



Named Data Networking

Patrick Crowley, John DeHart & the NDN Team

2013 China-America Frontiers of Engineering
Symposium

Beijing
5/15/2013



Goals for today

- Introduce Named Data Network (NDN)
- Illustrate NDN concepts
- Show it in action, via live demonstration

Share This Presentation?



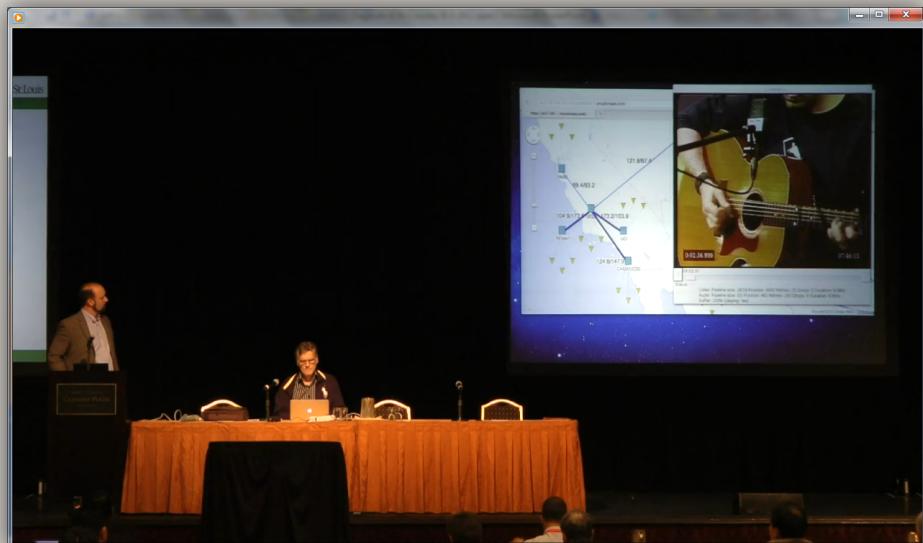
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What about video? What would happen if it became popular?

What is the best way for me to share these slides with you right now?





Trust This Message?

From: C. D. (Dan) Mote, Jr. <dmote@email.edu>

Date: Mon, May 13, 2013 at 7:39 PM

Subject: Congratulations!

To: Patrick Crowley pcrowley@wustl.edu

Dear Prof. Crowley,

I write to inform you that you have been elected a Fellow to the National Academy of Engineering. As you may understand, this designation follows a process of nomination and subsequent vote by existing Fellows. Congratulations.

Sincerely,

C.D. Mote, Jr.

President-Elect, National Academy of Engineering

Easy to forge Internet communications!

Use Connected Environment/IoT?





3 Challenges Caused By 1 Problem



Telephony/Internet Process

1. Find the number/address for the one you want to talk to.
2. Use that number to establish a point-to-point connection.
3. Communicate!

Sharing

Must know address

Trust

Place all trust in address

IoT

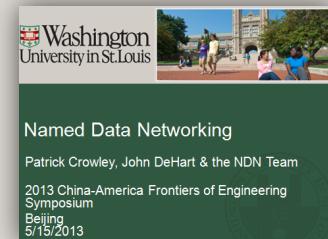
Know & trust all addresses



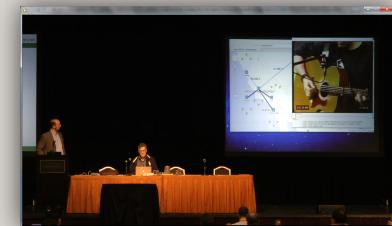
A Simpler Way

Suppose your device could ask for what it wanted?

[/wustl.edu/pcrowley/talks/CAFOE _2013.pdf](http://wustl.edu/pcrowley/talks/CAFOE _2013.pdf)



[/wustl.edu/pcrowley/video/thinkpad](http://wustl.edu/pcrowley/video/thinkpad)



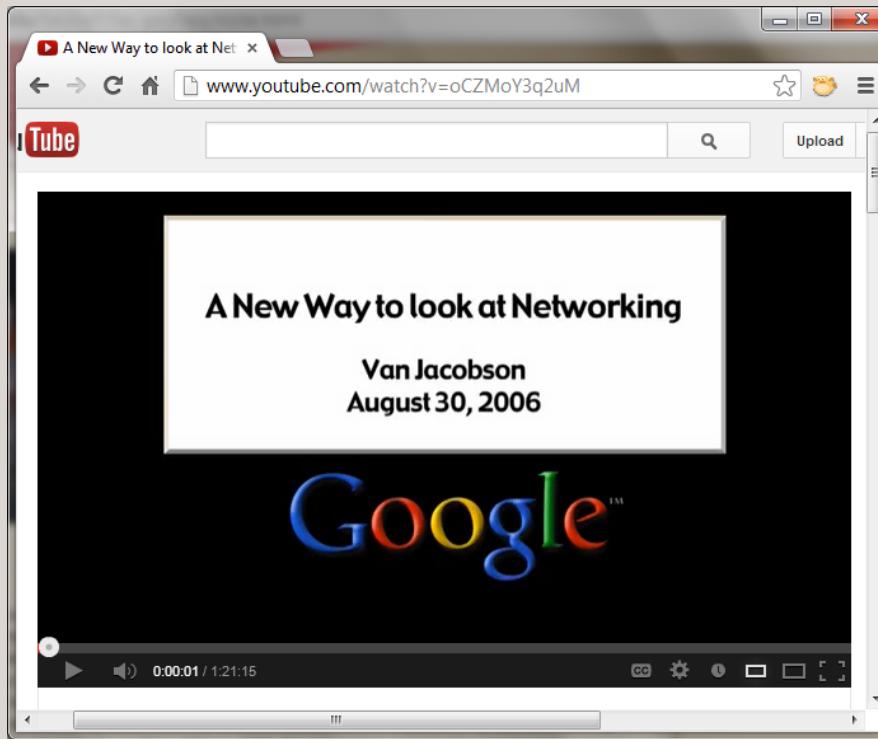
[/room/thermostat/1/status](http://room/thermostat/1/status)





The Web Has Named World's Data!

