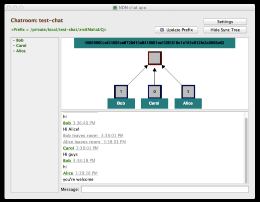
NDN Applications

NDNComm 2014 – ICN Tutorial Dry Run

September 3, 2014

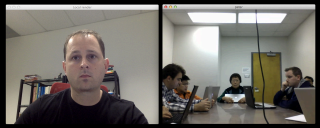
jburke@ucla.edu

NDN: Application-motivated Approach



<u>NSF FIA 2010-present</u>

Video streaming, live chat, file sharing, lighting control, sensing

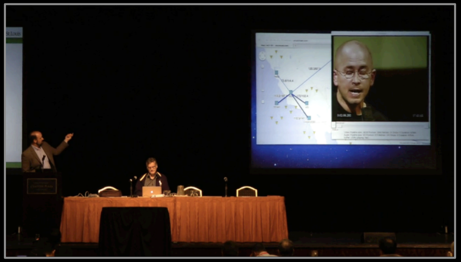


<u>NSF FIA "Next Phase" (2014-2016)</u>

Enterprise Building Automation & Management

Open Mobile Health

Mobile Multimedia Applications



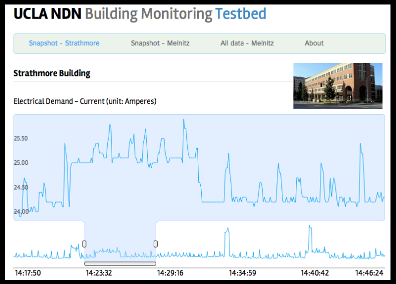
<u>Other ongoing work (2014-2016)</u>

Internet of Things, Raspberry PI support

Climate Modeling (Colorado State)

Information Maximizing Networks (UIUC)

Vehicular Networking (UPMC, UCLA)



Support from NSF, Cisco, Comcast, Toyota, Qualcomm, Verisign, and others.

ChronoChat

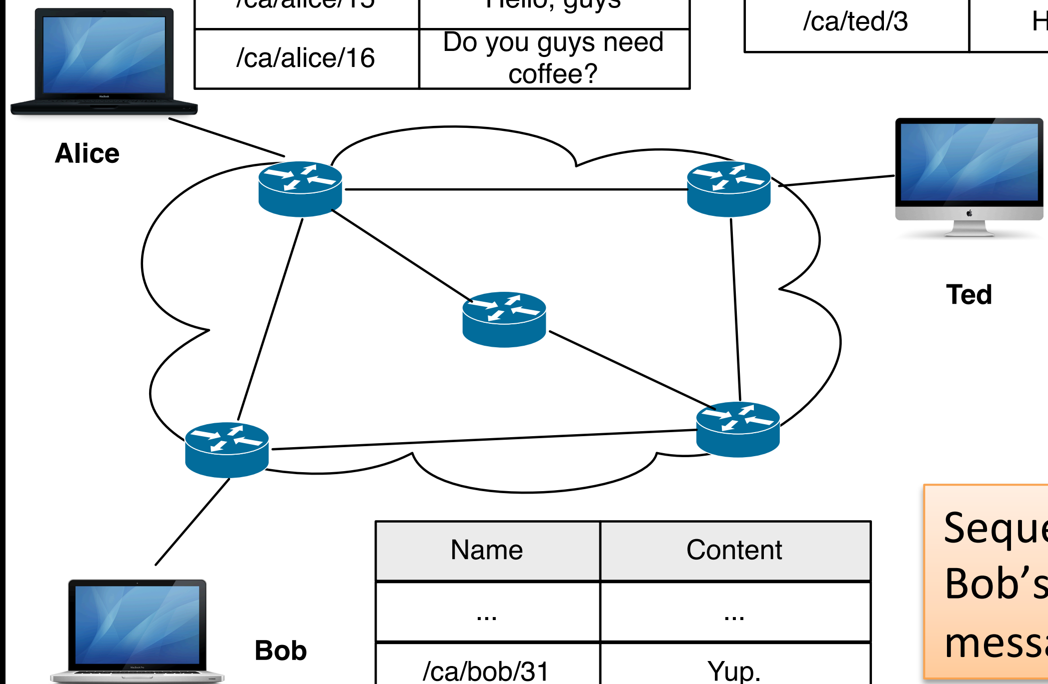
What is a group text chat application?

Sequence of Alice's messages

Name	Content
…	…
/ca/alice/15	Hello, guys
/ca/alice/16	Do you guys need coffee?

Name	Content
…	…
/ca/ted/3	Hello, Alice.

Sequence of Ted's messages



Name	Content
…	…
/ca/bob/31	Yup.

Sequence of Bob's messages

Synchronization of distributed chat room dataset (set of sequences of chat messages) among the participants

ChronoChat

Many Internet applications are collaborative by nature

- group text chat
- file sharing
- audio/video conferencing

Key piece in these applications

- distributed state synchronization
  - chat room messages
  - files and folders in the shared folder
  - voice/video streams from each participant

Based on ChronoSync

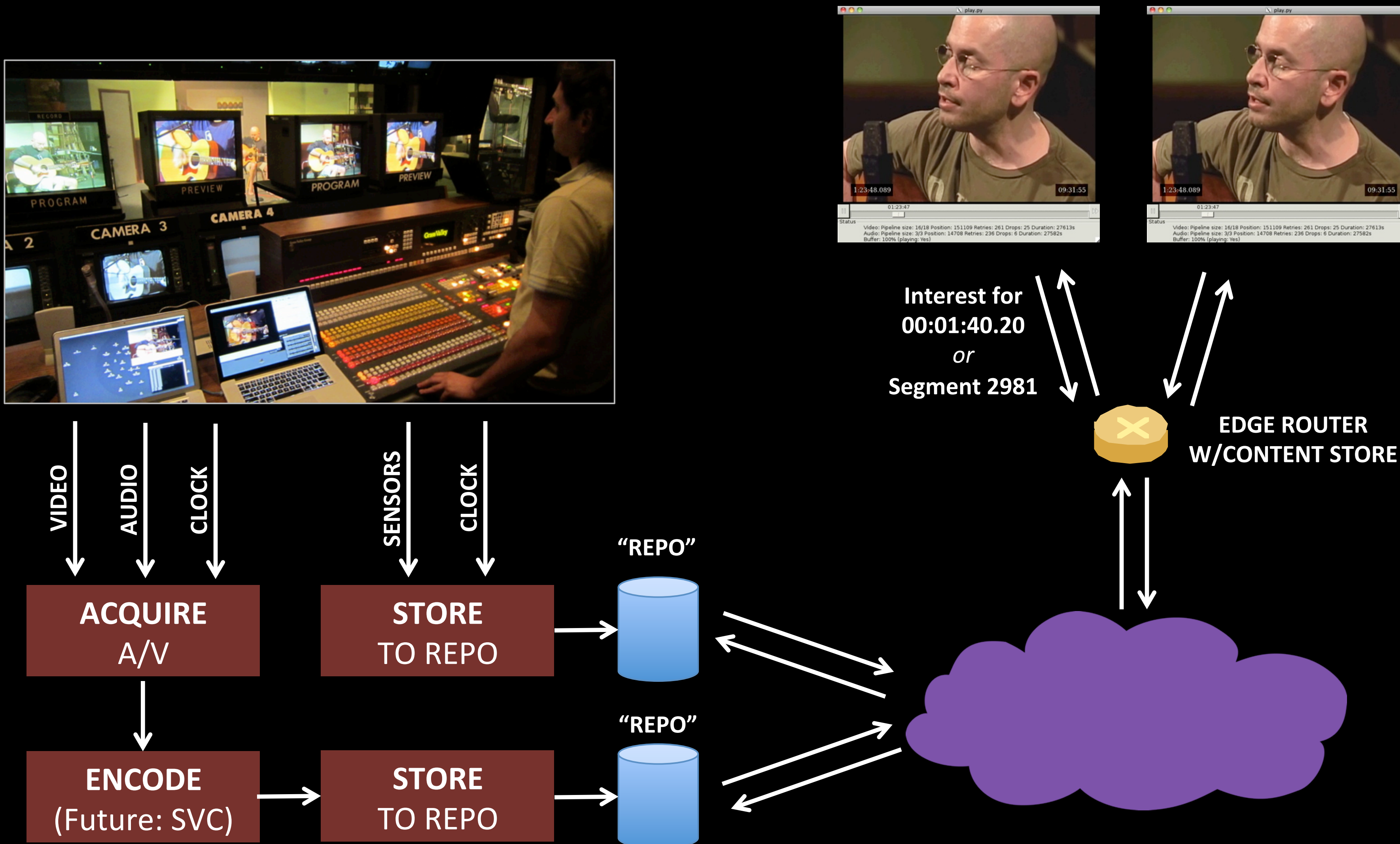
- synchronize the knowledge of the chat message set

