Conceptual representation and Survey of Dynamic Power Management (DPM) in Wireless Sensor Network

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Abstract: A Wireless Sensor Network (WSN) comprises many sensor nodes each one containing a processing unit, one or more sensor, a radio for data communication and power unit usually equipped with a low capacity battery. All sensors present in wireless sensor network are battery operated devices which have limited battery power. After the deployment of sensor nodes it is not possible to replace each and every battery in the network. Therefore optimal energy consumption for WSN protocol is a necessity. In a number of proposed protocols periodic sleep and wake time is used for the reducing the consumption of energy but these protocols result in increased end to end delay. In this research paper an improvement has been made, we propose an energy efficient dynamic power management technique which shuts down the sensor node when there is no work. The basic idea behind is to shut down the sensor devices when not needed and wake them up when necessary which yields better savings of energy and enhance lifetime.

Keywords: Wireless sensor network, Energy efficiency, Dynamic power management, Dynamic Operation Mode

I. INTRODUCTION

A wireless sensor network [1, 2] is made up of large number of low power sensor. Now a days, wireless sensor network find wide range of applications such as radiation level control, battlefield, noise pollution control, biological detection, structural health monitoring etc. A wireless sensor network (WSN) is a collection of sensor nodes which are deployed in a given area of interest. The concept of wireless sensor network is based on a simple equation:

Sensing+ CPU+ Radio= Thousands of potential application. The sensor nodes collect data from their surroundings and send the collected data to their neighbouring nodes in single hope. The neighbouring nodes in turn send the data to the nodes which are located in single hop distance. In this way data is transmitted to the sink node and it is responsible for deliver report messages to base station as shown in fig.1. The basic block diagram of a wireless sensor node [2] is presented in Figure 2.It is made by four basic components: a sensing unit, a processing unit, a transceiver unit and power unit. There can be application dependent additional components such as location finding system, a power generator and a mobilizer.
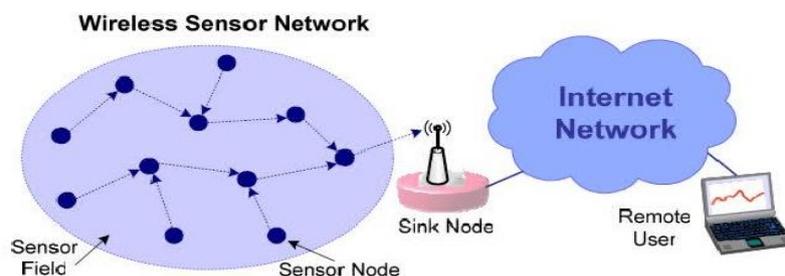

Figure 1: Typical WSN architecture and networking.

      Sensing Unit: Sensing units are usually composed of two subunits: Sensor and analog to digital converters (ADCs). Sensor is device which is used to translate physical phenomena to electrical signals. There exist a variety of sensors that measure environmental parameter such as temperature, light intensity, sound, magnetic fields, image etc. The analog signals produced by sensor based on the observed phenomenon are converted to digital signals by the ADC and then fed into the processing unit.

Processing Unit: The processing unit mainly provides intelligence to the sensor node. The processing unit consists of a microprocessor, which is responsible for control of the sensors, execution of communication protocols and signal processing algorithms on the gathered sensor data.
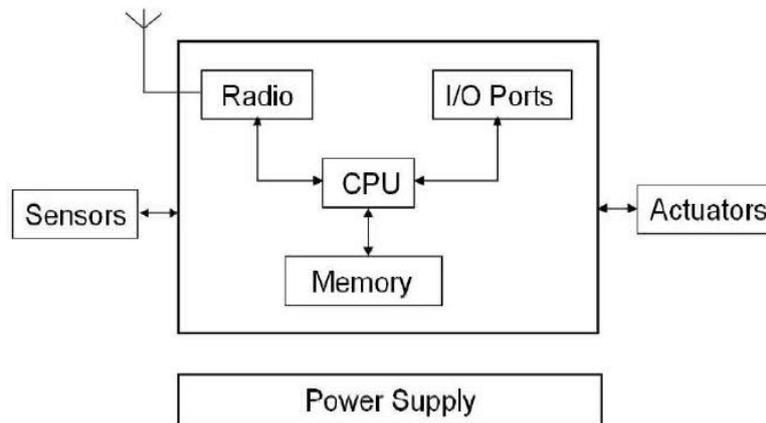
Figure 2: <u>Architecture of wireless sensor node</u>

