Abstract

With the growing network density and the limited channel bandwidth, the interference between nodes would degrade the performance in throughput, energy consumption and latency which is expected suitable for the application based on the information sharing between nodes. To solve this problem, this dissertation considers the solution using physical-layer network coding (PNC) which takes use of interference instead of dealing with interference. On the other hand, straightforward network coding (SNC) including intra-flow network coding (IANC) and inter-flow network coding (IENC) has shown its role in improving the network performance. PNC and SNC are employed in the different layer of the protocol stack, i.e., PNC is applied at the physical-layer, and SNC is applied at layer-2 or upper. IANC mainly is employed to improve network performance by reducing the protocol overhead via the feature of overlapped chunked codes (OCC). PNC can improve the network through significantly via IENC approach. Up to the present, there are few studies on the application of IANC with PNC where a big message is divided into blocks, and they are grouped into chunks. This dissertation aims to study the performance of the application of OCC with PNC.

In order to achieve this purpose, this dissertation considers a scenario of multi-source multi-relay network where a PNC approach, compute-and-forward (CF) based on nested lattice code(NLC), is employed for the simultaneous transmissions from the sources to the relays. A popular network coding technique, random linear network coding (RLNC), is employed within each chunk before encoding with NLC at each source. This dissertation provides a design of overlapped chunked code (OCC) for this scenario, called OCC/CF, and an OCC-based retransmission scheme called RLNC/CF.

OCC is an IANC approach where the feedback about the reception state information at the destination can be avoided, hence the transmission scheme employing OCC might have better performance than a feedback-based transmission scheme when the protocol overhead such as the transmission time of feedback and the loss of feedback is considered. The key to design OCC is the decodability condition which is provided in this dissertation, and an OCC with contiguously overlapping fashion is applied for the design for the performance observation and evaluation. The decoding scheme with this OCC is provided as well. In addition, the estimations of the decodability, the performance in term of channel efficiency (corresponding to network throughput) and the decoding complexity are given in order to provide the option to obtain the different desired term of performance. The design is done by using the empirical probability distributions where a new term, the probability distribution of the participation factor of a source to the forwarded data for a chunk, is introduced and plays an important role in the design of OCC/CF.

On the other hand, for the transmissions in lossy channel, in order to have data blocks received on time, the retransmission is made if these packets could not be recovered by the previous transmissions. An efficient retransmission is needed for data transmission in multi-source multi-relay network while CF is employed, because the destination could not ensure all blocks could be recovered after a retransmission round. The other advantage of contiguously OCC is that the unrecoverable transmitted blocks of a chunk could become recoverable by the transmission of the blocks of the next chunk. By taking use this feature, in RLNC/CF scheme, the determination of the number of overlapped blocks for each source by using the knowledge of the reception state of the previous chunk from the aid of feedback, empirical probability distributions and for an expected reception state of the transmission of the next chunk to obtain the highest expected decodability is given. In addition, different selections of expected reception state is studied to figure how to obtain the desired performance.

From the numerical results obtained by doing simulation in MATLAB, the improvement gained from employing OCC/CF depends on the level of the protocol overhead. The channel efficiency gained from employing OCC/CF in multi-source multi-relay network can approach the channel efficiency employing the OCC with the same overlapping fashion, contiguously overlapping fashion, in single flow transmission when the probability distributions of the participation factor of all source are dense near the chunk size. Although the applied OCC causes high design overhead for OCC/CF, but this design might provide a reference for the future design of OCC for this scenario with better performance. On the other hand, RLNC/CF scheme can provide some improvement in channel efficiency over a cooperative CF scheme, showing its advantage in reducing the protocol overhead and improving the efficiency of retransmission. On the other hand, selection of expected reception state does a trade-off between channel efficiency and reception delay.

Keywords: Network coding, Overlapped chunked code, Retransmission, Compute-and-Forward, Multi-source multi-relay network