# Named Data Networking "Next Phase"

## Network Environments

FIA-NP PI Meeting

May 19, 2014

# NDN Network Environments

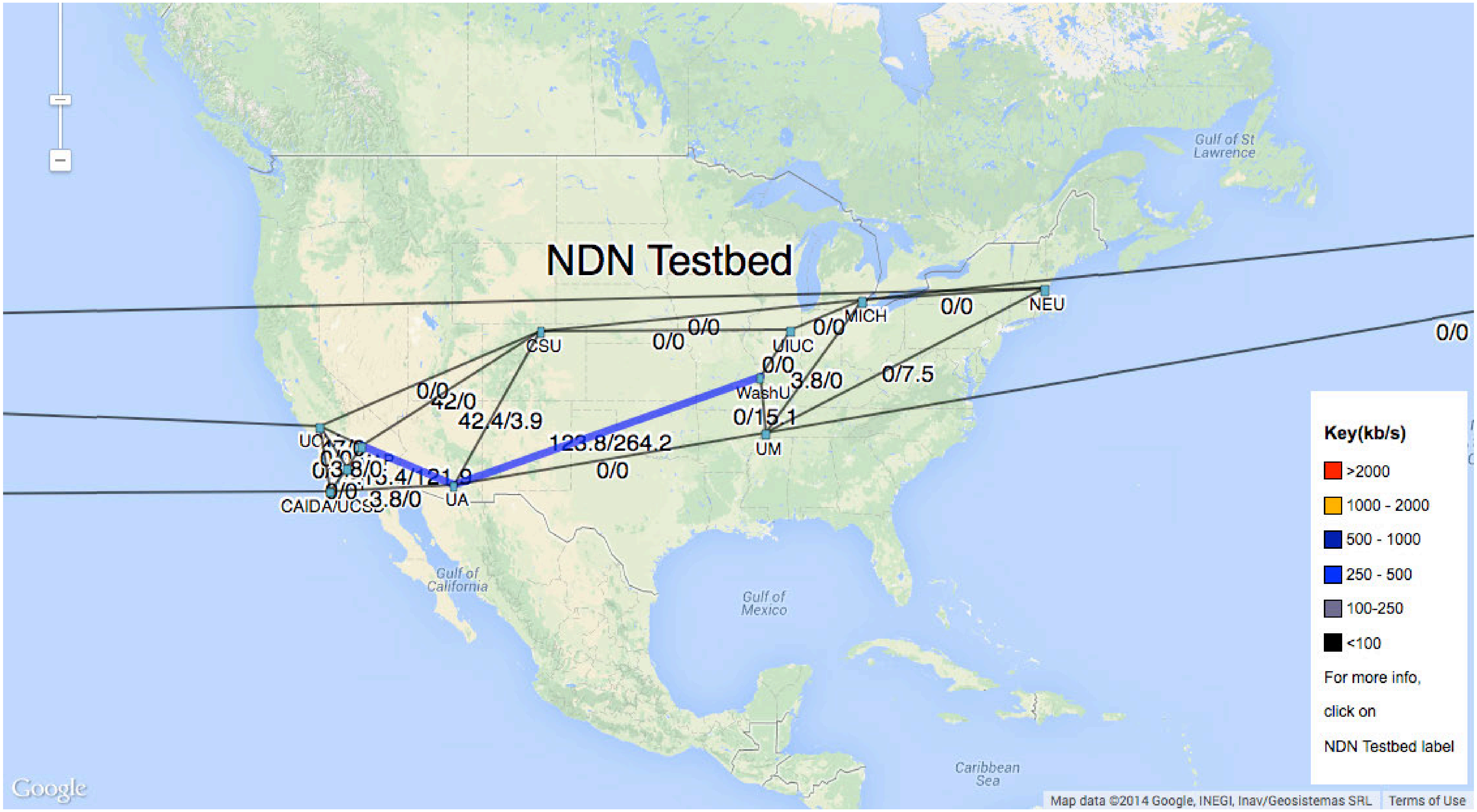
**1. Enterprise Building Automation & Management**

**2. Open mHealth**

**3. Mobile Media Application Cluster**

Not covered in this talk, but includes initial designs and running code in video playout; real-time conferencing – video, audio, chat; networked 3D environments; vehicular networking @ LIP6

# NDN Testbed


NDN Testbed
Gulf of St Lawrence
0/0
NEU
MICH
0/0
0/0
0/0
CSU
0/0
UIUC
0/0
3.8/0
0/7.5
WashU
0/15.1
UM
0/0
42/0
42.4/3.9
123.8/264.2
0/0
UC
0/0
0/3.8/0
13.4/121.9
0/0
3.8/0
CAIDA/UCSD
UA
Gulf of California
Gulf of Mexico
Caribbean Sea
Key(kb/s)
🟥 >2000
🟧 1000 - 2000
🟦 500 - 1000
🟦 250 - 500
🟪 100-250
⬛ <100
For more info,
click on
NDN Testbed label
Google
Map data ©2014 Google, INEGI, Inav/Geosistemas SRL
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# Open mHealth and E-BAMS

“The two environments represent critical areas in the design space for next-generation **Health IT and Cyberphysical Systems**, respectively.

“They also extend work started in the previous NDN FIA project on **participatory sensing and instrumented environments** to focus on specific application ecosystems where we believe NDN can address fundamental challenges that are unmet by IP.”

# 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.

  Focus: *Explore enterprise-level requirements for naming, device count scalability, security and trust management; workstation-class resources for storage and analysis.*

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

  Focus: *Create embedded device implementations using NDN (e.g., Raspberry PI) focusing on ease-of-configuration and simple communications*.

  *(will cover this one briefly first)*

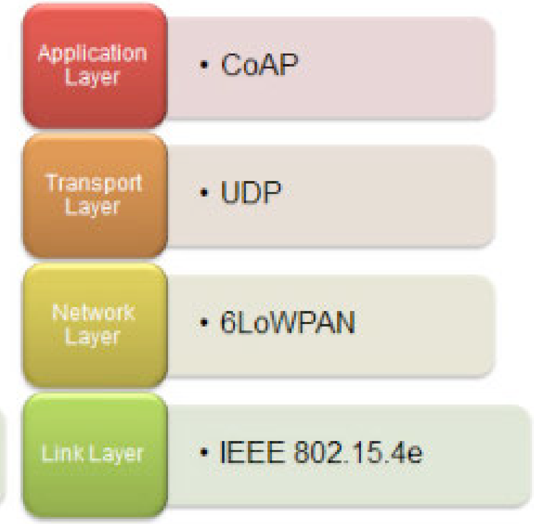
# Device-level Perspective / IoT

**NDNoT: Named Data Network of Things**

Supported by Qualcomm Research, 2014-2015

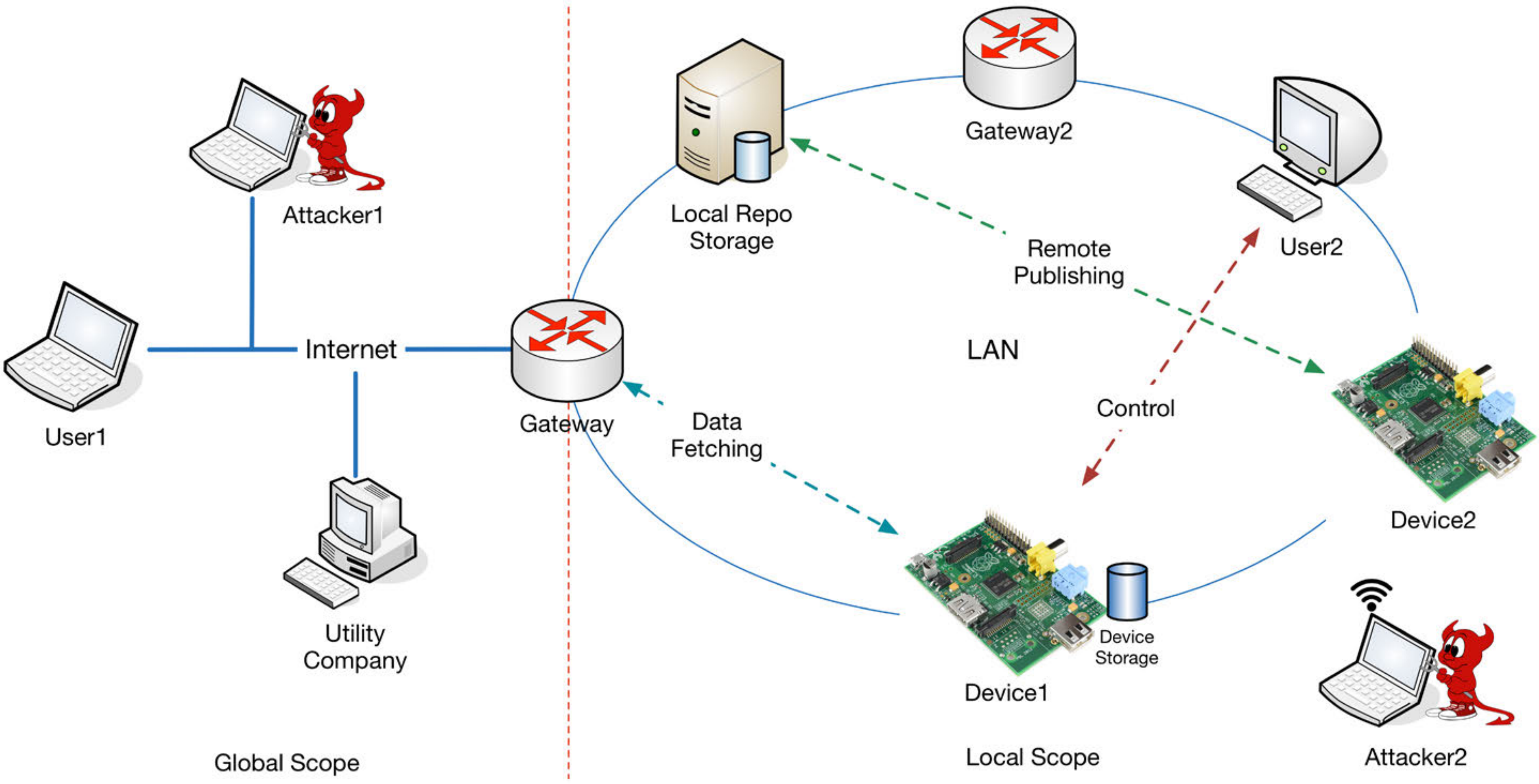
- Port of NDN codebase to the Raspberry PI, including support for Layer 2 communications and browser-based or IP-enabled gateways that allow NDN-based nodes to be used concurrently with existing networks.
- Mechanisms to minimize power consumption and handle low duty cycle / power managed devices, as well as developing initial approaches to discovery, bootstrapping, storage / data custodian functionality, trust and key management, and secure communications.