[/www.youtube.com/watch?v=oCZMoY3q2uM](http://www.youtube.com/watch?v=oCZMoY3q2uM)



[/www.youtube.com/watch?feature=player_detailpage&v=oCZMoY3q2uM#t=1736s](http://www.youtube.com/watch?feature=player_detailpage&v=oCZMoY3q2uM#t=1736s)

Core Idea

Modern communication consists of
requests for named data

Today's networks are based on
host-to-host connections

NDN is a general-purpose network protocol built
on requests for named data



Named Data Networking

- Leverages the strengths of the Internet, addresses weaknesses
 - Layers efficiently atop Ethernet, UDP, TCP, ...
- Naturally accommodates
 - Mobile devices
 - Wireless and other broadcast-based link types
 - Data authentication and security, privacy, anonymity
 - Policy-based forwarding, routing with loops
- With NDN, we aim to show that
 - Communication is more secure
 - Infrastructure is more efficiently utilized
 - Applications are simpler



Replace the Internet?

NDN : Internet :: Internet : Bell System

NDN operates gracefully atop the Internet Protocols, and does not require wholesale replacement



NDN Team

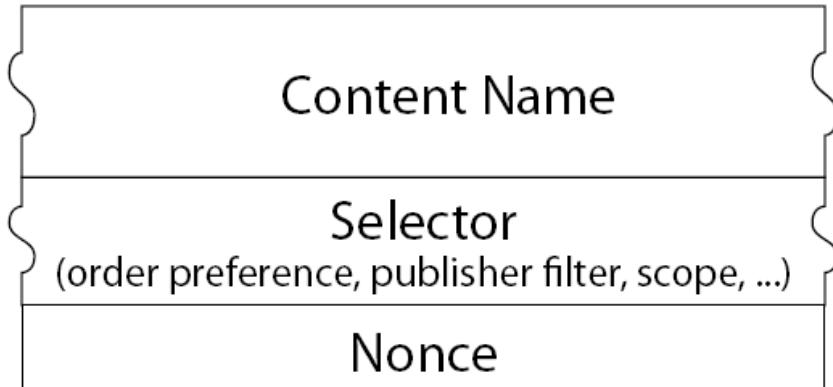
- Project launch:
9/1/2010, part of
NSF FIA Program
- Research Areas:
Architecture,
Routing, Security,
Applications,
Scalable
Forwarding

UCLA: Van Jacobson, Jeff Burke, Deborah Estrin, Lixia Zhang
University of Arizona: Beichuan Zhang
University of California, Irvine: Gene Tsudik
University of California, San Diego: Kim Claffy, Dmitri Krioukov
Colorado State University: Dan Massey, Christos Papadopoulos
University of Illinois, Urbana-Champaign: Tarek Abdelzaher
University of Memphis: Lan Wang
Washington University: Patrick Crowley
Northeastern University: Edmund Yeh
University of Colorado: Paul Ohm
University of Maryland: Katie Shilton
PARC: Ersin Uzun