Two trust models have been experimented

- hierarchical
  - authenticate users through a certificate chain that strictly follow the naming hierarchy
- web-of-trust
  - authenticate users through endorsements made by each other's directly/indirectly trusted users

NDNVideo

NDNVideo: Sessionless, Scalable Live, Pre-recorded Streaming

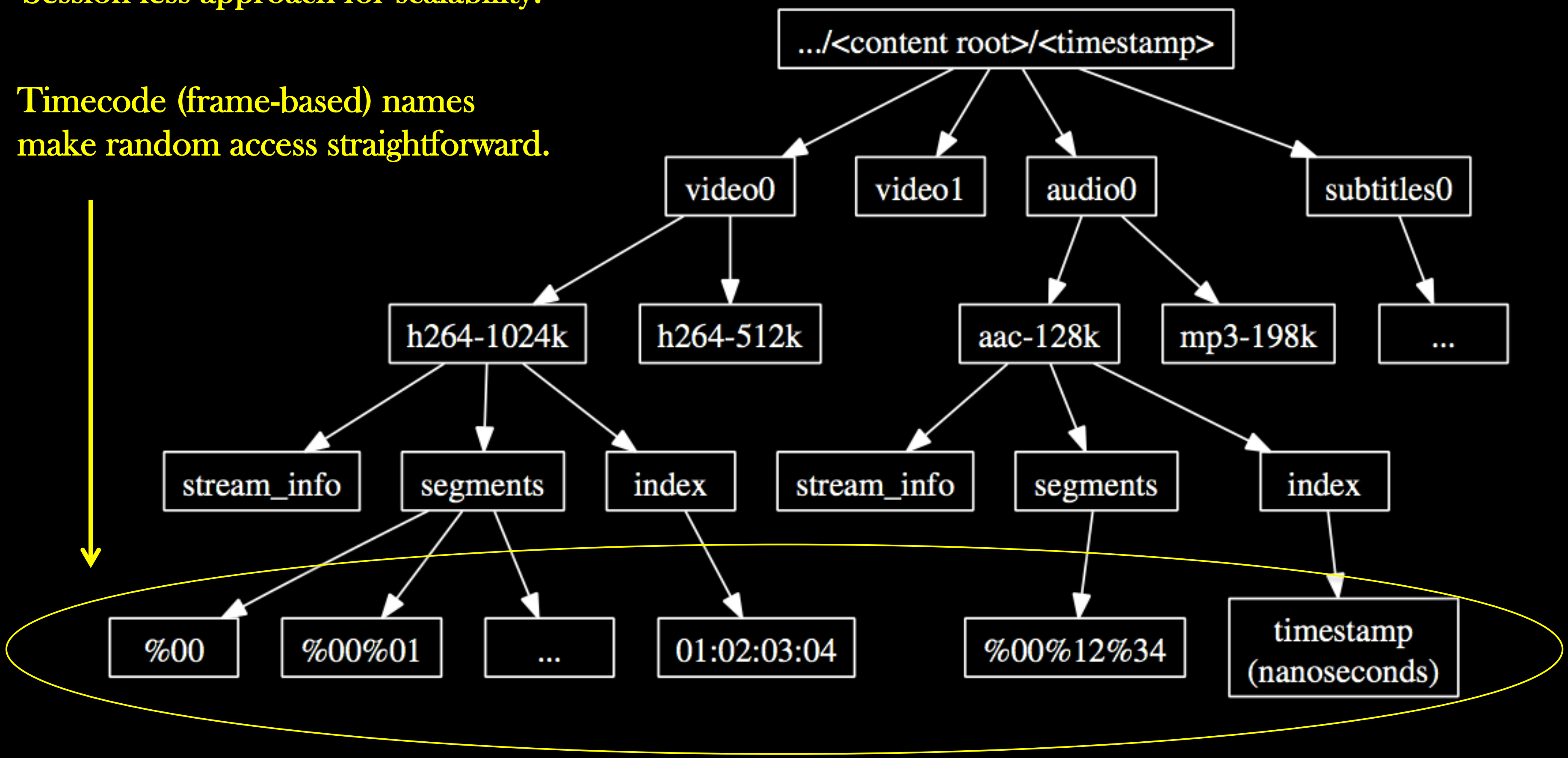


D. Kulinski and J. Burke. NDNVideo: Live and Prerecorded Streaming over NDN. Technical Report NDN-0007, September, 2012.

Design App Namespace to Leverage Architecture

Session-less approach for scalability.

Timecode (frame-based) names
make random access straightforward.



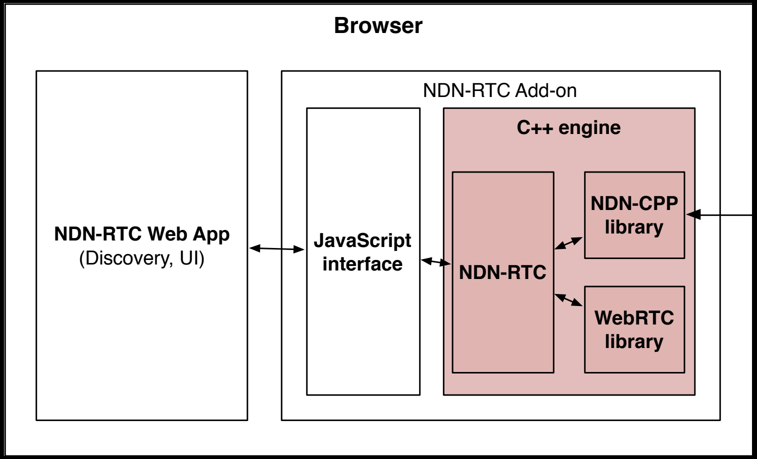
D. Kulinski and J. Burke. NDNVideo: Live and Prerecorded Streaming over NDN. Technical Report NDN-0007, September, 2012.

