

# Health Data from the (Consumer) Edge

## **Open mHealth over NDN**

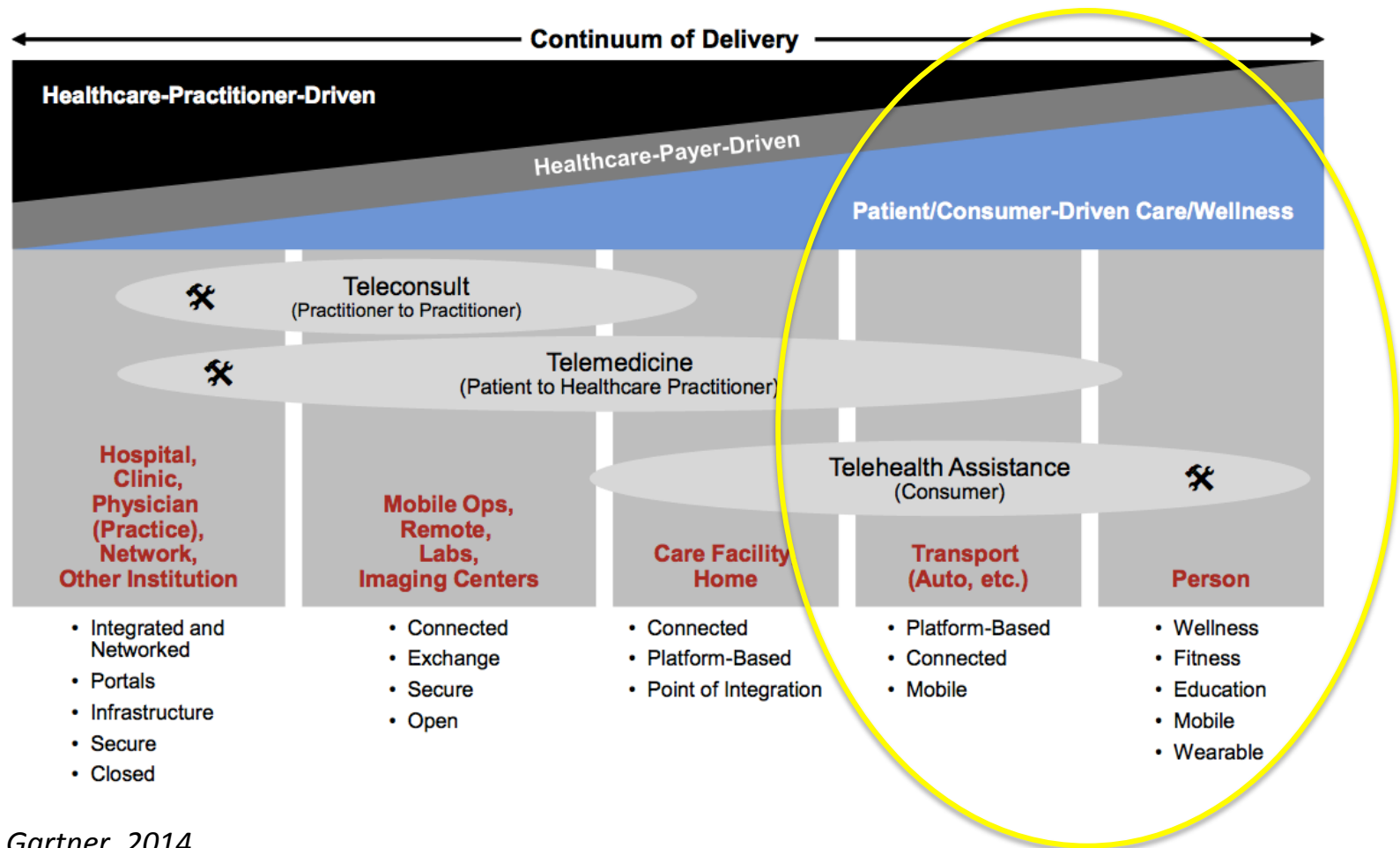
NDNComm 2014 – September 5, 2014

Jeff Burke <jburke@ucla.edu>



# NDN focus within “mobile health”

Consumer-facing mHealth applications can have significant impact but do not rely on integration with EHRs / HIPAA-compliant systems for initial success.

