

# Chapter 18

## Convergence Aspects of Autonomic Cooperative Networks

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### ABSTRACT

*The current efforts across industry and academia are to develop new paradigms that enable ubiquitous on-demand service provision. This aim may be achievable because of the envisaged deployment of cutting-edge technologies such as cooperative transmission. However, a real advancement is only attainable when autonomic system design principles are taken into account. Looking at the concept of the Relay Enhanced Cell, one may come across commonalities with Mobile Ad-hoc Networks. Especially in Local Area scenarios, Base Stations seem to resemble advanced Access Points, while fixed and movable Relay Nodes might be replaced by powerful mobile User Terminals. On top of it, Generic Autonomic Network Architecture would help accommodate the fact that network devices may expose autonomic cooperative behaviors, allowing them to play certain roles. Finally, such a network must interact with Operations Support System deployed by the network operator for uninterrupted, continued operation.*

### INTRODUCTION

The most recent trends in research, industry and academia domains aim to develop new networking paradigms that would enable ubiquitous service delivery upon request. In fact, the end user mobile devices are envisaged to be equipped with the most advanced technologies, such as cooperative transmission (Doppler, Osseiran, Wódczak, & Rost, 2007). However, a real advancement

will only be attainable, when the ground for convergence among different concepts supporting cooperative mobile networking has been accurately established. This will undoubtedly result in even further increased complexity as compared to the current solutions, however, the changes seem imminent. Looking at the concept of the Relay Enhanced Cell (REC), one can come across some commonalities with Mobile Ad-hoc Networks (Wódczak, 2007). Especially, for Local

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Area scenarios, the Base Station (BS) might be very generally perceived as an advanced Access Point (AP) and the fixed and/or movable Relay Nodes (RN) might be replaced by movable and/or mobile User Terminals (UTs). Going further, the resulting networked system needs to be designed to accommodate the fact that the UTs can expose certain dose of autonomic behaviors, allowing them to auto-discover and choose to play certain roles, such as cooperation. In this context and with the use of autonomic system design principles, cooperative transmission can be translated into autonomic cooperative networking. From the business perspective, such a system needs to be managed accordingly and, therefore; the Generic Autonomic Network Architecture would be incorporated into the global picture to enable the interactions with Operations Support System (OSS) (Jain, Hayward, & Kumar, 2003). Consequently, one can expect that in the nearest future, network operators might be able to exploit the possibility of cooperation among the devices belonging to the end users to extend the capabilities of their networks and to facilitate Quality of Service (QoS) provision. Obviously, certain issues need to be tackled by the business models, such as the necessity for the incorporation of special incentive mechanisms, so the end users would be more willing to agree to trade quicker drainage of their batteries for additional bandwidth or other benefits. This paper discusses the selected aspects of the current advancements in the area of autonomic cooperative networking and outlines the way forward in terms of progressing the convergence among the aforementioned technologies to allow the instantiation of cooperative behaviors for the benefit of mobile network operators, service providers and of course the end users.

## **COOPERATIVE MOBILE NETWORKS**

### **Current Deployments**

Cooperative relaying emerged as a very promising method for improving the process of transmission in wireless mobile networks (Herhold, Zimmermann, & Fettweis, 2004; Pabst et al., 2004). This approach is based on spatio-temporal processing and this work assumes the use of space-time block coding, while different techniques are applicable depending on specific requirements (Alamouti, 1998; Tarokh, Jafarkhani, & Calderbank, 1999). In general, cooperative transmission is performed by groups of nodes forming Virtual Antenna Arrays (VAA), and so making use of transmission diversity. This helps improve the quality of the radio links between the source and destination nodes. Such a process may also take place over multiple hops where multiple tiers of nodes cooperatively apply distributed space-time block coding (Laneman & Wornell, 2003) to process the transmitted signal in both the spatial and temporal domains (Dohler, Gkelias, & Aghvami, 2004). This will be further discussed in the section describing the convergence aspects related to the incorporation of network layer routines provided by the Optimized Link State Routing Protocol. Such an approach is beneficial because usually it not obvious which nodes should be assigned to different VAAs (Wódczak, 2007).

As it was already mentioned, the currently investigated Local Area Relay Enhanced Cells tend to expose common aspects with Mobile Ad-hoc Network set-ups. Yet still, even if the Base Station were to be replaced with an Access Point and Fixed Relay Nodes substituted by mobile User Terminals, the system would behave in way more specific for cellular networks. This is well illustrated by the scenario of interest, depicted in Figure 1, where the REC comprises one floor of the height of 3 m located in a building. The floor is organized into two corridors of the dimensions

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