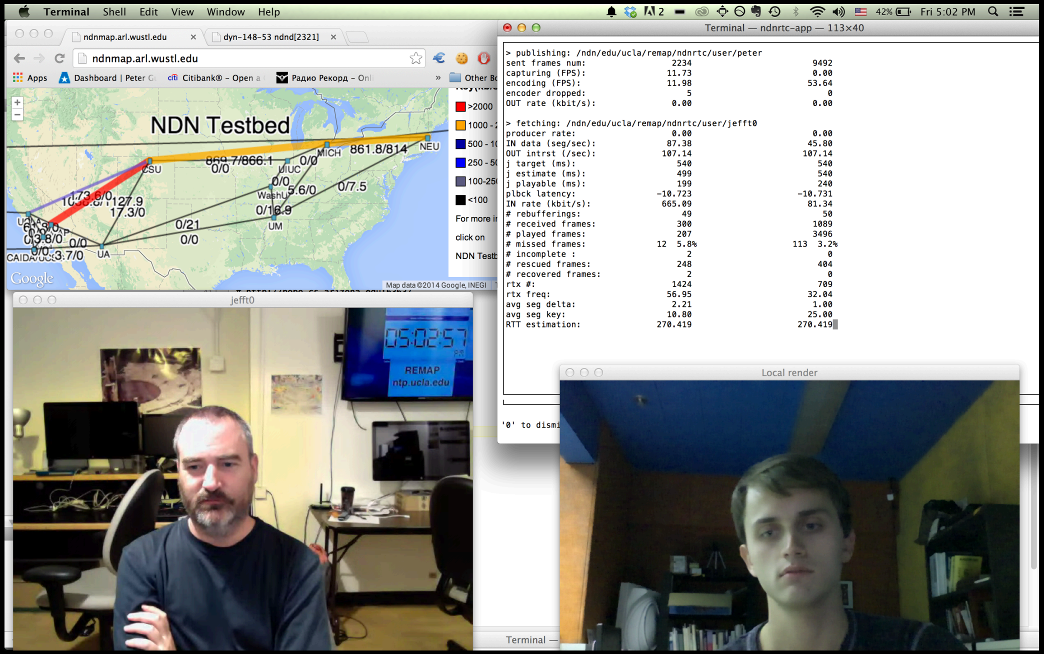
ndnrtc

NDN Real Time Conferencing Tool

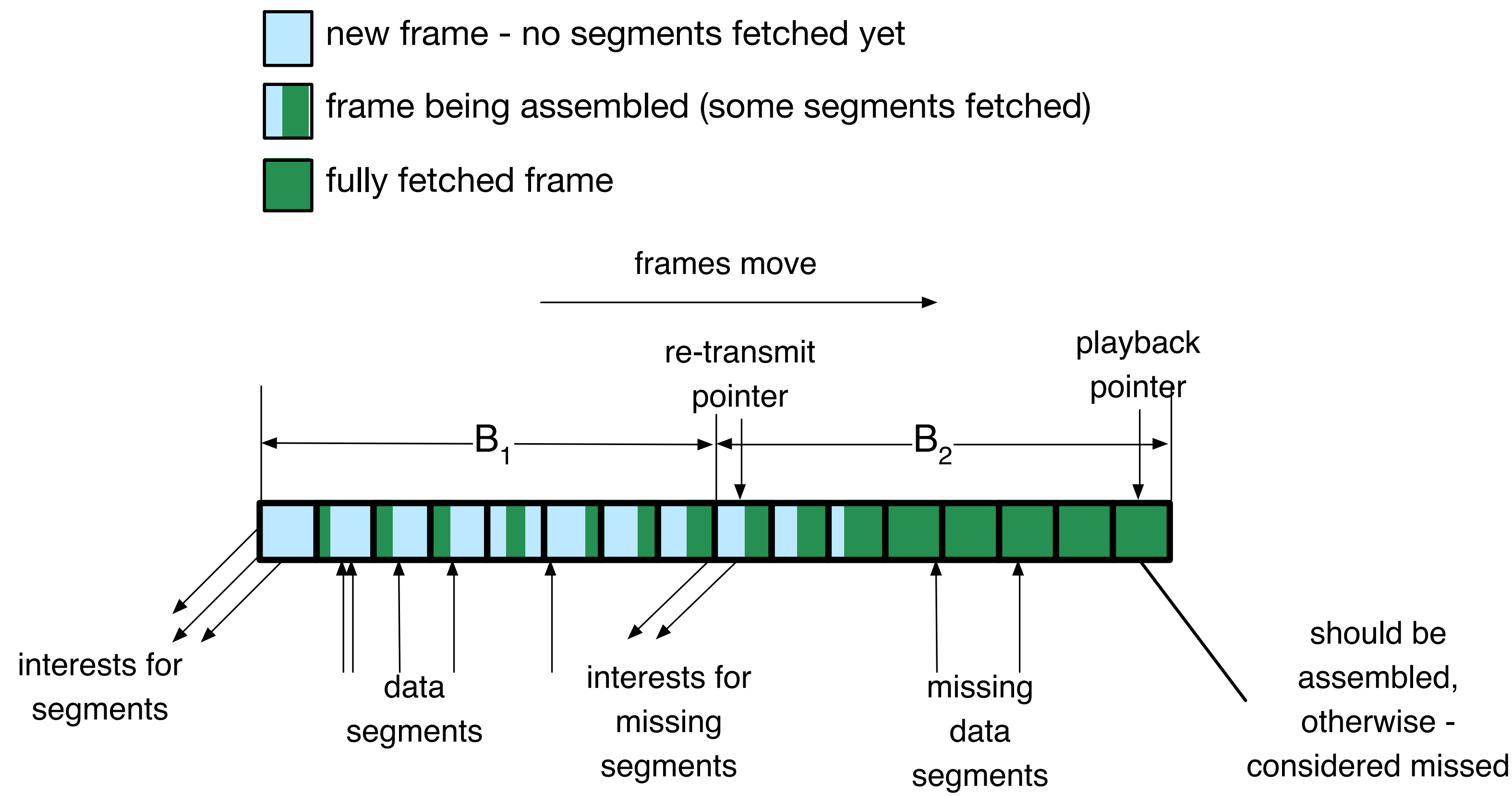
Goals:

- Real-time audio/video/text chat library which allows many-to-many conferencing over the NDN network and requires no direct communication between peers
- Traffic generator for the testbed
- Start point for NDN traffic congestion control algorithm research
- Test NDN-CPP library and TLV packet format





Deadline-based pipeline for driving interest retransmission



B_1 >= RTT, B_2 >= RTT

Minimal buffer size >= 2*RTT milliseconds

Vehicular networking

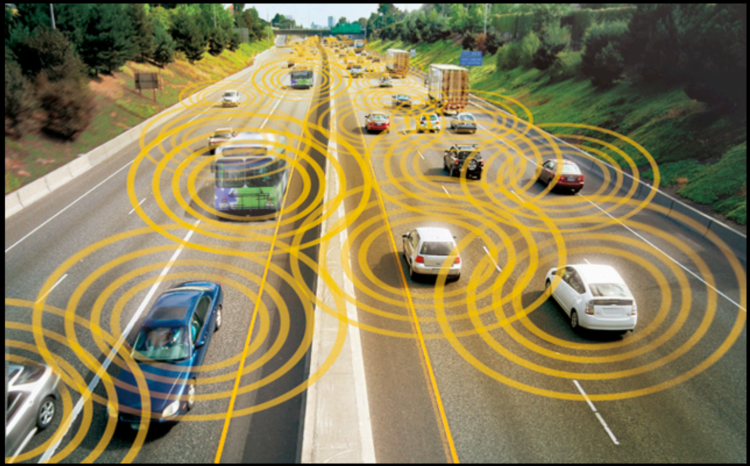
Applying NDN to vehicle networking

Question via the network: *Collisions ahead on I-80?*

```
/toyota/collision/by_road/us/california/I-80
/toyota/collision/recent
```

