Energy Efficient Data Maximization using Distributed Spatial Correlation Algorithm in Wireless Sensor Networks with Slepian Wolf Coding

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Abstract—“Energy efficient data maximization using distributed spatial correlation algorithm wireless sensor networks with Slepian Wolf coding”, is aimed at maximizing the samples using distribution correlation algorithm wherein it collects the raw data from the sensors and compress them before transmission. When the sensed data is compressed the number of transmissions decreases. The processed data is again compressed using Slepian Wolf coding providing energy efficiency due to reduced transmissions. In this project distributed spatial correlation algorithm is used to reduce the transmissions between the source and the sink node. It analyzes the characteristics of data samples by nodes. Spatial correlation between neighboring nodes is a method to compress the raw data and reduce the number of transmissions in WSN. Slepian wolf coding can achieve the compression rate as the optimal single encoder that has all correlated data streams as inputs. It can be used for multiple correlated data streams. The effect of this is cluster of nodes can exchange information

Index Terms— Slepian-Wolf coding, transmit power adaptation, rate allocation, transmission duration, circuit power consumption, optimization, residual energy

I. INTRODUCTION

Recent advances in low-energy wireless communication embedded computing and electronics have enabled the development of the low-power wireless sensor network (WSN) technologies. A WSN consists of a large number of low-cost micro-sensors, which are randomly deployed and self-organized through wireless links. The primary function of a sensor network is to collect the physical data from the environment and propagate to sink node or base station (BS). Sensor nodes are capable of monitoring a wide variety of ambient conditions [12], [4]. They can also be deployed over a battle field for military surveillance as well as emergent environments for search and rescue. The Wireless Sensor Network model is described in below figure 1 with the following components

Sensor Node: A sensor node is a node in a wireless sensor network that is capable of performing some processing, gathering sensory information and communicating with other connected nodes in the network.

DOI: 03.AETS.2014.5.140
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Cluster Head: Mobile nodes are portioned into clusters and a cluster head is elected using a distributed algorithm. All nodes in the communication range of the cluster head.

Base Station: Base station is transceiver station for communication.

![Wireless Sensor Network model](image1.png)

Figure 1. Wireless Sensor Network model

A. Sensor Node Architecture

A typical sensor node contains four basic components, as shown in Figure 2 processing unit (µcontroller), sensing unit, transceiver unit, and a power unit [1] [2]. Based on the application requirements, sensor node may contain additional components such as a location finding system and mobilizer. A wireless sensor node may also have multiple sensor units to sense the various ambient conditions.

![Sensor Node Architecture](image2.png)

Figure 2. Sensor Node Architecture

Microcontroller: A microcontroller is also called as processing unit of the sensor node; it can be process the sensor data and perform various protocol functions with some memory provision and I/O peripherals. In addition to the memory provided by the microcontroller, it is not uncommon for a wireless sensor node to include some external memory.
Transceiver: The RF data modem is a very critical component because it consumes considerable power compared to a microcontroller unit. It is responsible for modulation and filtering operations while sensed data is transmitting or receiving.

Sensing unit: A sensor is a device that measures some physical quantity and converts it into a signal to be processed by the microcontroller. A wide range of sensor types exist including seismic, thermal, acoustic, visual, infrared and magnetic[6]. The sensing of a physical quantity such as those described typically results in a continuous analogue signal, for this reason, a sensing unit is typically composed an analogue to digital converter (ADC) which digitizes the signal.

Power supply: In general, wireless sensor nodes survived by a power unit which is typically a battery. Recent developments in micro-electro-mechanical systems (MEMS) can enable the power harvesting techniques (solar cells, wind energy etc) on small devices as sensor nodes. Energy from power scavenging techniques may only be stored in rechargeable (secondary) batteries and this can be a useful combination in wireless sensor node environments where maintenance operations like battery changing are impractical.

![Figure 3. Slepian wolf encoder](image)

Fig3 describes the block diagram for Slepian-Wolf coding: independent encoding of ‘n’ correlated data streams.

Data gathering in Wireless Sensor Network refers to acquiring the sensed data from the sensors to the gateway node. Data gathering is used to reduce the data traffic and lower energy in WSN from the sensors to the gateway node [7][10]. A data-gathering WSN with source nodes where each node employs Slepian Wolf coding for distributed compression and the joint decoder reconstructs all the collected samples losslessly and the data gathering analysis is done using Slepian-Wolf Coding technique.

Distributed spatial correlation algorithm is proposed over raw data so that data transmission can be minimized and to this correlated data Slepian wolf coding is used to compress the data so that energy efficient data gathering can be provided in wireless sensor networks.

