Washington University in St. Louis

Performance in Named Data Networking

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2013 FIA PI Meeting
San Diego, CA
11/15/2013

Performance

Share our view via 3 simple questions

How does the NDN team

… think about evaluation ?

… demonstrate progress and capabilities ?

… compare to the fast-moving real-world ?

Question 1 of 3

How does the NDN team think about evaluation?

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How does the NDN team think about evaluation?

Answer: We focus on demonstrating end-to-end effectiveness.

We focus on use cases

- Team includes two app-focused PIs
  - Jeff Burke (UCLA), Tarek Abdelzehar (UIUC)
- Developed a growing collections of apps
  - HD Audio/Video player, “DropBox”, decentralized group chat, building automation, stage lighting, …
- We conduct annual, real-world demonstrations
- We compare to the Internet’s state-of-the-art

End-to-end Focus is Primary

- Do NDN applications and services work, given real-world contexts?
- Many lower-level mechanisms are important to evaluate, but have **secondary** significance
  - Routing protocols, forwarding, transport-level synchronization
- The value of end-to-end demonstrations
  - They help the team focus on the right issues
  - They help dispel misunderstandings about the architecture
  - Real code in real environments keeps the team honest

Question 2 of 3

How does the NDN team demonstrate progress and capabilities?

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How does the NDN team demonstrate progress and capabilities?

Answer: We regularly demonstrate NDN applications and services operating at a modest scale.

Annual Demonstrations

Demo Feature	2012 Demo	2013 Demo
Large-scale, **wide-area operation**	All 4 US time zones, ~300 machines	5 continents, ~1000 machines
Mix of content distribution and **interactive apps**	4 distinct services	Multiple services
Visualization of both app-level and net-level activity	NDN map	NDN map
Demonstrate both steady-state and **react-to-change** modes	Drop links during app sessions	Forwarding strategy
Something IP+HTTP cannot do	Scalable video streaming*, multi-path routing	Scalable video streaming*, multi-path routing
Integrated PKI, better security		Show key auth
NDN-based device monitoring		Stage lighting ctrl

Enablers of evaluation

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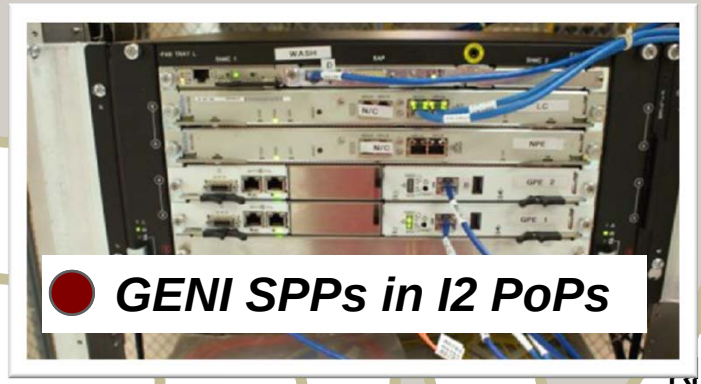

Enablers of evaluation

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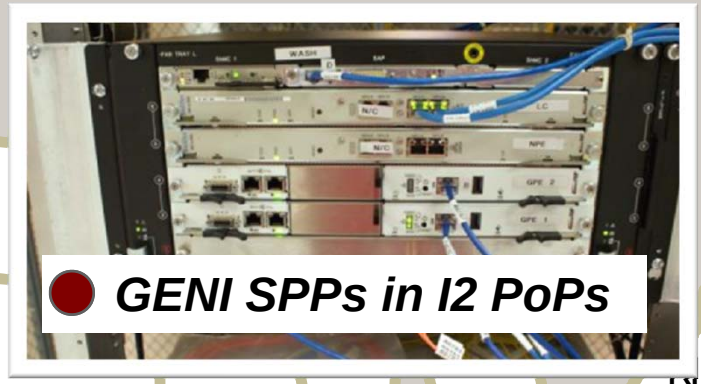

