View metadata, citation and similar papers at core.ac.uk
brought to you by CORE
provided by CiteSeerX

Anchor-less Producer Mobility in ICN

Jordan Augé
Cisco Systems
first.last@cisco.com

Giovanna Carofiglio
Cisco Systems
gcarofig@cisco.com

Giulio Grassi
UPMC, LIP6
first.last@lip6.fr

Luca Muscariello
Orange Labs Networks
first.last@orange.com

Giovanni Pau
UPMC, LIP6; UCLA
first.last@lip6.fr

Xuan Zeng
UPMC, LIP6; IRT SystemX
first.last@irt-systemx.fr

ABSTRACT

Mobility has become a basic premise of almost any network communication, thereby requiring a native integration into next generation 5G networks. Despite the numerous efforts to propose and to standardize effective mobility management models for IP, the result is a very complex, poorly flexible set of mechanisms not suitable for the design of a radio-agnostic 5G mobile core. The natural support for mobility, security and storage offered by ICN (Information-Centric Networking) architecture, makes it a good candidate to define a radically new solution relieving limitations of traditional approaches. If consumer mobility is supported in ICN by design in virtue of its connectionless pull-based communication model, producer mobility still appears to be an open challenge.

In this work we describe an initial proposal for an anchor-less approach to manage producer mobility via Interest Updates/Notifications in the data plane, even in presence of latency-sensitive applications. We detail the different operations triggered by producer movements and position our contribution in the context of existing alternatives, by discussing either user performance and network metrics.

Categories and Subject Descriptors

C.2.1 [**Computer-Communication Networks**]: Network Architecture and Design—*Network communications*

Keywords

Information-Centric Networking; Producer Mobility.

1. INTRODUCTION

With the phenomenal spread of connected user devices, mobility has become a basic premise for almost any network communication as well as a compelling feature to integrate in next generation networks (5G). The need for a mobility management model to apply within IP networks has striven a lot of efforts in research and standardization bodies (e.g. 3GPP), all resulting in a complex access-dependent set of mechanisms implemented in a dedicated control infrastructure. The complexity and lack of flexibility of such approaches (e.g. Mobile IP) calls today for a radically new solution dismantling traditional assumptions like tunneling and anchoring all mobile communications into network core.

Native support for mobility, security and storage functionalities inside network architecture, makes ICN a promising candidate for 5G and, specifically, for relieving current limitations in mobility management by introducing a radically new model.

In ICN, mobility is managed in a very different way than in IP: the communication focuses on names rather than network addresses, hence a change in physical location does not imply a change in the data plane. Consumer mobility is naturally supported in virtue of its connectionless and pull-based transport mode, implying a simple retransmission by the consumer of Interests for not yet received Data.

Producer mobility and real-time group communication are more challenging to support, depending on the frequency of the mobility and on the content lifetime. The contribution of this work is an initial proposal for an anchorless approach to manage local producer mobility, even in presence of latency-sensitive applications.

The rationale behind is to exploit ICN features like stateful forwarding, dynamic and distributed Interest load balancing and in-network caching to define a timely forwarding update mechanism populating a Temporary FIB (TFIB) at routers relaying former and current producer location.

In the following sections we describe the design principles (Sec.2) and the operations involved by our approach (Sec.3), before concluding and commenting on future work in Sec.4.

2. DESIGN PRINCIPLES

Our mobility manager MM results from the following design principles:

Anchor-less: Mobility management approaches can be roughly divided into three classes: *rendez-vous based*, involving a resolution of identifiers into locators performed by dedicated network nodes, *anchor-based* (or indirection-based), where a fixed network node is kept aware of mobile node movements and intercepts/redirects packets to him, *anchor-less*, where the mobile node is directly responsible for notifying the network about his movements. The first class of approaches (see [1] for an ICN example) has good scalability properties and low signaling overhead, but appears unsuitable for frequent mobility and for reactive rerouting of latency-sensitive traffic. Anchor-based approaches (see [5]) show better reactivity and good path stretch properties at the cost of larger signaling overhead. Also, they suffer from

Permission to make digital or hard copies of part or all of this work for personal or classroom use is granted without fee provided that copies are not made or distributed for profit or commercial advantage and that copies bear this notice and the full citation on the first page. Copyrights for third-party components of this work must be honored. For all other uses, contact the Owner/Author. Copyright is held by the owner/author(s)
ICN'15, September 30–October 2, 2015, San Francisco, CA, USA.
ACM 978-1-4503-3855-4/15/09.
DOI: http://dx.doi.org/10.1145/2810156.2812601.

single point of passage problem, preventing ICN multipath and limiting robustness to failure. Anchor-less approaches are less common and introduced to enhance reactivity with respect to anchor-based solutions (see e.g. [2], [4], [3]). Better reactivity, simplicity, insensitivity to frequency of relocations make anchor-less solutions appealing.

No name change. In order to avoid issues like triangular routing and caching degradation and to keep name semantics fully location-independent, MM does not require any change in content names.

