

## An Approach for QoE management in WSA

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**Abstract.** Wireless sensor and actor networks (WSANs) have wide range of applications and good management of quality of experience (QoE) metrics is a big challenge in these networks. In this paper, I proposed a new approach for management of QoE metrics in WSA. QoE metrics have complicated indirect relationships with each other and middleware layer of WSA plays important role in support of QoE metrics. Management of QoE metrics requires modeling basic tasks of the middleware layer and determining effects of configuration parameters of these tasks on the QoE metrics of WSA. I proposed a QoE management module for middleware layer that works based on these relationships and cooperates with basic modules of the middleware layer. This module dynamically adjusts configuration parameters of basic tasks of middleware for best support of QoE metrics.

**Keywords:** Layered architecture, Wireless sensor actor network, Quality of experience, Middleware layer, Middleware tasks

### 1. Introduction

Software of WSA follows from layered architecture like software of traditional computer networks. Layers of WSA are usually less than layers of traditional computer networks because existence of some layers are not feasible in WSA. Most applications of WSA are inherently distributed and require network level management of network's resources. Middleware layer is used for distributed management of network level resources. Middleware layer is usually located lower than application layer as is shown in Fig.1. This figure shows the different quality expectation view points in WSA's software architecture. In traditional networks we assume that our view point is the transport layer and we define quality of service (QoS) metrics like delay, jitter and bandwidth that transport layer expects their support from lower layers.

End users expect that application program provides results with appropriate level of quality. QoE metrics are application dependent. Application layer can guarantee required level of QoE metrics based on the supports of middleware layer that manages network level resources. In this paper I propose an approach for management of network level resources for controlling tasks of middleware level for best support of QoE metrics that application layer expects from middleware layer.

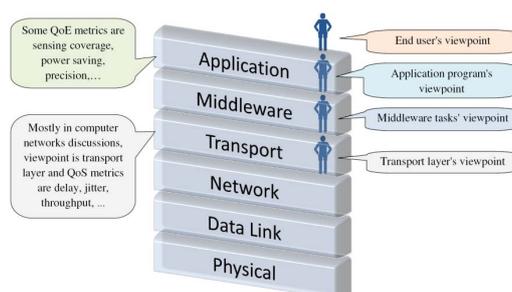


Fig.1 Layered architecture of WSA and different quality viewpoints.

## 2. Steps of Proposed Approach

Management of QoE metrics is a big challenge in most applications of WSN. Management of QoE metrics requires that relative importance degree of each QoE metric is determined. These importance degrees are application dependent. In some applications, importance of QoE metrics are dependent on the state of the system. Dynamic importance degree is other approach which can be considered too. Analytic hierarchical process (AHP) is one of the known methods for determining the relative importance degree of QoE metrics from end user's view point [1]. A cost function based on the weighted sum of QoE metrics can be used for best management of QoE metrics from end user's view point.

Some of the important QoE metrics for applications like environmental monitoring are coverage, accuracy, precision and power saving as is shown in Fig. 2. QoE metrics have complicated relationships with each other. Some of this metrics are mutually exclusive and some of them enforces each other. Exploiting relationships between QoE metrics is essential in management of QoE metrics by middleware layer. But relationship of this QoE metrics are indirect. Finding the complicated relationships between QoE metrics is a big challenge.

My proposed approach for driving these relationships is referring to the tasks of the middleware layer that directly influences QoE metrics in application layer. As Fig. 2 shows, tasks of the middleware layer influences the QoE metrics in application layer. For example, time synchronization directly influences the precision and power saving. Some of the important tasks of the middleware layer in applications like environmental monitoring are time synchronization, topology control, localization and information fusion as is shown in Fig. 2.

I propose modeling the WSN and main tasks of middleware layer. But this model will be very big. I suggest that numeras studies with focus on each task of middleware layer and modeling of each task for driving its influence on QoE metrics must be accomplished seperately. If modeling the effect of each task of middleware on all QoE metrics that this task influences their qulaity is big, we can model and study on the effect of each task of the middleware on each QoE metric seperately by considering whole features and conditions of the system. Then fusion of models or relationships can be done.

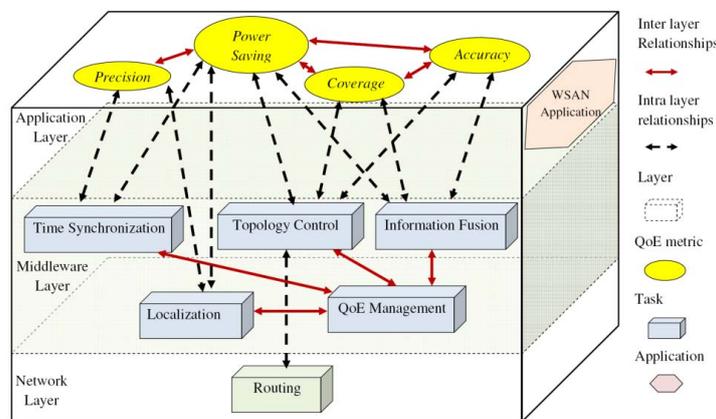


Fig.2 Relationships between QoE metrics and their relationship with middleware layer's tasks.

