

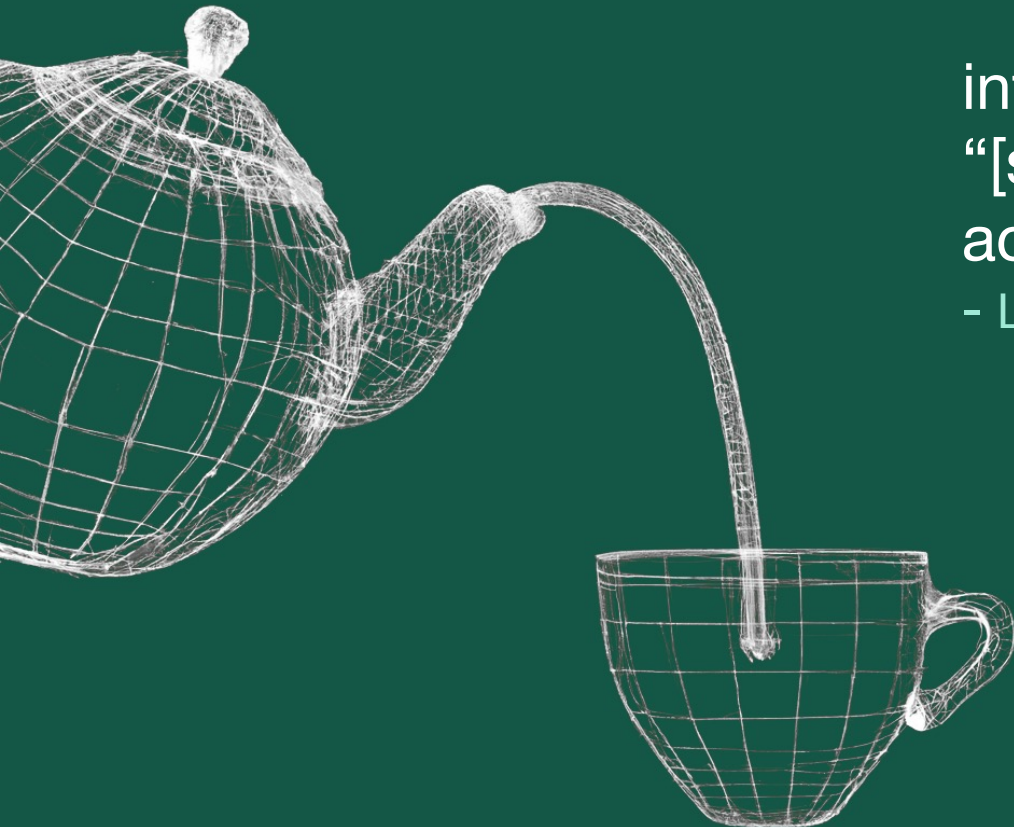
microverses: virtuality as if people mattered*