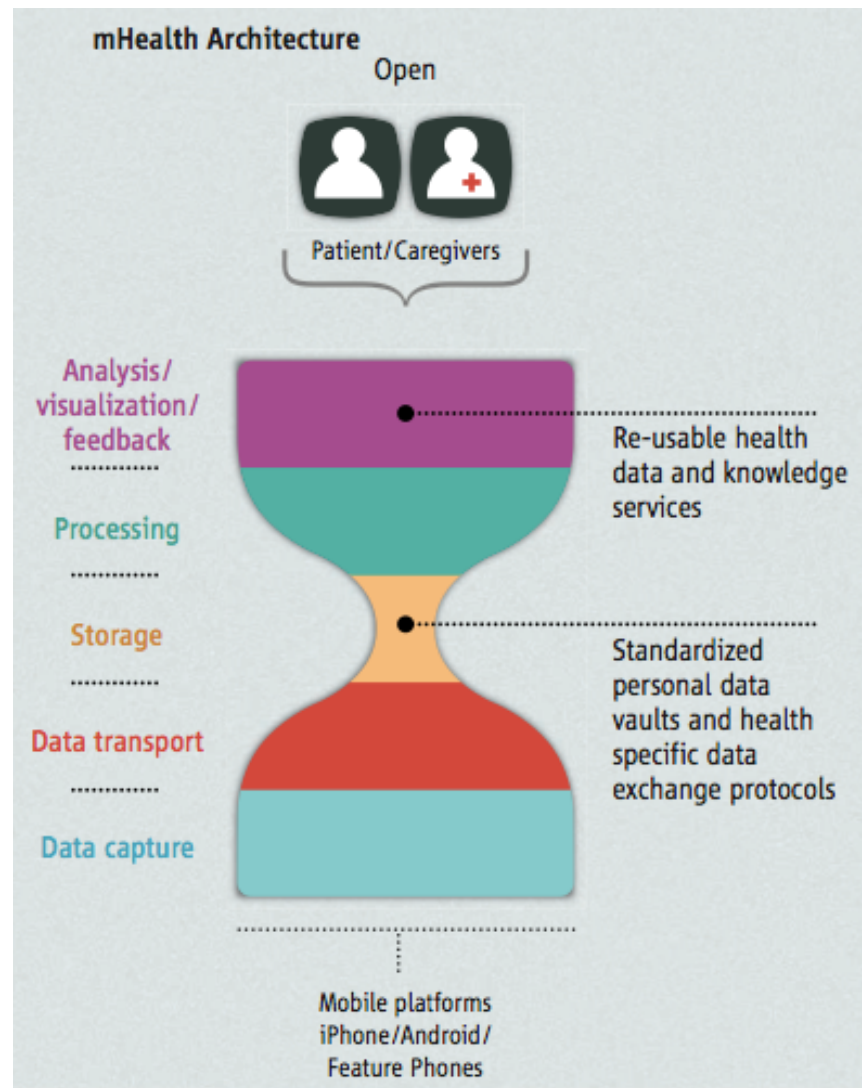


# Open mHealth: Approach

- **Leveraging the public's everyday mobile devices (cell phones, tablets, etc.) to extend evidence-based interventions** beyond the reach of traditional care and thereby improve disease management and prevention.
- e.g.: pre- and post-natal care of mothers; diabetes; everyday activity in stroke patients and others with chronic disease; and community exposure to environmental pollutants.
- Collaborators: Open mHealth project led by Deborah Estrin (Cornell) and Ida Sim (UC San Francisco).

# Open mHealth Fundamental Idea: 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



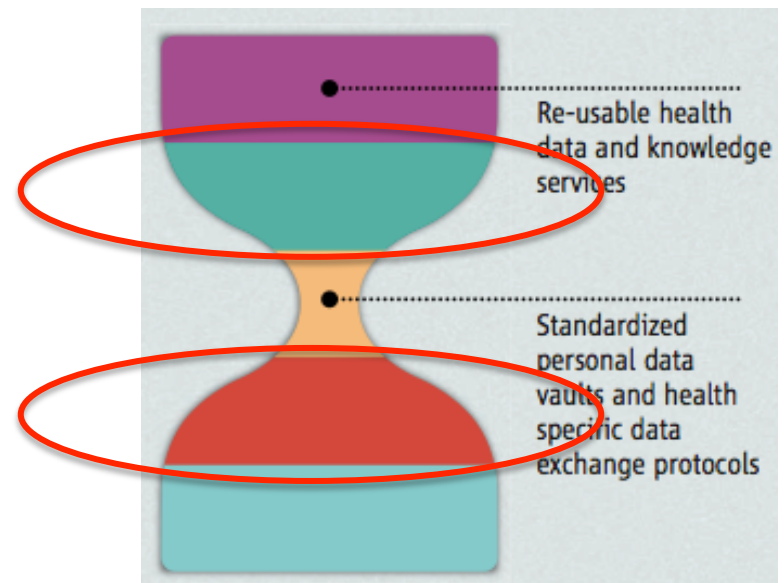
# Same Challenges, Different Layers

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

Thus, **solutions in the architecture have 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 (bottom-up)
- 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*



# NDN – Suitability / Benefits

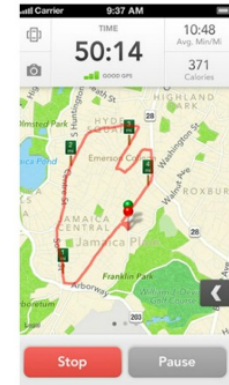
- **Open mHealth already focuses on named data as the “thin waist” of interoperability.**
- **Data-centric security** a good match, and could be a major improvement over a current pain point – OAuth, in terms of ease of development and overall security.
- **Distributed storage** is straightforward to 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.



