Forwarding Strategies in ICN networking with a 5G Application

Ivanildo Ramos, Ivanes Araújo and Aldebaro Klautau

Abstract— **The recent growth of Internet traffic and the forecast of new applications on context of fifth generation of network technology (5G) leads to changes in the communication paradigm of future Internet. The Information Centric Networking (ICN) is a new architecture that can cope with the emerging pattern of communication based on named-data instead of their locations. In ICN architecture, Forwarding Strategies (FS) are a relevant feature to improve the network performance. Therefore, this article examines forwarding strategies for an ICN scenario with new 5G applications such as smart grids networking. The results are performed in the ndnSIM simulator and show that the delay-based forwarding strategy was the most suitable for low latency application.**

Keywords— **Information Centric Networking, Named Data Networking, 5G Applications, Smart Grid Network.**

I. Introduction

There is a need to support a growing demand for faster and massive content delivery for 5G applications, such as vehicle-to-vehicle, virtual and augmented reality services, industrial automation, smart homes and smart grids, each of these applications have different requirements, latency, peak data throughput and connection density, that often can not be achieved by current networks [1][2].

Information Centric Networking (ICN) is a promising candidate for future Internet architecture, that can improve the communication for 5G scenarios, with native features such as content aggregation, dynamic forwarding and distributed network cache [3][4]. Currently, there are many research efforts in Forwarding Strategies (FS) direction for ICN. Therefore, this paper aims to investigate three different forwarding strategies widely used for a scenario with a 5G application and evaluate its performance in terms of delay and throughput.

II. Forwarding Strategies

In ICN the data delivery process occurs in a pull-based fashion through the exchange of two kinds of packets, interest and data. Both types of packets carry a name that identifies the chunk of data that is requested, the interests are sent by a consumer and driven through forwarding strategies to a copy of the requested item. Once the interest reaches a node that has the requested data in cache, the node will return a data packet which carries both the name and the content by the reverse path [3][4].

Ivanildo Ramos, Ivanes Araújo and Aldebaro Klautau, Institute of Technology, Federal University of Pará (UFPA), Belém-PA, Brazil, E-mails: ivanildo.ramos@itec.ufpa.br, {ivanes,aldebaro}@ufpa.br. This work was partially supported by LASSE - 5G & IoT Research Group.

The FS are responsible to provide the intelligence to make a decision for each interest packet on which outgoing interface it will be forwarded. Because ICN is named-based, this can be done in a more aware fashion than current protocols over end-to-end networks [5]. In this paper different FS will be employed, that are explained below.

a) Multicast: The Multicast strategy is based on overload, increasing the link redundancies that can contribute to improve the delivery reliability. Therefore, it sends every interest to all interfaces (except downstream) [5].

b) Best-Routing: This strategy forwards a new interest to the lowest-cost link (except downstream). If a retransmission of an interest is received, it is forwarded to the lowest-cost interface that was not previously used [5].

c) NCC: This strategy uses the lowest delay interface to forward packets and, in timeout case, sends interests to others routes to discover upstreams with lowest delay. The timeout is initialized between 8 and 12 milliseconds. If the forwarding strategy get a response within the timeout, it is decreased by 1/128, otherwise, it is increased by 1/8 [5].

III. Scenario

The goal of this scenario is to implement a network with ICN architecture and a 5G application, in order to evaluate the performance of each forwarding strategy for low latency applications. This scenario will be implemented in the Named-Data Networking Simulator (ndnSIM), it allows create scenarios for ICN networks and ensures that the simulations are maximally realistic and can be reproduced in real environments with virtually no changes.

a) Traffic Demand: In smart grids application, the most critical requirement is the latency that must be responsive to altered system conditions that may occur at a remote distance to avoid cascading failures and damage in equipments [2]. The traffic requirements are provide by IEC 61850 standard for communication between substation in a power grid, considering an average throughput of 150 Kbps with data chunks size of 200 bytes, and a latency lower than 8 ms. In order to compete with smart grids traffic, a background traffic will be also implemented, to model the web remaining traffic, with a data size of 1024 bytes, a data rate exponentially distributed with mean equal to 10 Mbps and with a popularity model Zipf ($\alpha = 0.7$) [6], some others simulation parameters are available in Table I.

b) Network topology: The network topology used as ICN network, depicted in Figure 1, is a typical down-scaled model of a mobile network backhaul topology [7]. In the

TABLE I
SIMULATION PARAMETERS.

Parameter	Value
Number of contents	10.000 packets
Number of users	8
Link latency	0.5 ms
Bandwidth	20,30,40 Mbps
Cache capacity	100 packets
Seed values	12,25,32,49,77,91,128

network edge are the gateways and base stations, the users are equally divided between smart grid and background clients, the network link capacities are the same for links on the same level in the tree topology and the cache replacement policy is Least Recently Used (LRU) with a capacity about one percent of total contents in the network, in this paper the cache resource is not employed for smart grid traffic to evaluate exclusively FS performance.

