Abstract

With the growing demands of wireless applications and mobile data connections, wireless communication is expected to provide the ever-increasing demand for higher data rate and efficient data communication. Energy consumption is also one of the main problems for the mobile wireless devices because they all depend on the limited battery power installed inside them. Recently, network coding has been introduced as an enabling technology to fulfil the highest achievable capacity of multicast transmissions in butterfly-topology networks. It is also said that network coding has a special advantage to the wireless networks with no extra cost due to the broadcast nature of wireless transmission. This dissertation investigates the potential benefits of network coding to provide efficient data communication for multihop wireless communication and to fulfil the requirements of future wireless networks.

The targeted problems are approached from the viewpoint of multihop communication and the proposed solutions involve the application of network coding techniques. Network coding has a high potential to be incorporated on the Internet in future due to its advantages such as reduction in the number of transmissions and providing high reliability and robustness. However, more work is still needed to realize the practical application of it. This dissertation considers the application of network coding in different scenarios to achieve the efficient data communication.

In this dissertation, an efficient network coding based data transfer framework is proposed, which utilises network coding (NC) to assist data transmission, data collection and data sharing among the wireless nodes to be more efficient in terms of high throughput, low latency, fairness and low energy consumption. Three schemes comprise in the framework for the three scenarios which have high potential to become popular soon. For the first scenario, a network coding-aware medium access control (necoMAC) scheme is developed, which is a combination of network coding-aware 2-hop path selection protocol (NCA-2PSP) and network coding-aware carrier sense multiple access (NCA-CSMA) protocols for the higher rate data transmission from one node to another. These MAC protocols exploit the multi-rate capability of IEEE 802.11 PHY and golden topologies such as chain and triangle inside the network as key resources for network coded transmissions. These protocols introduce a relay control message, which informs the sender to use a higher rate for transmitting the data frames.

The second scenario includes data gathering applications in a wireless sensor network (WSN), hundreds of nodes are spatially distributed to collect

information about the physical environment. Their energy is consumed not only for sensing but also for networking functions to propagate the sensed data to a remote device, base station (BS). The most obvious challenge of a WSN is energy efficiency. Ultra-low latency and ultra-high reliability are also needed for the real-time data collection from the physical environment. For this scenario, an energy-efficient network coding based data gathering scheme called necoDG is proposed. Random linear network coding (RLNC) is applied to the aggregator or cluster head (CH) node to support the reliable data communication from CH to BS. A network coding-aware medium access control protocol is incorporated into cluster-based WSN for the data transmission from each sensor node to the CH node.

For the problem of mobile data downloading from a base station (BS), a balanced cooperative network coded transmission scheme called BCCT is proposed to achieve fast downloading satisfaction. This work includes data sharing within a group of wireless devices by exploiting the two interfaces, cellular and Wi-Fi, which are present in a standard mobile phone. The BCCT scheme applies linear network coding and transmission of the combined data frames to the devices located in the one-hop distance. An algorithm for selecting the next transmitter and choosing the better combination is introduced to maintain fairness among members of the group. The purpose is to satisfy their required data frames as quickly as possible with the fewer number of transmissions.

The proposed schemes are evaluated by computer-based simulation in multihop wireless network environments in terms of the performance metrics such as throughput, energy consumption, latency, fairness and overhead ratio. The results show that the overall performance is improved by 30% compared to conventional methods. The necoDG scheme obtains about 15.2% energy saving on average. The BCCT scheme significantly balances the number of transmissions made from each device and reduces 8.92% of the total number of required transmissions.

Keywords: Network coding, Efficient data communication, Multihop wireless communication, MAC protocol, Cooperative data exchange