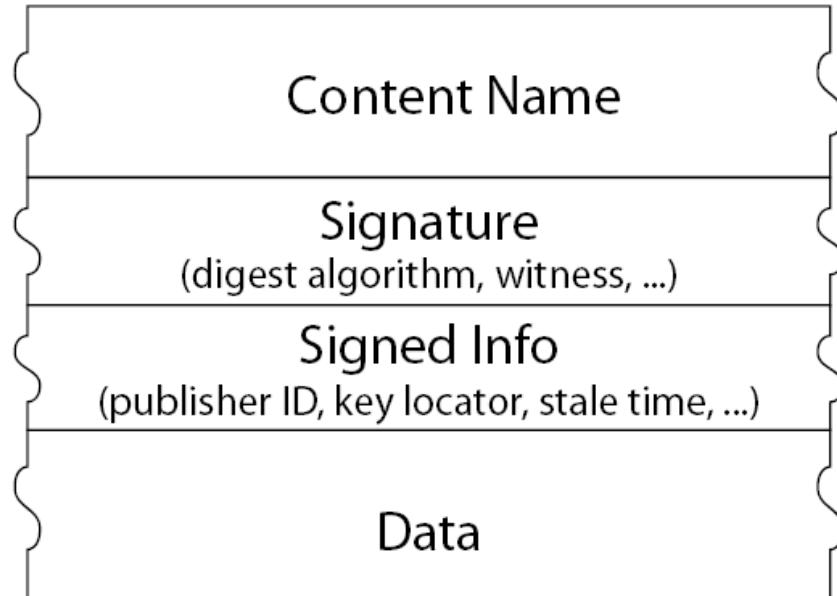


Two Packet Types

Interest packet



Data packet



- No addresses
- Publishers bind names to data; receivers verify

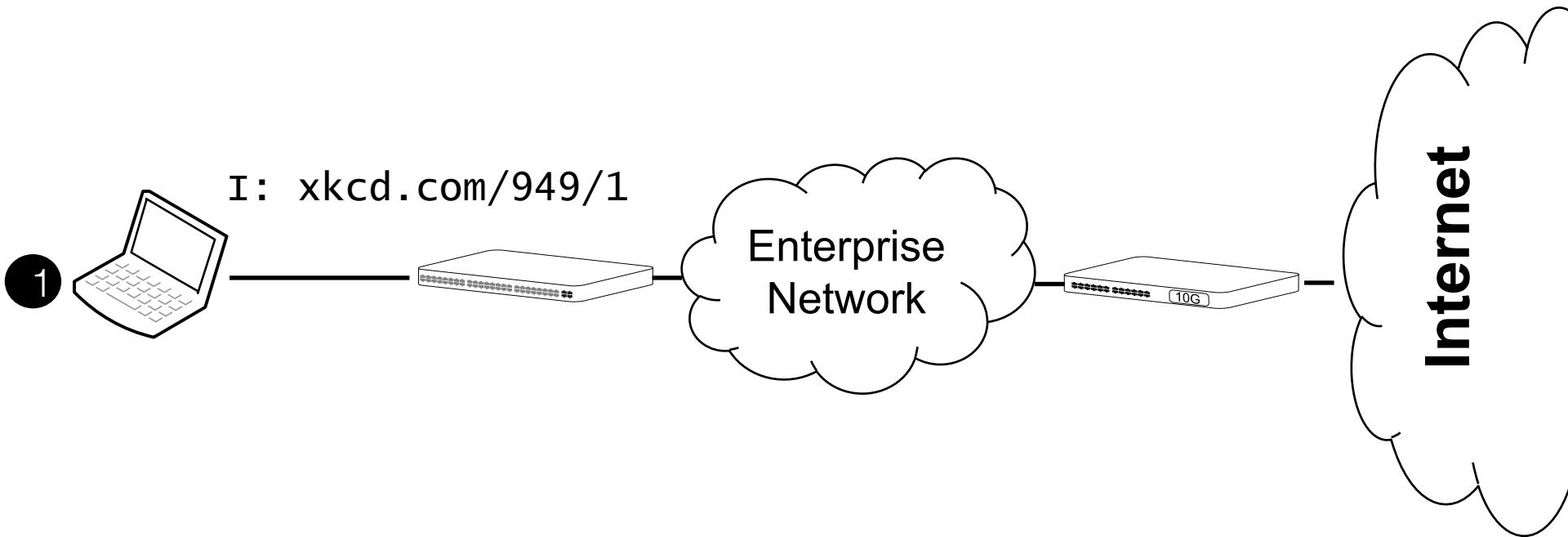


NDN Interest Forwarding

1. Do I have this data?
2. Is a request already pending?
3. Which next hop might lead to the source?

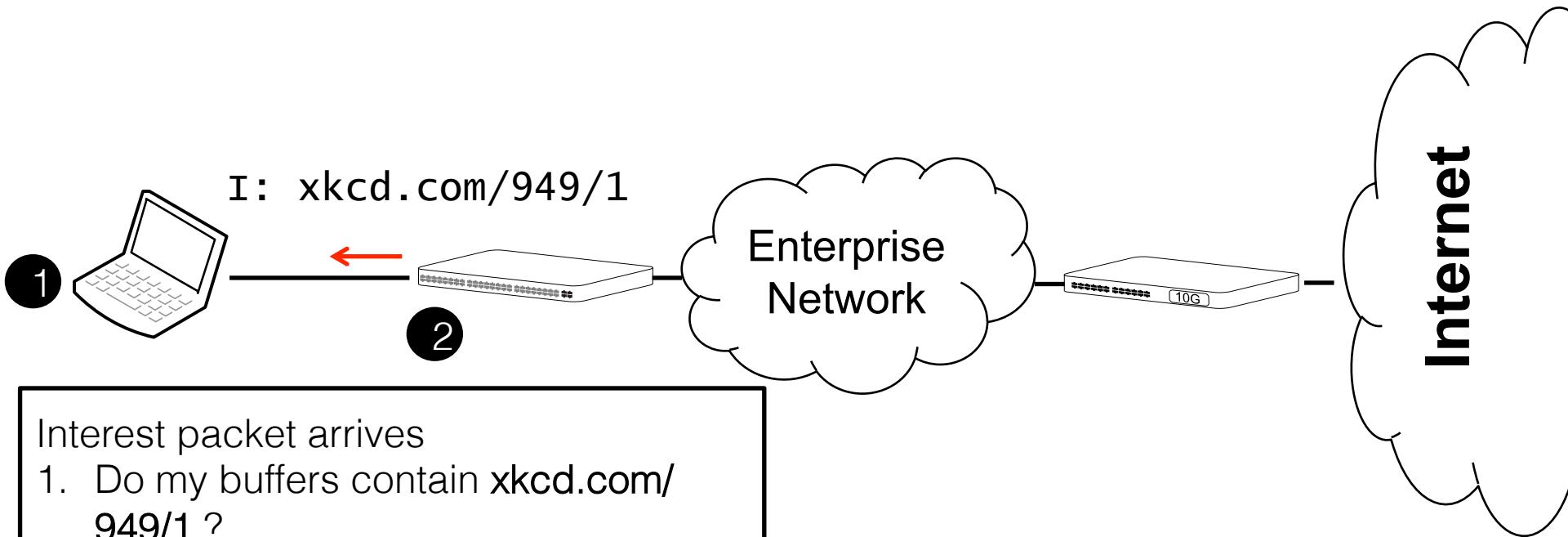
NDN Forwarding Illustrated

1 Emit Interest: xkcd.com/949/1



NDN Forwarding Illustrated

- 1 Emit Interest: xkcd.com/949/1
- 2 Interest arrives at switch

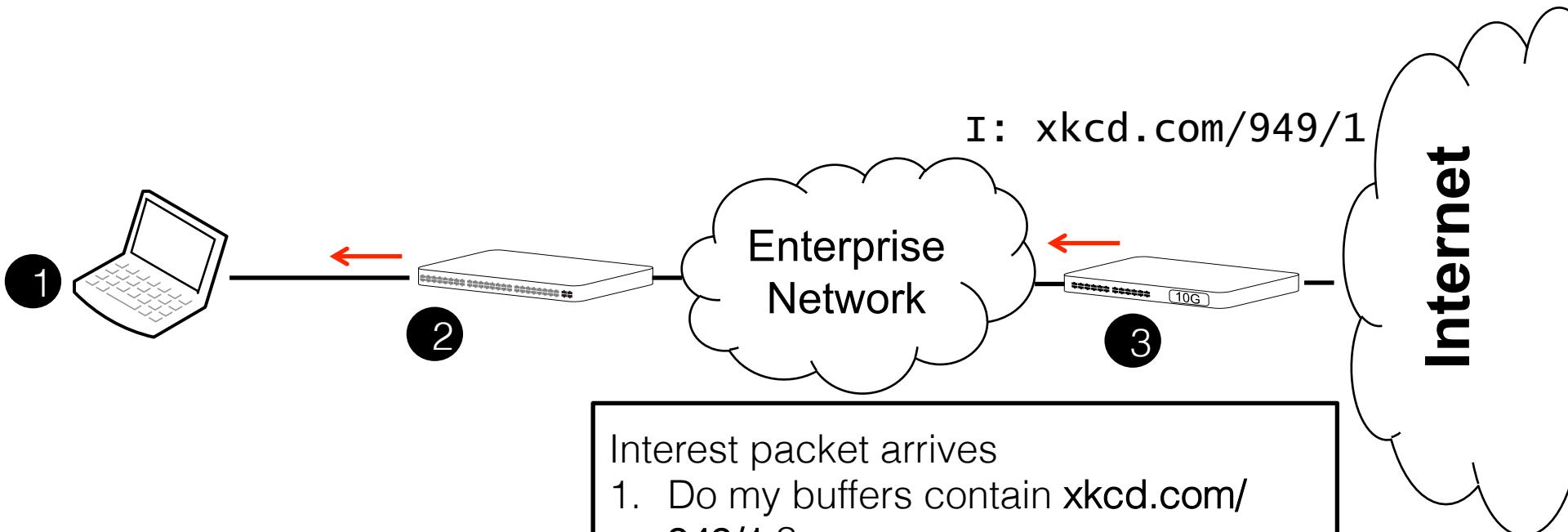


Interest packet arrives

1. Do my buffers contain xkcd.com/949/1 ?
2. Is a pending request for it in flight?
3. Where should I forward the interest?
Add arriving interface to the **pending interest list**.

