Green Communications

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1 INTRODUCTION

Nowadays the Green Communication Technology is becoming more important, especially in battery operated devices where the amount of energy is limited. Nobody is interested in changing the batteries of Wireless Sensor Nodes every day. Another issue is that many telecommunication networks need a lot of power, causing an increased CO2 emission world wide. The target of Green Communications is to reduce the energy consumption of a communication system without affecting the Quality of Service (QoS). One effective method is to apply the so called On-Demand strategy where the power consumption with the volume and location of the user demand is scaled. This reports consists of two sections. The second section describes an existing resource management scheme which was proposed for throughput/capacity optimization but is not energy efficient. In the third section an energy-delay trade-off problem of the author's research area is described.

2 FIND AN EXISTING RADIO TRANSMISSION, MEDIA ACCESS, OR RESOURCE MANAGEMENT SCHEME, WHICH WAS PROPOSED FOR THROUGHPUT/CAPACITY-OPTIMIZATION OR SPECTRUM EFFICIENCY BUT MAY NOT BE ENERGY-EFFICIENT

Round Robin is a scheduling method, in which every user gets served for a certain time interval. Every user has the same priority. **Figure 1** represents the Round Robin scheduling. The Reigen-Model is the easiest, oldest, most fair and most used algorithm. The idea of this model is that a certain time interval is assigned to every process in the ready queue. When the process is served for the time that has been assigned to it, then the next process is going to be executed and the current served process is added to the end of the ready queue, if it has not been terminated. (Irmscher.)

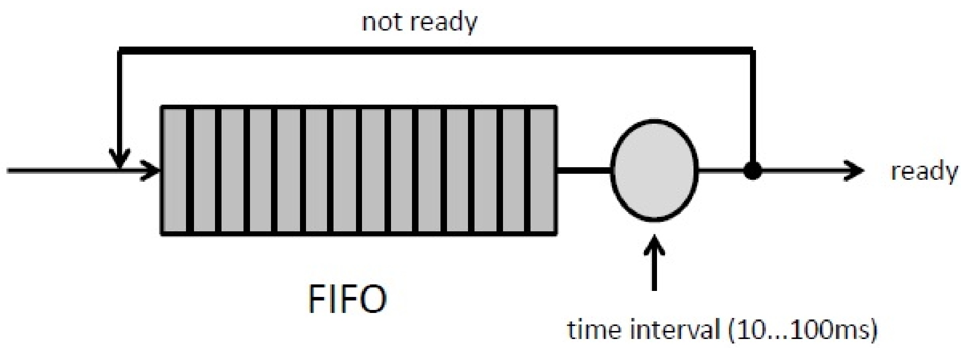

Figure 1. Round Robin Scheduling (Reigen Model).

According to Singh, Goyal & Batra (2010) the following factors must be considered when developing a good scheduling algortihm.

- the Central Processing Unit (CPU) should be kept as busy as possible
- throughput should be maximized, meaning that the maximum number of processes per unit of time should be served
- there should be less context switches
- waiting time should be minimized (”time a process has been waiting in the ready queue”)
- response time should be minimized (”time it takes to start responding”)
- turnaround time should be minimized (time to get into memory + waiting time in ready queue + execution time in CPU)

Assume there are ten different processes with an average CPU Burst Time (time the CPU needs to complete one process) of 50ms running on a CPU with a low clock speed. To decrease the CPU Burst Time, the clock speed has to be increased.

A lower CPU Burst Time reduces the delay time but it increases the power consumption. According to Mikkonen (2007: 8) the higher the clock speed the higher the current. A high current leads to more heat and thus the energy consumption is more inefficient.

3 ENERGY-DELAY TRADE-OFF PROBLEM IN THE AUTHORS RESEARCH AREA

The research topic of the author is "Mobility Control in Wireless Sensor Networks" with the target of achieving accurate distance measurement and localization results in a Wireless Sensor Network (WSN) so that a robot can be guided to a certain position. **Figure 2** illustrates a WSN where the Wireless Sensor Nodes are randomly distributed and each Wireless Sensor Node is equipped with a temperature sensor. As soon as one of the deployed Wireless Sensor Nodes detects a high temperature it will send an alert message to the robot. After receiving an alert message the robot must be able to compute the shortest path to the Wireless Sensor Node from where the alert message was sent.

