Title	Large Scale Distributed Decision Making Technique and Wireless Chief Executive Officer Problem
Author(s)	何, 昕
Citation	
Issue Date	2013-03
Type	Thesis or Dissertation
Text version	author
URL	http://hdl.handle.net/10119/11335
Rights	
Description	Supervisor:Tad Matsumoto, 情報科学研究科, 修士

Large Scale Distributed Decision Making Technique and Wireless Chief Executive Officer Problem

Xin He (1110017)
School of Information Science
Japan Advanced Institute of Science and Technology

February 6, 2013

Keywords: Error Probability, Estimation, CEO problem, Slepian-Wolf, wireless sensor networks, wireless mesh networks, LLR updating function

Abstract: Nowadays, the major focus of the research topics in information and coding theory community has shifted from point-to-point to network communications, such as co-operative communications using joint source, channel and network coding. Recently, a lot of significant theorems/theories as well as practical algorithms that can asymptotically achieve the performance bounds supported by the theory have been found in this category; the new results have been utilized by many information theory communities, including our research group, with the aim of creating a beyond-the-state-of-the-art technologies in communications systems. The most significant achievement of our research group is that the establishment of technological basis for distributed cooperative communications where even though intra-links (source-to-relay and relay-to-relay links) suffer from errors, still the transmitted information can be reconstructed at the destination by utilizing the correlation knowledge between the information part sent from the originator and its relayed information.

In fact, this is a straightforward application of Slepian-Wolf theorem. However, it is based on a strong assumption that the information at the source itself does not contain any errors. The goal of this research is to eliminate this assumption, and hence all the links are unreliable. This problem is called Chief Executive Officer (CEO) problem in networks information theory. The CEO problem can be applied to many forms of applications in wireless networks. This motivates us to work on the CEO problem and its applications

to wireless communications. Our aim is to make a paradigm shift from the Slepian-Wolf lossless-based wireless network design to lossy link-based design, based on the CEO problem frame work.

The CEO problem belongs to distributed lossy compression category, of which terminology is related to the situation where a firms CEO is interested in a source data sequence that he cannot observed directly. The CEO then deploys a team of agents who independently observe the corrupted version of the source data sequence and transmit their observations to the CEO under a sum-rate constrained channel. The CEO aims to form an optimal reconstruction of the source data sequence based on the received versions of the observations. The CEO problem can model many categories of wireless networks, for example, wireless sensor networks (WSNs) and wireless mesh networks (WMNs).

In practice, the power and the resource are limited at the agent, it is crucial to introduce some coding techniques requiring very low power consumption when making such data gathering/monitoring systems. The target of the CEO problem, in general, is to determine the minimum achievable distortion under a given sum rate constraint. The rate region is only found for some special cases because there are a lot of mathematical difficulties in analyzing the limit. Nowadays, the CEO problem attracts a lot of attention with the recognition of not only an open problem of information theory, but also significant importance on its applications to many forms of wireless communication systems, such as distributed sensor networks.

In this thesis, we have investigated the coding-decoding strategies for a parallel WSN and a very simple WMN from the viewpoint of the CEO problem.

At the agents (sensors/forwarding nodes), heavy decoding process is not involved. Instead, extract and forward (ErF) strategy is used for reducing the complexity of the agents, and hence also reducing the energy consumption. We then propose a novel decoding technique which can well exploiting the correlation knowledge among those agents by using the log-likelihood ratio (LLR) updating function at the CEO node (final destination (FD)/fusion center (FC)). Excellent performances can be achieved with our proposed technique.

In Chapter 2, we first introduce the Slepian-Wolf relaying system which our research group has already solved with achieving excellent bit-error-rate (BER)/frame-error-rate (FER) performances. Then, we simply explain the reason why we shift from the lossless cases to the lossy cases.

In Chapter 3, the case where multiple sensors gathering data from the sensing object aim to transmit the observed data to FC via parallel links is considered. We modeled this parallel WSN from the viewpoint of the CEO problem. A simple coding-decoding strategy was proposed to exploit the correlation among those sensors. Further, we proposed an iterative estimation algorithm for estimating observation error probabilities only by the FD/FC. From the simulation results, it can be found that the estimation algorithm can be applied in many situations. Therefby, reality and scalability of our proposed system are proven.

In Chapter 4, we further apply the coding-decoding strategy to a simple WMN where none of the forwarding nodes has error-free information part from the originator. The EXIT chart analysis and BER performance are evaluated for the proposed system model. In addition, we shortly discuss the rate optimization for the channel encoders in the network by using linear programming technique based on the EXIT chart analysis.