The Content-Centric Networking Architecture and its Opportunities Bruno Kauffmann

May 14th 2013





▲ロ ▶ ▲周 ▶ ▲ ヨ ▶ ▲ ヨ ▶ ● ● ● ● ●

Outline

Introduction

CCN Architecture

Opportunities

Introduction

CCN Architecture

Opportunities

・ロト・西ト・ヨト・ヨー うへぐ

Information-Centric Networking (ICN)

Current Network : centered on "where"

- Hosts are named ;
- Content naming at application layer;
- Requests are made by host address;
- The network is responsible for connecting two end-hosts;

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

• Content request is an application convention.

Information-Centric Networking (ICN)

Current Network : centered on "where"

- Hosts are named ;
- Content naming at application layer;
- Requests are made by host address;
- The network is responsible for connecting two end-hosts;
- Content request is an application convention.

ICN : centered on "what"

- Contents are named;
- Host names do not exist / are not visible;
- Request are made by content name;
- The network is responsible for finding the content.

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

• 1876 : Telephone ; Circuit based networking ;



- 1876 : Telephone ; Circuit based networking ;
- 1960s : Telecommunation/Computer networks; packet-based networks;

- 1876 : Telephone ; Circuit based networking ;
- 1960s : Telecommunation/Computer networks; packet-based networks;
- Since 1993 : Web, P2P, Streaming : Content distribution is now the main application ;

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

- 1876 : Telephone; Circuit based networking;
- 1960s : Telecommunation/Computer networks; packet-based networks;
- Since 1993 : Web, P2P, Streaming : Content distribution is now the main application ;

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

The Internet becomes ICN-ish (CDNs, dynamic DNS resolution, etc.).

Content-Centric Networking

• First ICN proposal : A Data-Oriented (and Beyond) Network Architecture (DONA), SIGCOMM 2007;

< □ > < 同 > < □ > < □ > < □ > < □ > < □ > < □ > < □ > < ○ </p>

- CONEXT 2009 : Proposal by Van Jacobson *et. al.* from PARC;
- Other proposals : NetInf, PSIRP, TRIAD;

Content-Centric Networking

- First ICN proposal : A Data-Oriented (and Beyond) Network Architecture (DONA), SIGCOMM 2007;
- CONEXT 2009 : Proposal by Van Jacobson *et. al.* from PARC;
- Other proposals : NetInf, PSIRP, TRIAD;
- CCN eco-system :
 - NSF Named Data Networking (NDN) project;
 - Emerging Network Consortium (ENC) industrial consortium;
 - ▶ Many project/studies over the world (ANR CONNECT, ...).

Introduction

CCN Architecture

Opportunities

・ロト・西ト・ヨト・ヨー うへぐ

Architecture Outline

- Packets ;
- Naming;
- Transport and Node Architecture;

- Routing;
- Security.

Packets

Two types of packets

- Interests :
 - Consumers ask for content;
 - Small packet;
 - Similar to TCP acks;
 - Allows (relative) selectors

(/parc.com/videos/WidgetA.mpg RightmostChild).



◆□ > ◆□ > ◆豆 > ◆豆 > ̄豆 = 釣へで

Packets

Two types of packets

- Interests :
 - Consumers ask for content;
 - Small packet;
 - Similar to TCP acks;
 - Allows (relative) selectors

(/parc.com/videos/WidgetA.mpg RightmostChild).

- Data :
 - Carries data ;
 - Always answers to an interest;
 - Consumes the interest;

| Interest packet | |
|--|---|
| Content Name | Ş |
| Selector (order preference, publisher filter, scope,) | ξ |
| Nonce | 5 |
| | 一 |



・ロト・西ト・ヨト・ヨー シック・

Naming

- Atomic chunks (4kB maximum);
- Hierarchical names;
- Data satisfies an interest if the interest name is a prefix of the data name;
- Arbitrary variable-length components;
- Meaningful for higher layers;
- Can be context dependent (/ThisRoom/Projector).



Figure 4: Example Data name













Node Architecture



◆□▶ ◆□▶ ◆三▶ ◆三▶ →□ ◆○へ⊙

Forwarding

- Interest
 - 1. Check CS;
 - 2. Check and update PIT;
 - 3. Use FIB and update PIT;
- Data
 - 1. Check and update PIT;
 - 2. Eventually store in CS.