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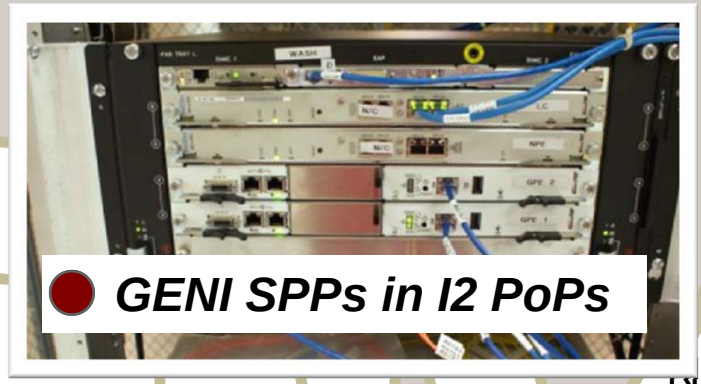


amazon web services™

NDN clients on EC2

NEU

Washington DC

Kansas

UIUC

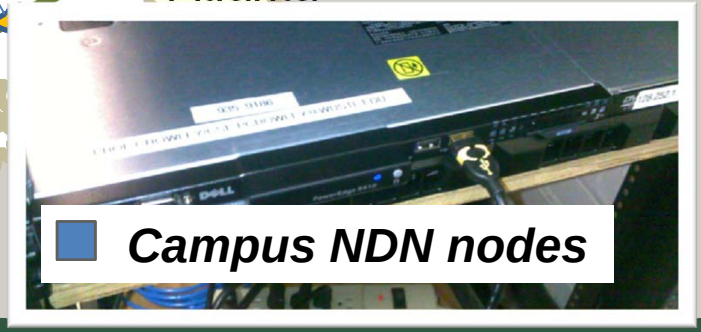
WashU

Memphis

Atlanta

Arizona

Houston



Enablers of evaluation

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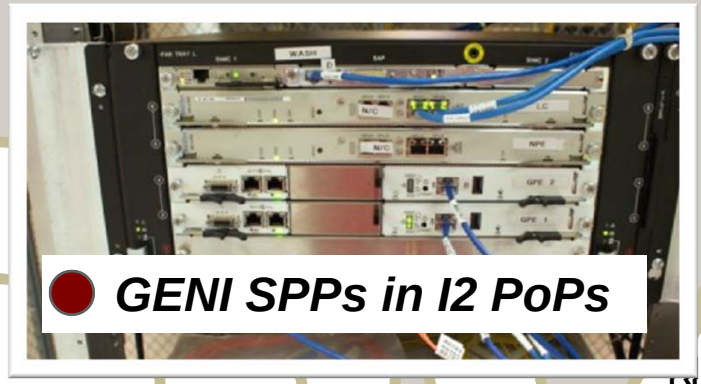


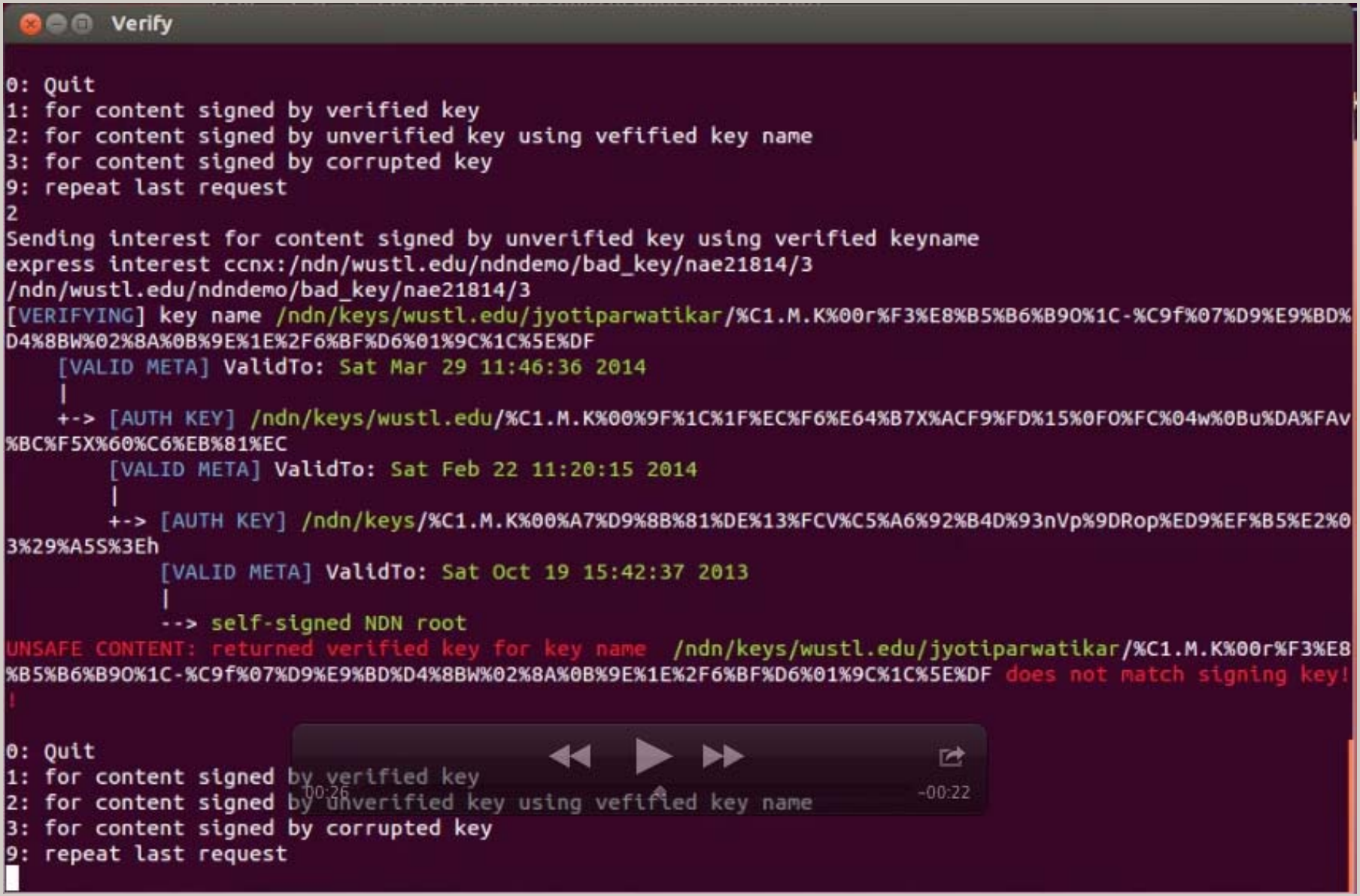
Between SPPs: I2, udp
SPPs and campuses: I2, udp
Campuses and clients: Internet, tcp