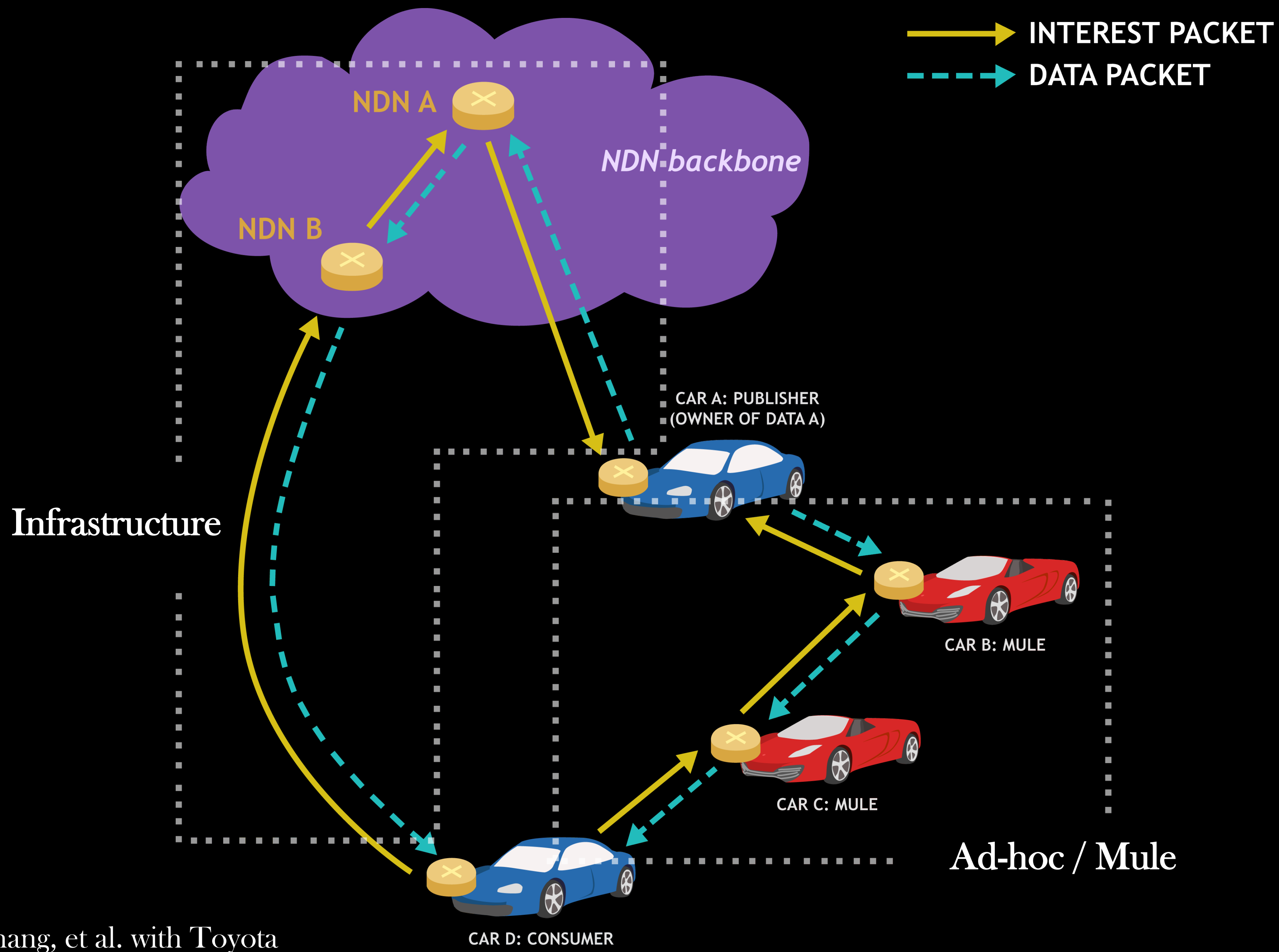
Research goal: a *single framework* for vehicles

- to fully utilize all available physical channels
- to communicate in an infrastructure-free manner
- to communicate with infrastructure servers
- to provide delay-tolerant delivery



No need to deal with host addresses;
still must design application namespace.

(Mobile) data gets to (mobile) consumers any way it can



Pau, Zhang, et al. with Toyota

Climate Modeling

NDN Approach

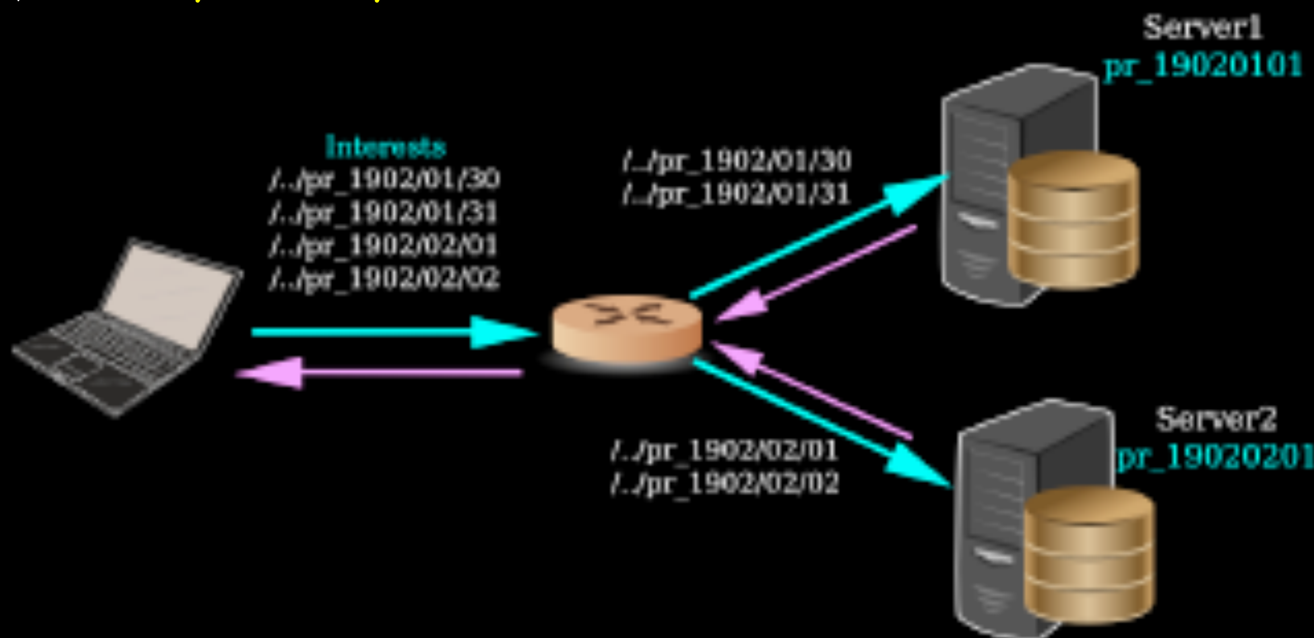
Consumer Request

- Client wants Jan 30 – Feb 02
- NDN routes Jan requests to Server1 and Feb requests to Server2

```
/cmmap/precipitation/
    GCRM/GridZ/
    <horiz_resolution>/
    <field>/<date>/<time>/
```

Publisher Announcement

- Server 1 advertises January prefix
- Server2 advertises February prefix
- Routing protocol propagates announcements
- Servers answer at appropriate granularity for the application



Naming in Climate Modeling Application

CMIP5: ".. a common naming system to be used in files, directories, metadata, and URLs to identify datasets wherever they might be located within the distributed CMIP5 archive. It defines controlled vocabularies for many of the components comprising the data reference syntax (DRS).

Directory encoding:

- /<activity>/<product>/<institute>/<model>/<experiment>/ <frequency>/ <modeling realm>/ <variable name>/<ensemble member>
- **Example:** /CMIP5/output/MOHC/HadCM3/decadal1990/day/atmos/tas/r3i2p1/