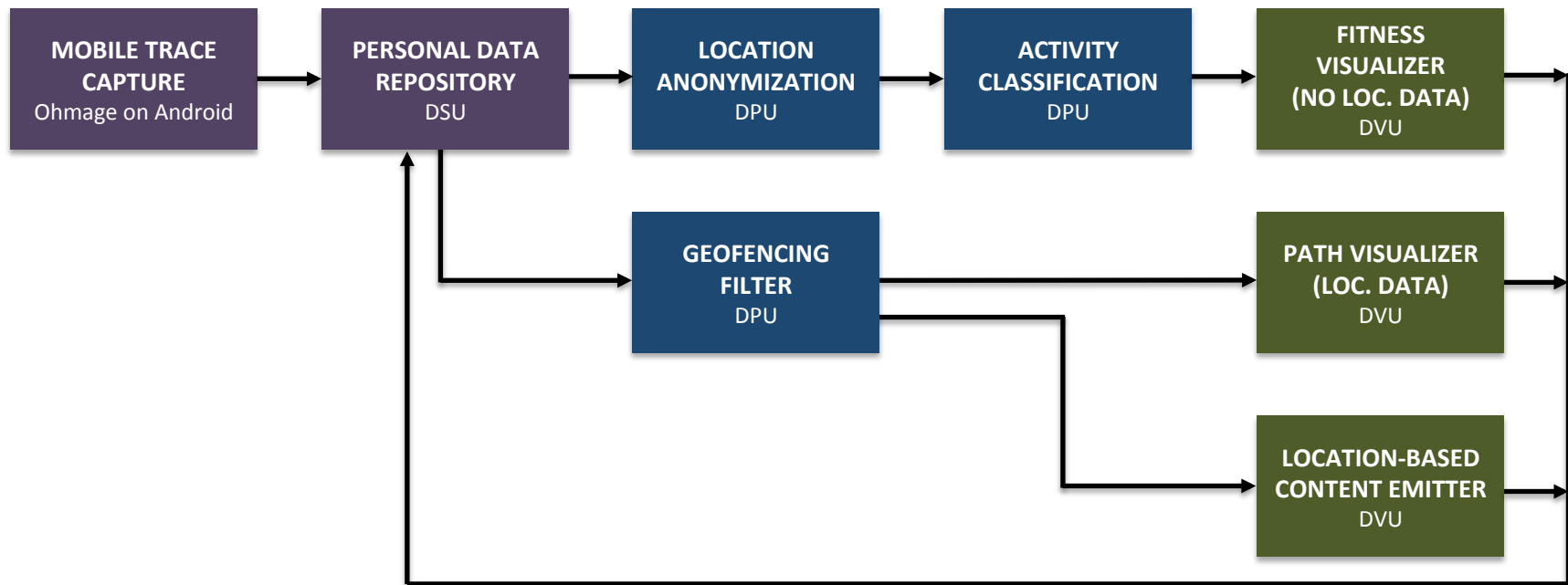
## 2014 Open mHealth Driver Application

# NDNEx - Physical Activity Data Ecosystem

- Supporting physical activity is both a critical part of building healthy communities and a key retail market.
- For NDN-NP in 2014, explore a **non-proprietary ecosystem for consumer physical activity data**.
- Start with **end-user mobile+web application** that captures and reports walking, jogging, and running activity.
- Calculate and report activity metrics based on GPS and accelerometer data – both automatically and self-identified rounds of exercise.
- Capable of location-based content “push” during the exercise, which can be used for health, entertainment, local, and team-related content.
- Envisioned as an open-data ecosystem.



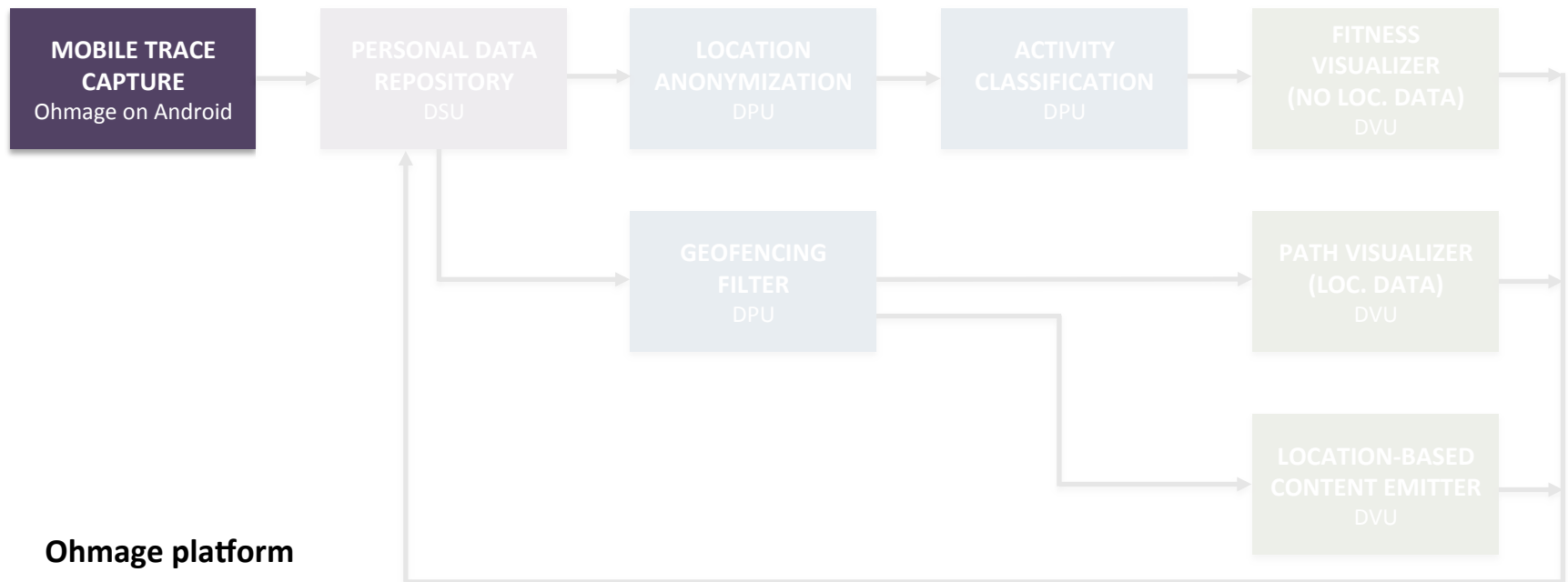
# Conceptual Block Diagram: Data Flow



Data flow for a single user who gets 1) fitness / activity metrics, 2) walking or running path visualizations, and 3) location-based content during exercise – all through the same ecosystem, but from different providers.