2013 Demo Highlights

2013 China-America Frontiers of Engineering Symposium

Demo Phase 1: Demonstrate Keys

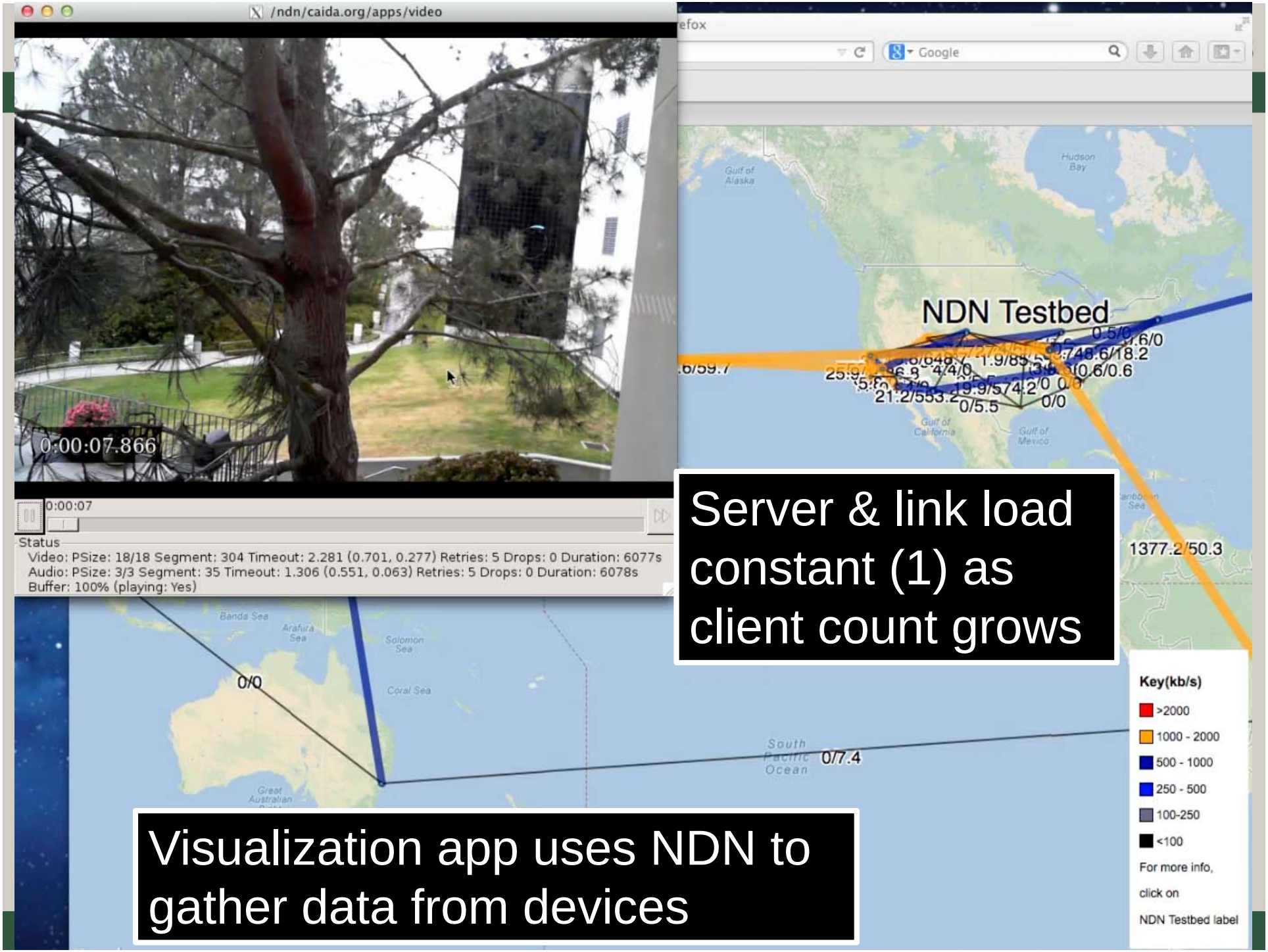
- In NDN, all packet data is signed with the key of the publisher
- Keys can be signed transitively to form a chain of trust


