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NNSRAM-Clustering Based Energy Efficient System for Wireless Sensor Networks

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ABSTRACT

In recent years, the number of wireless sensor network deployments for real life applications has increased spectacularly. But still the energy problem remains one of the major barriers somehow preventing the complete exploitation of this technology. Sensor nodes are typically powered by batteries with a limited lifetime and, even when additional energy can be harvested from the environment, it remains a limited resource to be consumed. Efficient energy management is a key requirement for any wireless sensor network. A neural network static random access memory implementation in a clustering based system for energy-constrained WSNs is proposed in this paper. The scheme is about high energy efficiency by reducing the total amount of energy requirement in storage and transmissions during the data dissemination process. Compared to other digital logic clustering based systems, the proposed system reduces the energy consumption up to 76.99 %.

Keywords: Clustering, Wireless Sensor networks, neural networks, SRAM.

I. Introduction

With the development of wireless sensor technology, energy reservation of wireless sensor nodes is becoming a hot research topic. There is need to reduce network energy consumption in order to prolong node lifetime. There are so many approaches supposed to deal with such an issue. One such approach is compressive sensing [1], [2] which depends on compressing data before transmission and decompressing it upon reception. Another approach is clustering [3], [4], which divides the sensor network into a group of clusters with each cluster having a cluster head. The cluster heads then communicate with each other and transmit the available data to a base station which directly communicates with the server; however, all the presented protocols depends mainly on reserving the power of communication in between sensor node [5].

The presented approach deals with the processing and storage of information in a sensor node as a main resource of power consumption in wireless sensor node system. Using a neural network storage unit (NNSRAM) instead of the conventional RAM in a sensor node will lower the power consumption of the sensor node, thus expanding its life time. We propose to modify the design of wireless sensor network so that each sensor node contains an NNSRAM unit that plays the role of a temporary storage device. In section2 neural network SRAM design is presented, section3 presents the neural network static random access memory-clustering based energy efficient system (NNSRAM-CBEES) routing protocol, the simulation and performance is studied in section4, and finally the conclusion is presented in section 5.

II. Neural Network SRAM

Figure 1 shows the basic structure of the NN-SRAM cell, which is a binary data storage neural network that can be constructed using the basic neuron [6]. The inputs to the NN-SRAM are enabled by a select control signal (S). For Select equal to 0, the stored content is held. For Select equal to 1, the stored content is determined by the values of D (Data Input). The operations are summarized in the truth Table 1. The D input is sampled when S=1; if D is 1, then the Q output goes to 1 placing the NN-SRAM in the set state. If D is 0, then Q goes to 0, placing the NN-SRAM in the reset state.

Table 1: Truth Table for the NN-SRAM

Q	S	D	nd	nu	Next Q	Action	
0	0	0	0	0	0	hold	N.C.
1	0	0	0	1	1	hold	N.C.
0	0	1	0	0	0	hold	N.C.
1	0	1	0	1	1	hold	N.C.
0	1	0	0	0	0	D	Reset
1	1	0	0	0	0	D	Reset
0	1	1	1	0	1	D	Set
1	1	1	1	0	1	D	Set

The NN-SRAM latch receives its designation from its ability to hold data in its internal storage. The binary information present at the data input D is transferred to the Q output when the control input is enabled; the output Q follows changes in the data input, as long as the select control input is enabled. On the other hand, when the select control input is disabled, the binary information that is present at input D cannot be latched; and the Q output will retain its value until the select control input is enabled again. Figure 2 shows the simulation result of the NN-SRAM cell.

