A Research on Methods of Top-k Query Processing in Wireless Sensor Networks

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Abstract. In typical wireless sensor networks (WSNs), sensor nodes have limited resources such as battery power, computing capability and memory. Their widespread deployment requires providing solutions to efficiently utilize those resource-limited devices. In this paper, we focus on top-k queries in WSNs. A top-k query returns the k highest ranked nodes for the communication. This results in reducing overwhelming amounts of traffic in the network and prolonging overall lifetime of the network. In this paper, we conduct a research on methods of top-k query processing in WSNs. We discuss different design dimensions in the existing approaches including data access methods and query models.

Keywords: Wireless sensor networks, database, query processing, top-k.

1 Introduction

Wireless sensor networks (WSNs), a set of tiny and low-cost devices equipped with sensors, small microcontroller, radio transceiver, and power source, offer an interface to the real world with environmental monitoring, data acquisition, processing and threat detection capabilities. Due to those capabilities, WSNs are widely used in numerous applications, such as military target tracking and surveillance, meteorological hazards, wildlife monitoring, and natural disaster relief. However, in typical WSNs, sensor nodes have limited resources such as battery power, computing capability and memory. Thus, their widespread deployment requires providing solutions to efficiently utilize those resource-limited devices.

In this paper, we focus on top-k monitoring queries in WSNs. A top-k query returns the k highest ranked nodes for the communication. This results in reducing overwhelming amounts of traffic in the network and prolonging overall lifetime of the network. However, efficient processing of top-k monitoring query in WSNs poses great challenges due to the unique characteristics of sensors [1]. In this paper, we conduct a research on methods of top-k query processing in WSNs. We discuss different design dimensions in the existing approaches including data access methods and query models. The rest of this paper is organized as follows. Section 2 describes top-k query processing in WSNs. Section 3 concludes the paper.
2 Top-k Query Processing in WSNs

In this section, we describe methods of top-k query processing in WSNs. We discuss different design dimensions in the existing approaches including data access methods and query models.

Wu et al. [6] proposed a novel energy-efficient approach, called FILA (Filter Based Monitoring approach), for top-k monitoring in WSNs. The basic idea of this approach is to embed a filter in each sensor node to decrease unnecessary sensor updates. The authors guaranty the reliability of the top-k result by updating all sensor nodes using their filters. They demonstrated the superiority of their approach by comparing it to in-network data aggregation technique, known as TAG [4]. TAG-based technique implements a routing tree at the base station, and aggregates collected data along the way to the base station through the implemented routing tree. Through examples and simulation, the authors showed that TAG-based approach wastes the energy for unnecessary updating data.

Malhotra et al. [5] studied the exact top-k query problem in WSNs by considering the importance of underlying structure of network. The primary contribution of their approach is EXTOK provably correct and topology-independent new filtering-based algorithm. The secondary contribution of this paper is to improve the proposed algorithm by simply choosing a proper underlying logical tree topology. The authors analyze EXTOK’s performance according to many parameters and different logical tree topologies while using both synthetic and real data sets. The experimental results demonstrated that EXTOK consistently outperforms well-known FILA. Comparing to FILA proposed algorithm is capable of handling ties and guarantees exact answers while decreasing any extra energy-cost overhead.

Chen et al. [1] introduced a new concept, called time interval top-k query. It returns k the set of highest sensed values collected within a specified interval of time. The authors then proposed an optimization framework for time interval top-k query evaluation, consisting of a filter-based algorithm for filtering out nearly a half unlikely top-k data from transmission, and online algorithm, called View-Filter, for answering time interval top-k queries with various ks and time intervals. The experimental results showed that proposed method outperforms existing techniques and thus can be used in order to significantly prolong network lifetime.

Zhang et al. [7] studied the security problems of WSNs and investigated verifiable fine-grained top-k queries in tiered sensor networks. The authors proposed three novel schemes, namely verification with additional evidence, verification by crosscheck and hybrid crosscheck. The basic idea behind of all schemes is that sensor nodes install symmetric cryptographic primitives among the data items they generated so that master nodes injecting fake data can be easily detected. Through the extensive simulations, they evaluated that the proposed schemas are suitable and practical for small and large query regions in resource-constrained sensor networks.
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3 Conclusions

In this paper, we presented a research on methods of top-k query processing in WSNs. We described representative methods of top-k query processing in WSNs, such as TAG, FILA, EXTOK and so on. In our research methodology, we discussed different design dimensions in the existing approaches including data access methods and query models. The result of this research can be drawn as following. In order to answer the top-k queries efficiently, we need to construct an index. Most of the discussed papers do not discuss this aspect. Index building techniques can be classified into methods using the layer-based index and list-based index. Representative methods for layer-based based methods are ONION [1] and HL-Index [5], which use a layer-based index and construct a list of layers using convex hull.

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References