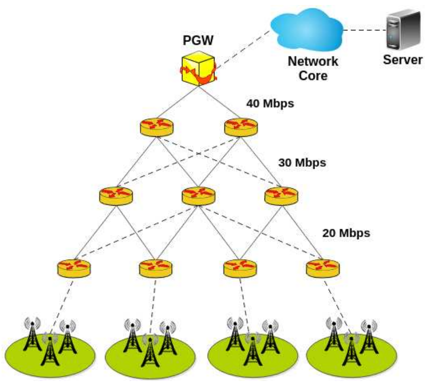

Fig. 1. ICN network topology

IV. RESULTS AND DISCUSSIONS

The results are divided into two parts, delay and throughput, which are shown respectively in Figures 2 and 3, this graphics were obtained with different seeds values. Different FS were used for the smart grid users (Multicast, Best-Routing, NCC), while users with background applications are forwarded via multicast, to generate the most stressed scenario for the network, the goal of the simulations is to verify which strategies are best suited for applications with low latency requirements.

The Figure 2 shows the delay values for the distinct strategies over time, from which can be observed that all results are below 8 ms. The Best-Routing strategy have achieved the lowest delay results, however, there is some stress points near the 8 ms limit, otherwise, the delay-based strategy NCC have performed more steadily to drive low latency applications because it sends the packets by the lower delay path.

In Figure 3 it can be observed which forwarding strategy offer the best performance in terms of throughput. The results for Best-Routing and NCC were similar, and outperformed Multicast results, given the higher amount of interest transmission implied in Multicast strategy, leading to increase in network congestion.

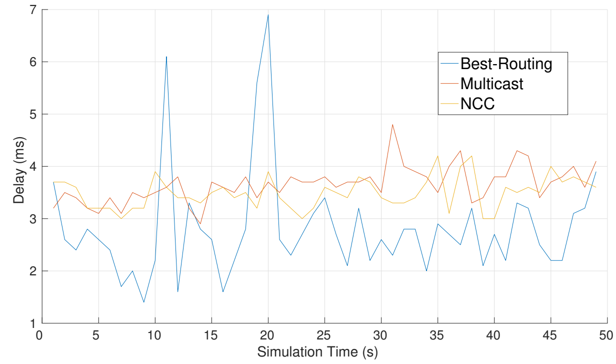

Fig. 2. Users delay performance

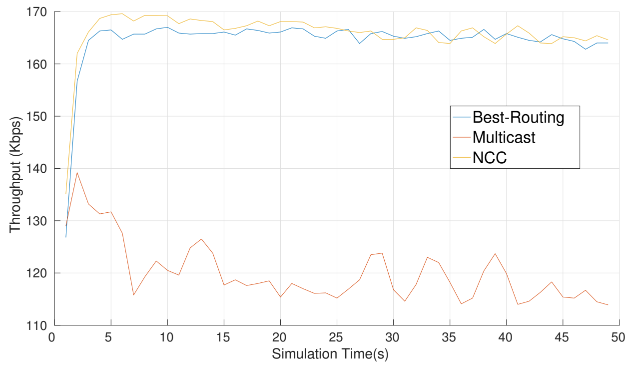

Fig. 3. Users throughput performance

V. CONCLUSIONS

This paper discusses an emerging 5G application and its requirements and how they can be addressed by ICN networks through FS. We first identify the current main FS and quantify their results through network simulation. The analysis reveals that the Best-Routing achieved good results, however, with some large delay variations not suitable for delay sensitive applications. Thus, the NCC was the most suitable for low latency applications.

REFERENCES

[1] GSA, *The Road to 5G: Drivers, Applications, Requirements and Technical Development*, Nov 2015.

[2] P. Popovski, V. Braun, H. Mayer, P. Fertl, *et al.* "Scenarios, requirements and KPIs for 5G mobile and wireless system". *IEEE Communications Magazine*, v. 52.5, pp. 26-35, May 2013.

[3] L. Zhang, A. Afanasyev, J. Burke, V. Jacobson, C. Papadopoulos *et al. Named Data Networking*, Jul 2014.

[4] G. Xylomenos, C. Ververidis, V. Siris, N. Fotiou, *et al. A Survey of Information-Centric Networking Research*, Jul 2013.

[5] A. Afanasyev, J. Shi, B. Zhang, L. Zhang, I. Moiseenko, *NFD Developers Guide*. NFD Team , Oct 2016.

[6] K. Katsaros, G. Xylomenos, G. Polyzos, *GlobeTraff: a traffic workload generator for the performance evaluation of future Internet architectures*, May 2012.

[7] G. Carofiglio , M. Gallo, L. Muscariello, D. Perino, *Scalable Mobile Backhauling via Information-Centric Networking*, Apr 2015.