ICE-AR: ICN-Enabled Secure Edge Networking with Augmented Reality

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What is AR (VR/XR)

- Most AR/VR prototypes by industry today tend to be siloed applications

- ICE-AR: AR equivalent to the web as a platform, over which a variety of apps can flourish

AR as a Web of Distributed Content

- Exploration-oriented perspective, for browsing connections between content

- Vision of a (decentralized) data web integrated with physical world, supported by edge-fog-cloud components.

- Sessions replaced by multi-party context-content exchange.

- Many entry (rendezvous) points into content navigation – brand, location, etc..

- Common services expressed as data-centric protocols

- Security and consistent user experience (HCI) challenging.

How to manage proliferation of entry points and trust models?

- *Slow start:* start with simple representative scenarios, address encountered research problems as we go along

How NDN helps AR/VR/XR

- Integration of heterogeneous *low-level wireless technologies* with *domain-specific acceleration* as a service.

- Support *many-to-many* edge communications over potentially ad hoc, intermittent, and/or DTN-style connectivity

- Management of identities and trust relations in dense deployments in large campus networks of the future where content can be generated by any/all edge devices.

Phase 1 sketch

Real time object recognition in the loop of AR.

Edge-supported "context".

https://vimeo.com/236001763/c9d5583175
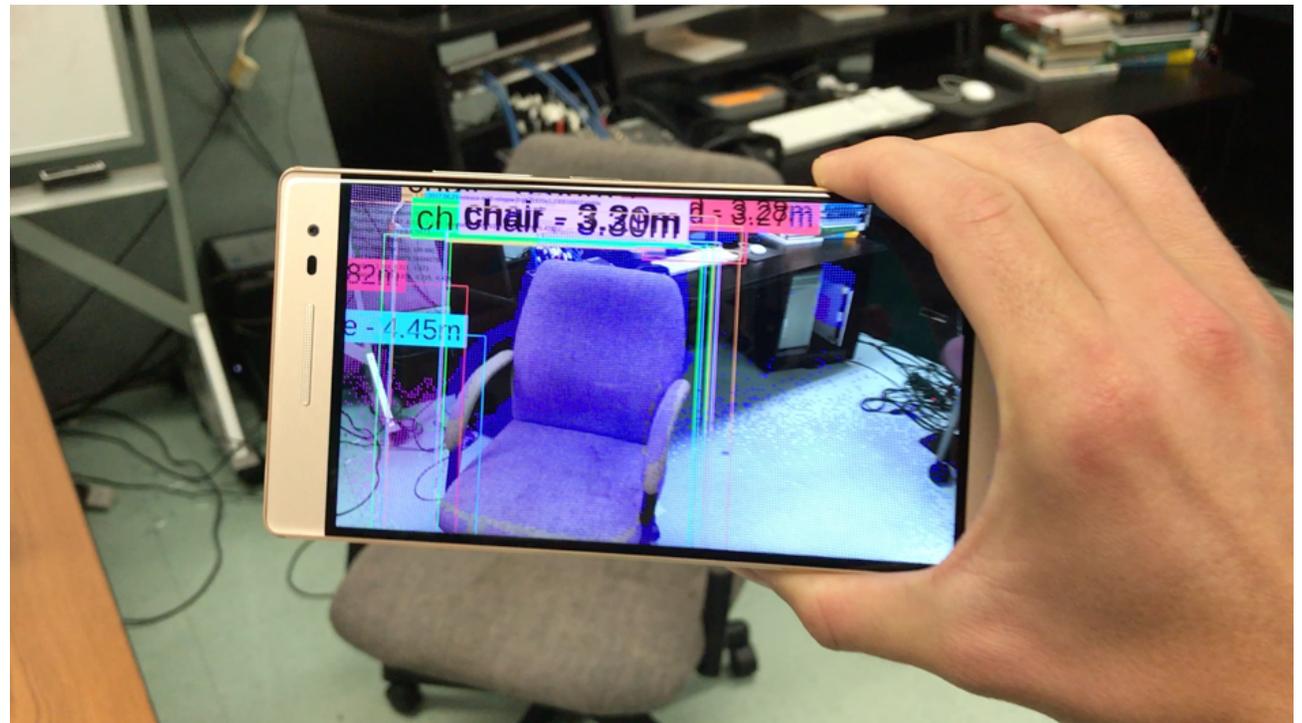
Slow Start from a single AR browser
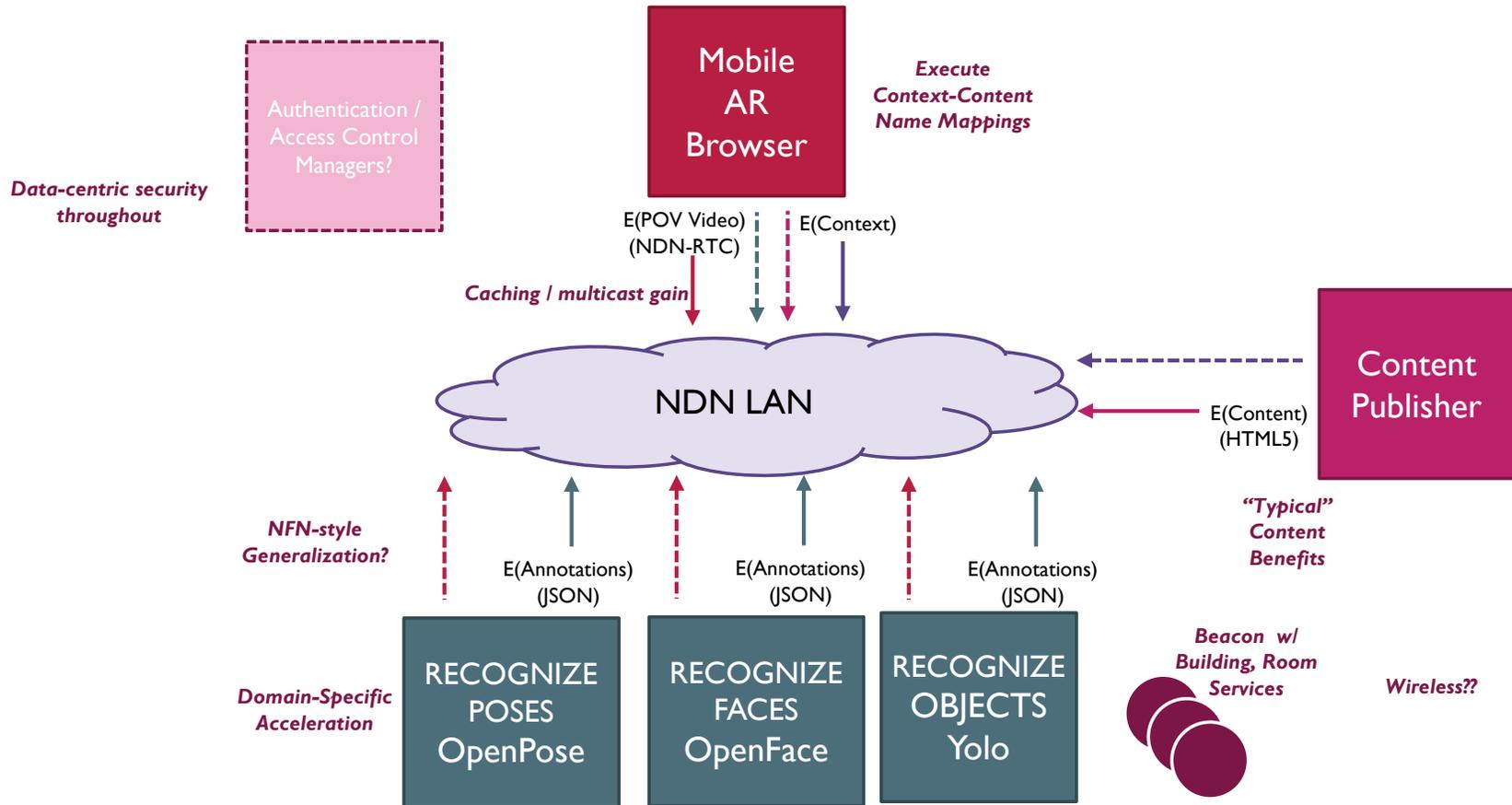
Progress to multi-user collaborative augmentation