II. METHODOLOGY

A. Existing System

It consists of Wireless Sensor Network, in which hundreds of sensor nodes are deployed randomly. Consider a network with sensors. Each sensor collects S samples during the network lifetime. A data-gathering WSN with source nodes where each node employs SW coding for distributed compression and the joint decoder reconstructs all the collected samples lossless [11][1]. Here it was assumed that the orthogonal channels between sensors and the joint decoder are modelled as AWGN this can be easily extended to a Rayleigh fading case. And the data gathering analysis is done using Slepian-Wolf Coding technique. Here spatial correlation algorithm is used for energy efficiency.

B. Existing System

- Distributed spatial correlation algorithm is proposed over raw data so that energy efficiency can be improved.
- Slepian wolf coding is used to compress the correlated data so that the data rate can be improved

Distributed spatial correlation algorithm is to reduce the transmissions between the source and the sink node. It analyzes the characteristics of data samples by nodes [9] [8]. Spatial correlation between neighboring
nodes is a method to compress the raw data and reduce the number of transmissions in WSN. Slepian wolf coding can achieve the compression rate as the optimal single encoder that has all correlated data streams as inputs. It can be used for multiple correlated data streams.

Figure 4 Architecture of the proposed model

Fig4 describes the functional components of the architectural diagram.

C. Maximizing Collected Samples With Joint Decoder Energy Constraint.

One limiting node exists in the solution to send as much data as possible under Slepian wolf coding rate region constraints [3]. The other nodes can operate under different transmit durations, coding rates etc. all the nodes depend on the residual energy, power consumption and channel capacity constraints.

D. The Critical Energy Of The Joint Decoder

The critical energy of the joint decoder is the minimum energy storage at the joint decoder.

Optimal rate allocation algorithm

Initialize $E_{i,0} = E_i$, $E_0 = E_0$
calculate $\{S_0^*, R_{i,0}^*, T_{i,0}^*\}$ based on $E_{i,0}$, $E_0$
$m \leftarrow 1$; while $m \leq 4$

\[
\begin{align*}
&\text{do} \\
&m \leftarrow m + 1 \\
&\text{update residual energy } E_{i,m} = E_{i,m-1} - S_{m-1}^* E_{EN,i}, \\
&E_m = E_{m-1} - NS_{m-1}^* E_{DE} \\
&\text{calculate } \{S_m^*, R_{i,m}^*, T_{i,m}^*\} \text{ based on } E_{i,m}, E_m \\
&m \leftarrow 4; \epsilon \leftarrow \text{a small positive number} \\
\end{align*}
\]

while $0.5 (|S_{m-1}^* - S_{m-2}^*| + |S_{m-2}^* - S_{m-3}^*|) / S_m^* \geq \epsilon$

\[
\begin{align*}
&\text{update residual energy } E_{i,m} = E_{i,m-1} - S_{m-1}^* E_{EN,i}, \\
&E_m = E_{m-1} - NS_{m-1}^* E_{DE} \\
&\text{calculate } \{S_m^*, R_{i,m}^*, T_{i,m}^*\} \text{ based on } E_{i,m}, E_m \\
&m \leftarrow m + 1 \\
\end{align*}
\]

let $S_E^* = S_m^*$, $R_{E,i}^* = R_{i,m}^*$, $T_{E,i}^* = T_{i,m}^*$
III. NUMERICAL RESULTS

We have numerically verified the analytical optimal and near-optimal solutions we quantify the increase in the number of collected samples due to our optimization. Considering two cases with \( N = 10 \) and 20 source nodes and assuming that the nodes are uniformly placed.

Fig 5 shows the analytical and numerical results giving the performance metric. Depending on the conditional entropy the transmit power, coding rates differ. Maximization is the dominant factor in the absence of high spatial correlation between sources; it’s due to the less effectiveness of slepian wolf encoder.

Fig6 shows that the energy constraints in the joint decoder (inactive) are of more importance rather than the constraints of (active) decoder in joint optimization networks. In this the residual energies of the joint decoder are uniformly distributed in the networks.

IV. CONCLUSION

Collecting data continuously from Wireless Sensor Networks (WSNs) with limited power and bandwidth is a challenging problem. Such networks have potential utility in a wide range of disciplines such as medical,
industrial, environmental, and military applications. For long-term monitoring and surveillance applications, the objective is often times to cover as large an area as possible while still acquiring high-resolution information about the sensed environment.

The mechanism of data dissemination right from data collection at the sensor nodes, clustering of sensor nodes, data aggregation at the cluster heads and disseminating data to the base Station the overall motive of the paper is to conserve energy so that lifetime of the network is extended. This paper highlights the existing algorithms and open research gaps in efficient data dissemination.

Energy-efficiency and scalability used to acquire the substantial amount of data from the sensor network. Addressing these challenges, proposed a method that effectively exploits both spatial correlation algorithm and Slepian Wolf coding.

REFERENCES