NDN Forwarding Illustrated

- 1 Emit Interest: `xkcd.com/949/1`
- 2 Interest arrives at switch
- 3 Interest arrives at gateway

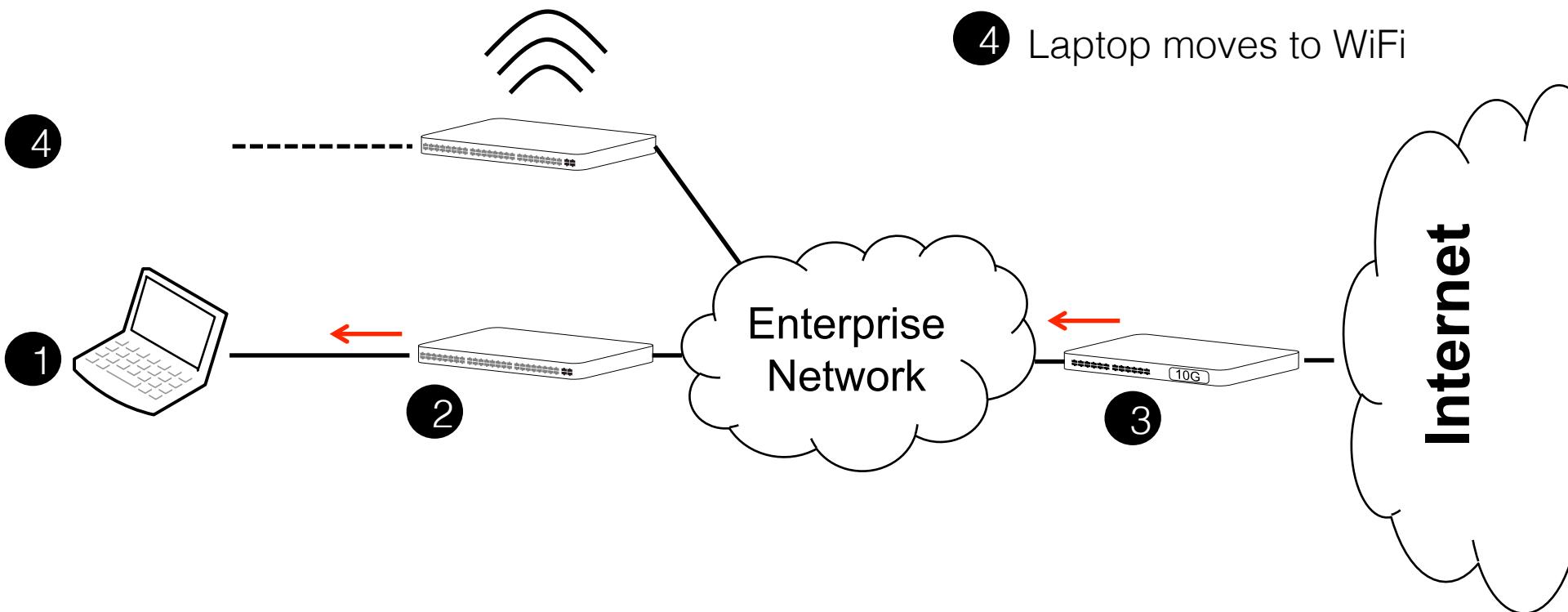


Interest packet arrives

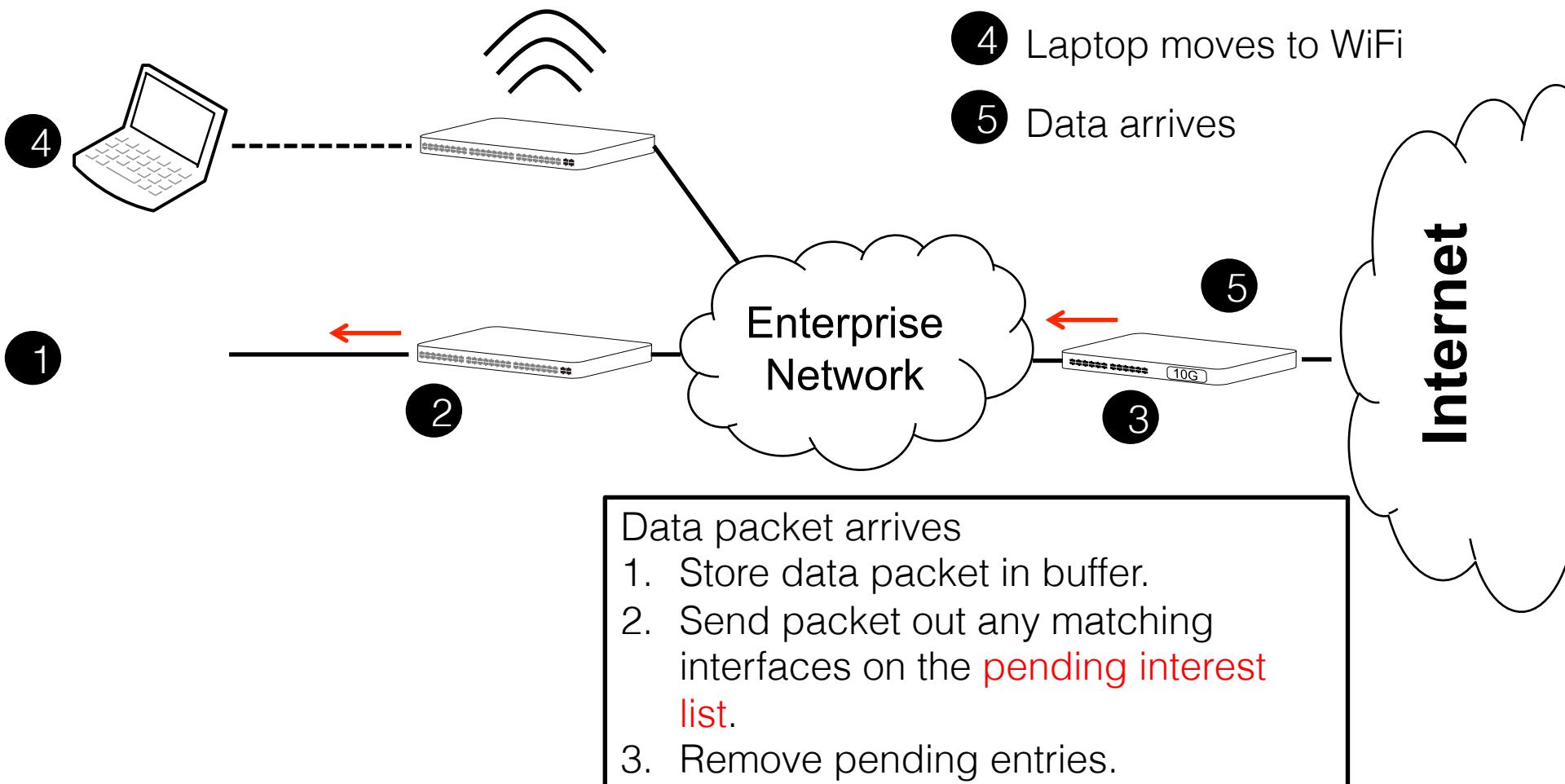
1. Do my buffers contain `xkcd.com/949/1` ?
2. Is a pending request for it in flight?
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Add arriving interface to the **pending interest list**.