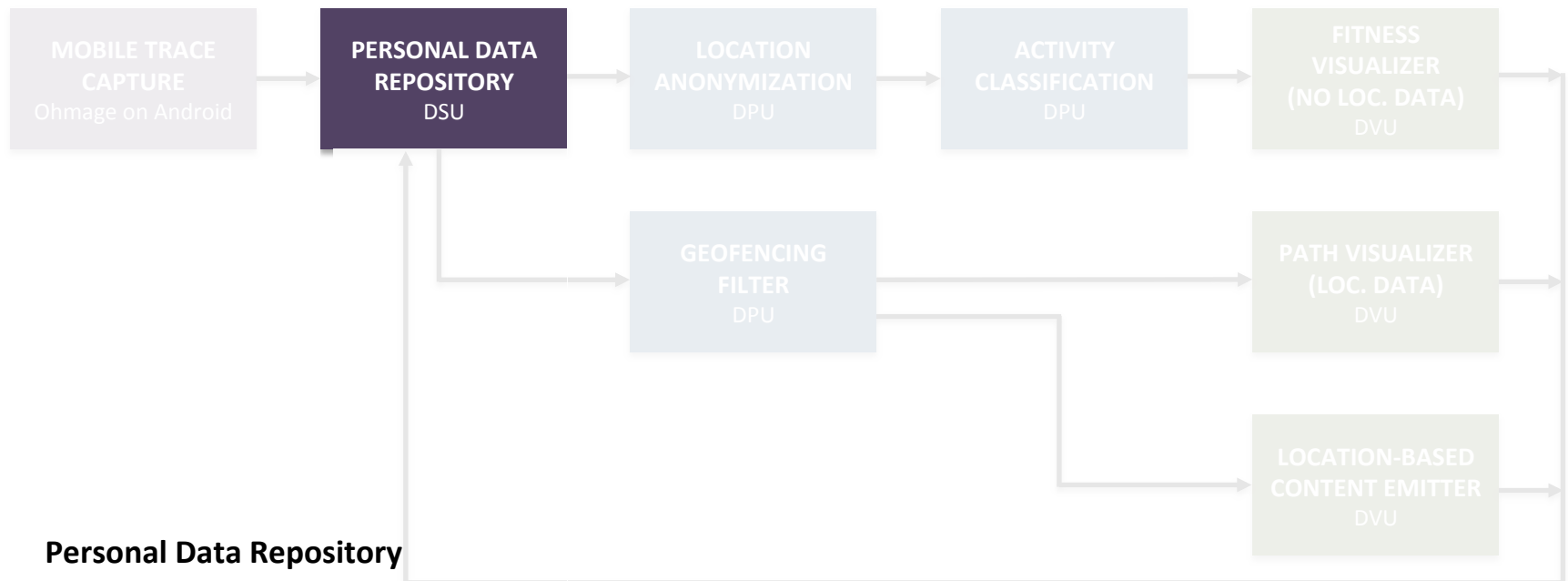
# Conceptual Block Diagram: Data Flow



## Ohmage platform

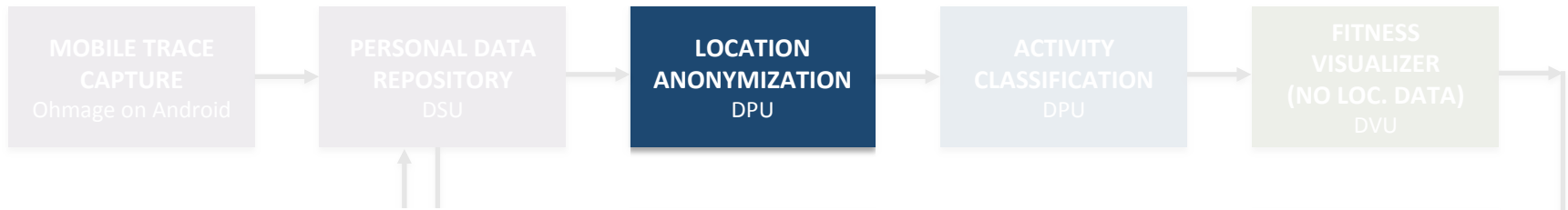
- <http://ohmage.org/>
- Tangmunarunkit, H., et al. "Ohmage: A General and Extensible End-to-End Participatory Sensing Platform." *In submission*. <http://ohmage.org/static/ohmagehome/papers/ohmage.pdf>

# Conceptual Block Diagram: Data Flow



- Kang, J., Shilton, K., Estrin, D., Burke, J. "Self-surveillance privacy." *Iowa L. Rev.* 97 (2011): 809. <http://escholarship.org/uc/item/1jk8b2q1.pdf>
- Mun, Min, et al. "Personal data vaults: a locus of control for personal data streams." *Proceedings of the 6th International Conference*. ACM, 2010. <http://remap.ucla.edu/jburke/publications/Mun-et-al-2010-Personal-Data-Vaults.pdf>