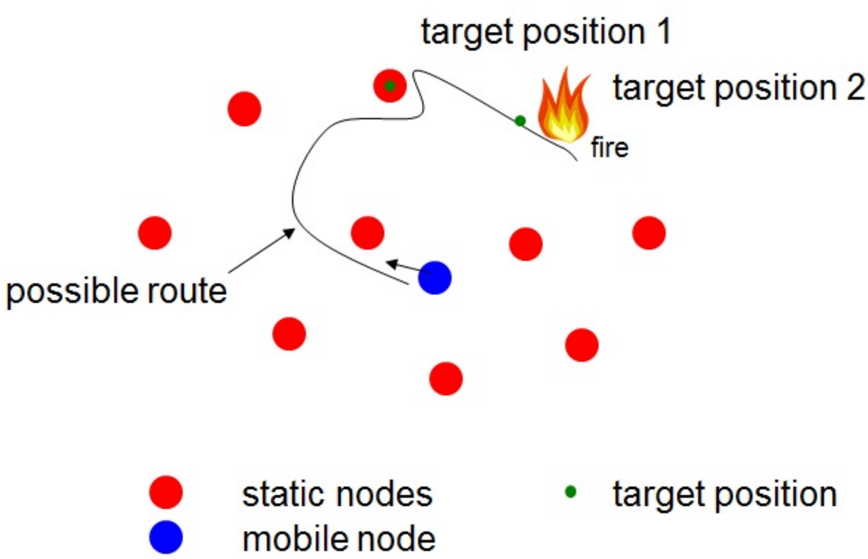

Figure 2. WSN with static nodes and mobile node (robot).

The two main problems of this research are latency and power consumption. According to Xia and Liang (2004) WSNs should be latency-aware, meaning that the packets among the sensors should be transfered as quickly as possible because a WSN has strict time constraints. It is to mention that the "packet transmission latency between the sensors include three parts: the wireless channel transmission delay, the Physical/MAC layer delay, and the queuing delay". The second problem is related to energy consumption which should be kept low, so that the batteries of a Wireless Sensor Node have a long lifetime. To achieve a long lifetime "[a] novel clustering algorithm for efficient energy saving in Wireless Sensor Networks" introduced by Moussaoui, Ksenttini, Naimi & Gueroui (2006) could be used for the data transfer between the static Wireless Sensor Nodes. The aim of this algorithm is to build efficient clusters in a WSN to reach the best possible lifetime. The following requirements must be fulfilled:

- connected clusters
- minimum and maximum size constraint for all clusters
- every Wireless Sensor Node should have a transmission range that is limited within a certain distance
- to reduce the power consumption each Wireless Sensor Node has to belong to one and a unique cluster
- reconfiguration time should be long to reduce communication costs

The algorithm works in the following way:

- In the first step, each node i need to find its neighbour set NS_i (1) that is inside the transmission range. V represents the set of nodes.

$$NS_i = \{j \in V / d(i,j) \prec tx_{range}(i)\} \tag{1}$$

- In the second step each node i computes its equivalency classes. "An Equivalency Class EC_i (2) of node i is the set of nodes that belong to NS_i, meanwhile two nodes (j,k) belong to the same EC_i, if j and k are neighbours for each other".

$$EC_i = \{j \in NS_i / \forall k \in EC_i \Rightarrow j \in NS_k\} \tag{2}$$

- In the third step the combined weight W_{EC} is computed which is defined as follows:

$$W_{EC} = \alpha||EC| - \chi| + \frac{2\beta}{(|EC|^2 - |EC|)} \sum_{j,k \in EC} d(j,k) + \gamma \sum_{j \in EC} 1/C_e(j) \quad (3)$$

  "where α, β and γ are the weights, $|EC|$ is the size of EC, and $C_e(j)$ is the energy level of node j". χ is the cluster size threshold.

- In the fourth step the equivalency class with the smallest W_{EC} is chosen as a cluster.

- The second to the fourth step is repeated until all nodes are assigned to a cluster.

- The node with the maximum energy level is chosen as Cluster Head.

(Moussaoui, Ksenttini, Naimi & Gueroui 2006.)

4 CONCLUSION

In this seminar, we got a lot of information about ICT Development and its Grand Challenges, Traffic, Energy, and QoS Models in Wireless Communication. One task of this homework was to find an existing radio transmission, media access, or resource management scheme which was proposed for throughput/capacity-optimization or spectrum efficiency but may not be energy efficient. The second task was to define an energy-delay trade-off problem in the author's research area. The first Task is presented in Chapter 2 and the second task in Chapter 3.

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