NDN Forwarding Illustrated

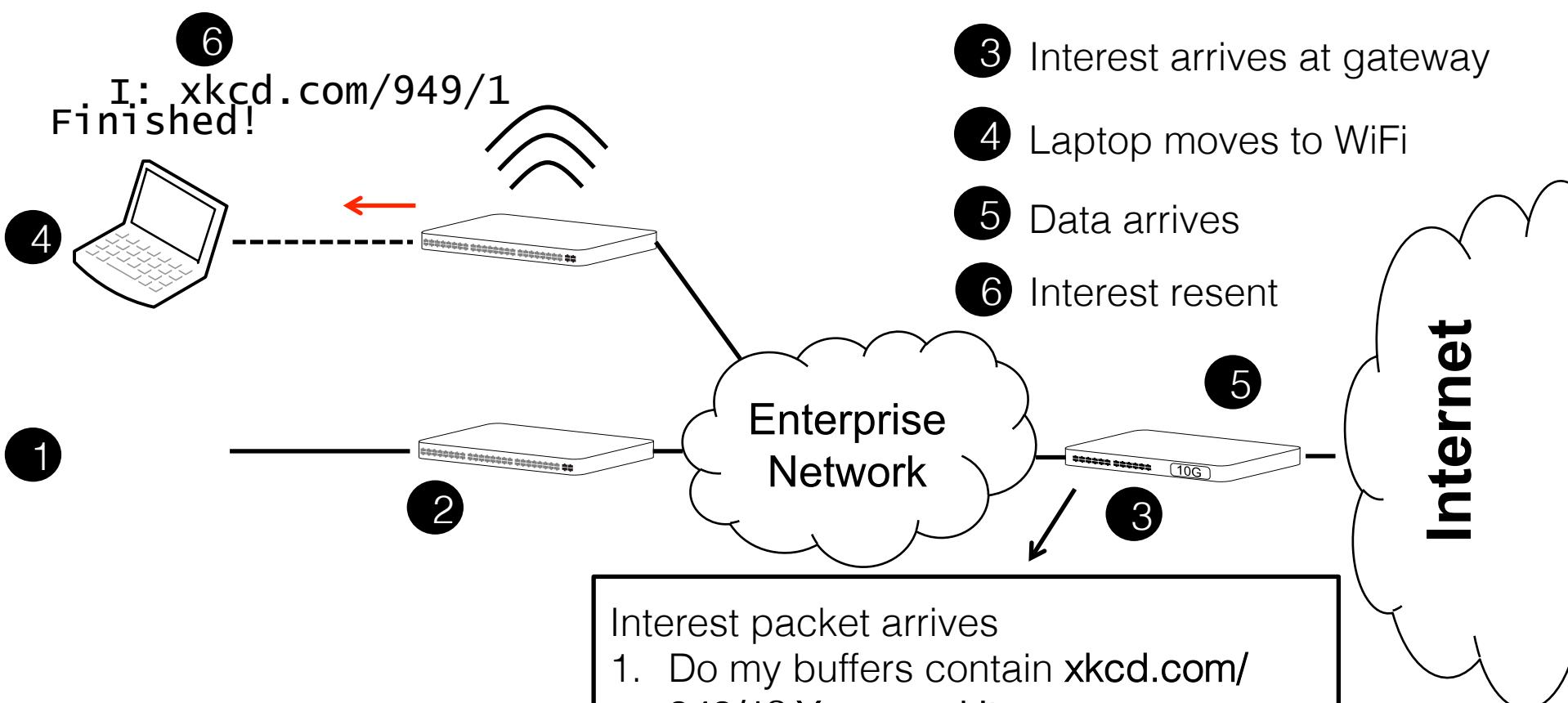
- 1 Emit Interest: xkcd.com/949/1
- 2 Interest arrives at switch
- 3 Interest arrives at gateway
- 4 Laptop moves to WiFi



NDN Forwarding Illustrated



NDN Forwarding Illustrated



Interest packet arrives

1. Do my buffers contain **xkcd.com/949/1**? Yes, send it.
2. Is a pending request for it in flight?
3. Where should I forward the interest? Add arriving interface to the **pending interest list**.