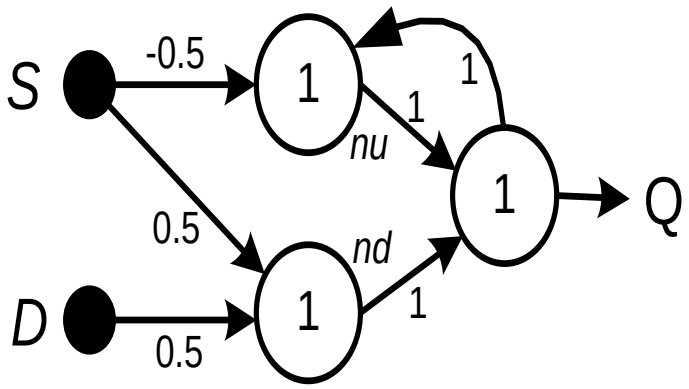

Figure 1: Basic Structure of NN-SRAM

Figure 3 shows the logic model of the NN-SRAM cell with the associated circuitry to control the operations (Select, Read/Write, and Input/output). The storage part of the memory cell is the same model as shown in Fig. 1. The inputs to the latch are enabled by a select signal (S). For S=0, the stored contents is held. For S =1, the stored contents is determined by R'/W (Read/Write).

To design the controlled NN-SRAM diagrams, the NN-SRAM cell will be controlled by read and write control signal as shown in Figure 3. The controlled NN-SRAM cell will be used as the main element to form the internal structure of m x n NN-SRAM chip. The loading of the NN-SRAM cell is now controlled by a Row Select input RS_i. If $RS_i = 0$, then the cell latch contents remain unchanged. If $RS_i = 1$, then the values to be loaded into the latches are controlled by data input D. In order to change stored value, the read/write signal R'/W must be 1 and the selected RS_i must be 1. If data in D is 1 the latch is set to 1, and if D is 0 the latch is reset to 0, completing the write operation. In order to read stored value, R'/W must be 0 and RS_i must be 1. If the stored value is 1, then the output C is set to 1; if stored value is 0, then the output C is reset to 0, completing the read operation. Table 2 shows the operation for controlled m x n NN-SRAM cell.

