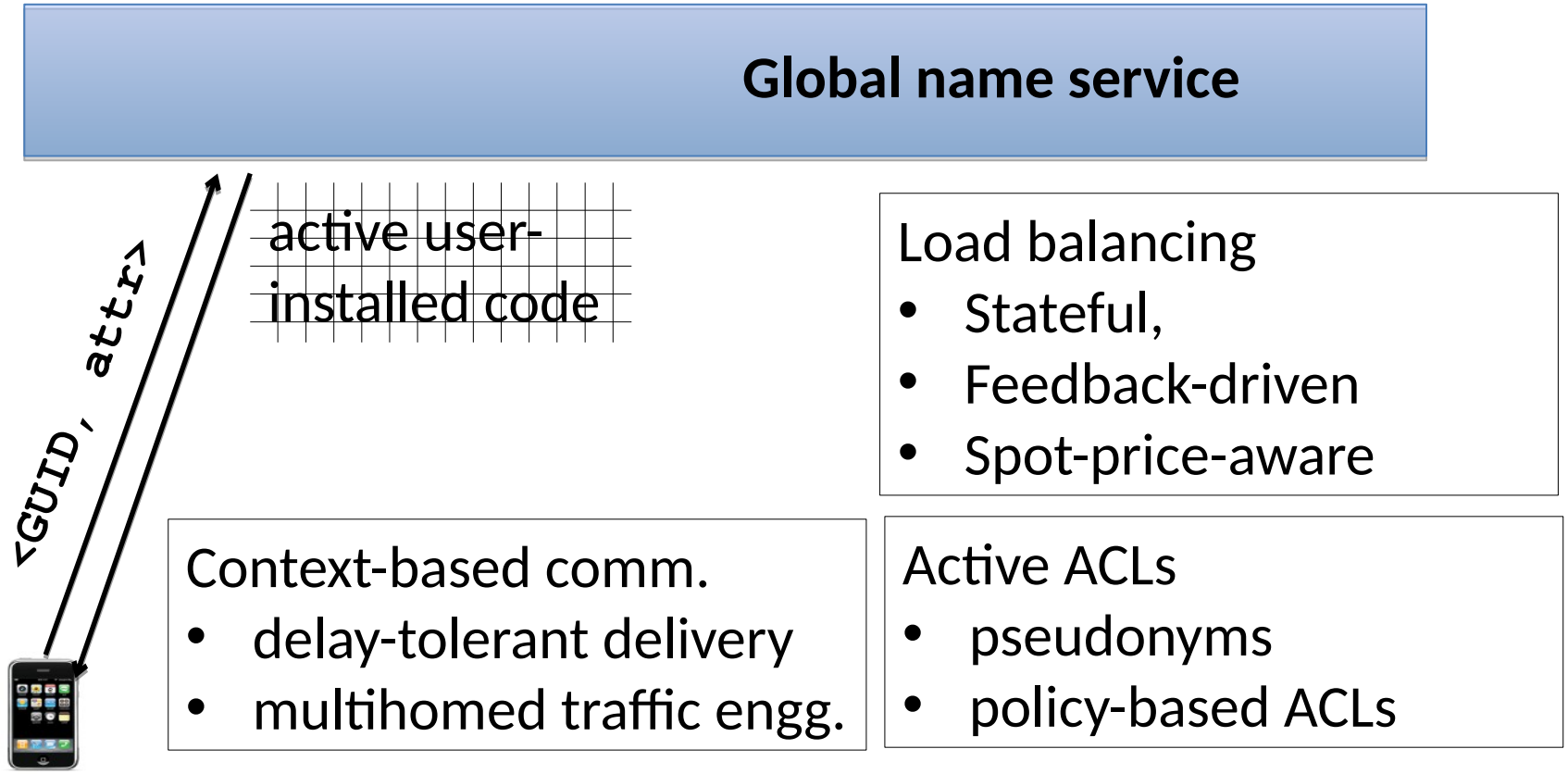
Conclusions [CKV18]

- Best-port: Best when TTC is high priority and control bandwidth is expendable.
- P-multicast: Best when endpoint has a high probability of being at a popular location, cutting average control cost 60% from best-port, but at the expense of an increased forwarding traffic cost.
- Indirection: Best for small # packets and when TTC is not a concern.
- GNS-based approach: Best when small TTC inflation above best-port is acceptable for a scalable data and control plane cost.

  Provides the most suitable balance of costs.

GNS with *active* names

- Programmable client code upon reads/writes to names



Auspice GNS summary

Enables secure, name-based communication

- arbitrary name/location representation
- flexible endpoint principals
- handles all types of mobility

- Key differences from DNS for today's Internet
  - federation decoupling certification and resolution
  - active replication
  - demand-aware placement

A logically centralized global name service dramatically enhances mobility, security, and network-layer functionality