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A Novel Hybrid Forwarding Strategy for Content Delivery in Wireless Information-Centric Networks

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Abstract

Information-centric networking (ICN) is a promising solution for content delivery in multi-hop wireless networks. In these environments, the ICN forwarding strategies typically rely on *broadcasting*, which facilitates content distribution by taking advantage of the shared medium, but brings about undesirable side effects. To avoid the broadcast-related issues of packet redundancy and unreliability due its unacknowledged mode, a few recent proposals advocated *unicasting* as the communication mode to resort to, once the content provider has been discovered. However, unicasting may suffer from connectivity breakages due to node mobility and harsh propagation conditions, and, generally, limits the data sharing capability of the wireless medium.

In this paper, we design a robust ICN-based forwarding strategy, called *Ad Hoc Dynamic Unicast* (ADU), that *wisely harnesses unicast and broadcast primitives on top of IEEE 802.11-based wireless networks*. ADU relies on unicasting for content dissemination after the provider discovery, and promptly falls back to broadcast to find a new content provider in case of a link failure notified by the Medium Access Control (MAC) layer. Extensive simulations in two different multi-hop wireless scenarios, i.e., mobile and vehicular ad hoc networks, under different load settings, assess the ADU performance against benchmark ICN forwarding schemes, representative of broadcast-based and unicast-based solutions. Results show that ADU outperforms them in all circumstances, proving its better responsiveness to link failures, which guarantees a shorter content retrieval delay and a lower message overhead and energy consumption.

1. Introduction

Research in the area of multi-hop wireless ad hoc networking is today revamping pushed by a more pragmatic development strategy [1]. Many scenarios such as public city-wide dedicated services (e.g., video-surveillance or enhanced transportation systems), environmental monitoring through sensing systems, and post-disaster management, ask for easy and quick, highly scalable and cost-effective network deployments, with the aim of extending, replacing and/or offloading the infrastructure. There, either densely or sparsely deployed purpose-built devices (e.g., sensors, access points, road-side units), but also smartphones carried by pedestrians [2], [3], and other networked objects like cars [4], may play an active role in the generation, sharing, dissemination and retrieval of contents.

Contents may span from small sized data (e.g., measurements retrieved from sensors) to medium-to-large files (e.g., city maps, pictures of a road segment) and may exhibit different *popularity levels* and *time-* or *spatial-relevance*. For instance, road traffic information are public utility (highly popular) locally-relevant data, the time validity of which lasts a few seconds or minutes.

Recent literature articles argued in favour of Information Centric Networking (ICN) [5] as a key paradigm to facilitate content retrieval in wireless ad hoc networks [4], [6]. The main ideas behind this paradigm, i.e., *(i)* content *names* used at the network layer for data retrieval, instead of end-host network addresses, *(ii)* interaction models *decoupling sender (a.k.a. provider) and receiver (a.k.a. consumer)* and supporting asynchronous communications, and *(iii) in-network caching*, well suit environments where connectivity with a specific end-host is difficult to set-up and maintain, because of the error-prone radio channel, the mobility of nodes or their battery-powered nature.

In the majority of ICN solutions for wireless environments such as mobile ad hoc networks (MANETs) [7], [8], vehicular ad hoc networks (VANETs) [9], [10], wireless sensor networks (WSNs) and, at a larger scale, the Internet of Things (IoT) [11], [12], [13], the requests for a named content are typically sent in *broadcast* to maximize the possibility of finding a content by taking advantage from packets overhearing and distributed in-network caching. However, broadcasting - if not wisely controlled - can lead to congestion and high packet redundancy, with consequent inefficient bandwidth usage and waste of devices' resources. Therefore, packet suppression techniques and/or further signalling have been proposed [8] to keep redundancy under control.

Meanwhile, few recent works argued in favour of *unicasting*, once content providers have been discovered through the initial request broadcasting [14], [15], [16]. Unicasting