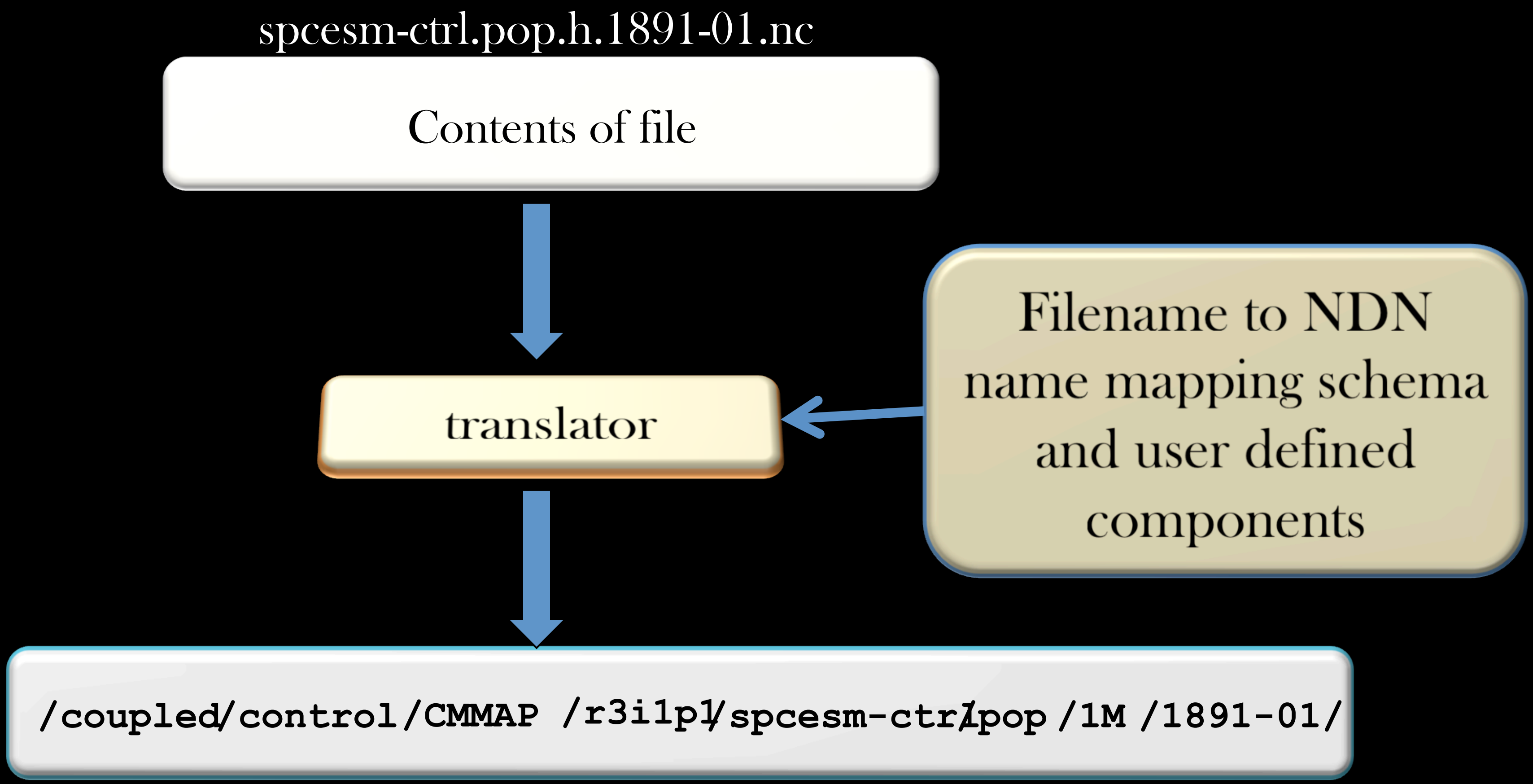
CMIP5 DRS is NDN-compliant

- Hierarchical
- Clearly defined name components
- Well-defined vocabularies
- Organizes components from less specific to more specific

Utilities to translate into DRS (CMOR)

Produces virtually ready-to-use NDN names

Our Translator Architecture



activity/sub-activity/organization/ensemble/experiment/model/granularity/start-time

NP Network Environments

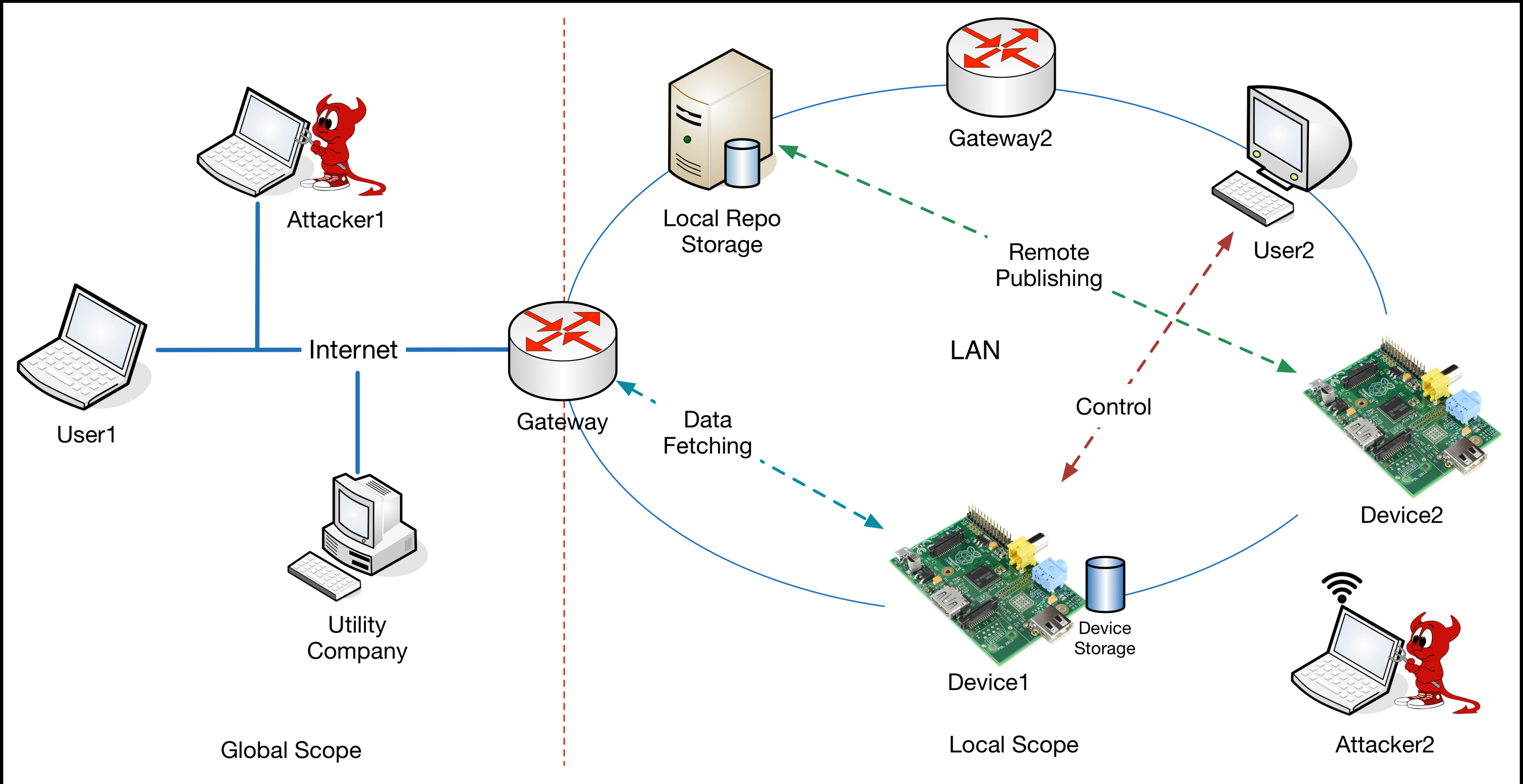
Enterprise building automation and management systems

Two research threads

- Enterprise-level BAS/BMS in collaboration with UCLA Facilities Management, based on work started in an EAGER.