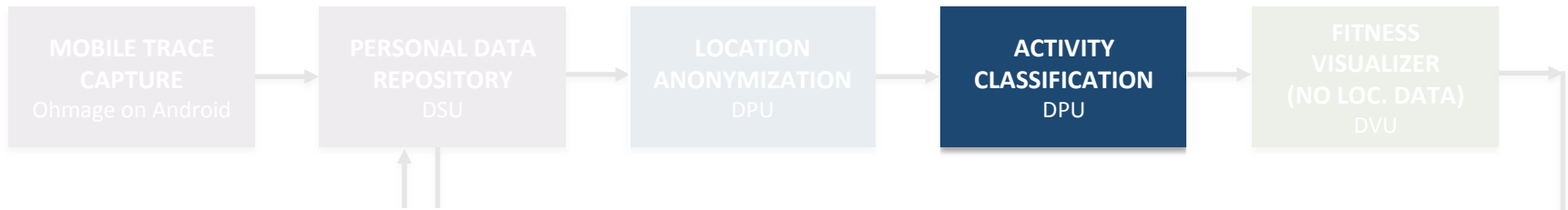
# Conceptual Block Diagram: Data Flow



## Location Anonymization

- Avoid providing specific location information to services that do not need it. Range of techniques from the simple, which may be used here, to the more sophisticated.
- Krumm, John. "A survey of computational location privacy." *Personal and Ubiquitous Computing* 13.6 (2009): 391-399.  
<http://msr-waypoint.com/en-us/um/people/jckrumm/Publications%202008/computational%20location%20privacy%20preprint.pdf>
- Xu, Toby, and Ying Cai. "Location anonymity in continuous location-based services." *Proceedings of the 15th annual ACM international symposium on Advances in geographic information systems*. ACM, 2007.  
<http://lbsstorage.googlecode.com/svn/trunk/Location-based%20Services/3.1%20Anonymity%20based%20defense/%5B21%5DLocation%20anonymity%20in%20continuous%20location-based%20services.pdf>
- Zang, Hui, and Jean Bolot. "Anonymization of location data does not work: A large-scale measurement study." *Proceedings of the 17th annual international conference on Mobile computing and networking*. ACM, 2011. <https://research.sprintlabs.com/publications/uploads/mobi13k-zang.pdf>

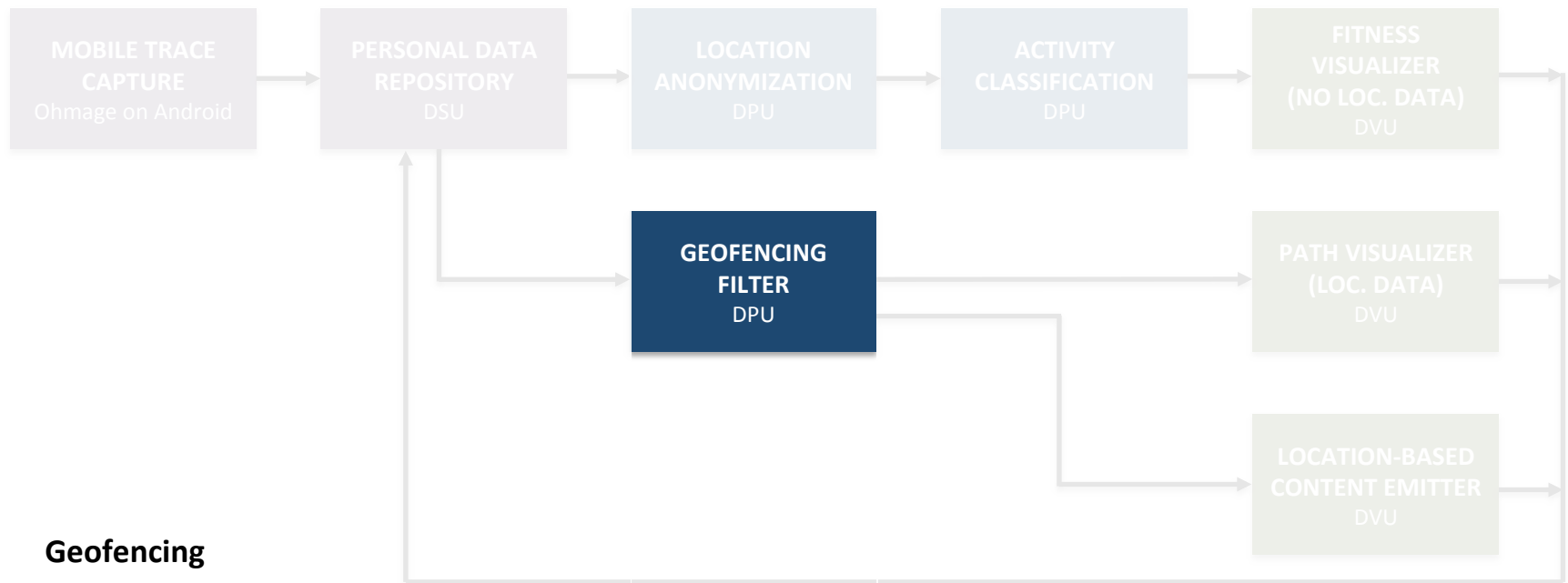
# Conceptual Block Diagram: Data Flow



## Activity Classification

- Generate classified / tagged location data, or simply activity streams based on GPS and accelerometer data.
- Some classification currently built-in to the Ohmage Mobility utility on the mobile device: <http://ohmage.org/static/ohmagehome/docs/Mobility%20tech%20report%20%28dec%202013%20v2%29.pdf>
- Hsieh, Cheng-Kang, et al. "Lifestreams: a modular sense-making toolset for identifying important patterns from everyday life." *Proceedings of the 11th ACM Conference on Embedded Networked Sensor Systems*. ACM, 2013. <https://www.dropbox.com/s/l0721457faswj5k/a5-hsieh.pdf>
- Longstaff, Brent, Sasank Reddy, and Deborah Estrin. "Improving activity classification for health applications on mobile devices using active and semi-supervised learning." *Pervasive Computing Technologies for Healthcare (PervasiveHealth), 2010 4th International Conference on-NO PERMISSIONS*. IEEE, 2010. <http://research.cens.ucla.edu/people/estrin/resources/conferences/2010-mar-Longstaff.pdf>