jeff burke

lixia zhang

dirk kutscher

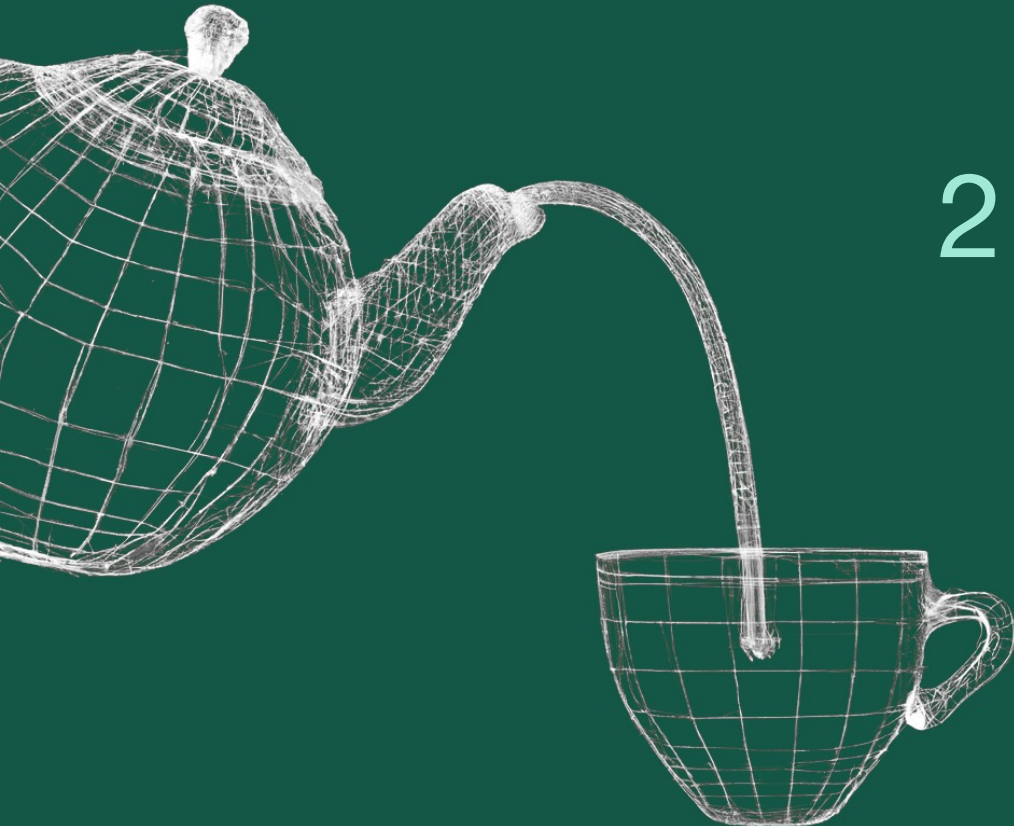
the teapot experiment



infrastructure reflects
“[s]hared visions of the possible and
acceptable dreams of the innovative.”

- L.L. Bucciarelli

in visions for 'the metaverse'



1 can you pour tea from one metaverse platform to another?

2 who controls whether the tea flows from pot to cup? and who ensures that you don't take milk?

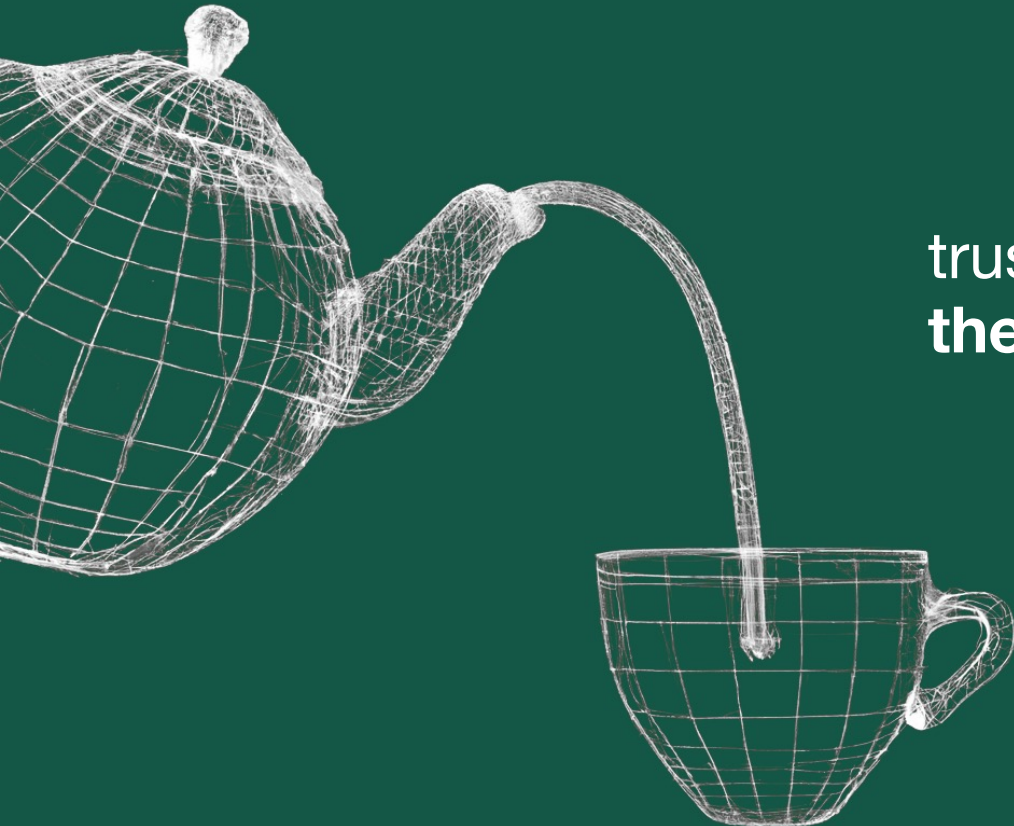
3 can you pour from one *device* to another, during a storm that has cut off Internet access?