Forwarding-based. Our approach does not rely on global routing updates (too slow and costly in presence of frequent mobility), rather it leverages hop-by-hop dynamic and distributed ICN forwarding. A temporary FIB is populated by updates/notifications originated at the new producer location and directed to its former positions.

Distributed. We design our approach to be fully distributed and limited to the edge of the network, to realize an effective traffic offload close to end-users and to eliminate dependency on in-network anchors.

Lightweight. We consider prefix granularity in updates (rather than content/chunk as in [5]) to minimize signaling overhead and temporary state kept by in-network nodes.

Reactive. We introduce network notifications and discovery mechanisms to support latency-sensitive communications even during high mobility.

3. MM OPERATIONS

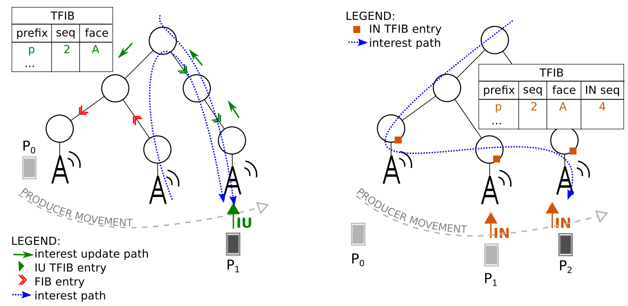
In this section we describe the operations performed in MM to properly route consumer Interests to a moving producer: The sequence of operations is the following: (*I*) whenever the mobile producer moves and attaches to a new network Points of Attachment (PoA), it notifies to the new PoA the prefixes it serves. (*II*) Once it eventually relocates or regularly every T_U (e.g. 5s), he triggers a forwarding update operation. Notifications/Updates modify routers forwarding state by populating a temporary FIB (TFIB). Consumers' requests directed to the producer either follow TFIB information or, in absence, are routed to the FIB and from there towards the producer via a discovery mechanism (*III*).

3.1 Mobility and forwarding updates

Every time a mobile producer stably relocates or every T_U s, it sends a special Interest message, called Interest Update (IU) for each prefix it serves. The Interest is then forwarded based of TFIB and FIB and it eventually reaches a producer's former position (see Fig. 1(a)). While traversing subsequent routers, IU updates the TFIB replacing output interface for the given prefix with the incoming face of the IU, thus steering future consumers' Interests towards the new producer's location. To avoid conflicts among subsequent updates, every IU is tagged with a unique sequence number incremented by the producer at each mobility event. When an IU reaches a previous producer location (identified by stale face information in TFIB), the update is completed. IU acknowledgments and retransmissions are used for reliability, while a security token carried by IU packets secures forwarding update operations.

3.2 Notifications and producer discovery

Performance of latency-sensitive traffic can be further improved by introducing a fast-single hop notification mechanism: every time a producer attaches to a new PoA, it sends to the latter an *Interest Notification* (IN), a special Interest



(a) Interest Update (b) Interest Notification

Figure 1: MM Update-Notification.

message differing from an IU only because it triggers a local TFIB update without being further forwarded. When a consumer Interest reaches a previous producer location before IU completion, the Interest is broadcasted in a discovery mode to one-hop neighboring nodes (we assume that, like in LTE, neighbouring PoAs talk to each other). The presence of TFIB information about the producer (presumably left by an IN) iterates the process, thus tracking current producer location in quasi-realtime (see Fig. 1(b)).

4. CONCLUSIONS AND FUTURE WORK

To provide a quantitative assessment of MM performance and comparison with previous proposals, we are currently implementing MM in NDNSim/ns-3 and preparing a realistic simulation setting leveraging synthetic and trace-driven mobility patterns.

We leave for future work the proof of correctness of MM in terms of connectivity/convergence guarantees as well as the analytical characterization of MM with the broader objective to demonstrate the advantages of an anchorless approach over anchor-based models.

Acknowledgments

This research work has been partially funded by the Technological Research Institute SystemX, within the project on Network Architectures ARE.

5. REFERENCES

[1] F. Hermans, E. Ngai, and P. Gunningberg. Global source mobility in the content-centric networking architecture. In *Proc. of ACM NoM Workshop*, 2012.

[2] D. Kim, J. Kim, Y. Kim, H. Yoon, and I. Yeom. Mobility support in content centric networks. In *Proc. ACM SIGCOMM ICN workshop*, 2012.

[3] J. Lee, S. Cho, and D. Kim. Device mobility management in content-centric networking. *Communications Magazine, IEEE*, 50(12):28–34, December 2012.

[4] L. Wang, O. Waltari, and J. Kangasharju. Mobiccn: Mobility support with greedy routing in content-centric networks. In *Global Communications Conference (GLOBECOM), 2013 IEEE*, pages 2069–2075, Dec 2013.

[5] Y. Zhang, H. Zhang, and L. Zhang. Kite: A mobility support scheme for ndn. In *Proc. of ACM ICN*, 2014.