Research on Energy Management in Adaptive WSNs System

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Abstract. Wireless Sensor networks is a dynamic domain develop innovative applications linked to a specific environment, and to the challenge of designing totally autonomous communicating objects. The aim of this work is to define architectural operational solutions able to maximize the lifetime of these sensor networks, the work that has been led aims to define the needs of performance, improve processing complexity and data collecting, solving particular sensor networks applicative scenarios. Here we promote a way of cross-level adapting duty-cycling sampling thoughts, and find it's a good method to make a high efficiency energy management system.

1.Introduction

Wireless sensor networks (WSN) consist of a large number of intelligent sensor with sensing, processing and wireless communicating capabilities. These sensor implement complicated tasks in the specific sensing field. Due to the strict energy constraint of sensor nodes, optimization of energy consumption is essential in all aspects of WSN. Hence, energy management become the challenge. The recent interest in WSN has led to network protocols. In [1], the authors propose a new minimum spanning tree-based protocol, called power efficient data gathering and aggregation protocol. Its power-aware version, PEDAP-PA, is proposed too. Some other researches adopted cluster-based network architectures to enhance network scalability [2].

Sensor nodes carry limited, generally irreplaceable, power sources. Therefore, while traditional networks aim to achieve high quality of service provisions, sensor network protocols must focus primarily on power conservation. They must have inbuilt trade-off mechanisms that give the end user the option of prolonging network lifetime at the cost of lower throughput or higher transmission delay.

Many researchers are currently engaged in developing schemes that fulfill these requirements. In this paper, we present a survey of method and algorithms proposed thus far for sensor networks. Our aim is to provide a better understanding of the current research issues in this field. Here we promote a way of cross-level adapting duty-cycling sampling thoughts, and find it's a good method to make a high efficiency energy management system.

2.Framework for Energy-efficient Sensor Management

A generic sensor node platform is described according to the application constraints analysis, from the lower-level hardware processing to the higher-level applicative tasks. This highly adjustable integrated environment gives a global vision of the processing of the nodes, which gives the means to study cross-layer optimizations. Most monitoring applications based on sensor networks rely, the readings are carried out with a given sampling frequency. In such a case two main approaches can be considered to reduce the energy consumed by a sensor duty cycling and adaptive sensing.

Duty cycling consists in waking up the sensorial system only for the time needed to acquire a new set of samples and powering it off immediately afterwards. This strategy allows us for optimally managing energy provided that the dynamics of the phenomenon to be monitored are time-invariant and known in advance. Since such hypotheses only partly hold in many applications, periodic sensing is typically considered. Here, the (fixed) sampling rate is computed a priori, based on partial available information about the process to be monitored and assuming that the process dynamics are stationary. As a consequence, the sampling rate is larger than necessary (oversampling) 3 to 5 times, inducing, in turn, energy wasting. A better approach would require an adaptive sensing strategy able to dynamically adapt the sensor activity to the real dynamics of the process.

It is obvious that an efficient sensing strategy, by reducing the number of samples, also reduces the amount of data to be processed and -possibly- transmitted to clusters and/or the base station in. Duty cycling and adaptive sensing are complementary approaches that can be used in combination as shown in figure 1.

1) The operating system has to provide a set of primitives for powering on and off the sensors to support duty cycle mechanisms.
2) Afterwards, the application uses such primitives to acquire data according to the (adaptive) sensing strategy it implements.
3) It must be considered to grant an effective handling of the duty-cycle issue: failing in doing that might result in not-valid acquired data, and/or energy dissipation larger than that associated with the always-on mode [5].
4) Finally, the drivers should be designed by using, at least, information about wakeup latency and break-even cycle for the sensors to provide an effective sensor-specific energy management .

Unfortunately, most currently available operating systems for sensor nodes do not follow this philosophy and let the application programmer decide when to power the sensor on and off (manual management). Future operating systems will have to adopt the automated and sensor specific approach for both relieving the application programmer from manual handling and improving the effectiveness of the duty-cycling mechanism.

The general framework of figure 1 allows the WSN designer for focusing on the selection of the best adaptive sensing strategy leaving low-level duty cycling aspects to the Operating System.

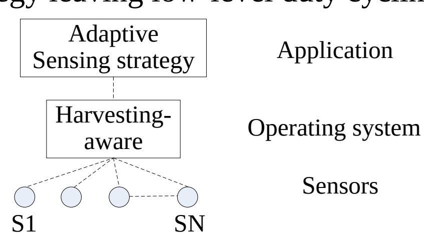

Figure1: framework for sensor energy management

Survey of the most interesting and novel adaptive sensing strategies will be given in next sections: the philosophy behind each technique is introduced to permit the WSN designer to identify the best adaptive sensing strategy for its application.