*Comparison to:*



| | |
|---|---|
| Application Layer | • CoAP |
| Transport Layer | • UDP |
| Network Layer | • 6LoWPAN |
| Link Layer | • IEEE 802.15.4e |

# Home environment



W. Shang et al.

# Work plan in this area

- Port NDN codebase to the Raspberry PI.
  - NDN-CCL: C++, Python
  - Security Library
  - Forwarder: First NDNx-TLV, then NFD
  - **Layer 2 / raw "wifi" support based on previous work**
  - New work – **Discovery/bootstrapping library** based on lighting
  - New work – **Experimenter-friendly configuration** management?

- Create application-specific gateways
  - Support communication to NDN testbed over IP
  - Browser-based using NDN-JS

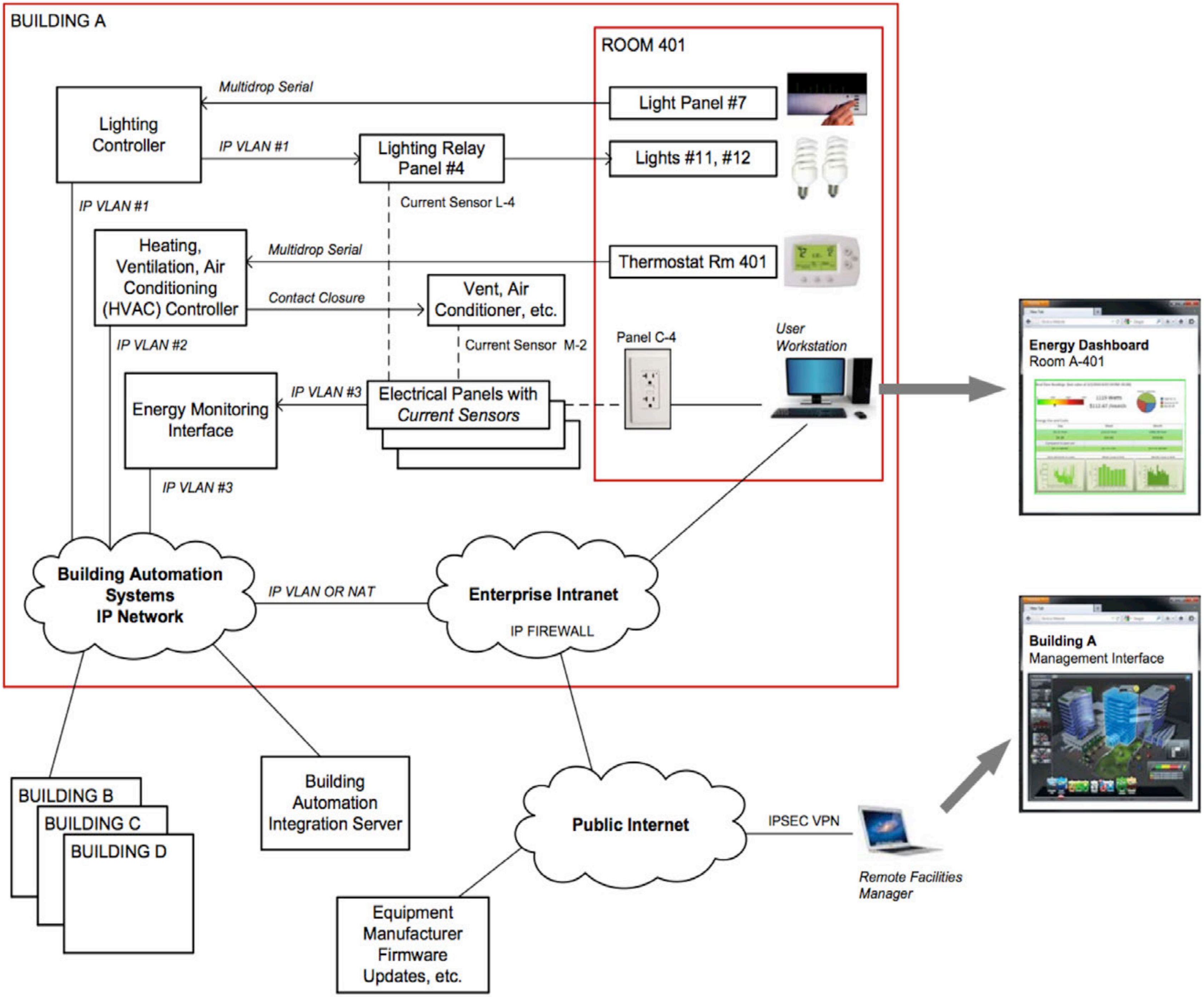
- New mechanisms / considerations
  - **Minimize power consumption**
  - **Support low duty cycle / power managed devices**
  - **Initial approaches to discovery, bootstrapping, storage/data custodian functionality, trust and key management, and secure communication**

# Enterprise Building Automation and Management Systems

- For the NP phase, this environment enables us to engage with several critical areas:
  - industrial control systems (ICS), including supervisory control and data acquisition (SCADA) and so-called smart grid,
  - enterprise networking,
  - the Internet of Things (IOT) movement.
- These  environments bring the critical infrastructure considerations of ICS together with the IoT vision.
- In this domain, significant engineering challenges have emerged along with the promise offered by the convergence of networking in ICS with traditional IT.
- E-BAMS are deployed *now*, and give us a way to workwith a rich set of existing data on the UCLA campus.
- Continuation of our work in lighting control, BMS, and IoT.

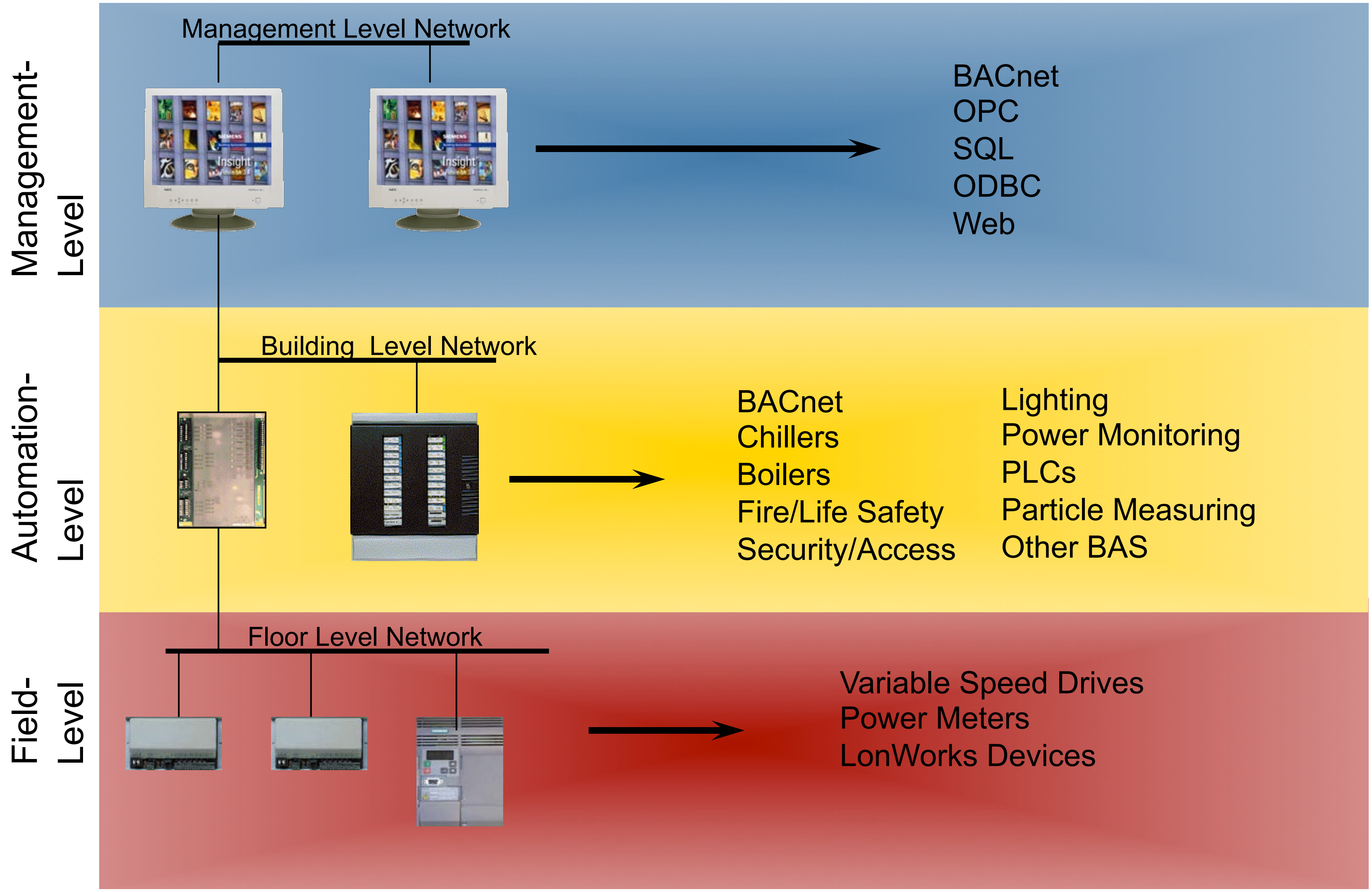
# **E-BAMS**: Definition

- BAS and BMS are software/hardware systems that perform control, monitoring and management of heating, ventilation and air conditioning (HVAC), lighting, water, physical access and other building components.
- O(100k) data collection and control points often implemented by special-purpose embedded devices and managed by a single enterprise [with many off-site employees, contractors, vendors, and consultants!]
- The IP protocol suite is increasingly used to network components and as such is now a fundamental substrate of new buildings / campuses.
- However, IP networks suffer from limitations that impact innovation and trust, which we believe can be addressed with NDN.
- E-BAMS historically employed physical or logical isolation of the network as a primary security measure, which limits interoperability and integration.


