Evolving Internet into the Future via Named Data Networking

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Why this talk

◊ To tell you the basic idea behind NDN
◊ To initiate a discussion
◊ To convince you that NDN represents the right direction for future Internet
◊ To invite everyone to join the effort
Three basic questions

◊ How today’s Internet works

◊ What are the problems

◊ How communication by data names can help fix these problems
How today’s Internet works

◊ TCP/IP architecture

◊ Enables any computer on the Internet to talk to any other computer
  ✷ Name boxes
  ✷ End-to-end connection
  ✷ Datagram delivery
30 years down the road
TCP/IP has changed the world

Interconnections of computers
Moore’s Law & silicon revolution

A new world of applications & computing devices
Naming boxes got us to where we are today
but no longer fits today’s communication needs
What are the problems

◊ Massive scale of data dissemination
◊ Computing devices becoming increasingly mobile
  ✷ Ad hoc networking, disruption-tolerant networking
◊ Network security
◊ Internet Of Things
◊ Robust data delivery

…… Just to list some of the top issues
Point-to-point for data distribution
Naming location for mobile devices

Mobile IP (and other solutions) patches up the problem, but did not resolve it
Naming location vs disruption tolerance

Vehicle networking as an example

- IP address $\rightarrow$ existence, connectedness
- Intermittent connectivity $\rightarrow$ ?
Network security: why so difficult?

◊ IP identifies interfaces, networks

◊ Current solutions
  ✅ Securing the channel
  ✅ Securing the box
  ✅ Securing an IP network by firewall
Securing perimeters

확화: examining each and all in/out packets
🔗 But how many entries into your network?

Communication: exchange data across boundaries

확화 perimeter → barrier to communication
Named-Data Networking

moving the **universal component** in Internet protocol stack from IP packets to **named data**
What is this name you are talking about

◊ Applications use names
  ✷ Today we piece up multiple things from the protocol stack to match that name

◊ An example
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  \([\text{IP}_{\text{sender}}, \text{IP}_{\text{recv}}, \text{Protocol-ID, send-port#}, \text{recv-port#}]\)
  for data delivery

◊ NDN delivers data by directly using the names from applications
Communication by Names

- Data does not walk out itself
  - Interested receivers pull data down
- Interest forwarding: needs routing protocols to build FIB
  - Different from IP: Interests leave **state** at each router
NDN routing & data planes

Looking from 3000 feet:

◊ Routing plane: data producers announce names/name prefixes

◊ Data plane: data consumers send Interest packets to request data, leaving state at routers along the way
  ✧ Data packets follow Interest state to reach users
  → Creating a feedback loop for routers to measure performance, choose among alternative paths
Comparison with IP Packet Forwarding
NDN Interest Forwarding

**Content Store**

<table>
<thead>
<tr>
<th>Name</th>
<th>Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>/parc.com/videos/WidgetA.mpg/v3/s0</td>
<td>...</td>
</tr>
</tbody>
</table>

**Pending Interest Table (PIT)**

<table>
<thead>
<tr>
<th>Prefix</th>
<th>Requesting Face(s)</th>
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<tbody>
<tr>
<td>/parc.com/videos/WidgetA.mpg/v3/s1</td>
<td>0</td>
</tr>
<tr>
<td>/parc.com/videos/WidgetA.mpg/v3/s2</td>
<td>0</td>
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</table>

**Index**

<table>
<thead>
<tr>
<th>ptr type</th>
<th>Prefix</th>
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<tbody>
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<td>P</td>
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<tr>
<td>F</td>
<td>/parc.com/videos/WidgetA.mpg/v3/s2</td>
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</table>

**FIB**

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<th>Face list</th>
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</thead>
<tbody>
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<td>0, 1</td>
</tr>
</tbody>
</table>

**Application**

- **get /parc.com/videos/WidgetA.mpg/v3/s2**
- **data**
NDN data retrieval from cache

Packets say “what”, not “who” or “where”
NDN data retrieval via multiple paths

- Forwarding decision is local
- Upstream performance is measurable
NDN: Scalable Data Dissemination
ad hoc networking, mobility, DTN

◊ If two or more mobile nodes can physically reach each other, they can communicate

◊ Naming data provides efficient streaming to mobiles on the move
Securing communications by securing data

- NDN makes data the first class entity in the architecture
- NDN secures data directly, not the containers
  - Each name associated with a key, data is signed together with its name at creation
  - Data integrity and provenance can be verified independent from where it comes
Design Principle: Hourglass architecture

△ IP’s “thin waist” has been a key enabler of the Internet’s explosive growth

△ NDN keeps the same hourglass-shaped architecture

✧ In addition: build security right into the thin waist
Design Principle: the end-to-end principle

◊ Internet’s end-to-end principle
  ✦ Enables robust applications in face of network failures
  ✦ facilitates support for unforeseeable new applications

◊ NDN retains and expands the E2E principle
  ✦ End-controlled reliability
  ✦ End-to-end security
Design Principle:
Routing & forwarding planes separation

Routing-forwarding plane separation: proven necessary for Internet development

NDN sticks to the same principle

Rolling out NDN with the best available forwarding technology while new routing system being researched in parallel
Design Principle:

No name semantics in the infrastructure

◊ IP’s original design deliberately fixed as little as possible about how its 'names' (addresses and ports) were assigned

◊ NDN follows IP's successful strategy
  ✦ The only assumption: hierarchically structured name space
New Design Principles

◊ Flow-balanced data delivery is essential to stable network operation
  ✷ IP: open loop datagram delivery
  ✷ TCP congestion control was added in later
  ✷ NDN designs flow-balance into the thin waist

◊ facilitate user choice and competition
Addressing challenges in today’s architecture

- Enabling multipath delivery
- Built-in network flow balancing
- Built-in data security
- Built-in multicast delivery
- Built-in data dissemination
- Built-in components to facilitate mobility, ad hoc and disruption-tolerant networks
- Elimination of unwanted traffic
Rolling out NDN

- Like IP, NDN is a “universal overlay”
- Existing Internet infrastructure services readily usable by NDN
  - Namespace administration
  - AS topologies, inter-domain routing policies
  - IP routing protocols
- Apply NDN approach to today’s problems
- Developing applications that directly take advantage from NDN
NDN project team

parc®
Palo Alto Research Center

Van Jacobson (architect)

UCLA

arizona

The University of Memphis

Colorado State University

UC Irvine

University of California, Irvine

UCSD

Washington University in St. Louis

Yale University
What to take away

◊ Where the NDN idea came from: successes and lessons from today’s Internet

◊ NDN focuses on data directly to build the communication infrastructure

◊ You can help!

http://www.named-data.net/