

Chapter 6

HWN* Framework Towards 4G Mobile Communication Networks

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ABSTRACT

The objective of the Hybrid Wireless Network with dedicated Relay Nodes (HWN) proposal is to interface the Base Station (BS) Oriented Mobile Network (BSON) and the 802.11X assisted Mobile Ad hoc Wireless Network (MANET) so that one system can be utilised as an alternative radio access network for data transmissions, while the incorporation of the Relay Node (RN) is to extend the communication coverage, optimise medium resource sharing, increase spatial reuse opportunity, stabilise MANET link and create more micro-cells. The HWN* keeps the existing cellular infrastructure and a end-user Mobile Terminal (MT) can borrow radio resources from other cells through secured multi-hop RN relaying, where RNs are placed at pre-engineered locations. The main contribution of this work is the development of a HWN* system framework and related medium access and routing protocols/algorithms. The framework dedicatedly addresses the transparent multiple interface traffic handover management, cross layer routing, RN positioning and network topology issues to increase communication system capacity, improve Quality of Service (QoS), optimise transmission delay and reduce packet delivery delay.*

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INTRODUCTION

The evolving cellular communications industry was originally focused on providing voice services. However, ever increasing demand for multimedia mobile services required new architectures to extend indoor and outdoor coverage, increase system capacity, improve service quality and reduce transmission delay. For example, a large amount of bandwidth is needed to support mobile broadband applications. Current solutions require the installation of expensive BSs to increase the system capacity with reduction of cellular cell sizes, which result in large costs in equipment, wiring and complex system management. The alternative approach is to install wirelessly linked multi-functional Relay Nodes (RN), which not only creates smaller cell sizes but also provides packet relay functions, introduces networking flexibility, saves end terminal power and largely mitigates the pass loss. In this work, we propose to realise high quality mobile communication services in a novel system infrastructure that includes a cellular network, a Mobile Ad hoc Network (MANET) and an integrated dual radio access interface on each RN and MT.

The proposal brings out many research challenges as the infrastructure lends itself to complex change in topology, medium access, resources sharing and routing path selection. The ad hoc interface has limited transmission range thus multi-hop communication and RN infrastructure support are required for data exchange. The cellular interface offers robust communication but the bottleneck is at the resource sharing between base stations and relay stations, which require the development of a traffic sharing approach between entities. In order to exploit the advantages of the infrastructure, algorithms and protocols have been proposed to tackle resource management problems e.g. inter-network traffic management and heterogeneous network route selection in a distributed manner.

Hybrid wireless networks with multiple active interfaces towards 4G wireless networks are still

being developed and as yet no real world prototype has been deployed except the 3GPP Long Term Evolution (LTE) test operating by Motorola, Nortel and NTT DoCoMo, the IEEE 802.16j multimedia traffic relaying project and Alcatel-Lucent 3G Femto high speed mobile home access where a large number of Femto relay cells are required on per house basis. The HWN* represents another possible realisation of the hybrid wireless network concept. The HWN* and associated algorithms are proposed and evaluated by means of computer simulation (Rea, 2006) to analyse node mobility, scheduling algorithm, handovers, routing, resource sharing and topology design schemes. The complexity of the HWN* system is such that performance evaluation does not lend itself to pure mathematical treatment but more accurate evaluation is only possible by means of simulation, which also provides more practical options for parameter changes.

The following chapters will first briefly review the state of the art of the cellular network, MANET, relay concept, recent hybrid network system approaches, and hybrid wireless networks related algorithms to provide an understanding of the effectiveness of our HWN* infrastructure. The major achievement of our research is then discussed. Apart from the cost-effective HWN* architecture proposal with minimal change on existing cellular and MANET structures, other core contributions can be summarised as:

- **Network Design:** In order to maximise the spectrum usage and facilitate load balancing, RN positioning planning has been developed and investigated. Our approach focuses on heuristic relay placement to explore the node mobility pattern's impact, cellular system, MANET and relay characteristics.
- **Solving complexity:** For large scale hybrid networks, more components are added to the system. Therefore simple route management algorithms may produce larger

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