the metaverse is an opportunity to recenter networking around human beings

just decentralizing transactions
about data isn't enough

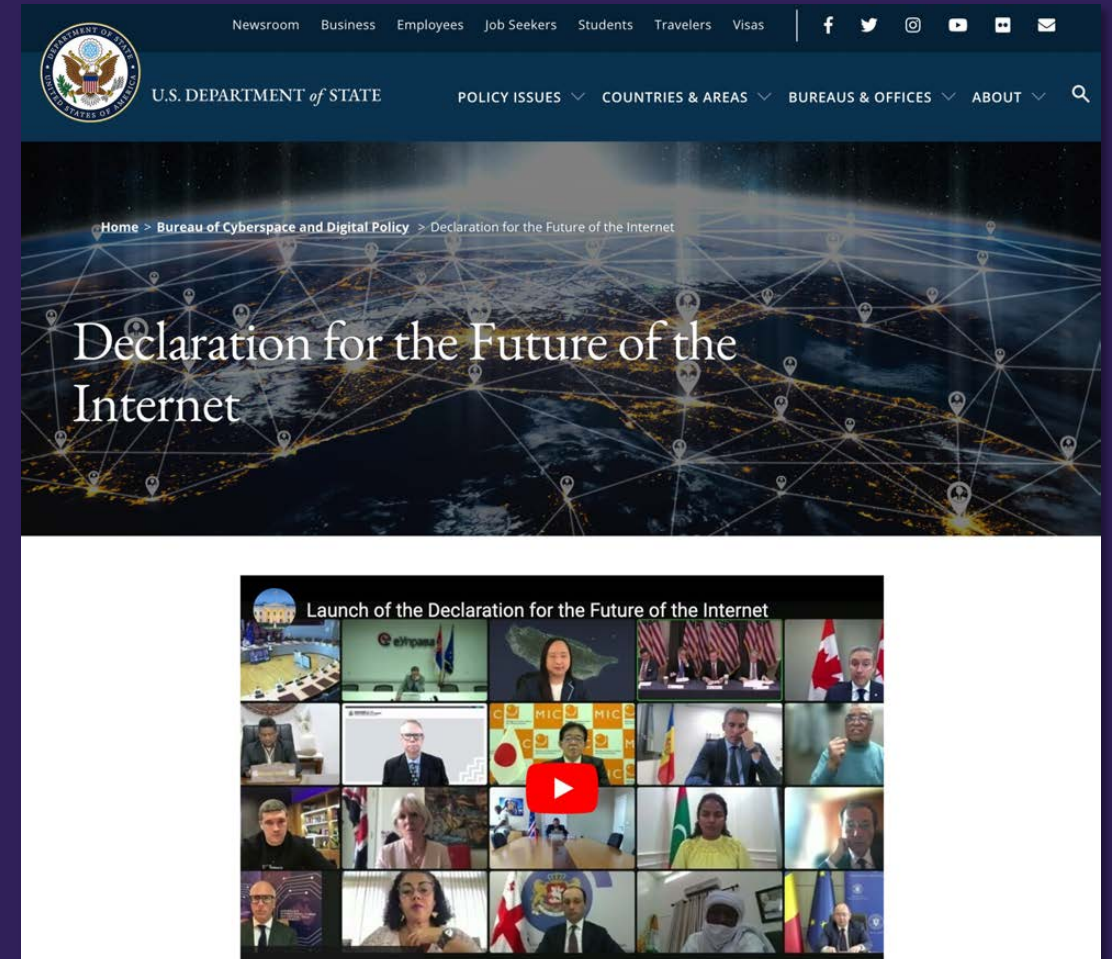
trust should stem from **who created
the data**, not who stores or carries it

local interactions shouldn't
require global connectivity



can the metaverse be a 'network of networks' ?

“the **immense promise** that accompanied the development of the Internet stemmed from its design: it is an **open 'network of networks'**, a single interconnected communications system for all of humanity”



yes, but:

**there is incredible reliance on large providers
for scalability and security, who in turn must
deal with incredible complexity**

named data networking proposes a solution

**NDN can be best understood within a
brief history of the current Internet**

so, bear with us...