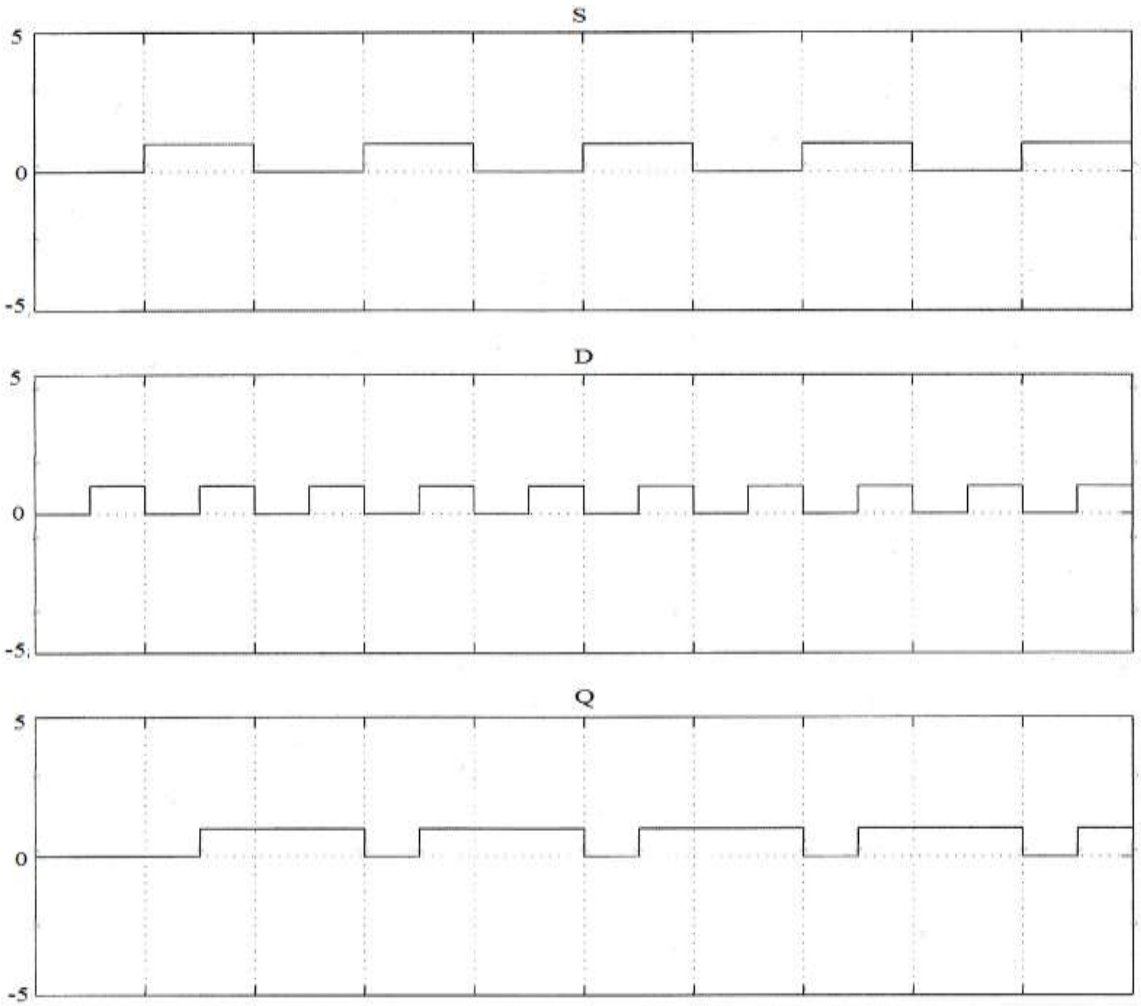

Figure 2: Simulation result of the NN-SRAM cell.

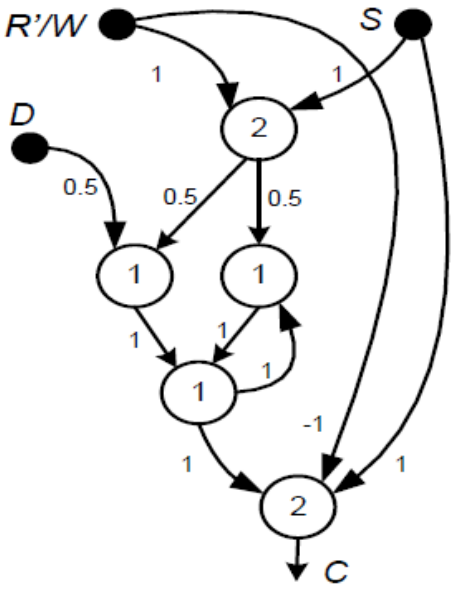

Figure 3: logic model of the NN-SRAM cell with the associated circuitry

Table 2: operation for controlled m x n NN-SRAM cell

S	R'/W	Memory operation	
0	0	N.C.	hold
0	1	N.C.	hold
1	0	read	Q C →
1	1	write	D Q →

III. NNSRAM-CBEES ROUTING PROTOCOL

A. Background

LEACH is a protocol that was proposed to lessen the power consumption of a wireless sensor network [7]. The transmitted data in a LEACH protocol contains only meaningful data. The Clustering approach used in LEACH protocol divides the sensor network into a group of clusters with each cluster having a cluster head [8]. The cluster heads then communicate with each other and transmit the available data to a base station which directly communicates with the server. Such a protocol lessens the amount of transmitted data because each cluster head checks the data for duplication before it is received. If the data is received before, the cluster head eliminates it, else it will be accepted.

B. Proposed System

In order for the cluster head to check if the data is received before, it needs a temporary storage, which consumes a high percentage of power of the cluster head. Since Neural networks are characterized by fault tolerance because they are able to hold incomplete and noisy data [9].In addition, their ability to deal with non-linear problems and, once trained, can perform prediction and generalization at high speed, NN-SRAM has proven to be less power consuming than conventional RAMs .Errors reported in these models are well within acceptable limits, which clearly suggest that artificial neural networks can be used for modeling in many fields of lessening energy consumption.
In order to achieve the design goal, the key tasks performed by NNSRAM Clustering Based Energy efficient system for wireless sensor networks

- An NN-SRAM is used instead of conventional RAM in all sensor nodes
- Randomized rotation of the cluster heads (CH) and the corresponding clusters of each one
- Co-ordination, localization and control for cluster setup and operation
- Low energy consumption media access control
- Applications specified data processing.
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The cluster heads can be chosen stochastically (randomly based) in NNSRAM-CBEES system, where the overall operation is divided into rounds each of which consisting of two main phases [8]:

A. Setup Phase

- Dividing the overall network into clusters.
- Choosing the cluster heads and their announcements.
- Transmission/reception schedules creation.