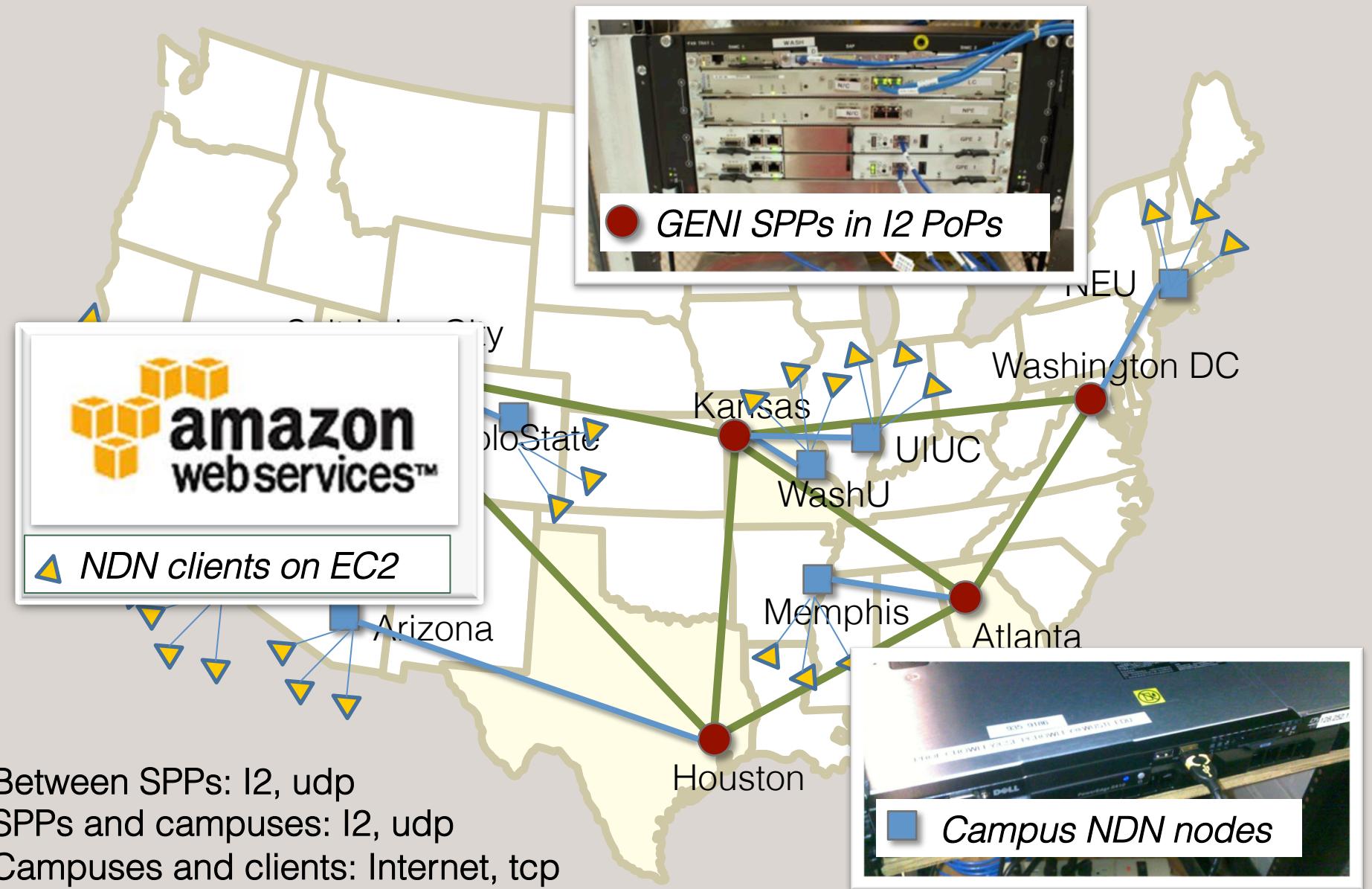
Questions

- Can NDN efficiently support host-to-host patterns?
- Can NDN efficiently support user-specific data and services?
- Can you count clicks and ad impressions in NDN?
- Can you efficiently route all those names?
- Can you scale the forwarding plane?
- Can you prove security and privacy properties?

Yes!

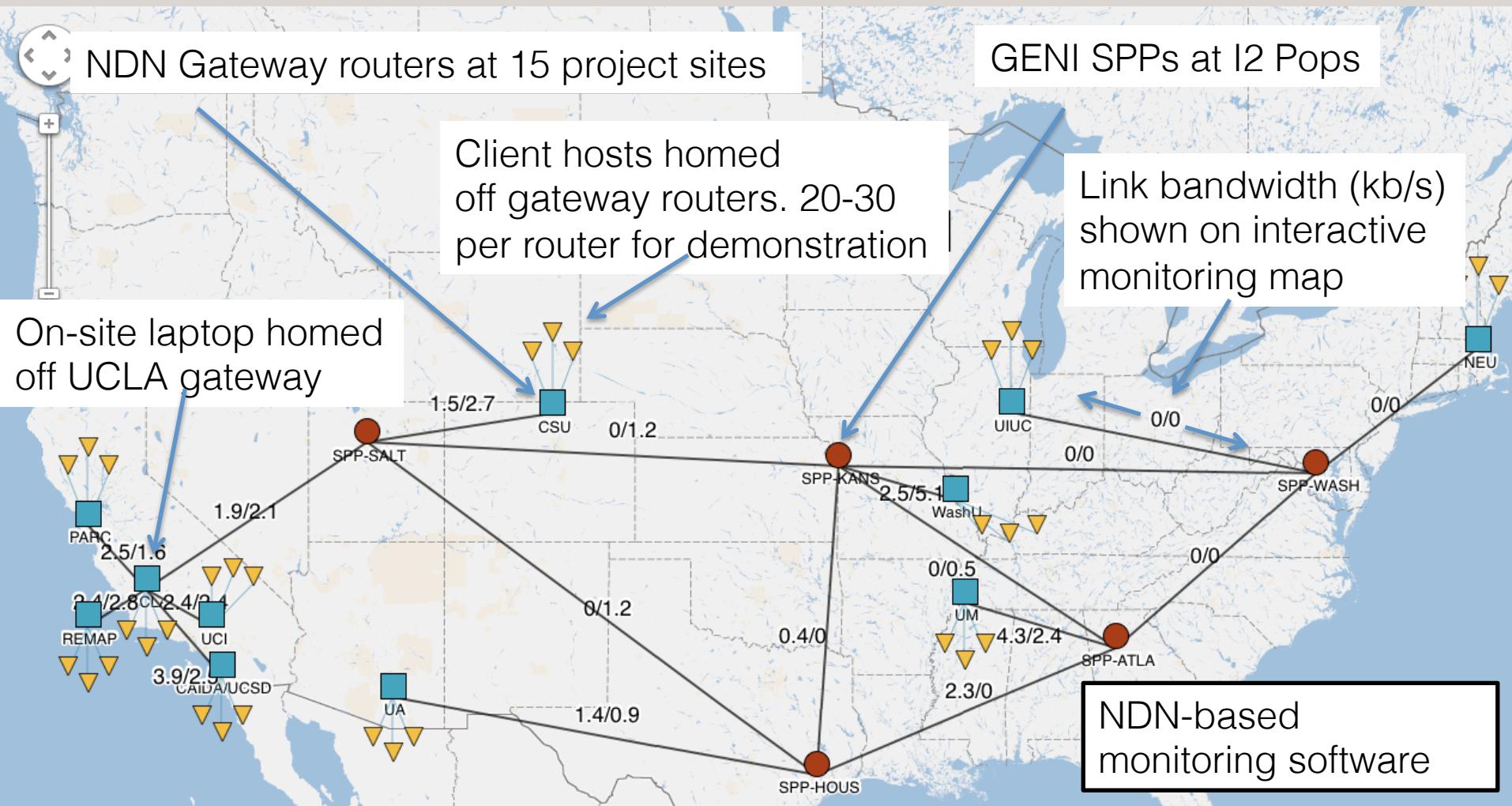
Yes, mostly!