TCP/IP focused on **connecting computers** by virtualizing connections (1970s)



client-server model (1980s)

securing host connections (1990s)

modern cloud services (2000s)

**host-independent models,
data-centric APIs** (2010s)

now, focus on **exchanging secure data** by virtualizing data exchange (2020s)

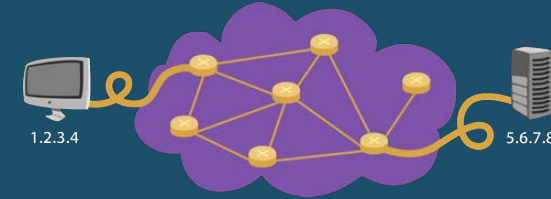


host/connection-independent trust

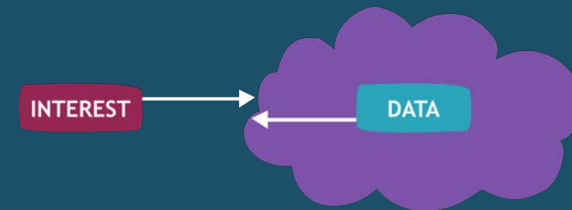
cloud-optional local communications

data-centric extended reality models

moved on from limitations of circuit-switched communication of the telephone network



moves on from limitations of host-centric communication and security of TCP/IP



named data networking

a **network architecture** in which all data packets are named and cryptographically signed at creation

can run **on top or instead of TCP/IP**, providing **secure, web-like semantics at packet granularity**

based on **12+ years of research** supported by NSF, DARPA, DOE, and NIST

News Release 10-156

NSF Announces Future Internet Architecture Awards

Awards will help develop new ideas and innovations towards the development of a more robust, secure and reliable Internet



Children using the Internet for a school project.
[Credit and Larger Version](#)

August 27, 2010

This material is available primarily for archival purposes. Telephone numbers or other contact information may be out of date; please see current contact information at [media contacts](#).

The Directorate for Computer and Information Science and Engineering (CISE) at the National Science Foundation (NSF) announced today awards for four new projects, each worth up to \$8 million over three years, as part of the Future Internet Architecture (FIA) program.

NETWORKWORLD UNITED STATES



THE NETWORK ARCHITECT

By Matt Conran, Contributor, Network World | OCT 11, 2018 12:49 PM PDT

OPINION

Introducing Named Data Networking

No more IP addresses.



ThinkStock

SECURITYWEEK
CYBERSECURITY NEWS, INCIDENTS & ANALYSIS

CYBERSECURITY FUNDING

Operant Networks Emerges From Stealth With SASE Solution for Energy OT

Operant Networks has emerged from stealth mode with \$3.8 million in seed funding and a secure access service edge (SASE) solution focused on operational technology (OT) in the energy sector.



By Eduard Kovacs
September 20, 2022

Operant Networks has emerged from stealth mode with \$3.8 million in seed funding and a secure access service edge (SASE) solution focused on operational technology (OT) in the energy sector.

INTELLIGENCE COMMUNITY

Perspecta receives \$4.8M contract for DARPA SHARE program

By Loren Blinde - April 8, 2019



Perspecta Inc. of Chantilly, VA announced on April 3 that its research arm, Perspecta Labs, has received a \$4.8 million contract modification for Phase 2 of the Defense Advanced Research Projects Agency's (DARPA) Secure Handhelds on Assured Resilient networks at the tactical Edge (SHARE) program.

NIST

Search NIST

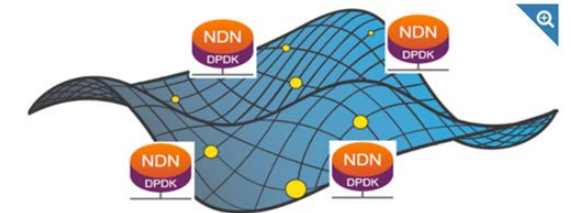


Menu

UPDATES

NSF-funded Testbed to Deploy NIST's NDN Router Allowing Users to Find and Get Data at High Speeds

