Abstract

Number of connected devices is increasing unprecedentedly that by the year 2020 more than 50 billion devices are connecting to the networks. This situation motivates us in this thesis to develop efficient transmission strategies using multiway relay networks (MWRN) to serve *massive* number of devices (users) as solutions for the massive connection challenges.

First, this thesis studies very simple case of MWRN, where a single relay terminal is employed to help users to fully exchange information among themselves, termed as *multiway single relay networks* (MWSRN). To date, MWSRN is proposed with fixed transmission scheduling that inherits high complexity when the number of users is very large. To solve this problem, this thesis proposes uncoordinated transmission (random access) strategy, where the users are allowed to transmit their information (messages) randomly to the networks, and hence, no transmission scheduling is required. Conventionally, uncoordinated transmission suffers from low throughput performance due to the fact that the collided messages are discarded. Contrarily, in this works, instead of avoiding the collision, we exploit the collided messages using successive interference cancellation (SIC) to improve throughput performance. This thesis further proposes iterative demapping (IDM) algorithm to be incorporated into SIC to achieve networks throughput beyond $T = 1$ packet/slot, which is the limit of the conventional random access throughput.

This thesis shows that the proposed uncoordinated transmission strategy in MWSRN resembles a coding structure similar to low-density parity-check (LDPC) codes structure that can be represented by a bipartite graph. Accordingly, the similar analysis techniques, extrinsic information transfer (EXIT) analysis, which is basically for physical layer, is utilized to analyze the decoding convergence behavior of the networks. The network capacity bound expressing maximum offered traffic that can be reliably handled by the networks is derived based on EXIT chart area theorem. It is shown that with IDM algorithm the proposed MWSRN has two times higher bound compared to the conventional MWSRN, which also implies that throughput of $T = 2$ packets/slot is *asymptotically* achievable using the proposed technique. The computer simulation results confirm the superiority of the proposed techniques in terms of throughput and packet-loss-rate (PLR) performances. In practice, the proposed MWSRN can achieve throughput greater than $T = 1$ packet/slot. It also offers very low PLR floor because the probability

of degree-two stopping set can be eliminated by employing IDM algorithm in SIC.

The rest of the thesis focuses on the extension of MWSRN to serve wider and larger network coverage by proposing multiple relays, called *multiway multirelay networks* (MWMRN). The uncoordinated transmission strategy is adopted in multiple access channel (MAC) phase. The relays decode all received messages using the proposed IDM-based SIC, yielding significant performance improvement in MAC phase. The decoded messages in the relays are correlated since they are originally sent from the same source. Joint decoding that exploits the correlation of messages in the relays is proposed to achieve excellent performances. In the final step of joint decoding, the selection of *host decoder*, of which the outputs are used for finals decision, is of significant importance to obtain the best decoding results. This thesis solves *host decoder selection* problem using mutual information calculated by the relays. The results of computer simulations show that the proposed techniques outperform the conventional techniques in terms of throughput and bit-error-rate (BER) performances. It is also confirmed that $Q \in \{1, 2\}$ are the practical optimal numbers of relays in terms of throughput or BER performances for MWMRN with randomly distributed users. All findings in this thesis are expected to solve the future massive networking problems by the year 2020.

Keywords: Multiway Relay Networks, Multiway Multirelay Networks, Uncoordinated Transmission, Graph-based Successive Interference Cancellation, Joint Decoding, Iterative Demapping Algorithm, Source Correlation.