NDN Testbed Context





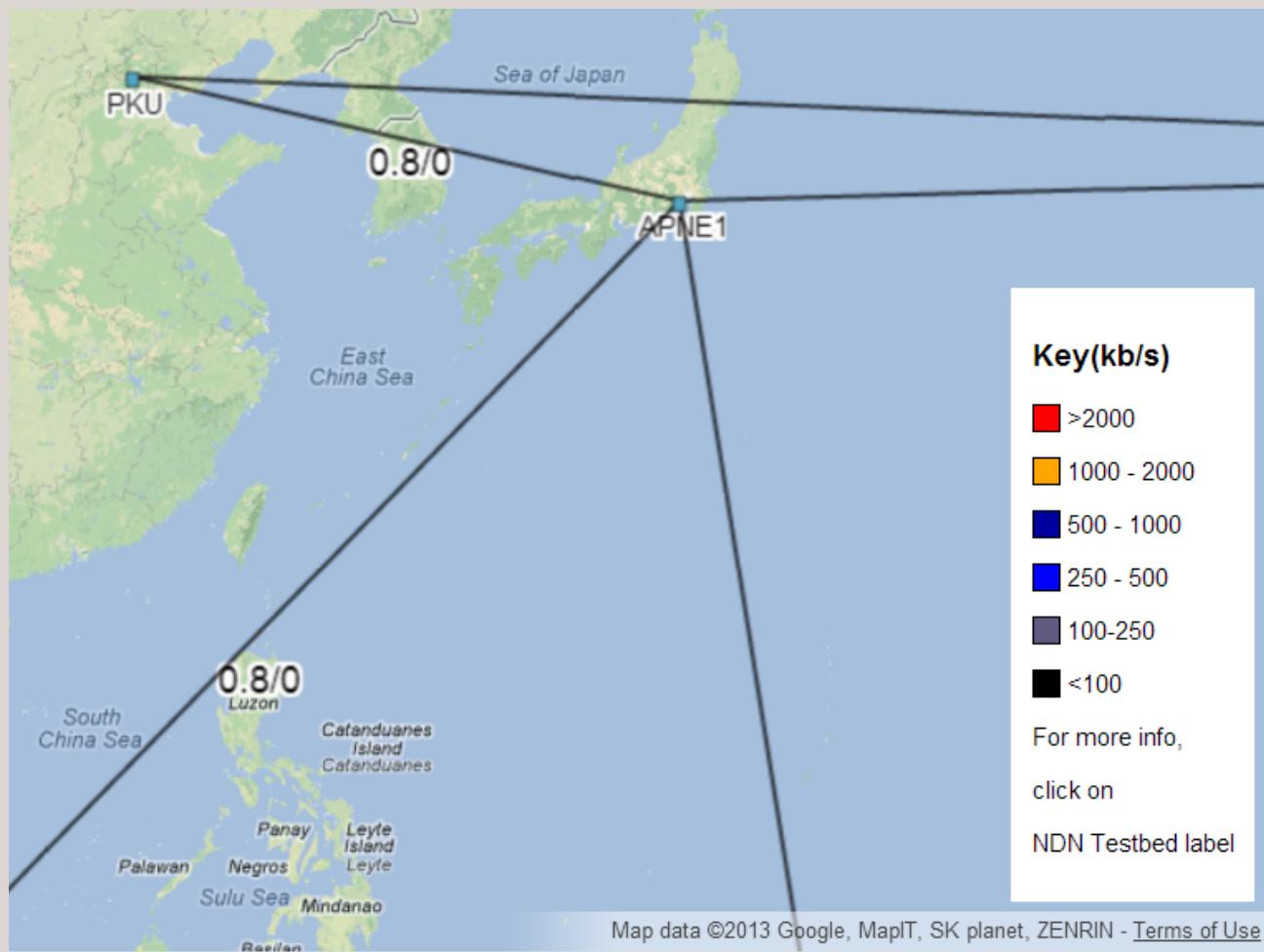
NDN Testbed & Live Visualization





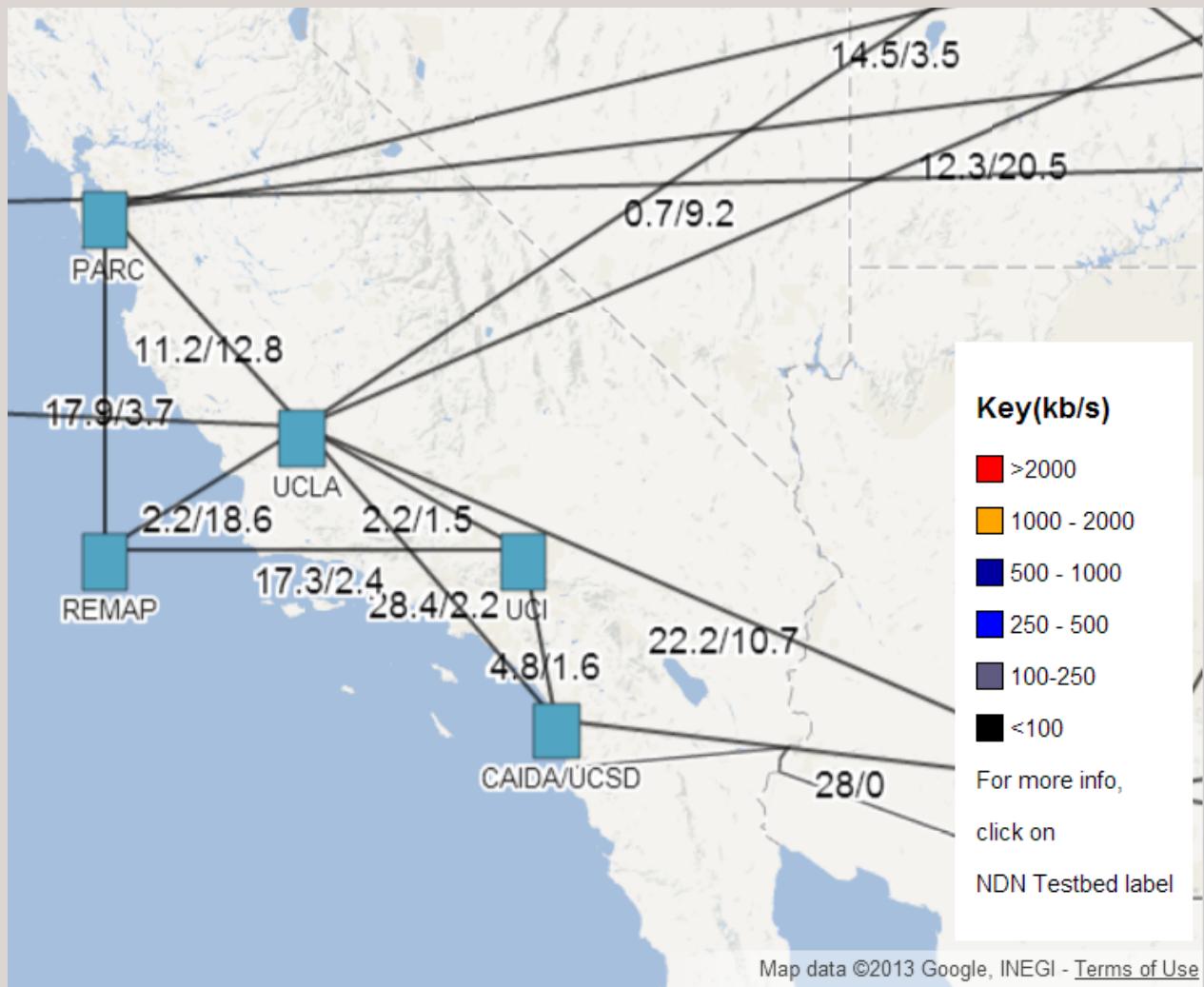
NDN Testbed & Live Visualization

- Laptop is connected to the Tokyo gateway



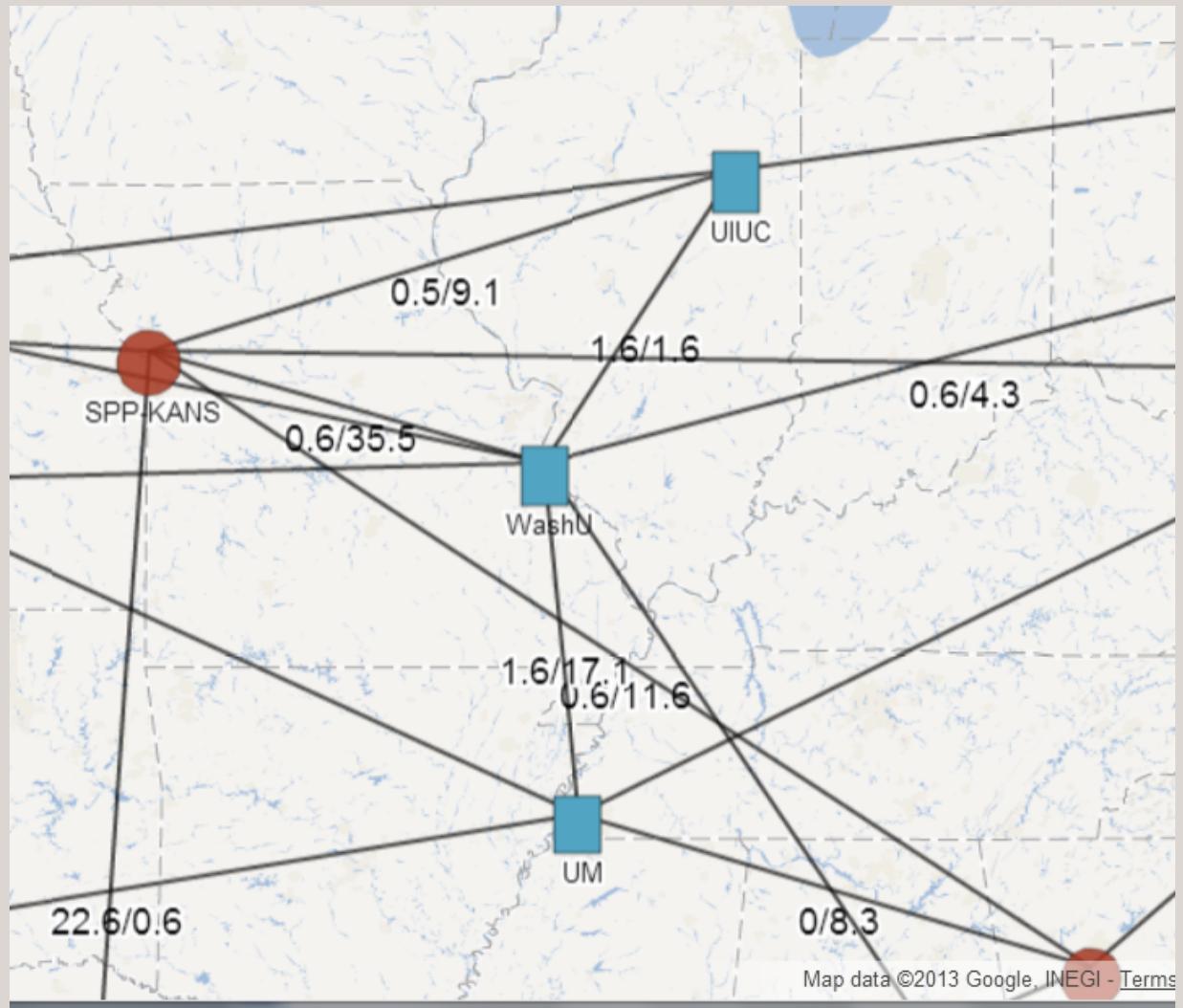
NDN Testbed & Live Visualization

- UCLA
collaborators
will join us
shortly



NDN Testbed & Live Visualization

- John DeHart from Wash U will join shortly



Demo Phase 1: Demonstrate Keys

- In NDN, all packet data is signed with the key of the publisher
- Keys can be signed transitively to form a chain of trust

Demo Phase 2: Video Streaming

- 60-70 clients homed off each of 15 gateways
- Each client retrieving the same video stream
- Only one copy of data on any link
- Automatic multi-path route switching
- On-site client shows video delivery

- In total, video is shared with ~1000 video clients spread across 5 continents

Demo Phase 3: Lighting Control & Live Audio/Video

- Delivery of live audio and video from performance studio at UCLA
 - Jeff Burke's Center for Research in Engineering, Media and Performance (REMAP)
- Lighting control application is NDN-based
- Server at studio homed off REMAP gateway
- Laptop on-site homed off Tokyo gateway

Conclusion

- Growing evidence that with NDN
 - Communication is more secure
 - Infrastructure is more efficiently utilized
 - Applications are simpler
 - New things are possible
- In coming years
 - Growing commercial support and adoption
 - Focused deployments in healthcare, building automation
- Research community is growing
 - We share an open-source code base with related projects and groups moving forward in Europe and Asia

<http://named-data.net>