November 01, 2022



FABRIC

NIST's high-speed NDN-DPDK router deploying on FABRIC testbed for cutting-edge network research

microverse project goals

enable the **metaverse as a network of networks**

building blocks: **microverses of named data**,
ecosystems of platform-independent content controlled
by entities as small as an individual, interoperating via
NDN with or without cloud support

balance **democratization, trust, and scale**, as well as
opportunities for market-based innovation

scaling microverse-by-microverse

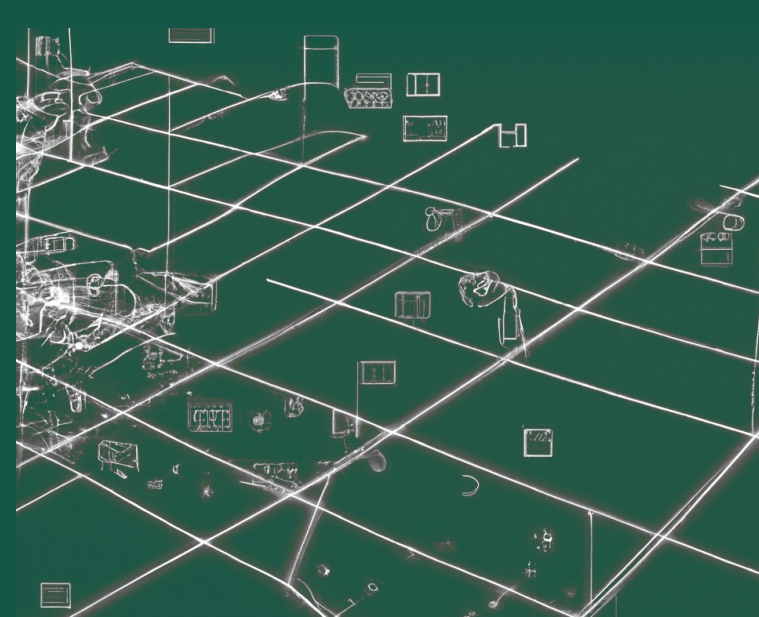
named data strategies enable global interactions to scale independently from producer capacity



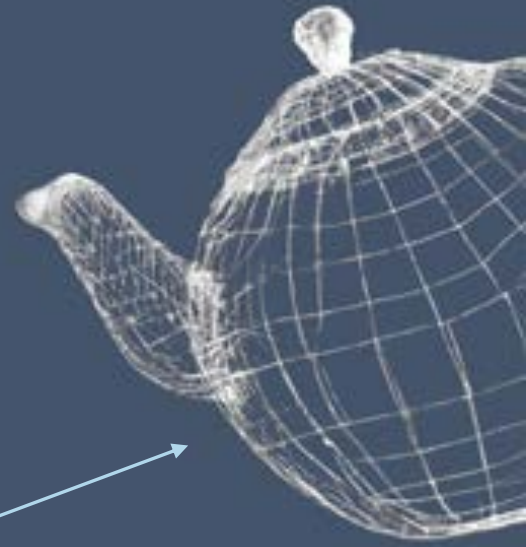
live performances



exchange of virtual goods



public datasets



but, blockchain?

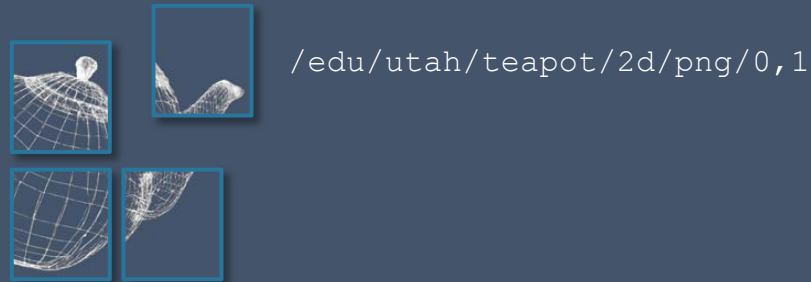
decentralizing transactions about content does not decentralize content storage or interactions

... IPFS?

most decentralized content approaches do not support real-time interaction or cloud-optional communication critical to **disaster resilience**, **robust mobility**, **vehicular networking**, etc. or **secure name-data binding** needed by apps

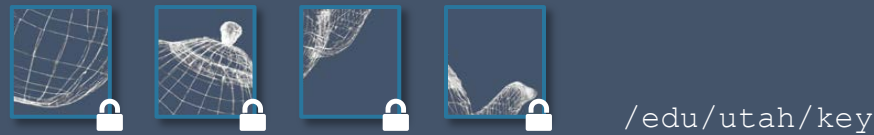
building blocks for microverses

named data packets
app-named, crypto-signed



Zhang et al. "Named data networking." *ACM SIGCOMM Computer Communication Review* 44.3 (2014): 66-73.