BUILDING A
ROOM 401
Lighting Controller
Multidrop Serial
Light Panel #7
IP VLAN #1
Lighting Relay Panel #4
Lights #11, #12
IP VLAN #1
Current Sensor L-4
Heating, Ventilation, Air Conditioning (HVAC) Controller
Multidrop Serial
Thermostat Rm 401
Contact Closure
Vent, Air Conditioner, etc.
IP VLAN #2
Current Sensor M-2
Panel C-4
User Workstation
Energy Monitoring Interface
IP VLAN #3
Electrical Panels with Current Sensors
IP VLAN #3
Energy Dashboard
Room A-401
Building Automation Systems IP Network
IP VLAN OR NAT
Enterprise Intranet
IP FIREWALL
Building A
Management Interface
BUILDING B
BUILDING C
BUILDING D
Building Automation Integration Server
Public Internet
IPSEC VPN
Remote Facilities Manager
Equipment Manufacturer Firmware Updates, etc.

# Focusing on “Management” / “Automation” levels

Siemens Apogee System



Management-Level

Management Level Network

BACnet
OPC
SQL
ODBC
Web

Automation-Level

Building  Level Network

BACnet
Chillers
Boilers
Fire/Life Safety
Security/Access

Lighting
Power Monitoring
PLCs
Particle Measuring
Other BAS

Field-Level

Floor Level Network

Variable Speed Drives
Power Meters
LonWorks Devices

# Enterprise: UCLA Facilities Management Partnership

- UCLA Facilities Management has agreed to act as domain experts and help define the practical requirements of this network environment.
- UCLA's currently deployed building management system has >150,000 points of monitoring across the campus, potentially growing to >400,000 points in the next five years.
- UCLA FM has already helped us install a dedicated Siemens electrical demand monitoring system for a laboratory space for NDN research.
- Plan to install a dedicated server that will provide near online access to 10k-20k points worth of data from campus' operational systems, probably about 10 buildings worth of data. This server will act as a gateway to our own NDN testbed.

# Related Prior Work

- **Securing Building Management Systems Using Named Data Networking.** W. Shang, Q. Ding, A. Marianantoni, J. Burke, and L. Zhang (2014). IEEE Network May/June 2014.

- **Security Evaluation of a Control System Using Named Data Networking.** V. Perez, M. T. Garip, S. Lam, and L. Zhang. Eighth Workshop on Secure Network Protocols (NPSec), October 2013.

- **Securing Instrumented Environments over Content-Centric Networking: the Case of Lighting Control.** J. Burke, P. Gasti, N. Nathan, and G. Tsudik. Proc. IEEE INFOCOMM 2013 NOMEN Workshop, April 2013.

- **Authenticated Lighting Control Using Named Data Networking.** J. Burke, A.Horn, and A. Marianantoni. NDN Technical Report NDN-0011, October, 2012.

# IP – Some Challenges

- **Addressing spread across many layers** (e.g., VLAN, host IP, port, device #, etc.) that over-emphasizes gateways over actual sensors/actuators.
- Legacy protocols **rely on logical / physical isolation** of control and monitoring networks from IT systems.
- Use of IP protocol provides many **new integration possibilities but new security risks**; traditional perimeter and channel-based security insufficient.
- Many devices don't have user interfaces. **Discovery and bootstrapping** still relies on DHCP, TFTP, etc. or manual configuration.
- **Middleware has been proprietary and often heavyweight**. To get data-centric communication, often building on SOAP/HTTP, etc.
- COAP also proposes a request-response model but still the channel-based security of DTLS as the primary approach, with IPSec as an alternative. Multicast support is limited across all of these options.

# 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.

# NDN – Challenges

- Namespace design / “name engine” to tackle overlapping roles of names in application design, device deployment, security, etc.
- Storage/repository design.
- Discovery and bootstrapping.
- Trust model development and implementation (a good problem to have).
- Efficient crypto performance and group / multi-cast cryptographic challenges (not NDN-specific).
- Low-frequency, high-importance notifications (alarms).
- Low-complexity/low-power design (in IoT / device-level case).

# Authenticated Actuation: Lighting

Explored at the device level in first phase.

Addressing currently spread across many layers in the network:

VLAN 4
IP 128.97.152.23
Port 4722
Universe 2
Channel 1
Descriptive name, properties, URI

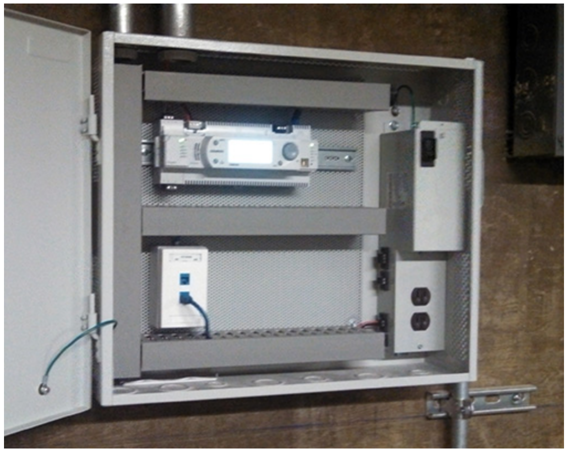
Many possible NDN names

- **Manufacturer-assigned:** /lighting/etc/0041F31C493EF01A
- **Controller-assigned:** /controller_root/<port#>/<chan#>
- **Physical location:** /enterprise_root/<controller_id>/<fixture_id>
- **Region of responsibility:** /room_root/region/downlight/center
- **Designer-assigned:** /app_root/chandelier

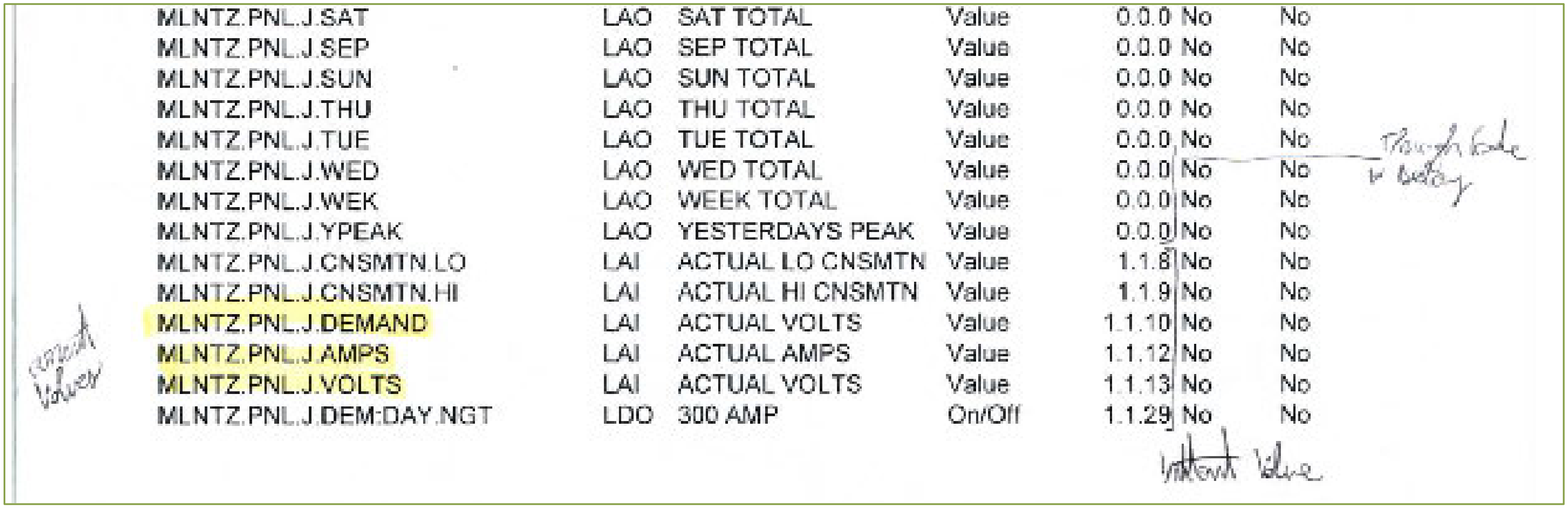
Sign (or generate a MAC) for the data packet, verify against hierarchical key space.

# Sensing: Electrical Demand & Chilled Water

Two testbeds at UCLA – one shared and one unique.



# Hierarchical naming already used at application layer

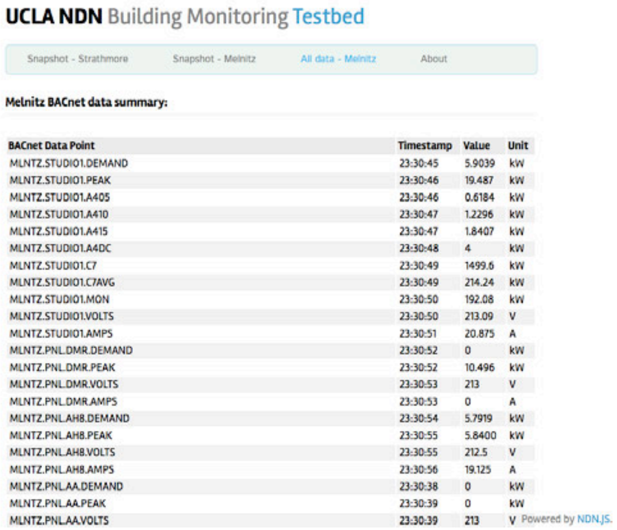


| | | | | | | |
|---|---|---|---|---|---|---|
| MLNTZ.PNL.J.SAT | LAO | SAT TOTAL | Value | 0.0.0 | No | No |
| MLNTZ.PNL.J.SEP | LAO | SEP TOTAL | Value | 0.0.0 | No | No |
| MLNTZ.PNL.J.SUN | LAO | SUN TOTAL | Value | 0.0.0 | No | No |
| MLNTZ.PNL.J.THU | LAO | THU TOTAL | Value | 0.0.0 | No | No |
| 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 |