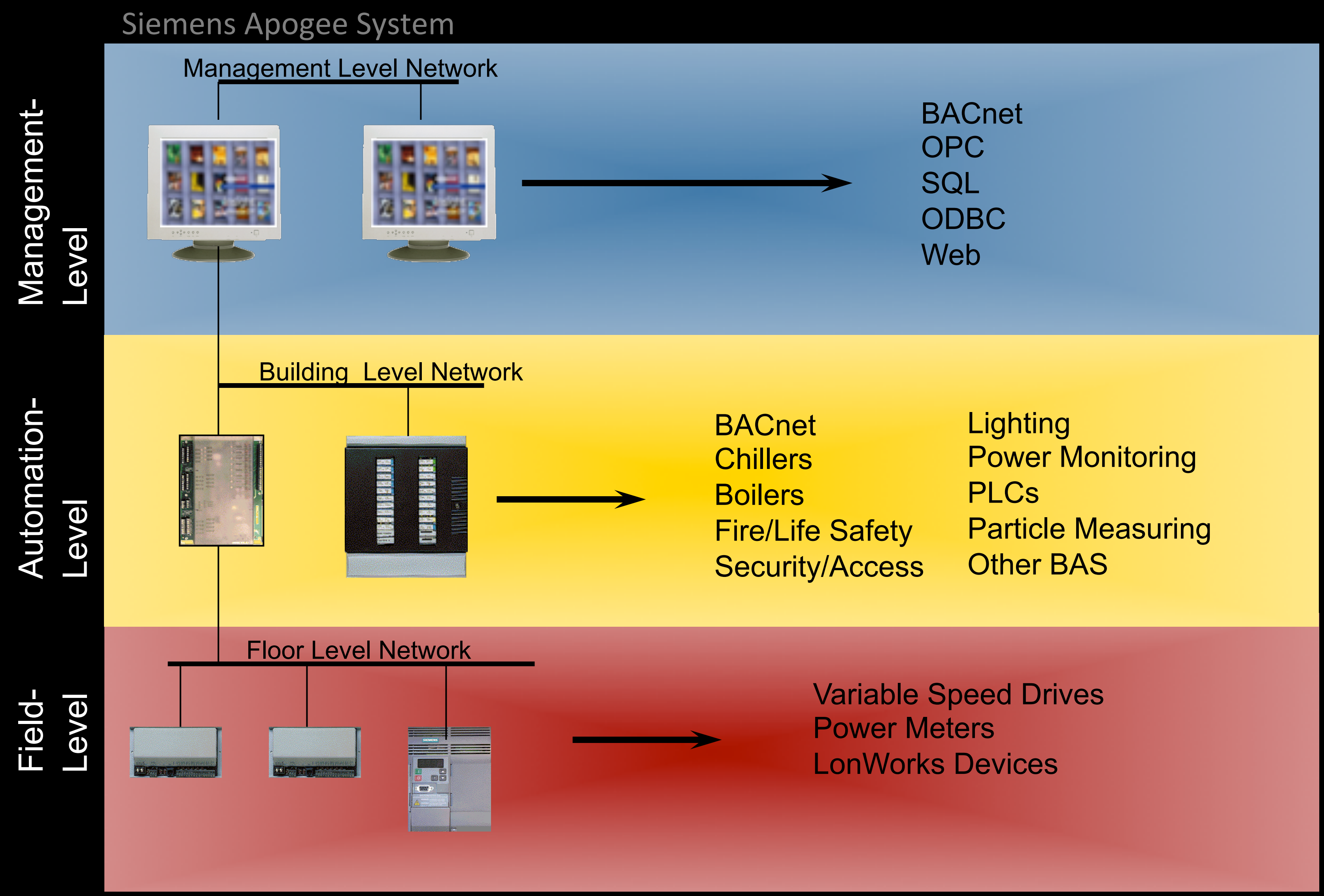
- Device-side IoT, motivated by consumer experience / home environment for now. (External support from Qualcomm and potentially Huawei.)

Home environment



W. Shang et al.

EBAMS: Focusing on "Management" / "Automation" levels



Sensing: Electrical Demand & Chilled Water

Two testbeds at UCLA – one shared and one unique.

NDN – Suitability / Benefits

Massive addressing simplification, with a potential for huge impact when scaled to the enterprise. Simpler network infrastructure needed to deploy complex monitoring and automation.

New way of working with edge resources that de-emphasizes gateway addressing while preserving support for topological heterogeneity.

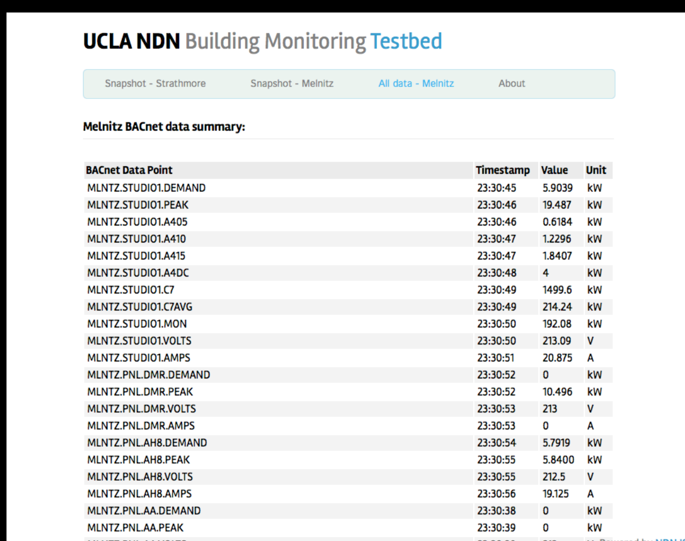
Lighter-weight, data-centric security options easier to develop, with data verification intrinsically part of the architecture.

Caching and storage integration may provide significant advantages in distributed storage at all levels of the architecture, increasing data availability without power increase.

Intrinsic multicast; many-to-many communication easier to deploy.

Hierarchical naming already used at application layer

MLNTZ.PNL.J.SAT	LAO	SAT TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.SEP	LAO	SEP TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.SUN	LAO	SUN TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.THU	LAO	THU TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.TUE	LAO	TUE TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.WED	LAO	WED TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.WEK	LAO	WEEK TOTAL	Value	0.0.0	No	No
MLNTZ.PNL.J.YPEAK	LAO	YESTERDAYS PEAK	Value	0.0.0	No	No
MLNTZ.PNL.J.CNSMTN.LO	LAI	ACTUAL LO CNSMTN	Value	1.1.8	No	No
MLNTZ.PNL.J.CNSMTN.HI	LAI	ACTUAL HI CNSMTN	Value	1.1.9	No	No
MLNTZ.PNL.J.DEMAND	LAI	ACTUAL VOLTS	Value	1.1.10	No	No
MLNTZ.PNL.J.AMPS	LAI	ACTUAL AMPS	Value	1.1.12	No	No
MLNTZ.PNL.J.VOLTS	LAI	ACTUAL VOLTS	Value	1.1.13	No	No
MLNTZ.PNL.J.DEM:DAY.NGT	LDO	300 AMP	On/Off	1.1.29	No	No