Verify
0: Quit
1: for content signed by verified key
2: for content signed by unverified key using vefified key name
3: for content signed by corrupted key
9: repeat last request
2
Sending interest for content signed by unverified key using verified keyname
express interest ccnx:/ndn/wustl.edu/ndndemo/bad_key/nae21814/3
/ndn/wustl.edu/ndndemo/bad_key/nae21814/3
[VERIFYING] key name /ndn/keys/wustl.edu/jyotiparwatikar/%C1.M.K%00r%F3%E8%B5%B6%B9O%1C-%C9f%07%D9%E9%BD%D4%8BW%02%8A%0B%9E%1E%2F6%BF%D6%01%9C%1C%5E%DF
[VALID META] ValidTo: Sat Mar 29 11:46:36 2014
+-> [AUTH KEY] /ndn/keys/wustl.edu/%C1.M.K%00%9F%1C%1F%EC%F6%E64%B7X%ACF9%FD%15%0FO%FC%04w%0Bu%DA%FAv%BC%F5X%60%C6%EB%81%EC
[VALID META] ValidTo: Sat Feb 22 11:20:15 2014
+-> [AUTH KEY] /ndn/keys/%C1.M.K%00%A7%D9%8B%81%DE%13%FCV%C5%A6%92%B4D%93nVp%9DRop%ED9%EF%B5%E2%03%29%A5S%3Eh
[VALID META] ValidTo: Sat Oct 19 15:42:37 2013
--> self-signed NDN root
UNSAFE CONTENT: returned verified key for key name /ndn/keys/wustl.edu/jyotiparwatikar/%C1.M.K%00r%F3%E8%B5%B6%B9O%1C-%C9f%07%D9%E9%BD%D4%8BW%02%8A%0B%9E%1E%2F6%BF%D6%01%9C%1C%5E%DF does not match signing key!
!
00:26
-00:22
0: Quit
1: for content signed by verified key
2: for content signed by unverified key using vefified key name
3: for content signed by corrupted key
9: repeat last request