Each task of middleware has some parameters that controls the operation and quality of that task. In modeling and studying the task of the middleware layer and their influence on QoE metrics, effects of these parameters must be considered.

After modeling all tasks of the middleware and their influence on QoE metrics, we can combine all models or derived relationships in a composite big model. This model will be composed of a set of equations and relationships that contains adjaustable parameters of the middleware tasks and represent their effects on the QoE metrics of application layer. These equations and relationships represents the constraints of a complex optimization program that its cost fuction is defined based on the relative importance degree of QoE metrcis. Solving optimization problem for best adjustment of parameters of the middleware's tasks is difficult. Meta heuristic methods like genetic algorithms and particle swarm optimizations are good choices.

I propose append of a QoE management module in architecture of middleware layer. Responsibility of this module is adjustment of parameters of the middleware's task for best support of QoE metrics that application layer expects from middleware level. This proposed module must have communication with the basic tasks of the middleware as is shown in Fig. 2.

Movement of the actor nodes, failing of sensor nodes, dynamic state of the system, dynamic needs of QoE metrics causes that QoE management module in the middleware layer will be required. This module must dynamically controls parameters of middleware's tasks by solving optimization problem.

### 3. Relationships between QoE Metrics

Driving relationships between parameters of the middleware layer's tasks and the affected QoE metrics in application layer by means of them have been studied in different papers. Some of these studies are as follows.

Relationship between accuracy and sensing coverage in two and three dimensional acoustic target localization has been studied [2],[3]. Support of required sensing coverage degree is the responsibility of topology control subsystem of the middleware. Relationship between time synchronization error and accuracy of acoustic target localization has studied too [4]. Relationship between time synchronization error and precision of acoustic target localization has studied in [5]. Method that is used for information fusion influences the accuracy of the results. Modeling of QoE management in terms of an optimization problem has studied for pervasive healthcare systems [6]. This approach can easily extends for WSN's applications.

Fig. 3 displays four basic tasks of the middleware and their common influence on some of the important QoE metrics. This figure summarises some of studies that I did for QoE management.

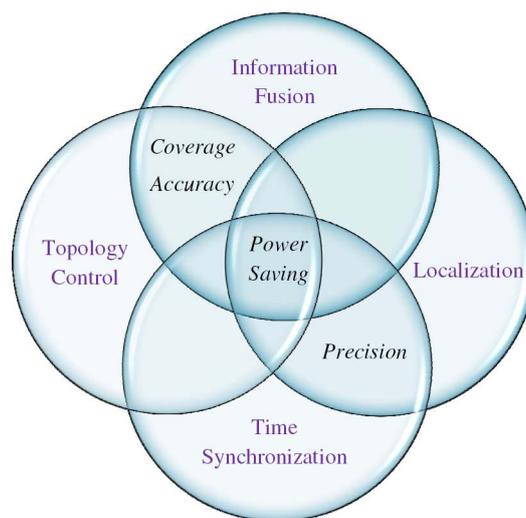


Fig.3 Middleware tasks and their common influences of some of the QoE metrics.

An example of relationships between parameters of middleware tasks and some QoE metrics is shown in Fig. 4. As this figure displays, decreasing time synchronization error requires increasing the time resynchronization frequency and this decreases the power saving. But decreasing time synchronization error increases the sensing precision and decreases power consumption. Therefore decreasing time synchronization error decreases and increases power saving. Therefore time synchronization error is an input parameter of time synchronization module of middleware that has two different effect on the power saving QoE metric in application layer.

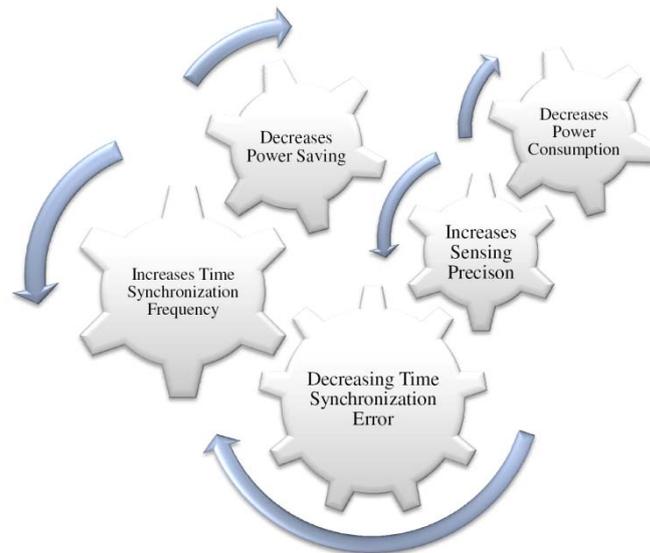


Fig.4 Relationships between parameter of time synchronization error and some QoE metrics.

#### 4. Conclusion

Management of QoE metrics in WSN can be done by adding a QoE management module in the middleware layer that dynamically solves an optimization problem. This problem consists of constraints and equations that represent the effect of adjustable parameters of middleware's tasks on the QoE metrics in the application layer. Cost function can be a weighted sum of QoE metrics and optimization computes best value of parameters of the middleware layer's tasks.

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