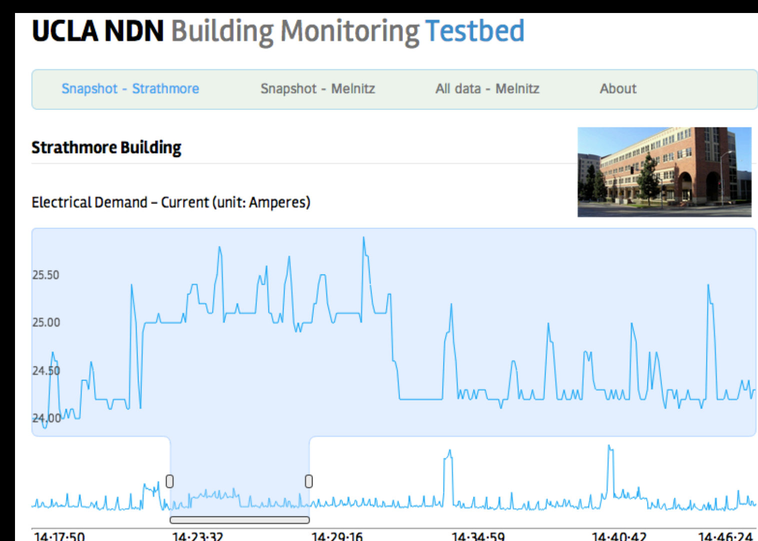
UCLA NDN Building Monitoring Testbed

Snapshot - Strathmore | Snapshot - Melnitz | All data - Melnitz | About

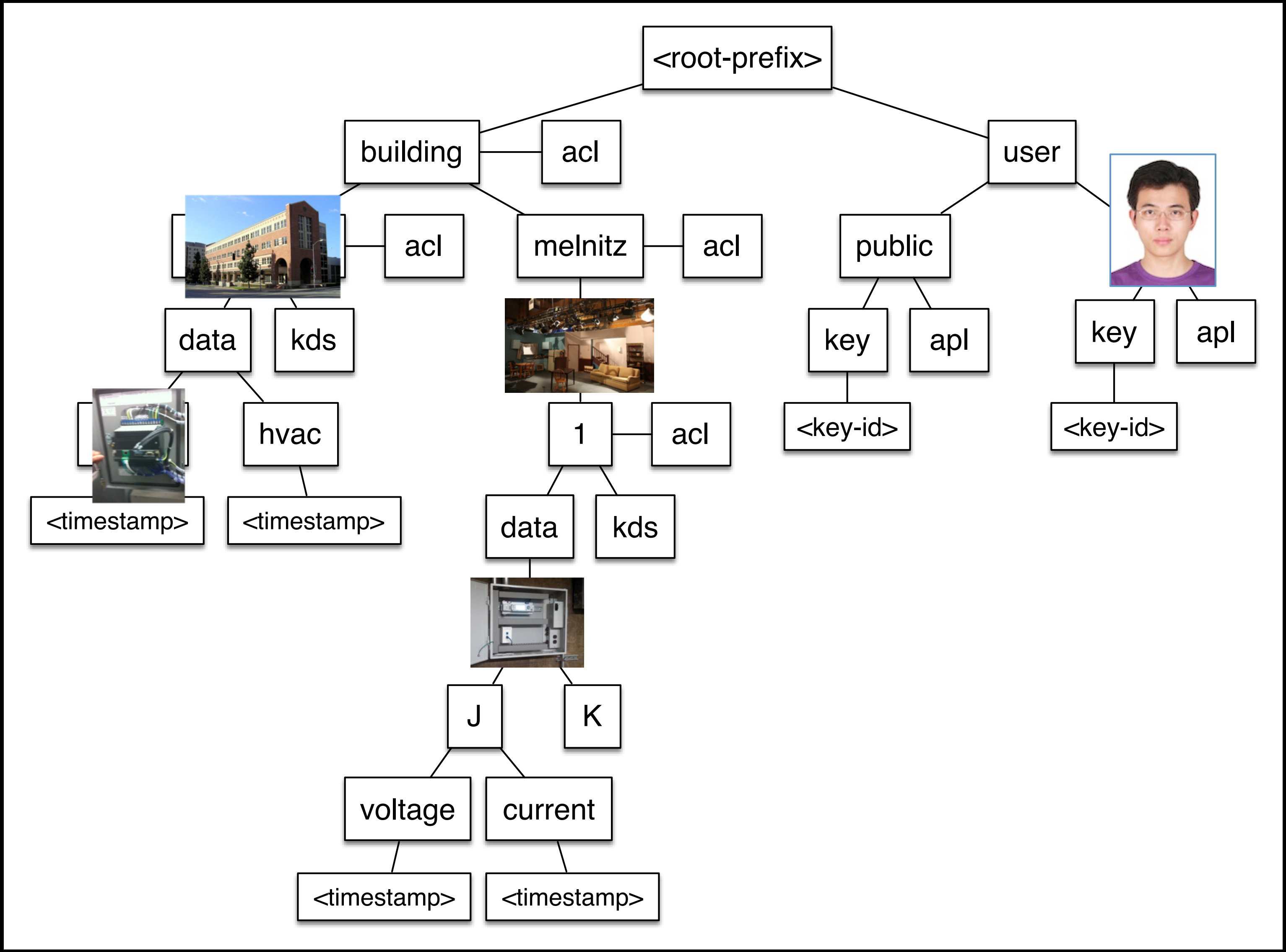
Melnitz BACnet data summary:

BACnet Data Point	Timestamp	Value	Unit
MLNTZ.STUDIO1.DEMAND	23:30:45	5.9039	kW
MLNTZ.STUDIO1.PEAK	23:30:46	19.487	kW
MLNTZ.STUDIO1.A405	23:30:46	0.6184	kW
MLNTZ.STUDIO1.A410	23:30:47	1.2296	kW
MLNTZ.STUDIO1.A415	23:30:47	1.8407	kW
MLNTZ.STUDIO1.A4DC	23:30:48	4	kW
MLNTZ.STUDIO1.C7	23:30:49	1499.6	kW
MLNTZ.STUDIO1.C7AVG	23:30:49	214.24	kW
MLNTZ.STUDIO1.MON	23:30:50	192.08	kW
MLNTZ.STUDIO1.VOLTS	23:30:50	213.09	V
MLNTZ.STUDIO1.AMPS	23:30:51	20.875	A
MLNTZ.PNL.DMR.DEMAND	23:30:52	0	kW
MLNTZ.PNL.DMR.PEAK	23:30:52	10.496	kW
MLNTZ.PNL.DMR.VOLTS	23:30:53	213	V
MLNTZ.PNL.DMR.AMPS	23:30:53	0	A
MLNTZ.PNL.AH8.DEMAND	23:30:54	5.7919	kW
MLNTZ.PNL.AH8.PEAK	23:30:55	5.8400	kW
MLNTZ.PNL.AH8.VOLTS	23:30:55	212.5	V
MLNTZ.PNL.AH8.AMPS	23:30:56	19.125	A
MLNTZ.PNL.AA.DEMAND	23:30:38	0	kW
MLNTZ.PNL.AA.PEAK	23:30:39	0	kW
MLNTZ.PNL.AA.VOLTS	23:30:39	213	V

Powered by NDN.JS.



Forward based on names closely mapped to physical world

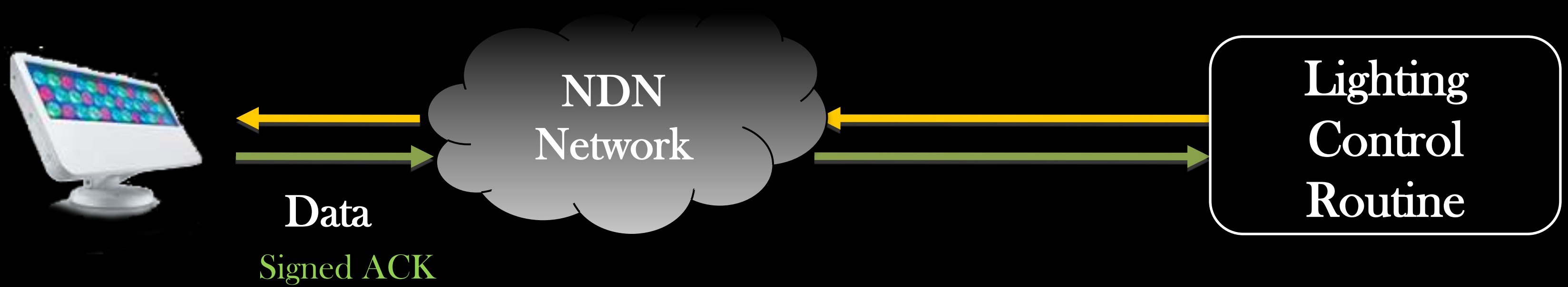


Shang, W, et al. "Securing Building Management Systems Using [NDN]." IEEE Network 2014.

Authenticated, Closed-Loop Control in NDN

Interest signed by app

boelter/3551/lights/fixture/41/rgb-8bit-hex/FAF87F/<state>/<authenticator>



- Asymmetric keys to work directly with PK-based identities
- Symmetric keys and HMACs for faster 'signatures'
- Leverage NDN to distribute keys and establish key relationships
- Command privacy by encrypting non-routable portion of name

Burke, J., et al. "Securing Instrumented Environments over Content-Centric Networking: the Case of Lighting Control." IEEE NOMEN 2013.