Through table to today

Current Values

Instant Value

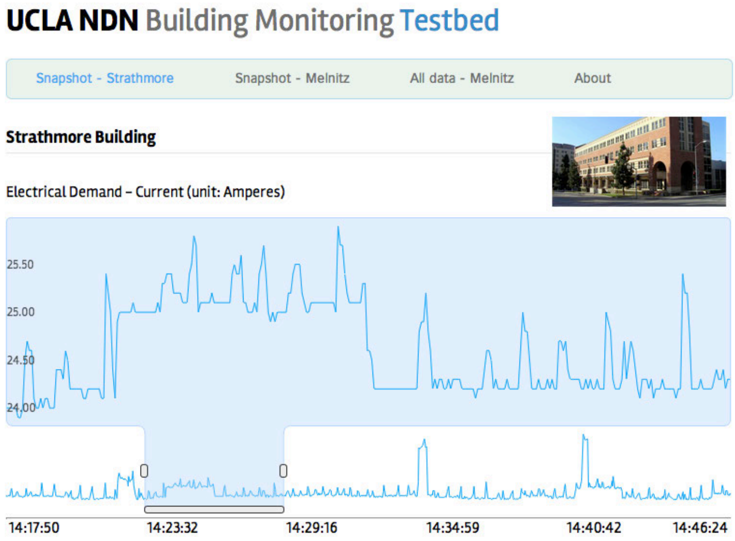


**UCLA NDN** Building Monitoring Testbed

**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.



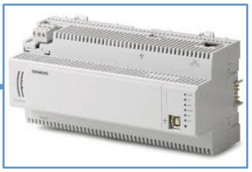
**UCLA NDN** Building Monitoring Testbed

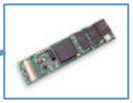
**Strathmore Building**

Electrical Demand – Current (unit: Amperes)

# Pilot sensing deployment and design

- Design focuses on the *actual* deployment
  - Data sources & sinks: sensors, actuators.
  - Groups: NDN-BmS developers at UCLA, UIUC, departmental/campus stakeholders, and testbed users.
  - Users: Users possessing a cert in new system, and anonymous users on the web.
  - Applications that are not associated with a real-world users but need credentials: aggregators, gateways, background processes, etc.
- Physical space / location will be involved in trust and should be described consistently and considered along with routing / application implications.

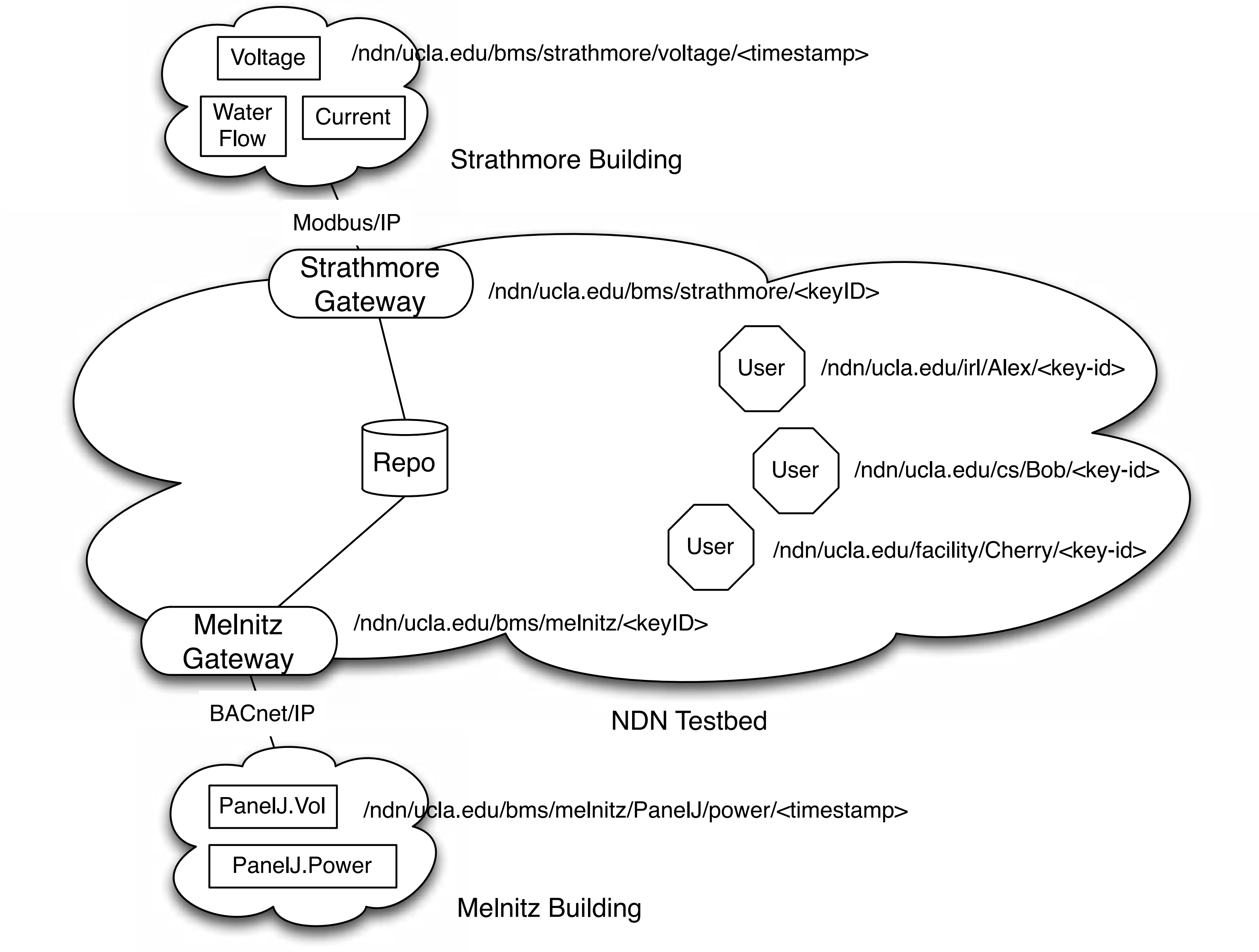




UCLA NDN Building Monitoring Testbed

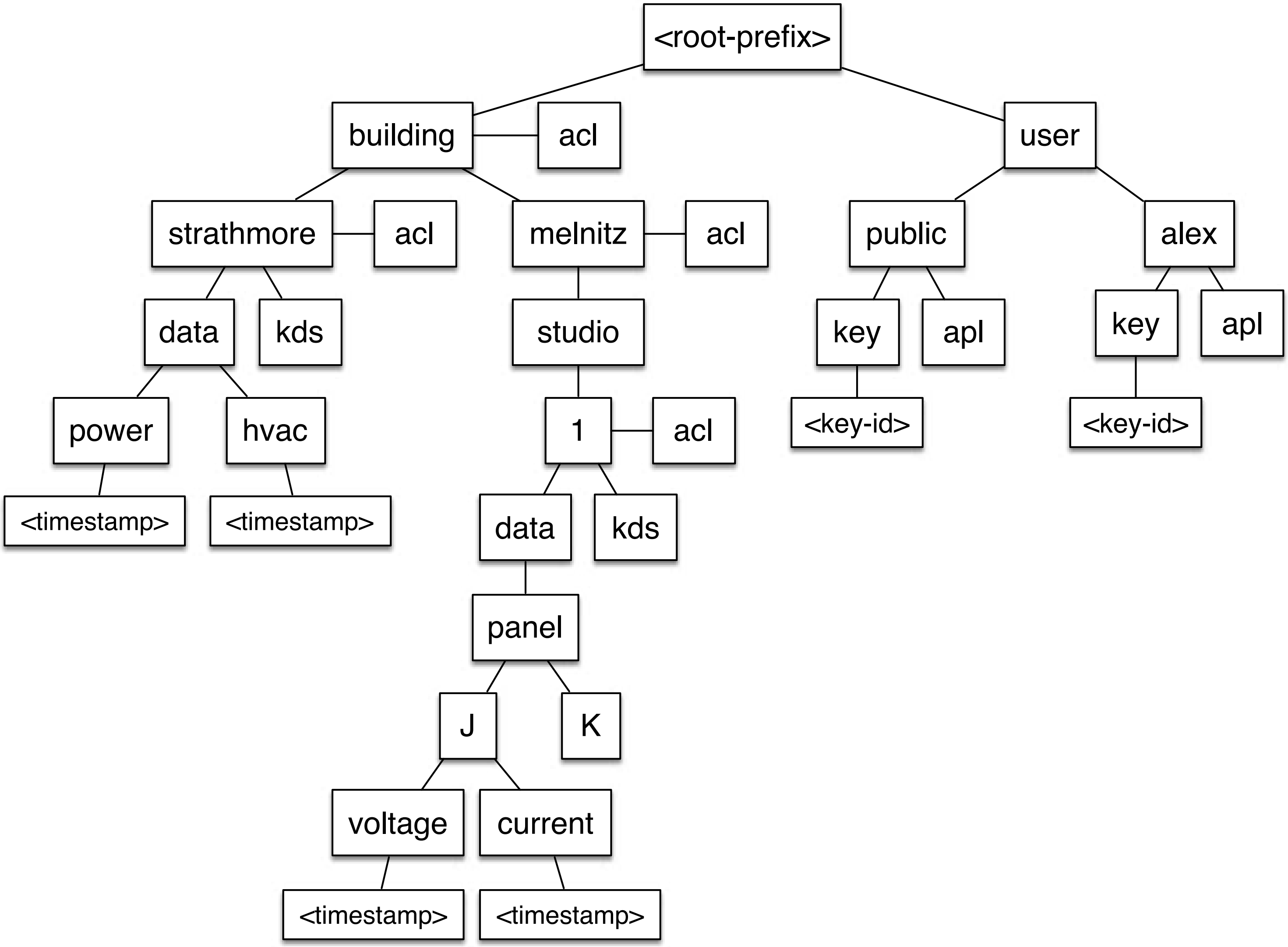
W. Shang et al.