data-centric security
schematized via names



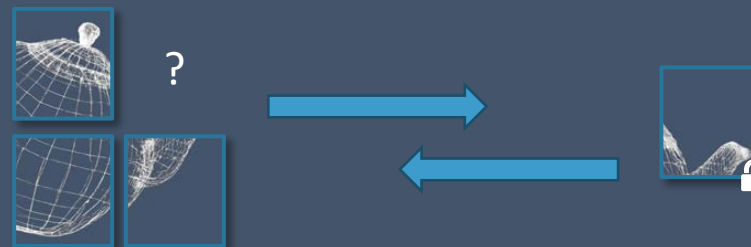
Zhang et al. "An overview of security support in named data networking." *IEEE Communications* 56.11 (2018): 62-68.

forwarding on names
intrinsically multicast



Yuan et al. "Scalable NDN forwarding: Concepts, issues and principles." *Intl. Conf. on Computer Communications and Networks*, 2012.

dataset synchronization
as a multiparty transport



Moll, Philipp, et al. "A survey of distributed dataset synchronization in named data networking." *NDN Technical Report NDN-0053, Revision 2* (2021).

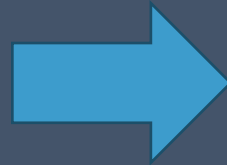
benefits

named data packets
app-named, crypto-signed

data-centric security
schematized via names

dataset synchronization
as a multiparty transport

forwarding on names
intrinsically multicast



host-independence so development and operation focuses on data flow

channel-independent security - each microverse can define a root of trust

multicast and **caching** built in offer efficiency for low-resource publishers

storage is intrinsic, enabling persistent microverses with just the basic stack

disruption-tolerant, cloud-optional approach for resilience, mobile, privacy

metaverse

metaphor	world / garden (singular)
control	world owner
real-time engine as...	application platform
objects	file-like assets
references	URLs to bundle
communication	cloud services
persistence	by the world owner
authentication	negotiated per connection
interactions	data channels, API calls within world
interoperability	share asset files across worlds
microtransactions	world owner must map assets

microverses

network / rhizome
content publisher / root of trust
browser, with layers instead of tabs
named data - immutable
URLs to content grain
by the network
by the network
intrinsic to data objects
context-content exchange (multiversal)
operate in multiple 'verses at once
operate directly on signed data

team



Jeff Burke
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Film and Television



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UCLA Department
of Computer Science



Dirk Kutscher
Hong Kong University of Science
and Technology (Guangzhou)

ndn foundations

architecture

Named Data Networking

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ABSTRACT

Named Data Networking (NDN) is one of five projects funded by the U.S. National Science Foundation under its Future Internet Architecture Program. NDN has its roots in an earlier project, Content-Centric Networking (CCN), which Van Jacobson first publicly presented in 2006.¹ The NDN project investigates Jacobson's proposed evolution from today's host-centric network architecture (IP) to a *data-centric* network architecture (NDN). This conceptually simple shift has far-reaching implications for how we design, develop, deploy, and use networks and applications. We describe the motivation and vision of this new architecture, and its basic components and operations. We also provide a snapshot of its current design, development status, and research challenges. More information about the project, including prototype implementations, publications, and annual reports, is available on named-data.net.

1. VISION: A NEW NARROW WAIST

Today's Internet's *hourglass* architecture centers on a *universal* network layer (i.e., IP) which implements the minimal functionality necessary for global interconnectivity. This thin waist enabled the Internet's explosive growth by allowing both lower and upper layer technologies to innovate independently. However, IP was designed to create a *communication network*, where packets named only communication endpoints. Sustained growth in e-commerce, digital media, social networking, and smartphone applications has led to dominant use of the Internet as a *distribution network*. Distribution networks are more general than communication networks, and solving distribution problems via a point-to-point communication protocol is complex and error-prone.