3.Diagrams of Adaptive Sensing Strategies

Figure 2 shows a possible diagram, based on the classification for the adaptive sensing strategies proposed in the literature.

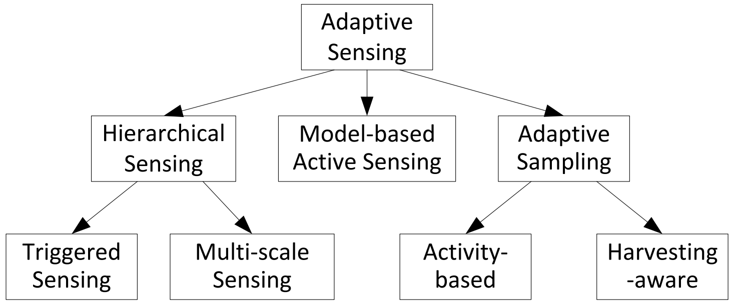

Figure 2. Classification of adaptive sensing strategies

1）**Hierarchical sensing** is one units equipped with different sensors, every characterized by its own accuracy and power consumption, to measure almost the same physical quantity. The measurement is inferred by processing data coming from all sensors. The simple sensors are energy efficient but provide a very limited resolution. On the other hand, advanced/complex sensors can give a more accurate characterization of the sensed phenomenon at the cost of higher energy consumption.

2）**Adaptive sampling** is adapting the sampling rate by exploiting correlations among the sensed data. For instance, if the quantity of interest evolves slowly with time, so that subsequent samples do not differ very much, is possible to take advantage of the temporal correlation. On the other side, it is very likely that measurements taken by sensor nodes that are spatially close each other do not differ significantly. Spatial correlation can thus be exploited to further reduce the sensing energy consumption.

3）**Model-based active sampling** consists in building the sensed phenomenon on top of an initial set of sampled data. Once the model is available and next data can be predicted by the model instead of sampling the quantity of interest or hence saving the energy consumed for data sensing.

4）**Hierarchical sensing** is techniques multiple sensors are installed in the sensor nodes and observe the same phenomenon and he can observe that with different resolution and power consumption, the idea is techniques to dynamically select which of the available sensors must be activated, by the trading off accuracy for energy conservation.

5）**Triggered sensing** the activation of the more accurate and power consuming sensors after the low-resolution some activity within the sensed area has been detected is referred to sensing. An example of triggered sensing is presented in [6] for health monitoring and damage detection of civil structure.

6）**Multi-scale sensing** a different use of hierarchical sensing consists in identifying areas within the monitoring field that require a more accurate observation. This is obtained by relying on a coarse-grained description of the field with lower accuracy sensors and activating additional high-resolution ones only in areas where their accurate acquisition are requested.

7）**Harvesting-aware adaptive sampling** the harvesting-aware adaptive sampling techniques exploits knowledge about the residual and the forecasted energy coming from the harvester module to optimize power consumption at the unit level. The approach requires the development of models able to characterize the evolution over time of energy availability and the energy consumption of sensor units.

8）**Low power architectural and algorithmic design** requires high performance tools and a particular vision. For this reason, the energy consumption evaluation has been studied, for all different steps of the design, and solutions have been given for the evaluation of energy consumption and performance of hardware and software designs. The approach described is based on code execution tracing on a general and portable event-driven system.

4.Conclusion

The paper surveys the main research directions for extending the lifetime of sensor units encompassing energy-hungry sensors. The general framework for energy-efficient data acquisitions is based on a duty cycle approach requiring the sensing board to be switched off in between two consecutive samples. The hierarchical sampling techniques are actually feasible when the network units are endowed with multiple sensors observing the same phenomenon with a different resolution and power consumption. This is a desirable property for credible deployments of sensor networks in real environments. These techniques have been introduced only recently and, thus, they represent an interesting research field. The main limitation of this approach is that it can only be used when the energy source is predictable.

Model-based active sensing is also very interesting. However, in most cases, solutions based on this approach are computationally expensive, and must be implemented in a centralized way. In this context, model-based techniques should be improved in the direction of deriving distributed algorithms for model computation and diffusion through the network. In addition, selection of the most appropriate model is the key issue in the design of a model-based active sensing strategy. In general, this choice is application specific.

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