International Journal of Wireless Networks and Broadband Technologies
Volume 8 • Issue 1 • January-June 2019

Reverse Cooperatively Routed Wi-Fi Direct in the Advent of 5G Driven Designs

Michal Wodczak, Samsung Research, Warsaw, Poland
https://orcid.org/0000-0003-2078-8352

ABSTRACT

In this article, the instantiation of the logic behind the so-called "Multi-Connect" mode of Wi-Fi Direct is advocated for and prescribed in order to make it possible to increase, if not multiply, the data throughput attainable by a given P2P Device thanks to traffic aggregation. In general, the described extension to the existing standard, defined by the Wi-Fi Peer-to-Peer (P2P) Technical Specification, enables the reversal of the logical roles of a P2P Group Owner (P2P GO) and its respective P2P Clients, while ensuring that the general architectural framework of Wi-Fi Direct should remain unchanged for backward compatibility reasons. This is achieved with the aid of a number of specifically tailored modifications including: new P2P Attribute allocation, extended Group Owner determination, modified P2P State Machine operation, enhanced Concurrent and Non-Concurrent operation, as well as expanded Reverse Operation Logic definition. The concept is illustrated with and verified through the analysis of cumulative virtual channel capacity and, therefore, the expected data throughput gain.

KEYWORDS

Cooperative Routing, Multi-Connect Mode, Standardization, Wi-Fi Direct

1. INTRODUCTION

This paper prescribes the instantiation of a logic behind the so-called "Multi-Connect" mode of Wi-Fi Direct for the sake of increasing, if not multiplying, as explained later, the cumulative virtual channel capacity and, therefore, the expected throughput gain achievable by a given P2P Device thanks to traffic aggregation (Li et al., 2019). Taking into account the fact that the term of "Multi-Connect" does not appear to be explicitly referred to within the Wi-Fi Peer-to-Peer (P2P) Technical Specification, it shall be perceived as much more representing the notion of a proper name, and, thereby, treated as equivalent to the idea of the "P2P 1:n topology" introduced therein (Wi-Fi Alliance, 2016). Given such a context, the extension in question shall be understood as pertaining precisely to the reversal logic changing the default roles of the P2P Group Owner and its respective P2P Clients yet maintaining the general architectural framework of Wi-Fi Direct unaltered for backward compatibility needs. For this reason, it becomes necessary to reformulate the said "Multi-Connect" functionality in order to allow for the operation in the opposite direction, where the P2P GO would take the role of a logical "Client," while the P2P Clients would form a set of distributed feeding nodes, just as if they were logical "Servers" (Khan et al., 2019).

DOI: 10.4018/IJWNBT.2019010102

Most importantly, the resulting cumulative virtual channel capacity and, therefore, the expected throughput multiplication is anticipated to be achievable in a much more efficient way compared to the nowadays available concatenation of Wi-Fi and cellular technologies, serving as a fairly easily implementable, yet a much less scalable, alternative. In other words, the extension in question addresses an urgent need for a neat solution that would not only be free of such limitations but could also be based on a globally adopted Wi-Fi Direct standard, thereby providing a substantially competitive advantage over the other niche solutions. For the sake of clarity, one should note, however, that traffic aggregation shall by no means be perceived as what the extension attempts to solve directly. In fact, the concept in question rather claims that the operation of Wi-Fi Direct be specifically reversed so that such an aggregated approach could be facilitated. Fairly alike, even though the title touches upon a cooperatively routed scheme, once again, such a development is neither what the extension is intended to instantiate, especially given the variety of options available. This is so, even though the logic outlined in more detail below is well designed to trigger any such scheme following additional guidelines (Wódczak, 2012, 2014, 2018).

The paper is arranged as follows. Right after the opening Section 1 of a fairly introductory nature, a more detailed context setting information is provided in Section 2, where not only the 5G-realted context setting is outlined, but also the background information along with the motivation and objective, as well as the assumed approach towards the extension in question are touched upon in the context of the global picture of the Wi-Fi Direct standard. Given such a background and following the related guidelines, the workings of the extended logic are put forward in Section 3, where the key components are described with a special emphasis being laid on the conceptual solution outline comprising the functionality behind the major enabling mechanisms such as the new P2P Attribute allocation, extended Group Owner determination, modified P2P State Machine operation, enhanced Concurrent and Non-Concurrent operation, as well as expanded Reverse Operation Logic definition. This part of the paper is complemented by Section 4 focusing on discussion and evaluation, where not only the question of virtual channel capacity and expected throughput gain is investigated, but also analytical results are provided along with additional commentary on practicality and comparability, as well as on the technical advantage. Eventually, the paper comes to its conclusion in Section 5, where the major points are summarised and reinforced once again for the sake of emphasising all the major advantages behind the extension.

2. CONTEXT SETTING

2.1. 5G-Related Context Setting

Looking not only at the concept of 5G (Zhang et al., 2019), but also taking into account the LTE-A technology (Liu et al., 2015), one may come to a conclusion that still before the forthcoming commercial roll-out of the former, what is potentially offered by the latter, in terms of Carrier Aggregation (CA) (Rostami et al., 2018), is rather a special mode of operation than an out-of-the-box experience. In other words, despite the promise of direct ultra-high data transfers brought by both the above-mentioned technologies, there appears to still exist room for a combined and complementary solution as proposed and explained in the reminder of this paper, where the transmission rates may scale beyond what is promised by regular Wi-Fi Direct, which most obviously derives its capabilities from being based on the Wi-Fi standard (Selinis et al., 2018). In fact, one should note that there are two options which are in general to be taken into consideration in this paper, one more related to throughput resiliency and another more related to throughput gain, yet none of them remaining is any conflict with the already well-established mechanism of Wi-Fi channel bonding (Bellalta et al., 2016).

This way, on the one hand, one may think, in the first place, of throughput resiliency as an approach taking place should the multiple MAC capability of Wi-Fi Direct, to be yet touched upon, be unsupported or unavailable, consequently demanding the application of the so-called non-concurrent