The Named Data Networking (NDN) project proposed an evolution of the IP architecture that generalizes the role of this thin waist, such that packets can name objects other than communication endpoints (Figure 1). More specifically, NDN changes the semantics of network service from *delivering the packet to a given destination address to fetching data identified by a given name*. The name in an NDN packet can name anything – an endpoint, a data chunk in a movie or a book, a command to turn on some lights, etc. This conceptually simple change allows NDN networks to

use almost all of the Internet's well-tested engineering properties to solve a much broader range of problems including not only end-to-end communications but also content distribution and control problems. Based on three decades of experience with the strengths and limitations of the current Internet architecture, the design also builds in security primitives (via signatures on all named data) and self-regulation of network traffic (via flow balance between Interest and Data packets). The architecture includes functionality designed to be conducive to user choice and competition as the network evolves, such as multipath forwarding and in-network storage.

NDN is one instance of a more general network research direction called *information-centric networking* (ICN), under which different architecture designs have emerged [29]. The Internet Research Task Force (IRTF) established an ICN research working group in 2012². In this paper we provide a brief (and necessarily incomplete) snapshot of the current state of the NDN architecture research project, which includes sixteen NSF-funded principal investigators at twelve campuses, and growing interest from the academic and industrial research communities. A more complete description of recent activities is in the third annual project report [20] and on the NDN web site (named-data.net).

¹[A New Way to Look at Networking](https://www.youtube.com/watch?v=02M6Y3qduH), <https://www.youtube.com/watch?v=02M6Y3qduH>

²<http://trac.tools.ietf.org/group/irtf/trac/wiki/icarg>

ACM SIGCOMM Computer Communication Review 66 Volume 44, Number 3, July 2014

Zhang, Lixia, et al. "Named data networking." *ACM SIGCOMM Computer Communication Review* 44.3 (2014): 66-73. (2100+ citations)

code

NDN Named Data Networking
41 followers <https://named-data.net/>

Overview Repositories (92) Projects Packages Teams (10) People (26) Settings

Pinned

- NFD** Public
Named Data Networking Forwarding Daemon
C++ 152 137
- ndn-cxx** Public
NDN C++ library with eXperimental eXtensions
C++ 122 139
- NLSR** Public
Named Data Link State Routing
C++ 45 35
- python-ndn** Public
An NDN client library with AsyncIO support in Python 3
Python 19 19
- ndn-svs** Public
State Vector Sync library for distributed realtime applications for NDN
C++ 8 3
- ndn-tools** Public
NDN Essential Tools
C++ 73 67

research community

Named Data Networking Community Meeting

September 10-11, 2020
Virtual event hosted by NIST



media tool pilots



testbed

Testbed

Status
Map
Join Testbed

Network of 33 sites across 4 continents, 14 countries.
Open to join and use

next steps

outreach to engage others in the opportunities and design challenges

design **named data strategies** for key content formats such as USD and gITF

compelling proof-of-concept demos via integration with real-time engines

continue to improve NDN code ease-of-use to encourage **developer adoption**

IEEE International Conference on Metaverse Computing, Networking and Applications (IEEE MetaCom 2023)
June 26-28, 2023 · Kyoto, Japan

Home Calls Committees Program Conference Venue

IEEE International Conference on Metaverse Computing, Networking and Applications (MetaCom 2023)

June 26-28, 2023 · Kyoto, Japan.
<http://www.ieee-metacom.org/2023>

IEEE MetaCom Workshop on Decentralized, Data-Oriented Networking for the Metaverse (DORM)

Call for Papers

The Decentralized Data-Oriented Networking for the Metaverse (DORM) workshop is intended as a forum to explore new directions and early research results on the system architecture, protocols, and security to support Metaverse applications, focusing on data-oriented, decentralized system designs. We view Metaverse as a new phase of networking with multi-dimensional shared views in open realms.

Most Metaverse systems today replicate the social media platform model, i.e., they assume a cloud platform provider-based system

Workshops

- DORM 2023
- DIM 2023
- MANP 2023
- MetaXP 2023
- VSM 2023

Important Days

- Mar 20, 2023 Paper Submission Due
- Apr 20, 2023 Author Notification
- May 10, 2023 Camera-Ready Due

more info

"While many theoreticians - who may not be too closely in touch with real life - are still engaging in the idolatry of large size, with practical people in the actual world there is a tremendous longing and striving to profit, if at all possible, from the convenience, humanity, and manageability of smallness."

- E.F. Schumacher, *Small is Beautiful: Economics as if People Mattered*, 1973

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named-data.net/microverse