Open mHealth

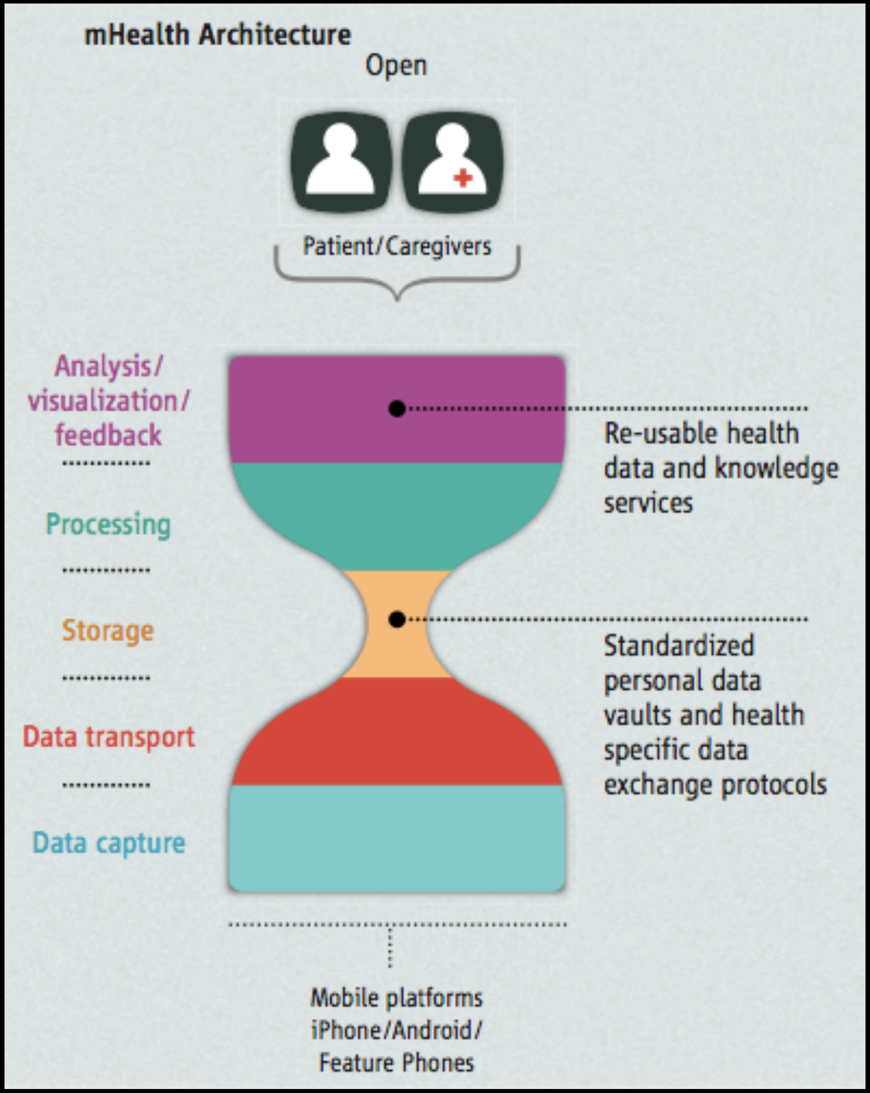
Open mHealth:
Data rather than System Interoperability

Interoperable, Internet-inspired data exchange as the backbone of the application ecosystem

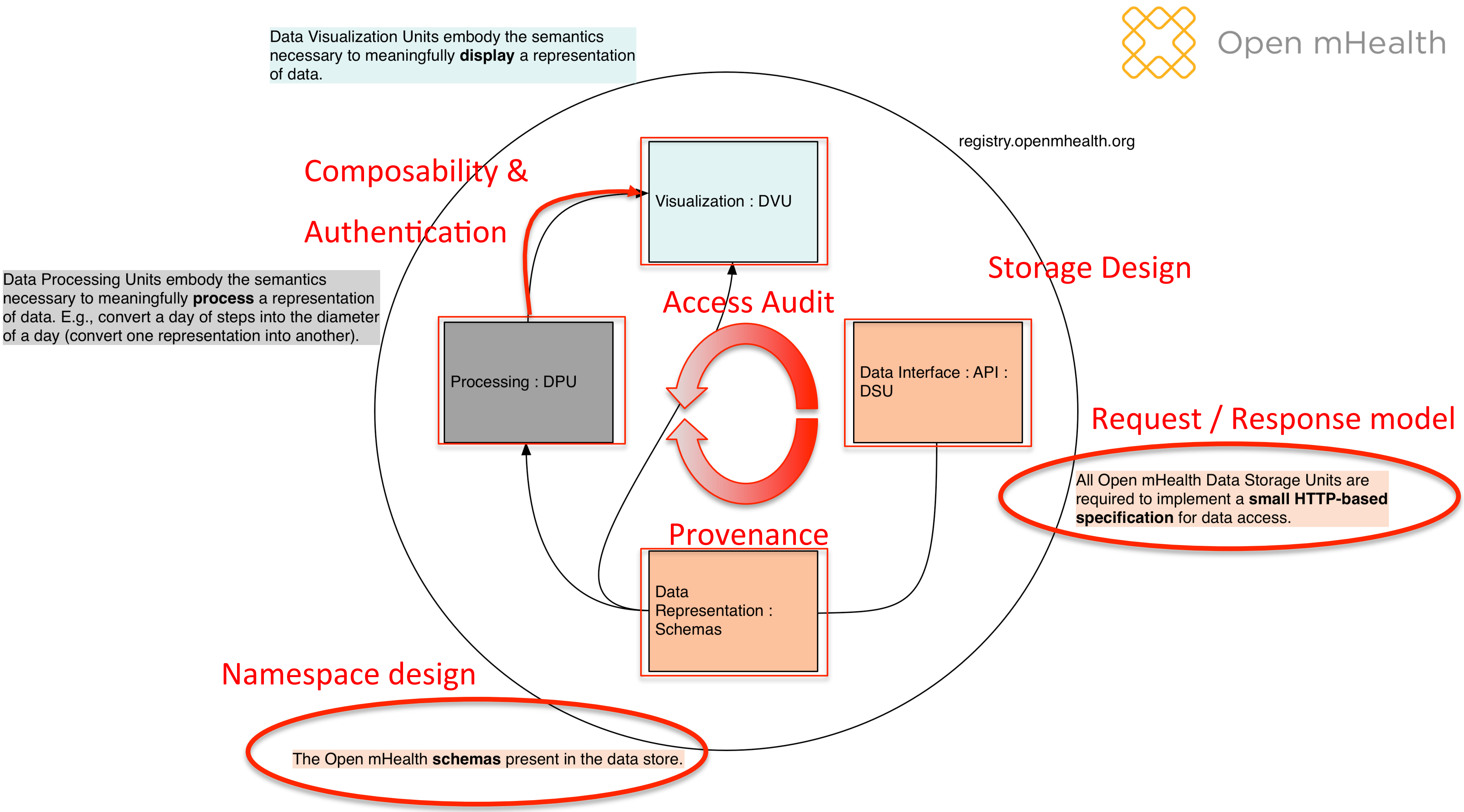
Thin waist of open data interchange standards that will enable an ecosystem of sensing, storage, analysis, and user interface components to support medical discovery and evidence-based care

Market-supported, patient-centered landscape of innovative health applications

Patient-controlled, privacy-aware data exchange across device, component, and application boundaries



Mapping the Open mHealth Architecture to NDN



http://openmhealth.org/

Same Challenges, Different Layers

For this application in particular, NDN provides much more relevant functionality at the network layer than IP.

So solutions in NDN have much more direct impact on the scalability, security, and ease of development; we need not build up additional layers on IP to get near the app challenges.

Namespace / schema design

Repository / storage design

Service composability

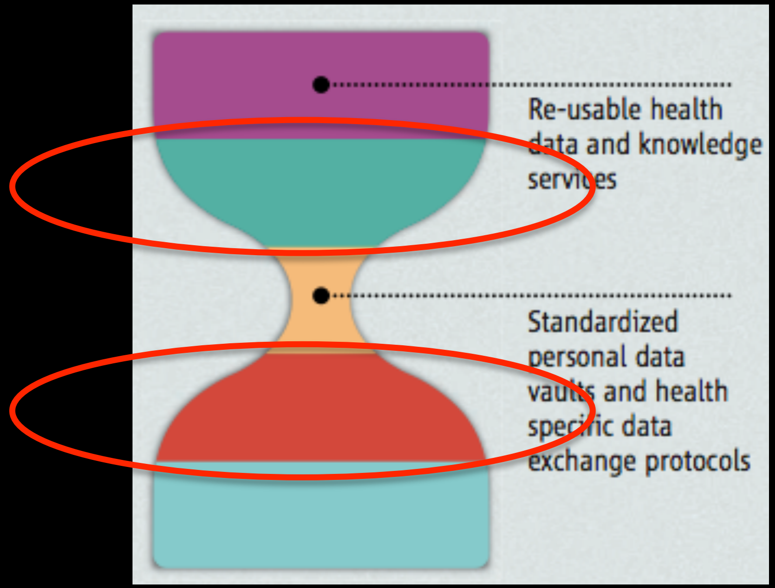
Authentication / identity assurance

Data provenance

Access auditing

Mobile publishing

Legal requirements for success



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