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

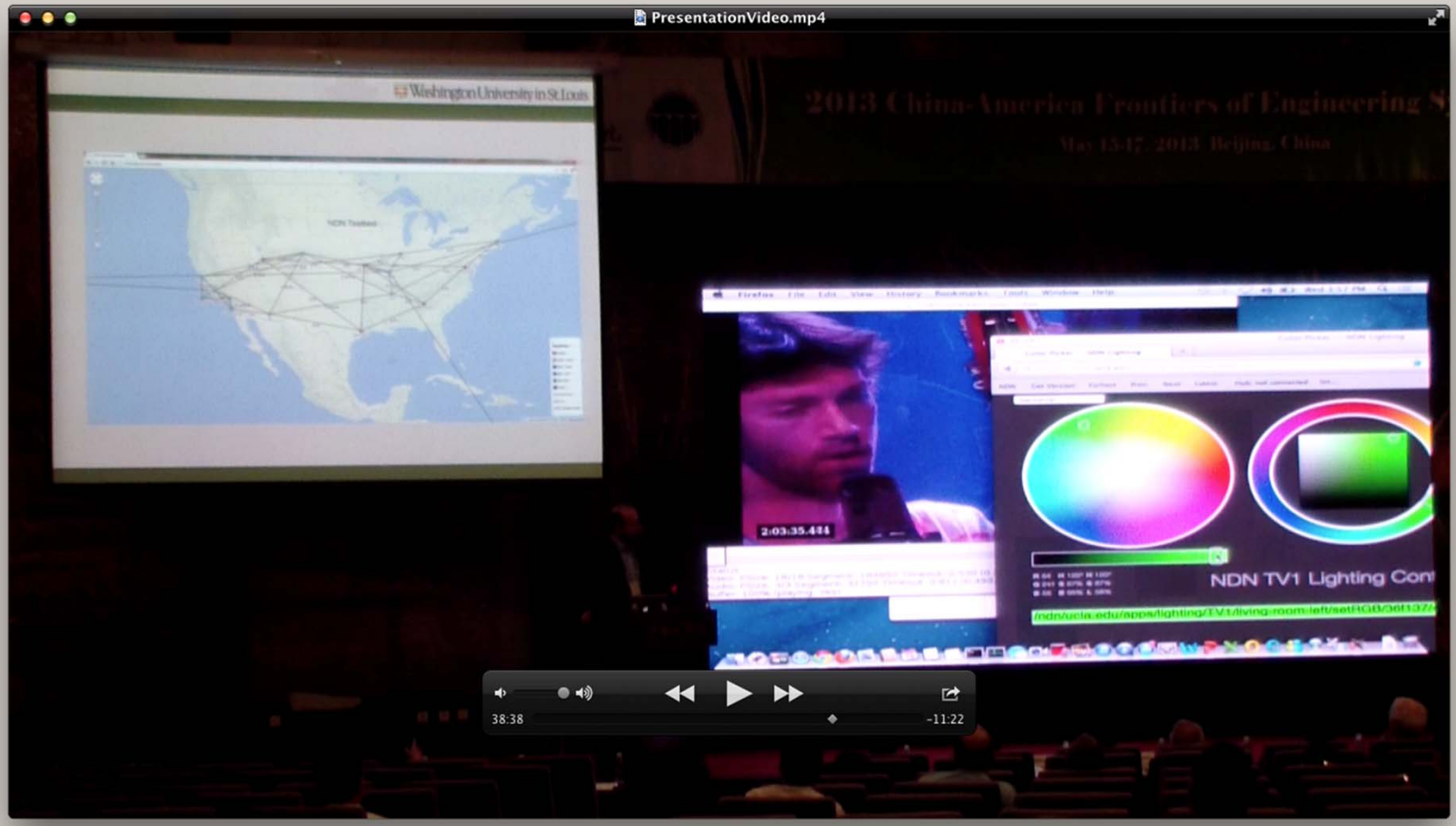
- **In total, video is shared with ~1000 video clients spread across 5 continents**


/ndn/caida.org/apps/video
0:00:07.866
0:00:07
Status
Video: PSize: 18/18 Segment: 304 Timeout: 2.281 (0.701, 0.277) Retries: 5 Drops: 0 Duration: 6077s
Audio: PSize: 3/3 Segment: 35 Timeout: 1.306 (0.551, 0.063) Retries: 5 Drops: 0 Duration: 6078s
Buffer: 100% (playing: Yes)
Google
NDN Testbed
Server & link load constant (1) as client count grows
Visualization app uses NDN to gather data from devices
Key(kb/s)
>2000
1000 - 2000
500 - 1000
250 - 500
100-250
<100
For more info, click on NDN Testbed label

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

Live bluegrass band performance, NDN-based control of stage lights



Question 3 of 3

How does the NDN team compare to the fast-moving real-world ?

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How does the NDN team compare to the fast-moving real-world ?

Answer: We strive to regularly compare NDN to the best available alternative.

Case Study: Broadcast of Streaming Web Video

- Use case: how can I broadcast my laptop's video feed to a global audience ?