# Pilot deployment and design


Voltage
Water Flow
Current
/ndn/ucla.edu/bms/strathmore/voltage/<timestamp>
Strathmore Building
Modbus/IP
Strathmore Gateway
/ndn/ucla.edu/bms/strathmore/<keyID>
User
/ndn/ucla.edu/irl/Alex/<key-id>
Repo
User
/ndn/ucla.edu/cs/Bob/<key-id>
User
/ndn/ucla.edu/facility/Cherry/<key-id>
Melnitz Gateway
/ndn/ucla.edu/bms/melnitz/<keyID>
BACnet/IP
NDN Testbed
PanelJ.Vol
/ndn/ucla.edu/bms/melnitz/PanelJ/power/<timestamp>
PanelJ.Power
Melnitz Building

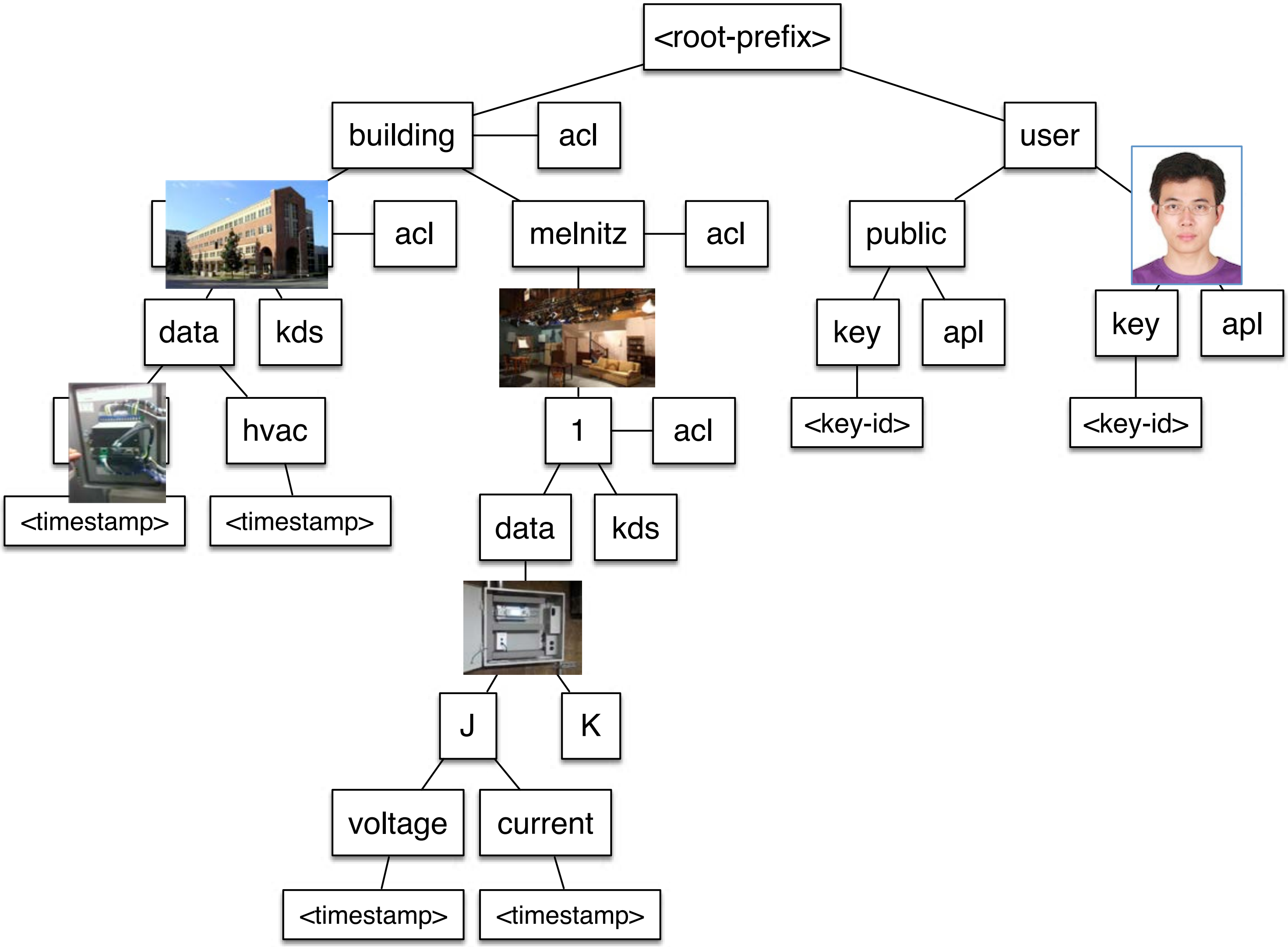
W. Shang et al.

# Pilot UCLA BMS Namespace



W. Shang et al.

# Pilot UCLA BMS Namespace



W. Shang et al.

# **E-BAMS**: Initial Research

- Naming and application design
  - Reflect system and physical world knowledge in the naming
  - Simplify application development (seeking evaluation approaches)
- Trust and security
  - Base on real administrative organization at UCLA
  - Trust model? Hierarchical may work but may be in a different namespace from the data
- Storage in the network
  - Support the basic reporting requirements of the campus operators!
- Embedded and real-time support / IoT
  - NDN support on resource-constrained devices.
  - Bootstrapping and name assignment.

# **E-BAMS**: Proposed Milestones

- Review limitations in current IP-based architecture, for Facilities Management needs. (Y1)
- Design NDN namespace, repository, trust and communication model for use cases, such as energy management, new building commissioning, feedback control. (Y1; updated in Y2)
- Implement low-level NDN applications, such as energy management data gathering. (Y1)
- Preliminary embedded platform support. (Y2)
- Integrate “live” UCLA building data into the NDN testbed, mirroring data from 10-20 UCLA buildings. (Y2)
- Implement high-level NDN application for enterprise building monitoring, based on the above data, applying distributed 3D visualization work done in the first FIA project. (Y2)

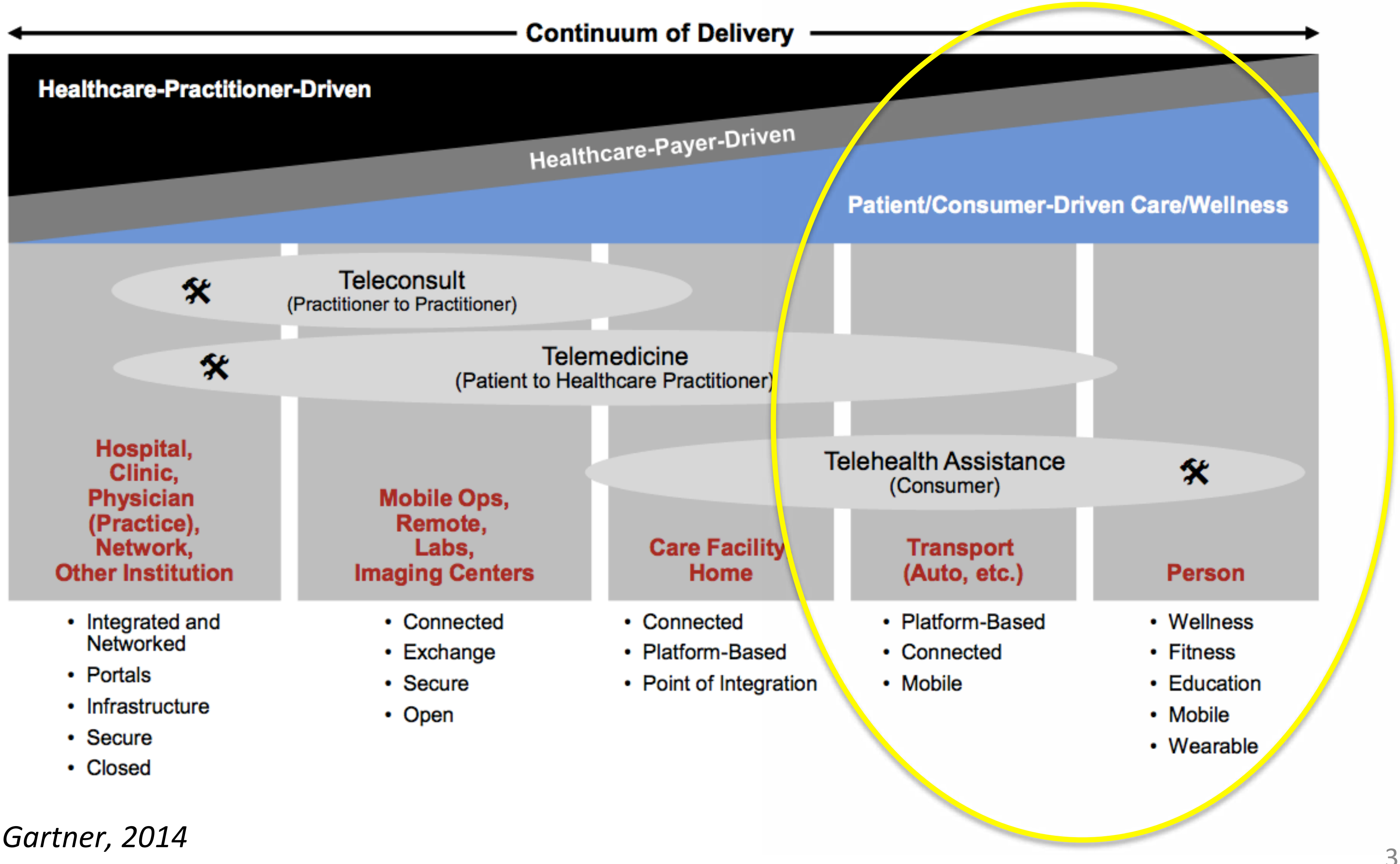
# OPEN MHEALTH

# **Open mHealth**: Motivation

- Mobile health (mHealth) has emerged as both an important commercial market and a key area of Health IT, a national priority.
- The 2013 mHealth Summit will host over 4,500 participants. Recent surveys suggest there are over 13,000 health-related apps available to Apple iPhone users, and over 6000 for Android users.
- The Internet's role as a critical enabler of mHealth will grow further over the next decade.
- Continuation of our "participatory sensing" application; motivation of NDN library support for mobile handsets.

# Our focus within "mobile health"

For NP, focusing on aspects of mHealth that can have significant impact but do not rely on integration with EHRs / HIPAA-compliant systems for initial success.