B. Steady state phase involves

- Data aggregation at the Cluster Head.
- Compression of data.
- Transmission to the base station.

The energy consumption in NNSRAM Clustering Based Energy efficient system for wireless sensor networks can be reduced by the reduction of the storage cost due to neural networks and the reduction of the communication cost between the sensors and their cluster heads. The non-head nodes can be turned off as much as possible.

IV. PERFORMANCE AND SIMULATIONS

We use a wireless sensor network size of 160 x 160 m, by taking 172 nodes, while the base station is found at a location outside the network. The processing delay is 82 ≠s, and the radio speed is 1 Mbps. Three systems were simulated, the first uses the direct communication, the second system uses LEACH protocol, and the third is NNSRAM-CBEES.NNSRAM-CBEES proved to be consuming 76.99% of the power consumed by LEACH and 64.2% of the used by direct Communication thus conserving 23.1% of available energy.

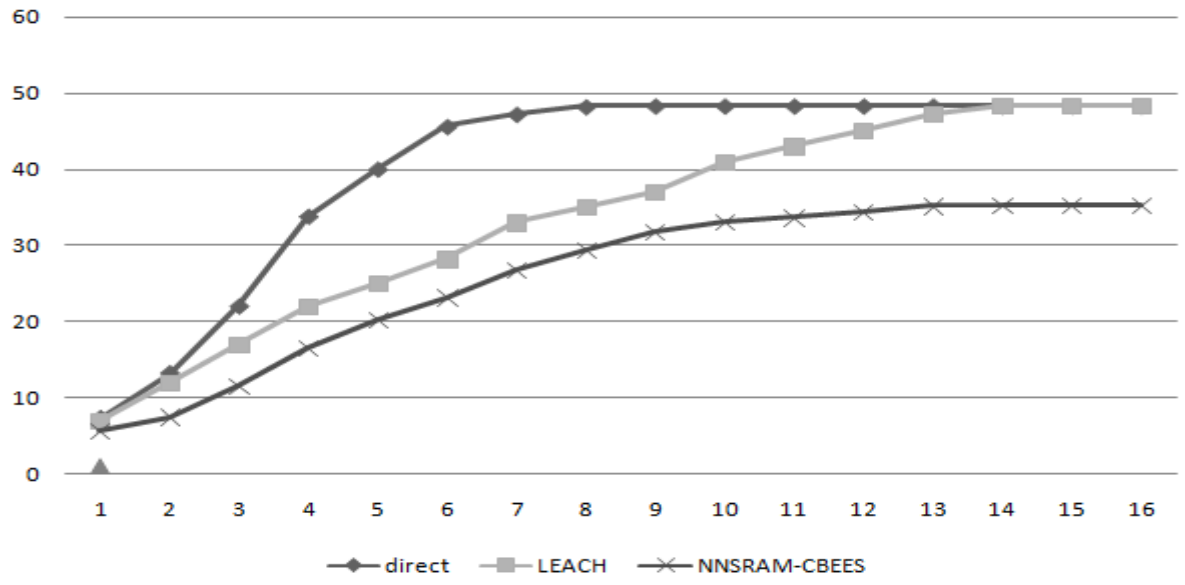

Figure 4: Energy Consumption Comparisons.

CONCLUSION

The energy consumption in NNSRAM Clustering Based Energy efficient system (NNSRAM-CBEES) for wireless sensor networks can be reduced by the reduction of the storage cost due to neural networks and the reduction of the communication cost between the sensors and their cluster heads. A novel Neural Network Static RAM (NN-SRAM) that consists of internal latches to store the binary information is proposed. The NN-SRAM stores binary data and remain valid as long as power is applied. Since the NN-SRAM reduces the energy consumption, it is used in wireless sensor networks for extending the life time. Finally, this paper presented simulation results (using Matlab/Simulink) for the NNRAM-CBEES system lessening the power consumption to 76.99%.

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