# Chapter 2
# Bandwidth Efficient Relay Transmission Strategy for MIMO–OFDMA Multicellular Networks: Relay Transmission in OFDMA Networks

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## ABSTRACT

*A bandwidth efficient relay transmission strategy is proposed and analyzed for MIMO – OFDMA cellular networks. Unlike other relay approaches studied in the literature, requested content plays a key role in the relay node selection procedure. The overall systems' architecture, including relaying selection procedures, data forwarding and reception is described, while privacy and security issues are analyzed as well. In the final section of the manuscript, performance metrics are provided demonstrating the superiority of the described approach compared to the non-content aware case.*

## 1. INTRODUCTION

Modern wireless communication networks should be in position to provide a variety of high data rate services to mobile users over a limited bandwidth area. Therefore, the design on next generation broadband wireless networks can be a rather complicated task, as bandwidth efficient transceiver architectures should be considered among others. In fourth generation (4G) networks, transmission and reception are based on the Orthogonal Frequency Division Multiple Access (OFDMA) physical layer protocol, where the available bandwidth is divided into a number of narrowband orthogonal subcarrier regions (Astély et al., 2009). These limited subcarrier areas in frequency domain result in an increased symbol period in time domain, thus combating Inter-

DOI: 10.4018/978-1-4666-8732-5.ch002

Symbol Interference (ISI). Moreover, bandwidth on demand is also supported, as different Mobile Stations (MSs) may be allocated with different subcarrier regions. If OFDMA transmission is coupled with Multiple Input Multiple Output (MIMO) architecture, then the capacity gain can be further increased with no additional spectrum requirements. In particular, two transmission modes can be supported: diversity combining and spatial multiplexing. In the first case, the same information is send and received from all links of the MIMO configuration. Hence, mean Bit Error Rate (BER) can be significantly reduced, as outage probability is minimized. On the other hand, in spatial multiplexing transmission mode, independent data streams are transmitted from different transmit antennas, in an effort to increase overall throughput. However, the diversity order of the system is reduced; hence advanced signal reception techniques should be employed at the received in order to maintain acceptable BER (Stüber et al., 2004). In recent literature, several studies have focused on transmission and resource allocation algorithms for MIMO – OFDMA networks. In this context, Space – Time (ST), Space Frequency (SF) and Space – Time – Frequency (STF) techniques have been analyzed in terms of achievable diversity gain and overall complexity. According to Zhang et al. (2007) for example, STF coding can achieve the maximum diversity gain in an end-to-end MIMO-OFDM system over broadband wireless channels.

In general, the vast majority of proposed algorithms for MIMO – OFDMA networks assume continuous data transmission, while at the same time ignore information related to requested content. However, in practical wireless orientations, MSs may request information on demand from their serving base stations (BSs). Since this information is usually related to multimedia content, the attempt to satisfy all MSs' requirements in cases of simultaneous requests (e.g. the live streaming case) may lead to reduced Quality of Service (QoS), limited active links or eventually link outage. Several approaches have been introduced in recent literature, in order to increase the offered data rates in next generation wireless networks, under specific bandwidth limitations. A promising solution is the use of relay nodes, which receive information from the BSs, decode it and then forward it to MSs. In this approach, relays that are appropriately placed in the topology of the network orientation, decode, amplify and forward the receive transmission streams from BSs to MSs (Boccardi et al., 2009, Yu et al., 2010, Behbahani et al., 2007, Kwan et al., 2009).

In this book chapter, an information-centric relay approach will be described and evaluated. In this approach, MSs can act as active relays, depending both on their channel quality and requested information. The added value of a system with content-aware nodes treated as active relays can be rather important, since the relay selection process will also consider which MSs receive the content anyway and, therefore, do not have to consume resources to fetch and forward information of no use to them.

This can be achieved through the emerging Information-Centric Networking (ICN) paradigm, which is considered as a possible solution for the future internet. The most common ICN developments consider content routing, based on a unique name that unambiguously represents each content chunk in the network. Being an indispensable part of the forwarded packet, this name can render a cross (physical-network) layer protocol, content-aware.

The algorithm for achieving this relaying approach has already been presented and evaluated by Anadiotis et al. (2014). In this book chapter, an integrated architecture will be presented, which will show how the proposed algorithm can be adopted in existing systems, considering practical issues raising in this context. This architecture will consider the advances in the standardization of adaptive video streaming over Information-Centric