Caching in Wireless Sensor Networks: A Survey

Harish Kumar[#1], Mritunjay Kumar Rai[*2]

[#]M.Tech, Electronics and Communication Engineering, LPU, Jalandhar, Punjab, India
[*]Associate Professor, Department of ECE, LPU, Jalandhar, Punjab, India

Abstract- **Wireless Sensor Networks are exploited in multiple applications. There are some issues like important data loss, many times during transmission and reception process by the small tiny sensor nodes presents in the WSNs. Further constraints like energy efficiency are present. To overcome such constraints the cooperative caching technique is used. If this technique is used efficiently then the networks lifetime can be enhanced and data loss may also reduce during transmission and reception process. We have discussed some techniques of cooperative caching. Main purpose of the paper is to provide the brief proposal of different techniques which are used for the enhancement of the networks parameter like energy, throughput and power all the proposed techniques are closely related with each other.**

Keywords- **Wireless Sensor Networks (WSNs), Caching, Cooperative Caching, Sensor Node.**

I. INTRODUCTION

Wireless Sensor Networks (WSNs) comprises different sensor nodes, which consists basically the components namely low cost sensors, processors, flesh memory and transceiver. All the components of WSNs are integrated by technology micro-electro-mechanical system (MEMS) to a single substrate known as wireless sensor node (SN) [1]. Sensor nodes transfer information to each other using wireless medium (radio frequencies, infrared or any other) as shown in Fig 1. WSNs emerged throughout the last decade because of the advances in low-power hardware and development of acceptable software system [2].

A wireless sensor network consists of wirelessly interconnected devices with the ability to calculate, manage and communicate with one another. WSNs have enormous variety of applications [3], for example tracking purposes, disaster relief, intelligent building, tracking in battle fields and atmosphere management purposes and consists of many more applications.

The wide majority of applications running over WSNs need the optimization of communications among the sensors so that serve the quires data with small latency and with less energy consumption.

The battery lifespan are often extended if the ‘amount’ of communication is reduced, that successively be done by caching required data for every sensor either in its native store or within the close neighborhoods. Additionally caching is very effective in reducing the requirement for network-wide transmissions so reducing the interference and overcoming the variable channel conditions. The cooperative data caching has been projected as economical and efficient technique to attain these goals [4] [5].

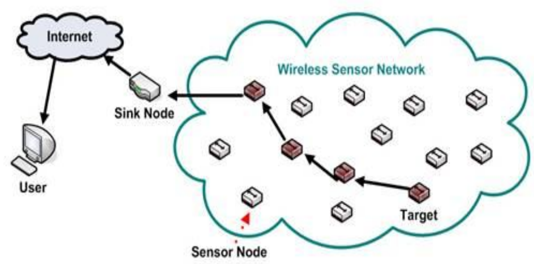

Fig. 1 Wireless Sensor Network

The broadcasting of the information all over the network consumes more nodes and more networks resources. It also consumes more energy and bandwidth for broadcasting over the networks. More data packages should be sent along shorter paths to achieve lower energy consumptions [7]. By caching the useful data for each sensor either in its local storage or in the neighborhood nodes can increase the network lifetime. Several works has been proposed which exploit caching the data either location nearer and in some at intermediate nodes to the multiple sink in the WSNs. Providing solutions to optimally caching the data have been a big area to be focus on, several proposed schemes perform well. Caching has been used for number of applications like fault tolerance, improving the TCP over Wireless Sensor Network, multicasting applications, and improving the performance [6].

In this paper we focus on some of the different important aspects related to the caching in WSNs, providing continuous data to mobile sinks with uninterrupted communication is a massive challenge in planning large-scale sensor networks. Plenty of research in data compression, data routing, and in-network aggregation has been planned in recent years. Which are described briefly under sections caching if deployed optimally will cut back plenty of network traffic and helps in providing higher data accessibility to the users.

In this paper we further discuss the different techniques brief ideas in section II for in-network aggregation. In section III we discuss data compression technique along with its one type. In section IV we discuss the cooperative caching along with some description. And section V provides a brief description for Distributed TCP caching.

II. IN-NETWORK AGGREGATION

In tentative sensor network situations, information is collected by sensor nodes throughout some space and has to be created accessible at some central sink nodes where it's processed, analyzed and utilized by different applications. In several cases, information generated by different sensors can be collectively processed while being forwarded toward the sink (e.g., by fusing together sensor readings associated with identical event or physical quantity, or domestically process data before it's transmitted). In-network aggregation deals with this distributed process of information inside the network. Data aggregation techniques are tightly including how data is gathered at the sensor nodes moreover as how packets are routed through the network, and have a major impact on energy consumption and overall network competency (e.g., by reducing the amount of transmissions or the length of the packets to be transmitted).

In-network data aggregation can be considered relatively complicated functionality, since the aggregation algorithms should be distributed within the network and thus need coordination among nodes to attain higher performance. Also we tend to emphasize that data size reduction through in-network process shall not hide statistical data regarding the monitored event. As an example, once multiple sensors collaborate in observing identical event, the amount of nodes reporting it and also the timing of the reports might reveal the event's size and/or dynamics, respectively.

In-network aggregation method can be defined as follows: In-network aggregation is the global method of gathering and routing data through a multi-hop network, process data at intermediate nodes with objective of reducing resource consumption (in specific energy), thereby increasing network lifespan for detailed description in network aggregation [8].

III. DATA COMPRESSION TECHNIQUES

Transmitting information is a lot of power dissipating than computation and therefore reducing data size before transmission is effective in total power consumption in wireless medium. So it's helpful for Wireless Sensor Networks to use a data compression algorithm program. One interruption is that almost all existing data compression algorithms aren't practicable for WSNs because of size of algorithms. One more reason is that the processor speed that is just four megahertz [9].