Transport

• On top of unreliable packet delivery services;

- No state at the sender;
- Control at receivers;
- Symmetric path for data.

Routing

- Not standardized ;
- Name-based routing;
- Current IP algorithms (e.g. IS-IS / OSPF) work;
- Allows several out-going interfaces for a prefix;
- Scalability issue for FIB size;
- Aggregation can be improved (indirection, containers with late binding);

< □ > < 同 > < □ > < □ > < □ > < □ > < □ > < □ > < □ > < ○ </p>

- Secures content rather than channel/connection;
- Uses signatures for support of arbitrary names;
- Each packet/chunk is signed ;
- Can be verified by any node;
- Certifies the content was signed with a given key.

< □ > < 同 > < □ > < □ > < □ > < □ > < □ > < □ > < □ > < ○ </p>

Security — Managing trust

- Contextual trust;
- Keys can be accessed as CCN data;

- Chains of trusts;
- Self-certifying names are allowed.

Stack hourglass model



◆□▶ ◆□▶ ◆三▶ ◆三▶ →□ ◆○へ⊙

Introduction

CCN Architecture

Opportunities

Outline

- Features
- Prototype and simulation tools

• Applications

Feature : Caching

• On path caches (Content-Store) can be added at every node;

< □ > < 同 > < □ > < □ > < □ > < □ > < □ > < □ > < □ > < ○ </p>

- No need of specific management (opposed to CDNs);
- Long-term caches need to advertise content for routing;
- Many recent papers for cache performance optimization/evaluation.

Features : Multicast and Multipath

- PIT allows requests aggregation, i.e. multicast;
- Small offsets are managed via caching;
- FIBs can have several faces per entry;
- Chunks from the same ADU can be obtained from several sources.

< □ > < 同 > < □ > < □ > < □ > < □ > < □ > < □ > < □ > < ○ </p>

Feature : Optimal forwarding

- Based on traffic symmetry;
- And on multipath ability;
- Nodes can learn the performance of faces;

▲□▶ ▲□▶ ▲ 三▶ ▲ 三▶ 三三 - のへぐ

• And adapt to the network condition.

Feature : Mobility

- No end-to-end connection state;
- The flow is the ennemy (D. Oran) : No sender end-point ;
- Receiver-based transport;
- Easy seamless receiver mobility
 - Possible in IP with protocol extension;
 - Transfert restarts as soon as physically possible;

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

- Caching allows to recover on-path packets;
- Content mobility / failure recovery
 - Requires a secondary path/content source;
 - Difficult in IP.

CCNx prototype

- Developped and maintained by PARC ;
- Low hardware requirements (e.g Orange Livebox);

- Overlay on IP ;
- FIB population by hand for small networks;
- Content-level interface;
- Works out of the box;
- http://www.ccnx.org/

Simulation Tools

- Ns3 integration ;
- ccnSim ad-hoc simulator;
- Content Centric Networking Packet Level Simulator (CCNPL-Sim).

Application : Voice over CCN

- Standard SIP / RTP payload;
- Single path for signaling and media;
- Uses name flexibility

/domain/sip/bob/invite/EpkB(sk)/Esk(SIP INVITE message) /domain/bob/call-id/rtp/seq-no

◆□▶ ◆□▶ ◆三▶ ◆三▶ ○ ● ●

- Inter-operable with VoIP using stateless gateway;
- VoCCN : Voice-over Content-Centric Networks, ReArch'09.

Application : Networked Execution

- M. Sifalakis, M. Monti, C. Tschudin (University of Basel), CCNxCon 2012;
- Uses name flexibility;
- Application are node faces and can advertize content;
- Programs / execution can be named;
- /bring/me (/the/digest (/my/content, "Jan to Sep 2012"));

/ietf/rtp (/domain/bob/call-id/seq-no

Network segment : Data Center

- Start-up using CCN in a Data Center;
- Infinio, formerly Silver Lining Systems;

• Founded by Vishal Misra.

Questions?

Thank you

bruno.kauffmann@orange.com