*Gartner, 2014*

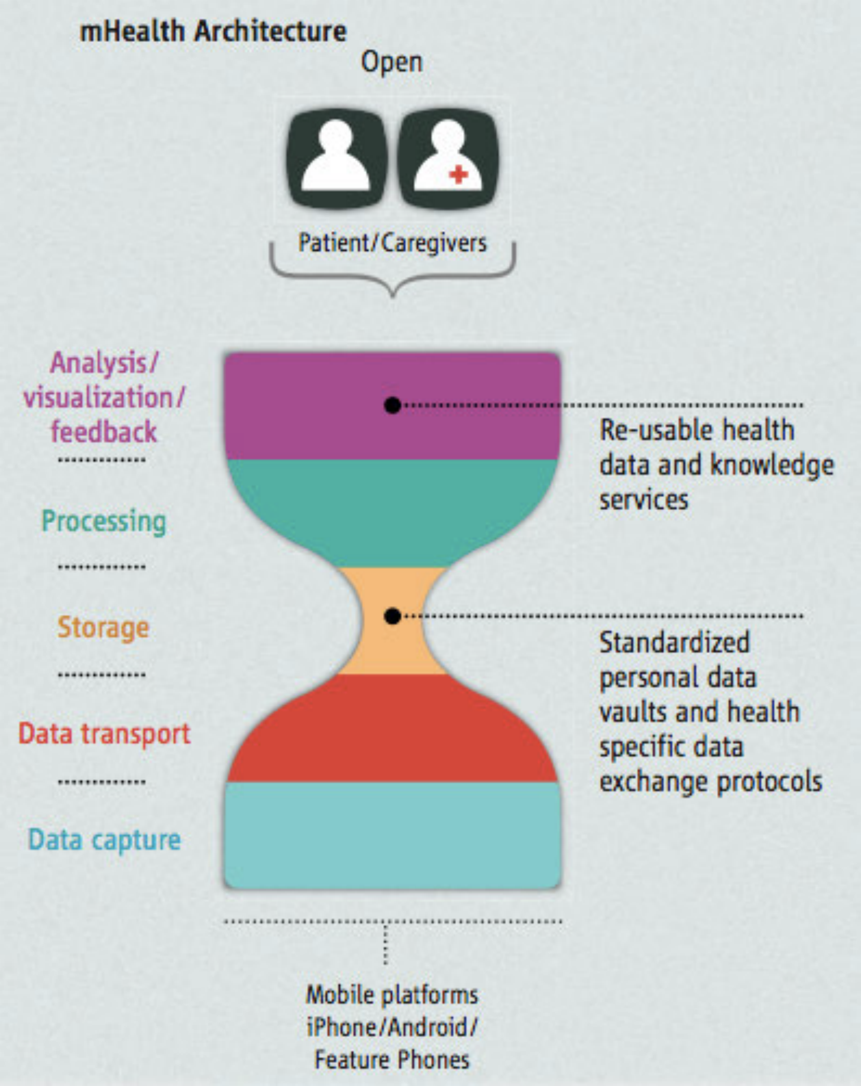
# mHealth Reality Check

- Are your systems interoperable?
  - Estrin & Sim in *Science*, 2010. *Open mHealth*.
- Are you using open standards?
  - WHO, 2013. *eHealth unit.*
- How will you evaluate?
  - Greenhalgh et al. in BMC Med Res. Methodology, 2011. *Realist and meta-narrative evidence synthesis*.

PLOS Medicine Editors. "A reality checkpoint for mobile health: three challenges to overcome." *PLoS Medicine* 10.2 (2013).

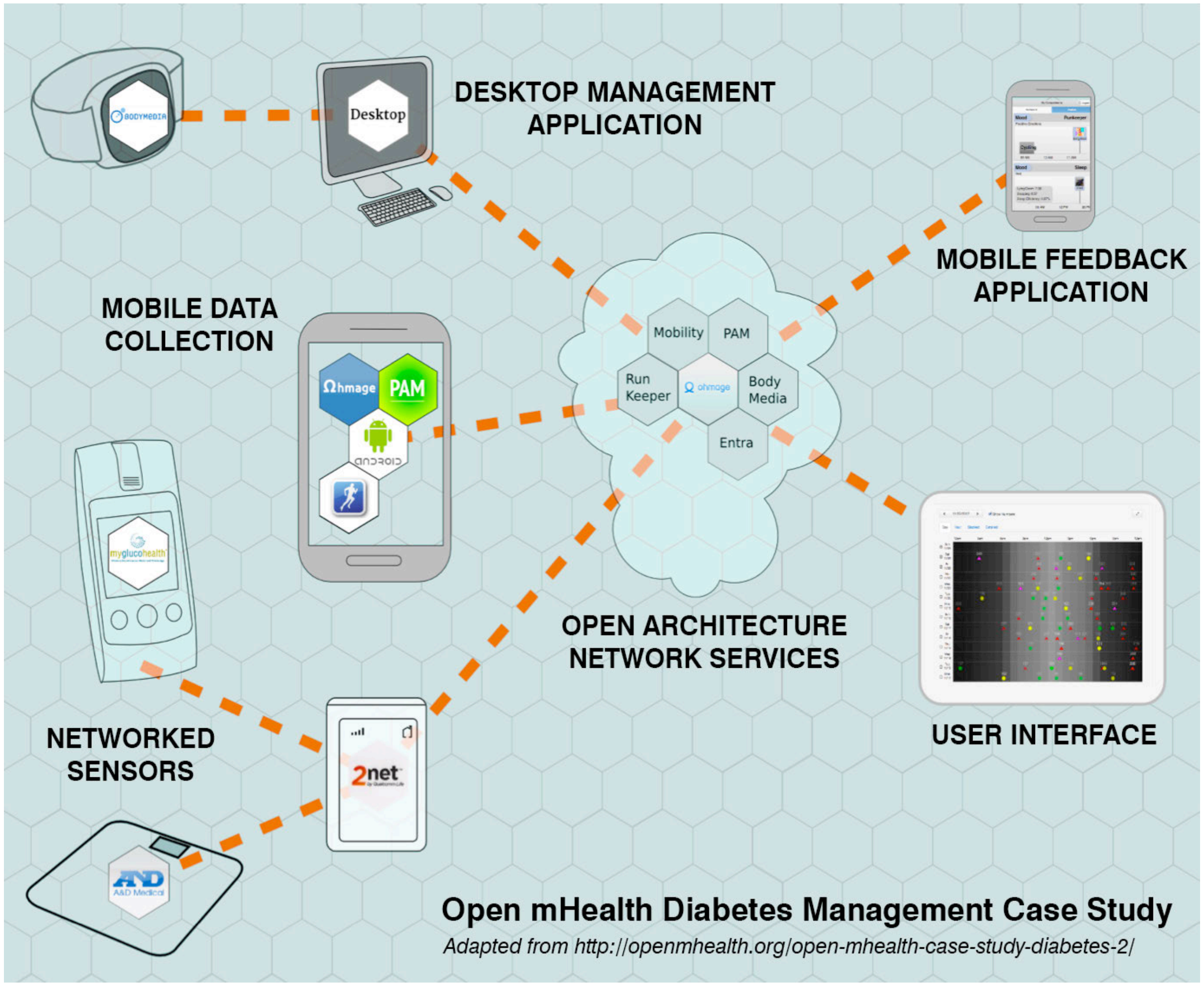
# **Open mHealth**:
# Data rather than System Interoperability

- 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


mHealth Architecture
Open
Patient/Caregivers
Analysis/visualization/feedback
Processing
Storage
Data transport
Data capture
Re-usable health data and knowledge services
Standardized personal data vaults and health specific data exchange protocols
Mobile platforms iPhone/Android/Feature Phones