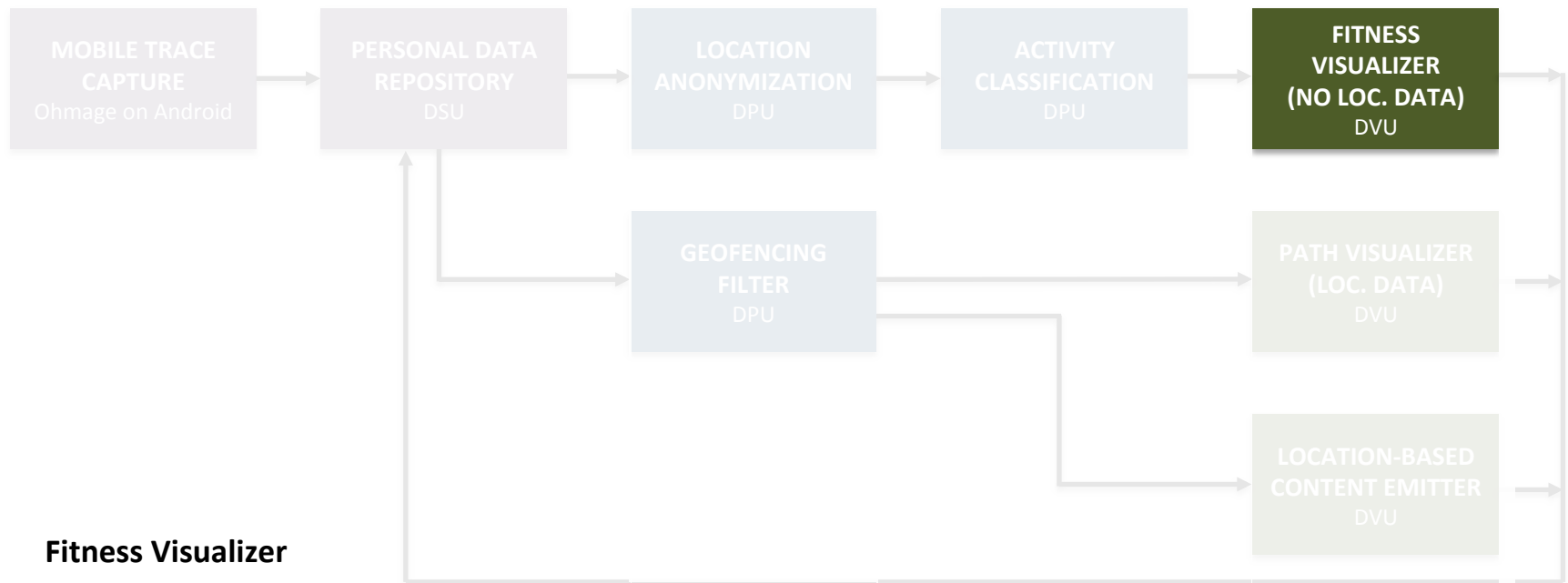
# Conceptual Block Diagram: Data Flow



## Geofencing

- Prevent service activation / data access outside of a location boundary.
- Implemented as (transparent) post-processor on raw location data.

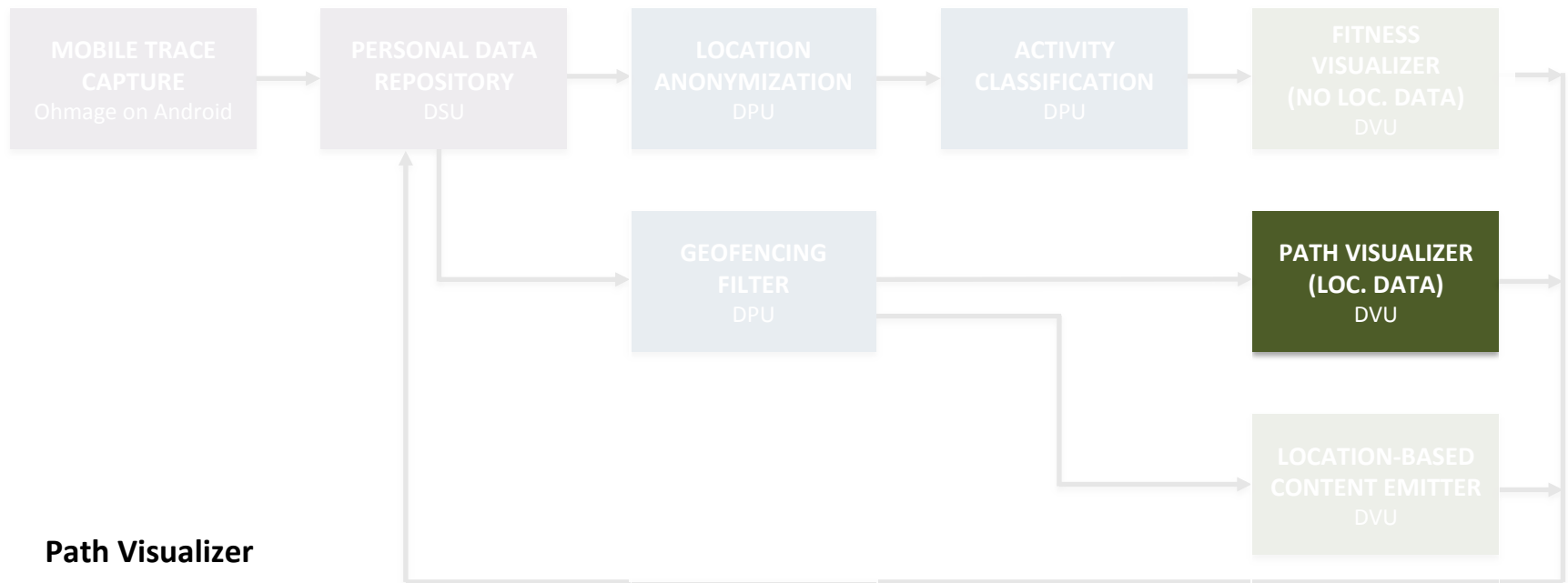
# Conceptual Block Diagram: Data Flow



## Fitness Visualizer

- Start with Ohmage front end (see previous slides).
- Web-based front end using NDN-JS to access derived data without location information.
- Examples: <http://quantifiedself.com/fitbit/>