- Alternatives
  - NDN
  - **Build** an HTTP video streaming infrastructure
  - **Use** an HTTP video streaming service

- Evaluation
  - Use similar topologies and machines to compare

NDN for Video Broadcast

- The May 2013 CAFOE demonstration
  - NDN can support broadcast of one laptop camera to 1000 clients around the world
- Software required
  - NDN daemon running on gateways & clients
  - ndnvideo application on clients & server
- Management required
  - NDN clients must join NDN testbed
  - ndnvideo clients must know video name

NDN Testbed

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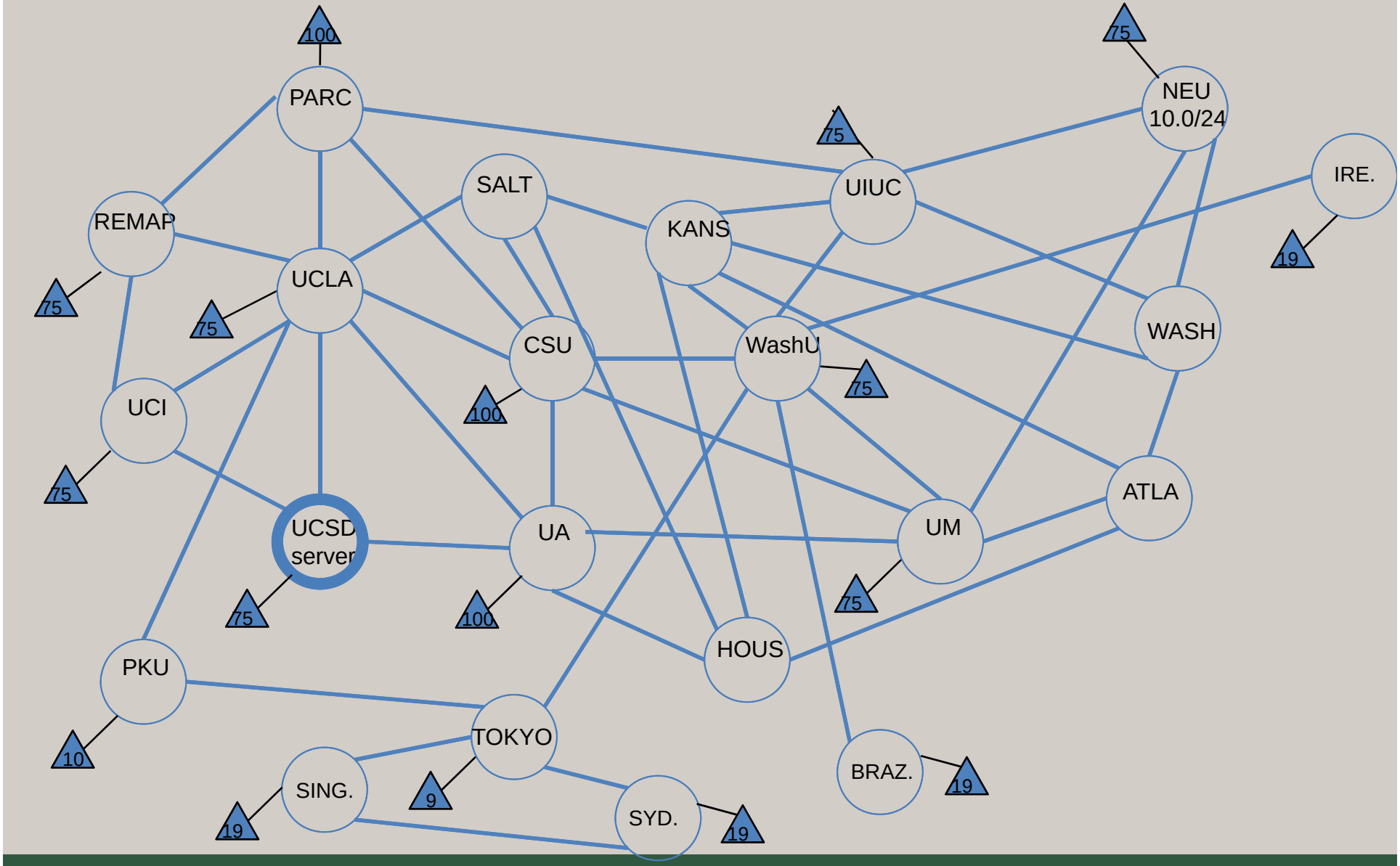
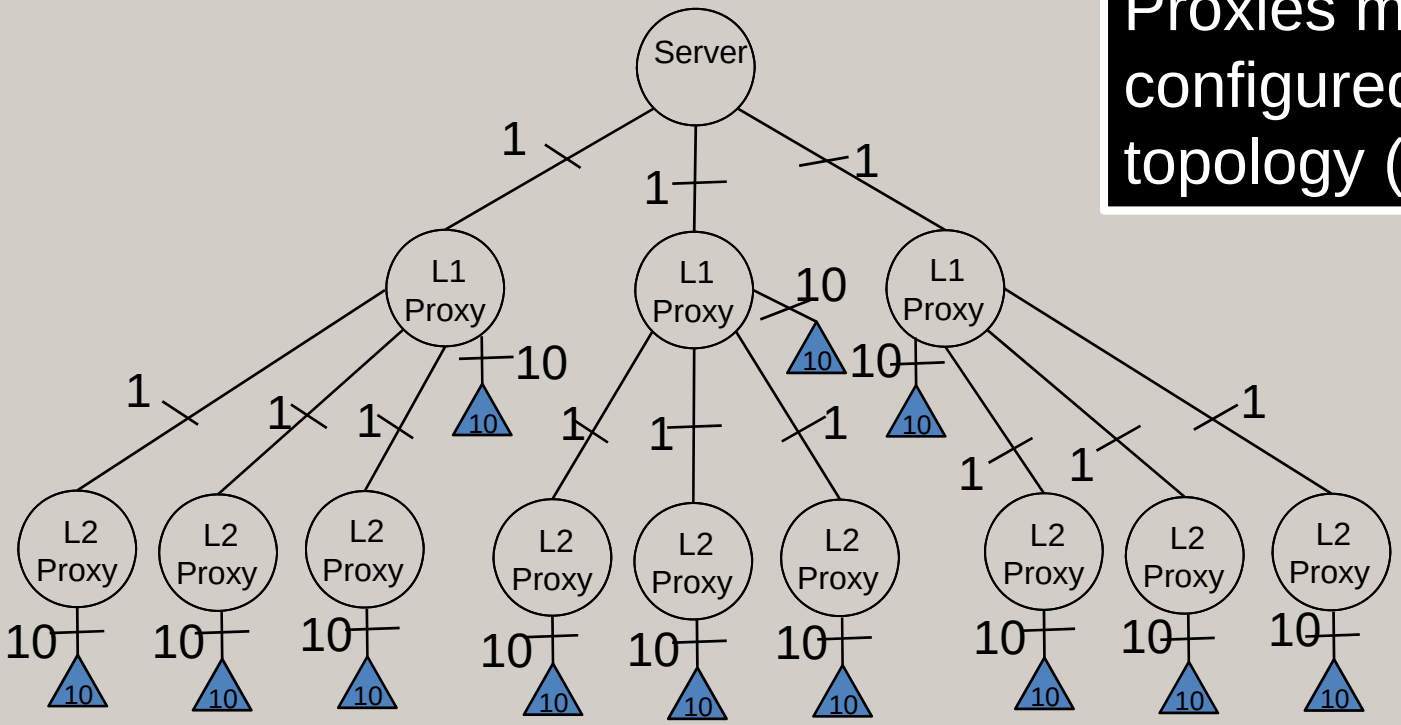


