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Distributed Digital Signal Processing Approach for Performance Enhancement of the Nodes in Wireless Sensor Networks

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Abstract

As wireless sensors has to work very remotely, these suffers from less processing capability, insufficient available energy and transmission distance, suitable signal processing technology can offer efficient sensor network for certain remote application. In the network with multiple nodes, each node can be connected to digital signal processor. Individual algorithm is associated with the node depending on the data to be processed, which ultimately improves the efficiency of entire network. FFT plays vital role in stated performance enhancement.

Keywords: *FFT, DSP*, sensors, signal processing, *network*

INTRODUCTION

The wireless sensors are used for remote object monitoring or object tracking in various environments in addition to many applications. The sensors mainly consist of Micro Electromechanical system, DSP which consumes low power, RF circuitry and battery [1]. Because its economic in nature and easy for construction, wireless sensors are facing some demerits like short transmission range, less efficient in computation and processing the data, less reliable and limited in energy perspective.

Networks consisting of many sensors should be designed to overcome these demerits to certain extent. This can be done by exploiting synergy between several nodes. If in a wireless network, data is supposed to be collected from various sensors to the distant information sink. The data gathering techniques and routing algorithm can be applied to transfer the information from remote sensors to the sink through relay nodes irrespective of the transmission range and distance spanned by the sensor [2].

Nevertheless large geographic area can be covered by employing multiple numbers of sensors. Whereas these sensors are also capable of controlling small portion of the data. A collaborative processing technique like beam forming and data fusion is applied to minimize data transmission. The correlated data sets are combined between nearby sensors before being transmitted to the sink node, which can avoid similar communications from neighbouring nodes. This ultimately helps to improve signal quality and statistics which considers redundancy in the received data packets. This can be obtained by employing multiple sensors which reports to a common target.

The energy efficiency can be obtained by:

1. Minimizing the power consumption by digital circuitry.
2. Power consumed by transceiver.
3. Reducing transmission power.

Though output transmission power is defining the transmission range for a sensor the total power consumption depend on the transmitted, received and processed data [3].

There are two domains which can support energy efficient techniques:

1. Digital Signal Processing.
2. Communication Protocol Architectures.

In signal processing the energy scaling algorithm is implemented and the algorithm is partitioned among multiple sensor nodes. In communication protocol architecture, low power network configuration algorithm is expected to be implemented in addition to energy efficient routing and medium access schemes. In this proposal, a collaborative signal processing is applied to implement distributed digital signal processing. This is nothing but divides and conquers approach in multiprocessor computing. The problem is divided into multiple sub problems of smaller size. Each processor solves each sub problem using same algorithm. Finally, a solution can be obtained by combining the outputs from all the processors. On the same lines, each sensor corresponds to a processor. The sensor can be made to operate as a distributed digital signal processor by designing appropriate communication protocol and collaborative computational technique.

The significant advantages of the scheme are:

1. The energy and computational limits of each sensor can be overcome.

2. The energy efficiency of overall network increases significantly.

DDSP APPROACH TO THE FFT ALGORITHM

Let consider a network which consist of S sensors as a set of interconnected processors, each of them have local memory and able to communicate with other sensors with the help of messages. The objective is to show how to distribute processing operations among sensors and to reduce the energy consumption. Ultimately, it is trade off between energy gain and information latency.

SENSOR FFT COMPUTATION

Consider a network with two sensors, Let S1 and S2. Let r is an indicator of N entries containing the total number of data samples over which FFT is to be computed. Consider decimation in time FFT algorithm, which has an execution time and complexity that scales into 0 (N log N). The basic computational block of FFT, i.e., 'Butterfly' is used in order to implement a distributed computation.

Let r be properly partitioned into two 2 vectors of N/2 data samples each, denoted by x and y. Data set x corresponds to S1 and the dataset y corresponds to S2. Let wL indicate the column vector of weights that is required to compute FFT. With x and y as two inputs, the output from butterfly operations are obtained as x+ wL.y and x-wL.y. Each sensor operates with a vector length of N/2. Therefore, the computational complexity is reduced if we compare this with the previous which was N. The distributed communication requires the communication between x and y.

Let discuss initial approach:

1. Node S1 sends copy of data set x to S2.
2. Node S2 sends copy of data set y to S1.
3. S1 computes x + wL.y.
4. S2 computes x - wL.y.

The total number of samples sent over the channel is N and number of transmissions are two. The two sensors are equally balanced, because each sensor consists of same amount of computation and communication. The algorithm is redundant in nature, because each sensor computes wL.y. To overcome the redundancy effect, the procedure is as follows,

1. Node S1 sends copy of data set x to S2
2. Node S2 computes wL.y and sends it to S1

3. S1 computes x+wL.y
4. 4. S2 computes x - wL.y

To evaluate the performance following parameters need to be considered:

1. Time required transferring a data sample.
2. Time overhead due to startup phase of the power amplifier.
3. Computational time of the floating point arithmetics.
4. Sensor power consumption in transmitting and receiving mode.
5. Energy consumption per floating operation at the sensor.

The energy consumption associated with the presented algorithms can be estimated by considering geographical proximity among the sensors that determine the output transmission power of inter-sensor communication.

CONCLUSION

By trading off between data processing at the individual sensors and inter-sensor communication, energy efficient network can be developed. This requires compromise between energy gain and delay or latency where sensor computation needs to meet precise requirements.

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