Many-to-many (more mobile clients)
Two or more testbed-connected enclaves
Auth/access control implemented
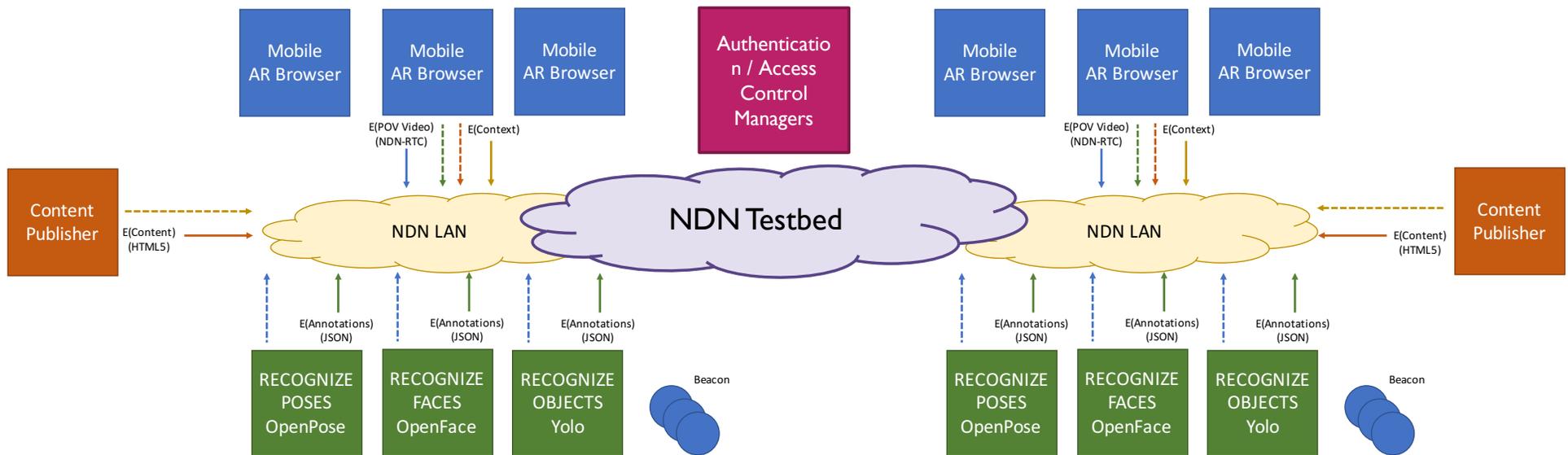
What NDN enables for AR -

- Web-like, highly granular retrieval of content
  - Direct name-based access to content grains with minimal number of roundtrips.
  - Enable viewpoint-/context-dependent, bandwidth-adaptive applications, in which candidate content is prefetched to enable apps to respond quickly to user interaction and navigation.
  - Expand the web model to better support local content discovery

- Enable many consumers to fetch content (and context) from mobile users without a cloud roundtrip, via in-network caching and intrinsic multicast.

- Expose content (and context) semantics at the network layer through data names, to support efficient forwarding, in-network storage decisions, etc.

- Provide a consistent mechanism for access on-demand and stored content, services, edge processing, as well as access to IoT and other data.

- Schematized trust1 and name-based access control2 offer opportunities for granular security that is not connection- or session-centric.

- Leverage multiple radios in current and future mobile devices easily, and in a way that takes advantage of the medium's characteristics.

1 - Yu, Yingdi, et al. "Schematizing trust in named data networking." Proceedings of the 2nd International Conference on Information-Centric Networking. ACM, 2015.
2 – Yu, Afanasyev, and Zhang. "Name-based Access Control." NDN Tech Report NDN-0034 Rev 2, 2016.

Questions from ICNRG Chairs to ICE-AR team

- Do the current protocol architectures have what we need? If not, what's missing?

- What routing/forwarding semantics might be useful beyond our current understanding

- (the perennial) do we need Push? What about multicast push?

- is there anything "special" in the namespace design?
  - Do we need something equivalent to Mobility first's "contextual naming" capability?

- **anything else you think would help generate a good discussion and possibly recommended directions for further research.**

The Principle of Science from Feynman Lectures on Physics

"The principle of science, the definition, almost, is the following: *the test of all knowledge is experiment*. Experiment is the *sole judge* of scientific "truth".

But what is the source of knowledge? Where do the laws that are to be tested come from? Experiment, itself, helps to produce these laws, in the sense that it gives us hints."

Recommended directions for further research:

• The source of knowledge for the ICN design should come from experimentation with modern applications such as AR/VR, IoT, V2V, etc that demand support beyond what TCP/IP/TLS offers.