Building an HTTP live video streaming infrastructure

- To compare, we built a comparable broadcast-capable video streaming infrastructure using HTTP
  - Distribute video to >100 clients, using HTTP-based clients & proxies
- Software required
  - VLC used as clients and server
  - Proxies run varnish, an HTTP video proxy/cache
    - Commercial-grade sw used by vimeo, BBC, and others
    - Version 3.0, Nov 2011, first support of video streaming
- Management required
  - Proxies must be configured to speak up stream
  - VLC client must know which proxy to connect to
  - VLC client must know video name

HTTP video streaming infrastructure

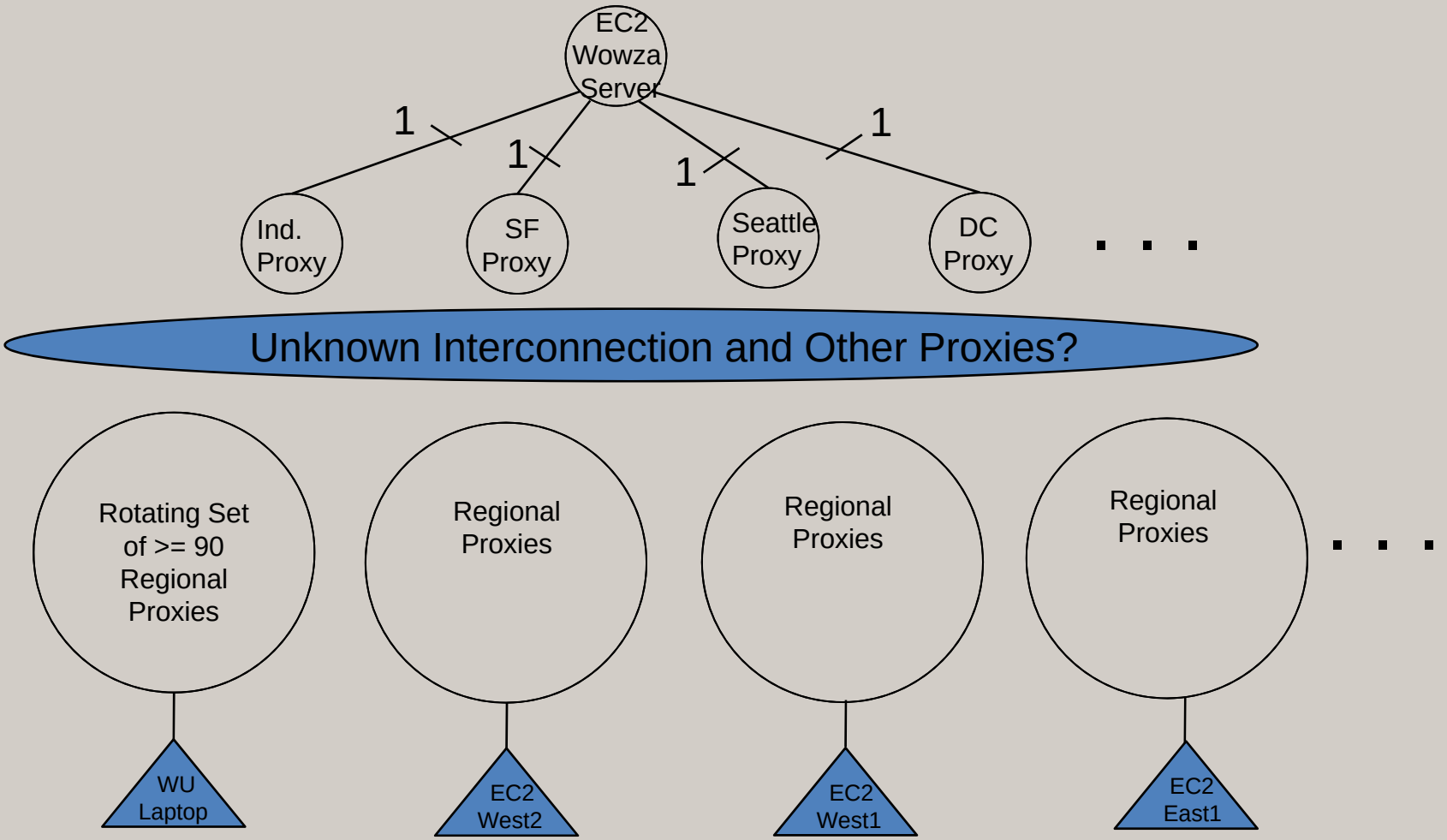


Proxies must be configured for topology (& load?)

HTTP live video streaming service

- Amazon CloudFront
  - Supports broadcast of video of HTTP
  - Leverages Amazon's global footprint
- Software required
  - Amazon AWS Console
    - Video streaming, released Dec 2009
    - Live Video streaming, released Apr 2011
  - Wowza streaming video server (in EC2)
    - Live transcoding, released Oct 2011
  - Any HLS-compatible client
- Management
  - Use AWS Console
  - Clients must know video name

AWS CloudFront Organization



Case Study Wrap-Up

- If you want to **use** a video streaming service
  - Use AWS CloudFront, it is shockingly good
- If you want to **build** a video streaming service
  - NDN was easier to setup
    - HTTP proxies and clients need topology-specific config
    - Using DNS/transparent proxies to avoid this would likely be just as complex
  - NDN required no tweaking
    - HTTP proxies needed to be tweaked to support changing topologies (and loads?)

Conclusion

How does the NDN team

… think about evaluation ?

A: **Focus on end-to-end effectiveness**

… demonstrate progress and capabilities ?

A: **Frequent real-world demonstrations**

… compare to the fast-moving real-world ?

A: **Compare against the best alternatives**