D. Estrin (Cornell), I. Sim (UCSF)

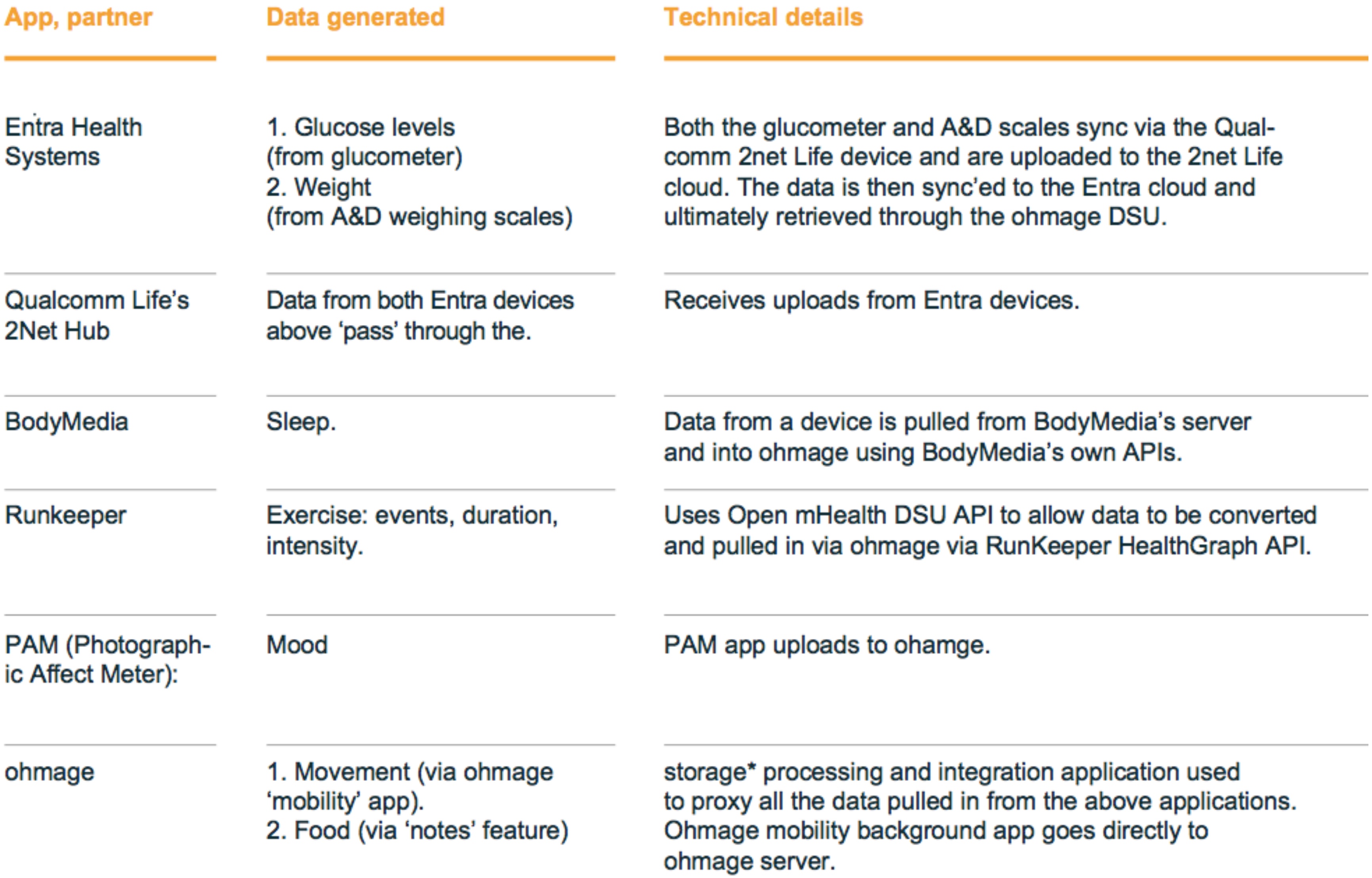
# **Open mHealth**: Approach



Open mHealth Diabetes Management Case Study

*Adapted from http://openmhealth.org/open-mhealth-case-study-diabetes-2/*

# Diabetes Mgmt Use Case



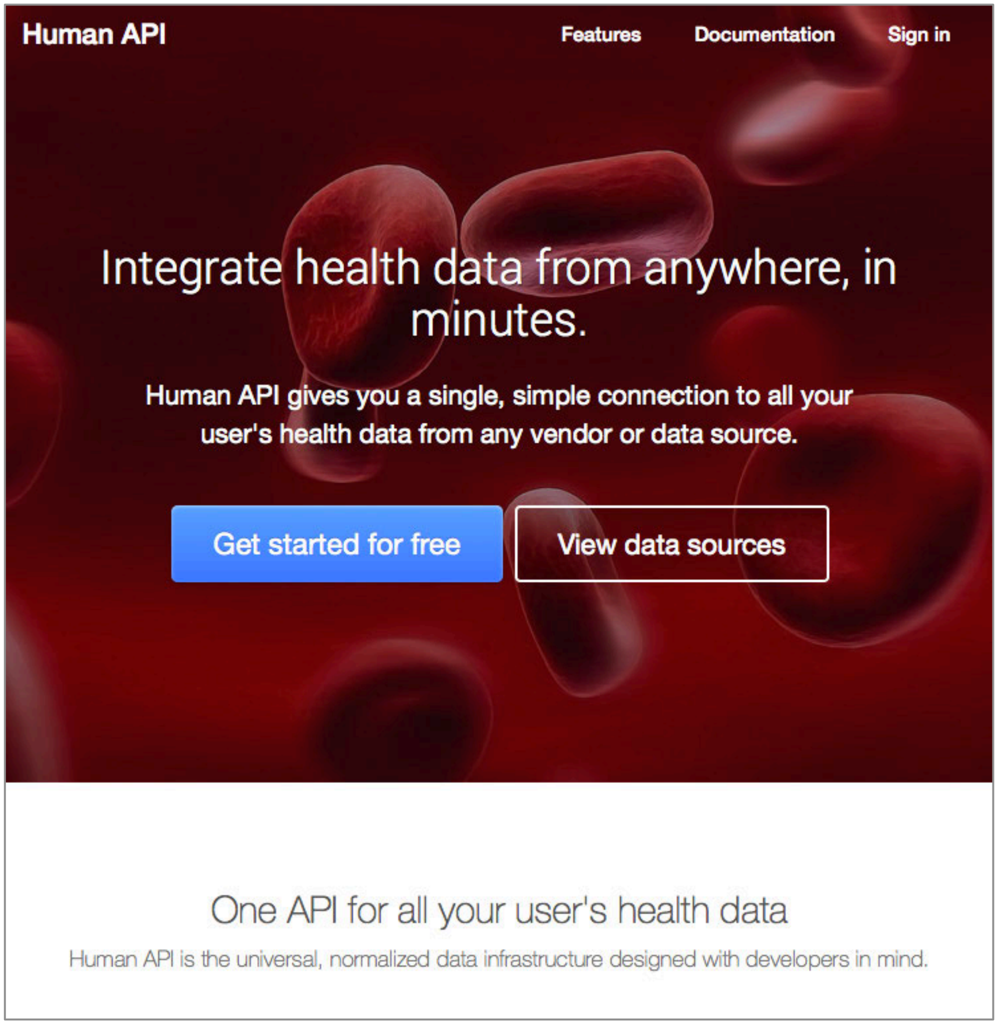
| App, partner | Data generated | Technical details |
|---|---|---|
| Entra Health Systems | 1. Glucose levels (from glucometer)<br>2. Weight (from A&D weighing scales) | Both the glucometer and A&D scales sync via the Qualcomm 2net Life device and are uploaded to the 2net Life cloud. The data is then sync'ed to the Entra cloud and ultimately retrieved through the ohmage DSU. |
| Qualcomm Life's 2Net Hub | Data from both Entra devices above 'pass' through the. | Receives uploads from Entra devices. |
| BodyMedia | Sleep. | Data from a device is pulled from BodyMedia's server and into ohmage using BodyMedia's own APIs. |
| Runkeeper | Exercise: events, duration, intensity. | Uses Open mHealth DSU API to allow data to be converted and pulled in via ohmage via RunKeeper HealthGraph API. |
| PAM (Photographic Affect Meter): | Mood | PAM app uploads to ohamge. |
| ohmage | 1. Movement (via ohmage 'mobility' app).<br>2. Food (via 'notes' feature) | storage* processing and integration application used to proxy all the data pulled in from the above applications. Ohmage mobility background app goes directly to ohmage server. |

# Diabetes Mgmt Use Case - Impact

- Self-learning
- Increased accountability
- Improved sensitivity to hypoglycemic symptoms
- Increased sense of safety
- More informed decision making

# Other examples

- HumanAPI
  - Also OAuth 2.0
  - Apparently similar objectives to Open mHealth
- Ginger.io
  - Platform for predictive modeling



Integrate health data from anywhere, in minutes.

Human API gives you a single, simple connection to all your user's health data from any vendor or data source.

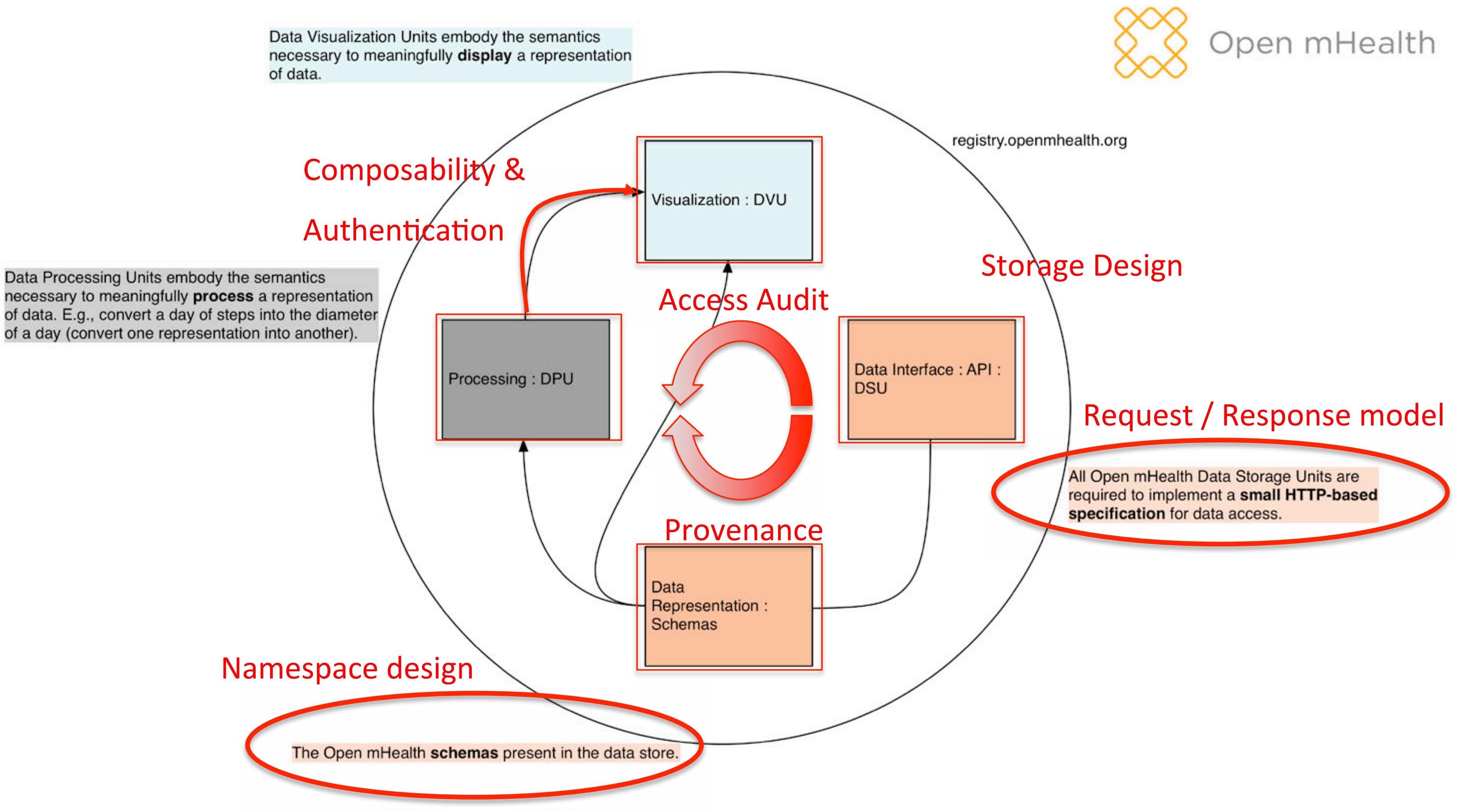
One API for all your user's health data

Human API is the universal, normalized data infrastructure designed with developers in mind.

# Related Prior Work

- **Personal Data Vault** – NDN Annual Report 2011-2012.
- **Self-surveillance privacy**. J. Kang, K. Shilton, D. Estrin, J. Burke and M. Hansen. *Iowa Law Rev.* 97 (2011): 809.
- **Open mHealth architecture: an engine for health care innovation.** Estrin, D., and Sim. I. *Science(Washington)* 330.6005 (2010): 759-760.
- **PEIR, the personal environmental impact report, as a platform for participatory sensing systems research**. Mun, M., Reddy, S., Shilton, K., Yau, N., Burke, J., Estrin, D., ... & Boda, P. (2009, June). Proc. ACM Mobisys 2009.

# Mapping the Open mHealth Architecture to NDN



Data Visualization Units embody the semantics necessary to meaningfully **display** a representation of data.

Data Processing Units embody the semantics necessary to meaningfully **process** a representation of data. E.g., convert a day of steps into the diameter of a day (convert one representation into another).

All Open mHealth Data Storage Units are required to implement a **small HTTP-based specification** for data access.

The Open mHealth **schemas** present in the data store.

