POSTER: Analysis of the Energy Saving in Emerging Information-Centric Metropolitan Area Networks

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***Abstract*—Named-Data Networking is a prominent solution for offering flexible communications in Metropolitan Area Networks. Its features were recently extended with SDN and MEC capabilities for better supporting consumer mobility and improving packet forwarding functionalities. However, the scientific literature lacks a thorough investigation on the impact on the energy consumption of these protocols. Focusing the attention on the novel approach presented by the same authors of this paper, this contribution analyzes the energy saving in Information-Centric Metropolitan Area Networks. Results demonstrate the efficacy of the investigated approach by evaluating the different components of energy consumption in the considered scenario.**

***Index Terms*—NDN, consumer mobility, energy saving, SDN, MEC**

I. Introduction

Literature proved Named-Data Networking (NDN) is a well-established solution to natively support flexible and efficient data exchanges in mobility conditions [1], [2]. But, reference NDN pull-based strategies, such as [2], do not deal with the stale forwarding information generated by the mobility of consumers. Hence, their implementation in Metropolitan Area Networks (MANs) brings to the undesired forwarding of data packet replicas to the previous locations of consumers. This leads to a waste of energy due to the unuseful forwarding and processing of packets.

Recent works in literature consider Software-Defined Networking (SDN) to enable dynamic, intelligent, and programmable forwarding in MAN [3], as SDN is able to enforce network logics dynamically. At the same time, the scientific literature already proved that Multi-access Edge Computing (MEC) is a leading solution to support the mobility of consumers throughout the network and improve the functionalities of NDN and SDN [4]. The joint deployment of NDN, SDN, and MEC has been investigated on the architectural perspective in several existing works, which point out the promising capabilities of the framework [1], [2]. Nevertheless, these works lack a thorough analysis of the impact of their proposals on the energy consumption. Other existing works, such as [5], evaluate the impact on the amount of energy consumed, but fail to carry a thorough investigation.

Starting from these premises, this work thoroughly analyzes the impact of the protocol architecture proposed in [1] on the energy consumption of the network, quantifying the energy saving achieved with the investigated protocol.

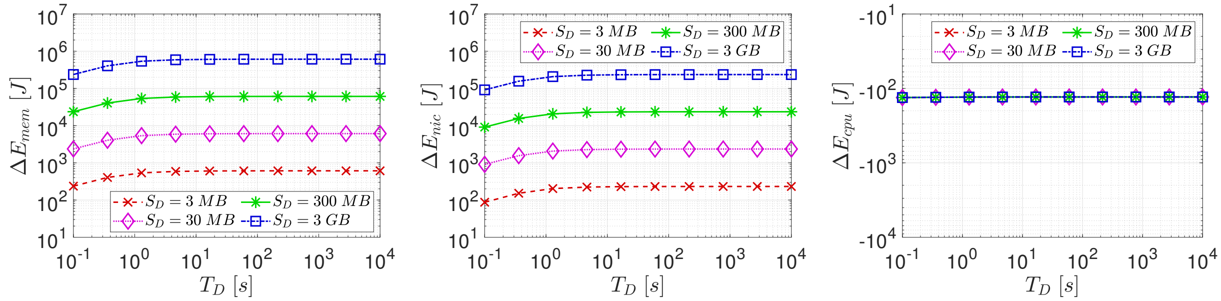
II. The Investigated Approach

This section provides a brief summary of the methodology addressing real-time services for mobile consumers proposed in [1], whose goal is to reduce the overhead generated by stale forwarding information in the reference NDN pull-based approaches. The considered scenario includes network attachment points, a centralized SDC, a fixed producer, and a mobile consumer. Network attachment points are deployed randomly in a metropolitan area, composing a wireless mesh scale-free network. Each network attachment point hosts a MEC entity that offers access to the network through several technologies and acts as a virtualized NDN router. The SDC exchanges control packets with the MEC entities to manage the network. The mobile consumer is interested to contents belonging to a specific topic name, which are generated by the fixed producer. The algorithm followed by the considered protocol architecture includes:

- *Subscription)* The mobile consumer subscribes to the nearest MEC entity.
- *Attachment)* The MEC entity notifies the new location of the consumer and the topic name of its interest to the SDC, which stores the information.
- *Re-synchronization)* The MEC entity retrieves the latest contents available for the topic name of interest of the consumer.
- *Data Exchange)* The MEC entity starts requesting up-to-date contents on behalf of the consumer.
- *Neighbor Inspection)* The SDC inspects virtualized NDN routers, starting from the previous location of the consumer, to remove stale forwarding information.

III. Summary of findings

For the investigation, we used a MATLAB script to simulate mobility, implement the data exchanges described in [1], and compute the energy saving by using the model presented in [6]. The simulations considered a mobile consumer following a random waypoint mobility model with average speed of 30 km/h in a 10 km x 10 km urban area, covered by randomly



(a) Memory (b) Network Interface Card (c) CPU

Fig. 1. Average amount of daily energy saving per consumer due to hardware components as a function of the application settings.

distributed network attachment points with a 150 m radius. The model separates the energy consumption in four different components, that are related to the CPU, memory, Network Interface Card, and chassis hardware parts. Fixed costs due to the idle consumption of network devices (i.e., the chassis component) are neglected in the analysis as they are not affected by the investigated protocol. The average amount of daily energy saving of each component is calculated as the difference between the energy consumption related to reference NDN pull-based approaches and the energy consumption related to the proposed protocol. Finally, the average amount of overall daily energy saving is calculated as the sum of the average amount of daily energy saving related to the memory, Network Interface Card, and CPU components.

Figure 1 shows the average amount of daily energy saving per consumer due to the investigated protocol, reporting the contribution of each hardware component separately. The amount of daily energy saving increases with the average time between the generation of consecutive contents, T_D, and increases with the content size, S_D, due to the unuseful forwarding of an higher number of packets. The analysis also highlights that the investigated protocol increases the consumption of the CPU hardware elements of a negligible amount, as virtualized routers have to process the control packets introduced by the investigated protocol. Finally, the contribution related to the memory access has paramount importance in reducing the energy waste. This is due to the control packets not using the caching mechanisms of NDN and preventing the contents carried by unuseful data packets to be stored in the caches.

Figure 2 shows the average amount of daily energy saving overall per consumer. Fittingly, the amount of overall daily energy saving increases with the average time between the generation of consecutive contents, T_D, and increases with the content size, S_D.

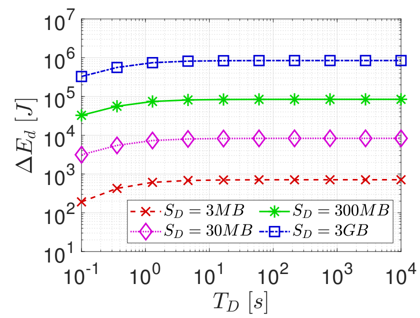


Fig. 2. Average amount of overall daily energy saving per consumer as a function of the application settings.

IV. Conclusion

This work analzyed the impact of the investigated approach on the energy consumption of a MAN and quantified the daily energy saving with respect to the reference NDN pull-based approaches. The conducted simulations considered the different contributions related to the hardware components of the network routers, proving the investigated approach capabilities to save energy in the considered scenario.

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