# Conceptual Block Diagram: Data Flow

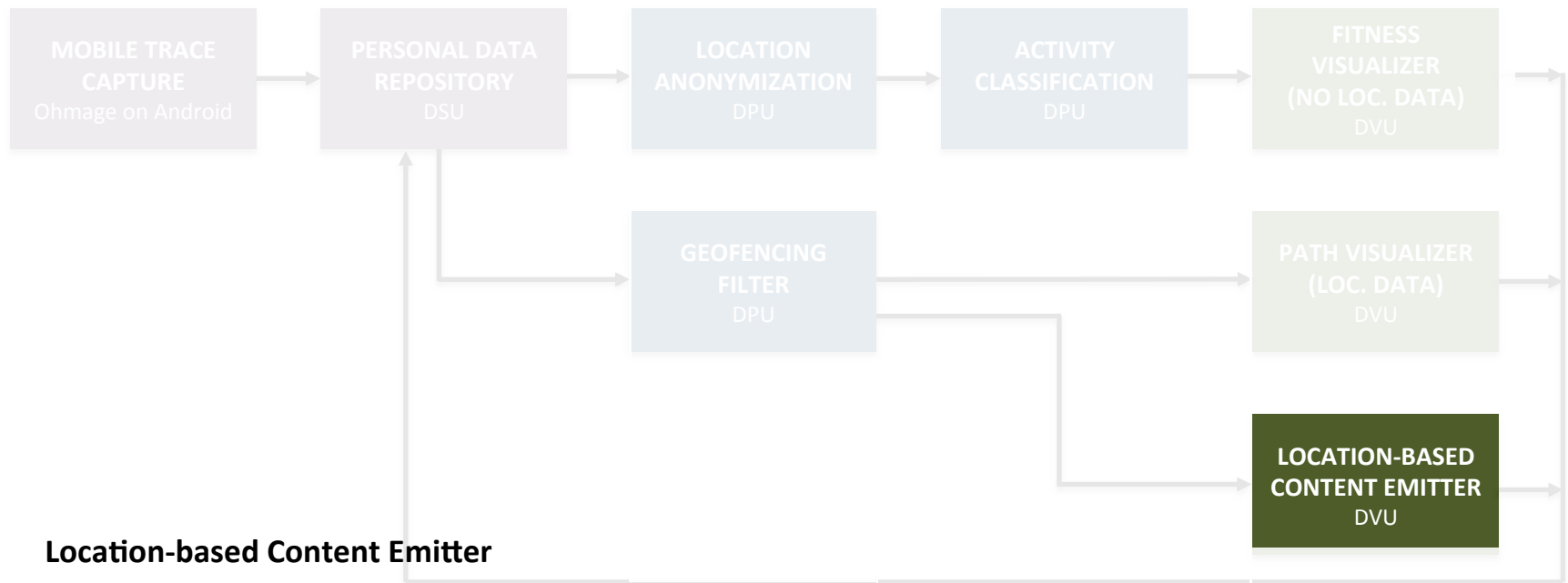


## Path Visualizer

- Web-based front end using NDN-JS with access to geofenced location information, providing (for example) running trail visualization.
- Perhaps use many GPX format visualizers. E.g., <http://flowingdata.com/2014/02/05/where-people-run/>



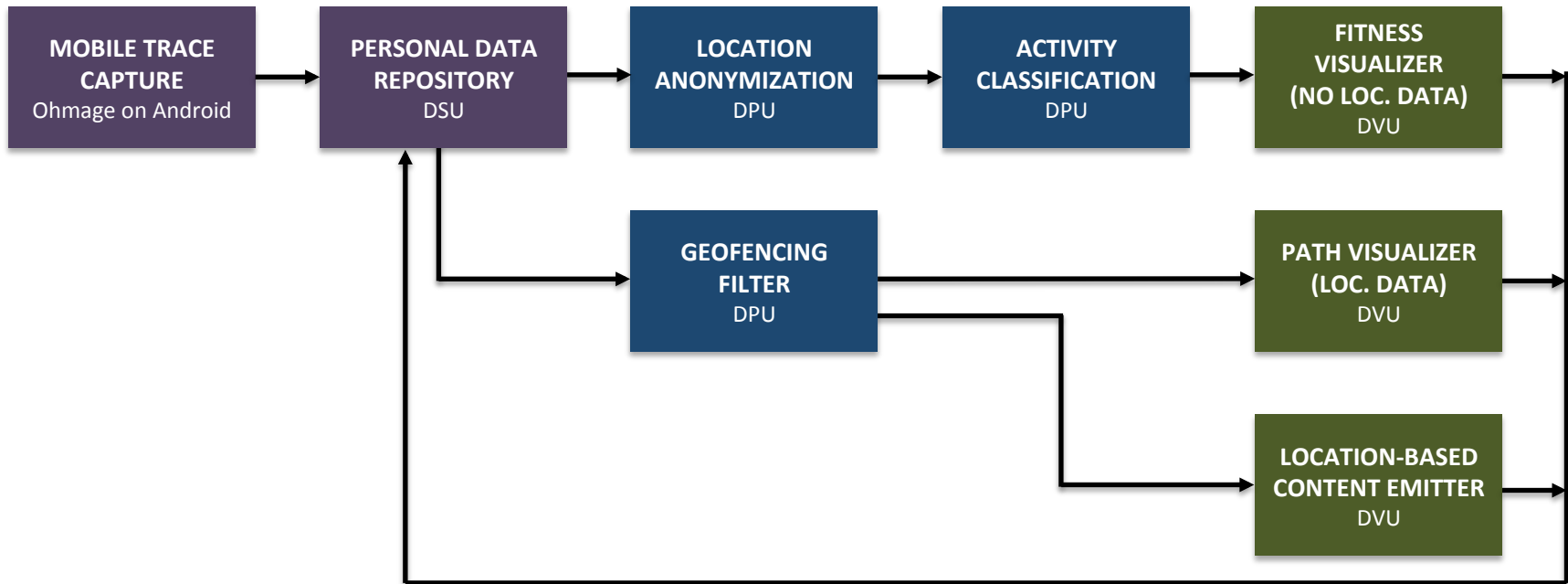
# Conceptual Block Diagram: Data Flow



## Location-based Content Emitter

- Web-based front end using NDN-JS with access to geofenced location information, providing location-specific content back to the mobile user.

