

Chapter 19

Cooperative Communication System Architectures for Cellular Networks

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ABSTRACT

An ever-growing demand for higher data-rates has facilitated the growth of wireless networks in the past decades. These networks, however, are known to exhibit capacity and coverage problems, hence jeopardizing the promised quality of service towards the end-user. To overcome these problems, prohibitive investment costs in terms of base station or access point rollouts would be required if traditional, non-scalable, cell-splitting, and micro-cell capacity dimension procedures were applied. The prime aim of current R&D initiatives is, hence, to develop innovative network solutions that decrease the cost per bit/s/Hz over the wireless link. To this end, cooperative networks have emerged as an efficient and promising solution. We discuss in this chapter some key research and deployment issues, with emphasis on cooperative architectures, networking, and security solutions. We expose some motivations to use such networks, as well as latest state-of-the-art developments, open research challenges, and business models.

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INTRODUCTORY NOTE ON COOPERATION

Background

Wireless networks have witnessed a tremendous upsurge in recent years; this is mainly attributed to a lasting demand of high data rates anywhere and at anytime, which has been partially realized by a variety of commercially viable voice and data oriented applications. Traditionally, a centralized network infrastructure, such as GSM, is deployed by service providers; this approach worked fine in the past but commences to exhibit drawbacks, such as high cost, high power consumption and limited throughput.

An extreme alternative are ad hoc networks, where packets are forwarded in a multihop fashion. In such networks, users cooperate to relay and process each other's information. Notwithstanding their low cost, rapid deployment and self-organization capabilities, ad hoc networks face QoS, security and scalability problems. Consequently, standalone ad hoc networks are not promising for service commercialization. Indeed, business models for real world deployments are fairly complicated, having prevented a commercially viable deployment of pure ad hoc networks to date.

A natural hybrid approach is to beneficially fuse both of the above wireless paradigms in order to construct a single network with high flexibility and improved network performance. In such a network, a centralized base station (BS) or access point (AP) communicates directly with some users or fixed low-cost relaying stations, which in turn cooperatively relay information in an ad hoc fashion to other users in connectivity range. In the cellular case, such networks are typically referred to as *multihop cellular networks (MCNs)* as introduced by Lin & Hsu (2000). Subsequently, we will partially focus on cooperative MCNs, bearing in mind that the majority of exposed techniques and architectures are equally applicable to non-cellular networks.

MCNs can reduce the required number of BSs/APs and/or improve the throughput performance, whilst limiting path vulnerabilities typically encountered in multihop networks. They are potentially opening new business opportunities for network operators and service providers, allowing commercial service provisioning with broader coverage. However, for wide-area deployments of MCNs, appropriate architectures are needed allowing for cooperative multihop communication between similar wireless technologies and cooperative communication between different operators and service providers, as well as different wireless technologies.

We hence focus on possible deployment architectures for cooperative MCNs and the major technical challenges that are currently being resolved in real deployment scenarios from cooperation perspectives, such as routing, appropriate QoS metrics, authentication, and authorization to services' access, etc. We will, however, precede the architectural description of such networks by some basics needed to understand cooperative communication systems.

Some Useful Definitions

A large body of recent publications has led to numerous independent terminologies, some of which we wish to harmonize below (Dohler & Aghvami, 2007). These definitions relate to the cooperative system, the cooperative information flow, the nodes' behavior and the actual method of relaying.

Often occurring in the exposures of cooperation is the concept of *infrastructure*. An infrastructure – be it physical or logical – can:

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