Chapter 10
Device-to-Device Communications

Ioannis Giannoulakis
National Centre for Scientific Research, Greece

Emmanouil Kafetzakis
National Centre for Scientific Research, Greece

Anastasios Kourtis
National Centre for Scientific Research, Greece

ABSTRACT

This chapter provides an account of the most significant areas of scenarios and applications relevant to Device-To-Device (D2D) communications. At first, a state of the art review is provided, with focus on the special technological challenges. In addition, integration initiatives with modern cellular technologies and standards are given. Important architecture concepts like e.g., resource management and mobility issues have been highlighted, in order to present the main areas of impact of D2D communications. Since D2D communications capitalise on the contemporary networking paradigm of cooperative communications novel methods for overcoming several limitations have been discussed and emerging paradigms such as proximity and location-based services, coupled with social networking and commercial services have been considered. Finally, possible future research directions relevant to D2D networking are discussed.

INTRODUCTION

The migration from voice towards 'intelligent' mobile services proceeds to meet the demands of 'anytime – anywhere' broadband wireless connectivity. 'Smart' portable devices enriched with processing and storage capabilities, and the penetration of resource demanding applications in the wireless domain, introduce fundamental changes to mobile networking and pose new challenges to the research community. If anything, next generation communications should be able to deliver aggressive improvements in all key aspects of wireless communications, including performance, coverage, and energy efficiency.

Whereas currently there is no complete technological definition of what comes after the state-of-the-art wireless technologies, the anticipated

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communication requirements may already be understood from users' perspective. People desire to be connected at all times, from any location, leveraging on the rich set of services provided by modern multimedia-over-wireless networks. The major upcoming challenge will be how the offered services will conform to the desire of the public for ubiquitous broadband wireless communications. The term D2D commonly refers to technologies that empower wireless devices with direct communication and data exchange capabilities, without the need of fixed infrastructure, although the latter may still be responsible for centralized management of resource allocation, signalling, radio link control and other important tasks.

Innovative wireless technologies like D2D receive increasing interest of hardware manufacturers, telecom operators and end-users, in consideration of the new wireless reality. Licensed spectrum becomes scarcer day-by-day and at the same time, large infrastructure investments are imperative. D2D communications come to address most of these issues by effectively reusing cellular resources and transforming user's connectivity experience in a systematic and methodical way.

A smooth yet powerful way for spatial spectrum reuse and cellular traffic offloading is envisioned. With the rise of context-aware software and the advance of location-based applications, D2D communications play an increasingly important role due to the ability to leverage on the discovery of nearby devices, reducing communication costs and optimizing the received quality of experience. In addition, D2D capabilities produce added value for existing wireless networks and constitute a continuously rising market. Mobile operators and vendors are increasingly interested to explore the dynamics of this novel wireless connectivity architecture, and to integrate such techniques to the existing infrastructure.

Currently, Wireless Local-Area Networks (WLANs) (i.e., based on the IEEE 802.11 standards) and Wireless Personal-Area Networks (WPANs) (as e.g., Bluetooth) have gained increased popularity, because they are able to provide Internet access and data services at reduced cost. However, communications that take place on some part of the licensed spectrum of a cellular network could become better in terms of interference avoidance. In addition, location based services through the above mentioned methods require users to manually pair their peers or establish connections through the access points.

Therefore, D2D communications could make things more convenient, since the base station can handle pairing of devices more efficiently and also it may provide better user experience. On the other hand, as will be explained later, although D2D communications can provide several benefits both for users and the cellular network, the extensive use of D2D communications can infer harmful interference to cellular users in case of sharing the same resources.

In this point it would be helpful to contrast D2D communications with Mobile Ad hoc NETworks (MANETs) that have been studied and analyzed extensively for over about three decades. A key difference resides in that D2D can normally rely on help from the network infrastructure (i.e., eNBs) for control functions like synchronization, session setup, resource allocation, routing, and other overhead-consuming functions that are severely resource consuming in a MANET. Moreover, D2D communications typically consist of local and single-hop links, while multihop routing is typically required in a MANET. When long transmission hops are unavoidable, network performance is unavoidably reduced.

The rest of this chapter is structured as follows. Section 2 provides a state-of-the-art in the region of D2D communications, succeeded by a description of potential application scenarios, presented in Section 3. The most significant aspects of the current Long Term Evolution-Advanced (LTE-A) standard and the integration of the D2D architecture have been introduced in Section 4. Section 5 presents the important concept of Cooperative Communications. Section 6 concludes the chapter.