However a processor speed of laptops, pc's is approximately three gigahertz. Hence its compulsory design low-complexity and little size data compression algorithmic for sensor networks. In this section, some of data compression schemes for WSNs are introduced. We describe only one technique here that is Pipelined In-Network compression, detailed elaborations in [10].

A. *Pipelined In-Network Compression*

The fundamental thinking is trading high information transmission latency for low transmission energy consumption. Collected sensor data is kept in aggregation nodes buffer period for a few period time. During that point packets of data are combined into one packet and in packets of data redundancies are removed to reduce data transmission: < measured value, node ID, timestamp>.

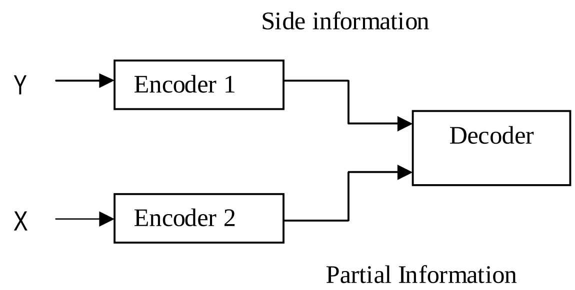

Fig. 2 Distributed compression

And a packet of data compressed has the following form: <shared prefix, suffix list, node ID list, timestamp list> [11]. "Shared prefix" is the most significant bits, which all measured values in combined data packets have in common. The length of shared prefix can be changed by a user based on the knowledge of data similarity. If the measured values are expected be close to each other, the length of prefix value can be set to relatively long.

The "suffix list" is the list of measured values excluding the shared prefix part. The "node ID list" is the list of node identifiers and the "timestamp list" is the list of timestamp [11].

Scheme for compression is shown in Fig 2. Where assume that 3 nodes send packets of data to the compression node. And at that node, 3 packets of data are compressed into one packet. In this example the length of shared prefix is set to 3. This compression scheme has advantage that the shared prefix system can be used for node IDs and timestamps. Due to which more data compression can be achieved [10].

IV. COOPERATIVE CACHING

In cooperative caching multiple sensor nodes share and coordinate cache information of the data to reduce communication cost and exploit the combination cache space of cooperating sensors. Each sensor node caches the frequently accessed data items in its non-volatile memory such as flash memory. The data items in the cache satisfy not only the nodes own requests but also the data requests passing through it from other nodes. For any data missed in the local caches the node first searched the data in its zone before forwarding the request to the next node that lies on a path towards the data source.

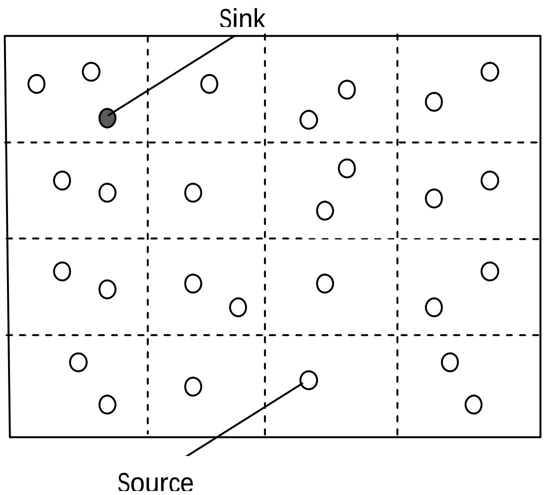

Fig. 3 Setup of wireless sensor network

The process of cache admission control is based on the distance criteria of a node from the sink and gives higher priority to the nodes located nearer to the sink. Utility primarily based data replacement policy has been devised to ensure that more useful data is retained in the local cache of a node.

- Cache Path
- Cache Data

A. *Cache Data*- data which is cached in the intermediate nodes used to serve the future, requests for the replacement of fetched data from their source.

B. *Cache Path*- path in the nodes which are changing their positions frequently, cache the data path and use it for redirecting future requests to the close node which has the data instead of the faraway origin node.

Cache can be utilized to improve the energy efficiency in Wireless Sensor Networks. Retrieving data directly from sensor node is not a good idea when sensed data does not changes. So we can make use of caching the data in the sensor nodes cache nearer to the sink or at some point in between sink and the source. This reduces unnecessary load from the network and helps in minimizing the power consumption [12]. Cooperative caching employs cache discovery process, cache consistency and cache replacement policies for the enhancement of the network lifetime.

V. DISTRIBUTED TCP CACHING

Initially reliable byte-stream TCP was designed for wired networks. In which bit errors are not common and congestion is main source of packet loss. Due to this TCP always illustrated as packet drops as congestion. As a result it TCP lower the sending rate however network is not in congestion. TCP is used for end-to-end reliable transmission; a multi-hop sensor network requires a retransmitted packet to be forwarded by every sensor node on the path from the sender to the receiver [14].

Distributed TCP caching based on segment caching and native retransmission in collaboration with link layer is deployed to deal with such issues as discussed previously. This provides improvement in the performance of TCP over wireless links such as TCP Snoop [15], and also improves TCP throughput with reductions in energy consumptions in it. Distributed TCP have no need for any protocol changes besides it reside in intermediate nodes in networks.

VI. CONCLUSION

In this paper we presented a precise review of the caching related techniques that are mainly concentrated on the enhancement of the network lifetime by exploiting the available resources efficiently. The techniques discussed are in-network aggregation, data compression technique and cooperative caching which are the open research areas for further enhancements that will increase the Wireless Sensor Network exploitation in different applications more proficiently.

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