# Collaboration: Join us



## The NDN-NP Campuses

Euihyun Jung, Anyang University

Dan Pei, Tsinghua University

Christian Tschudin, University of Basel

*\* Looking for a postdoc!*

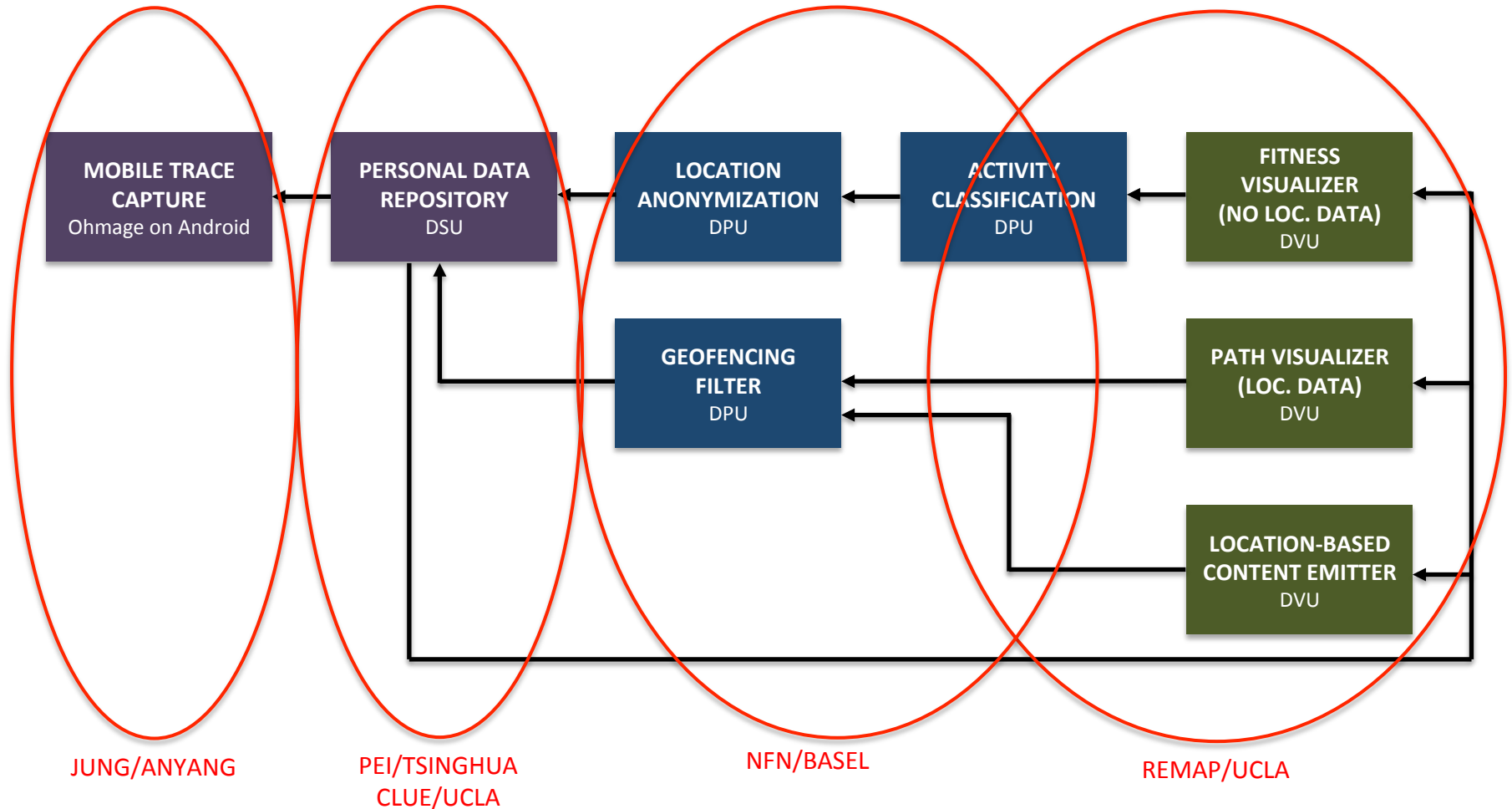
## Topics

Naming and application design

Trust and security

Storage in the network

# Possible Collaborative Approach??



## CROSS-CUTTING

DATA NAMESPACE DESIGN – INITIATED BY UCLA

TRUST / SECURITY DESIGN – U. MICHIGAN AND UCLA

# Intersection with “Values in Design”

**New NeTS-Small 2014-2017**, PI: Katie Shilton, University of Maryland

## *From Intentional to Enacted Values in a Future Internet Architecture*

- How will the NDN application choices reaffirm or reshape values in the NDN architecture?
- How do values embedded in architecture become enacted in application design and use?
- What social issues are bound up in NDN technical problems?
- How can values-in-design perspectives help solve these technical problems?
- What interventions and strategies encourage values conversations within the technical work of infrastructure design?

Focus on four technical challenges: **naming**, **trust management**, congestion management, and **evaluation** metrics.

# 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).