Composability & Authentication

Access Audit

Storage Design

Request / Response model

Provenance

Namespace design

http://openmhealth.org/

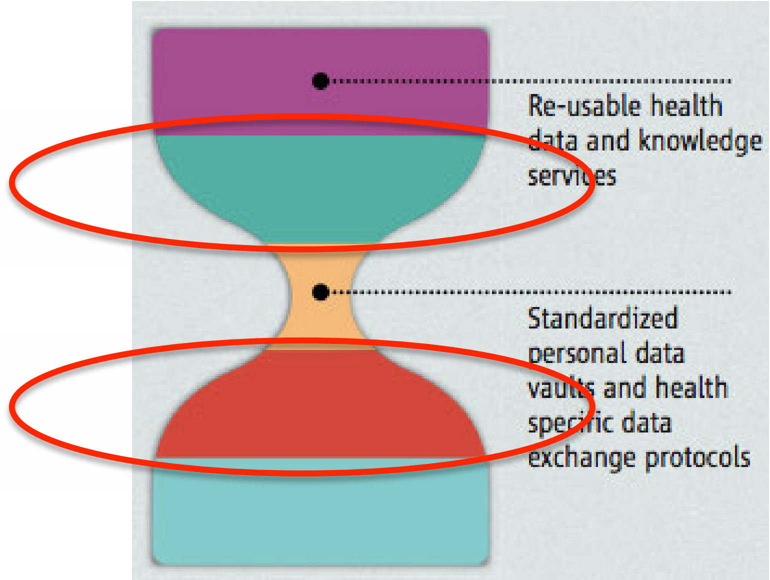
# Same Challenges, Different Layers

*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.*

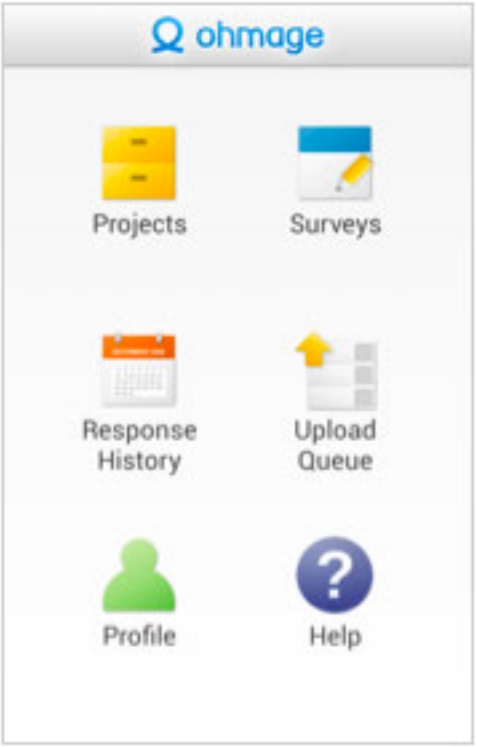
- Namespace / schema design
- Repository / storage design
- Service composability
- Authentication / identity assurance
- Data provenance
- Access auditing
- Mobile publishing
- Legal requirements for success

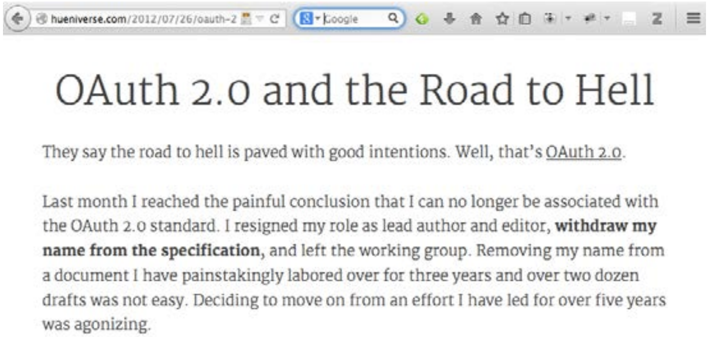
*Open mHealth arch. looks a lot like NDN*


Re-usable health data and knowledge services
Standardized personal data vaults and health specific data exchange protocols

# Ohmage: Reference Application

- Plan to create/port a mobile client for the Ohmage reference platform, which currently incorporates:
  - Mobile application
  - LAMP stack back-end
  - REST communication
- Key pain point is OAuth 2.0: Implementation relies on this – doesn't scale to the DPU model and has numerous problems.  Quickly identified by Open mHealth lead architect as a primary challenge.
- Same approach (apparently) used in Human API mentioned earlier.



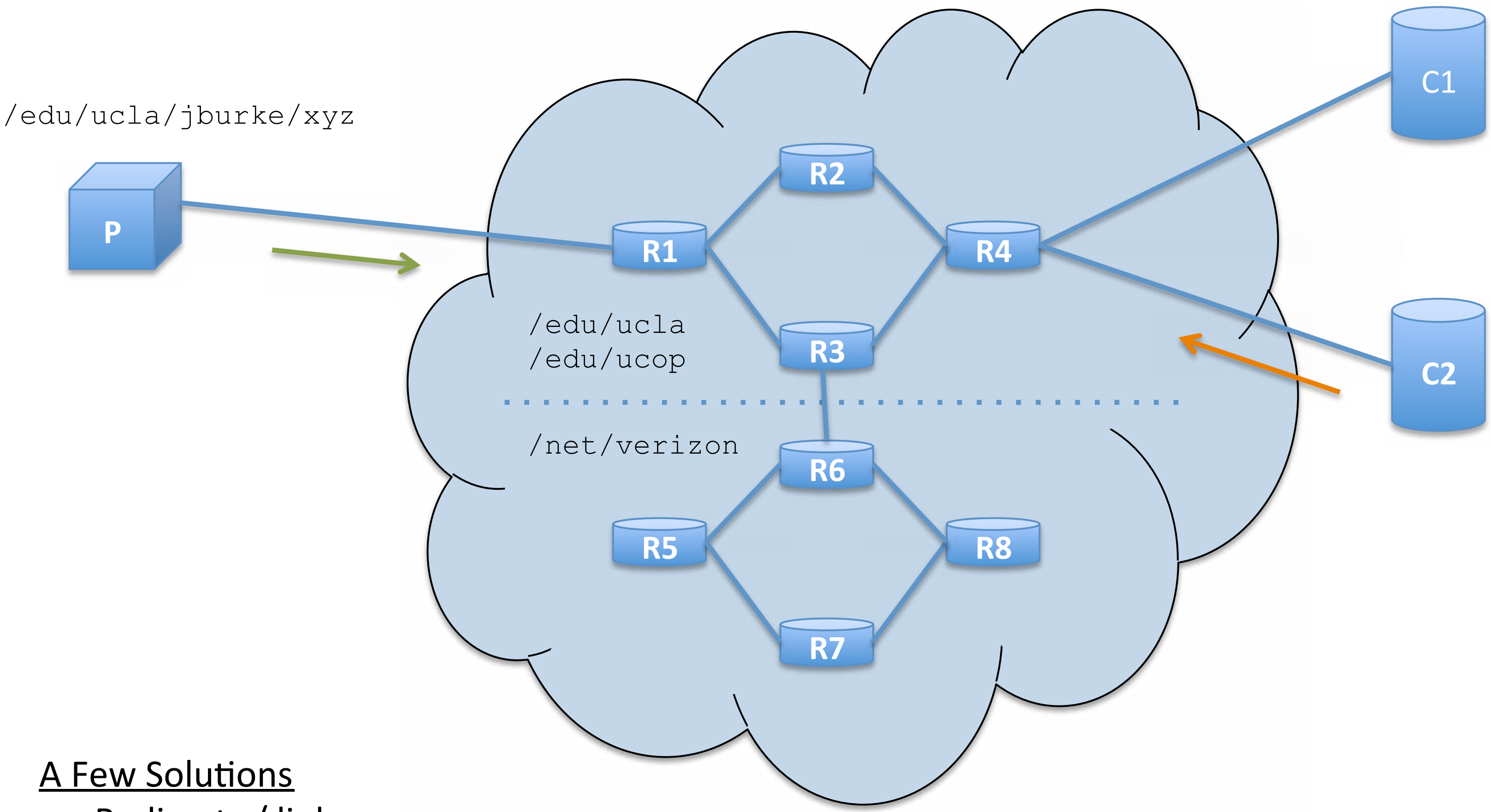


OAuth 2.0 and the Road to Hell

They say the road to hell is paved with good intentions. Well, that's OAuth 2.0.

Last month I reached the painful conclusion that I can no longer be associated with the OAuth 2.0 standard. I resigned my role as lead author and editor, **withdraw my name from the specification**, and left the working group. Removing my name from a document I have painstakingly labored over for three years and over two dozen drafts was not easy. Deciding to move on from an effort I have led for over five years was agonizing.

# Mobile publishing



A Few Solutions

- Redirects / links
- Home repo(s) republish
- Registration in multiple locations

# NDN – Suitability / Benefits

- **Open mHealth already focuses on named data as the "thin waist" of interoperability.**
- **Data-centric security** a good match, and could be a major improvement over a current pain point – OAuth, in terms of ease of development and overall security.
- **Distributed storage** is straightforward to implement. Could drive a new **data-diffusion focused model** for this application.
- **Reduction in overhead** for request-response architecture should be useful given that many apps are always running on a variety of types of devices.
- Intrinsic **disruption tolerance and multi-path support** are a good fit for mobile devices if challenges of mobile publishing can be addressed.

# **Open mHealth**: Initial Research

- Naming and application design
  - Translate existing REST-based approach? How quickly to move to a new model of data exchange where transactions are mostly about (for example) keys.
  - What schema? Initially, try direct mapping of Open mHealth schema to names
  - Borrow ideas from Named Function Networking concept for distributed processing
  - How to best handle mobile publishing?
- Trust and security
  - Replacing Oauth2 for distributed processing is critical
  - Data encryption requirements
  - Name privacy issues
- Storage in the network
  - Interaction of personal and shared stores
  - Support for mobile publishing
  - Data filtering at the repo?
  - New legal / economic relationship between the players

# **Open mHealth**: Proposed Milestones

- Review limitations in current IP-based architecture for Open mHealth needs. (Y1)
- Design namespace, repository, trust and communication model for use cases, e.g., diabetes or PTSD treatment (Y1; updated in Y2)
- Repository implementation providing backing storage for prototype applications. (Y1)
- Integrate named data networking into the Ohmage mobile data collection framework. (Y2)
- Pilot user-facing application using NDN, for beta testing by Open mHealth project team. (Y2)

# Named Data Networking “Next Phase”

Network Environments

FIA-NP PI Meeting

May 19, 2014