Transceiver Unit: The radio enables wireless communication with neighbouring nodes and the outside world. It consists of a short range radio which usually has single channel at low data rate and operates at unlicensed bands of 868-870MHz (Europe), 902-928MHz(USA) or near 2.4GHz(global ISM band).There are several factors that affect the power consumption characteristics of a radio, which includes the type of modulation scheme used, data rate, transmit power and the operational duty cycle.

Battery: the battery supplies power to the complete sensor node It plays a vital role in determining sensor node lifetime. The amount of power drawn from a battery should be carefully monitored. Sensor nodes are generally small, light and cheap, the size of battery is limited.

In WSN, the main source of energy is usually battery power. Sensor are often indented to be deployed in areas such as a battlefield or radiations plants; once deployment of sensor network it is impossible to recharge or replace batteries of all sensors. But long system life time is needed for any monitoring application. Important challenge to the design of a wireless sensor network is energy efficient problem. So energy conservation must be taken. We proposed an energy efficient dynamic power management technique which can reduce power consumed by each sensor node by shutting down some components of sensors according to our work. So the proposed design should extend the lifetime of the system.

Static power saving techniques (e.g., Energy-Aware Protocols) keeps the same characteristics throughout the network lifetime. On the other hand, dynamic techniques adapt to changes on the network, allowing enhanced power saving mechanisms for prolonged network lifetime. To save energy, both approaches apply the partial or total turn off of some or all node unit. Many researchers are doing their research to reduce power consumption in various aspects of hardware design, data processing, circuit design, network protocols and operating systems.

Once the system has been designed extra energy saving can be done by using dynamic power management (DPM), which shuts down the sensors node when there is no work. The basic idea is to shut down sensor devices when not needed and wake them up when really necessary to perform the sensor network tasks. However, it is not easy to decide which nodes should sleep and which should be active at any given time, because these decisions strongly depend on the application running on the top of the network. It is not desirable to keep nodes inactive for too long, because it can impact the network Quality-of-Service.

II .Literature Review

The sensor node lifetime is highly dependent on power consumption performed at each sensor node. A more efficient power management results in a longer network lifetime. Several methodologies have been proposed at hardware and system level, to design energy efficient communication process[4],sensor node operating system [5] and sensor circuits.
In addition, Dynamic power management schemes have proposed to reduce the power consumption by selectively shutting down idle components. Much work has been done exploiting sleep state and active power management [6][7],sentry based power management[8], dynamic voltage and frequency scaling[5,6,9], an application–driven approach[10], Dynamic power management with Scheduled Switching modes[11].
Depending on the approach that is used, DPM policies are classified as predictive or stochastic policies. Predictive schemes attempt to predict a device's usage behavior in the future usually based on the past history of usage patterns and decide to change power states of the device accordingly. A widely used predictive technique consists in turning OFF of the system components if the idle time is greater than or equal to a timeout threshold value T is detected. This approach is based on the assumption that if the idle time is greater than the threshold T, the system is likely to remain idles for a long time enough to save energy. A more accurate method is proposed in [12], where the upcoming idle time is predicted

by using an exponential-average approach. Work on prediction based dynamic power management can be categorized into two groups: adaptive and non-adaptive.

Non-adaptive strategies set the idleness threshold for the algorithm once and for all and do not alter them based on observed input patterns. On the other hand, Adaptive strategies use the history of idle periods to guide their decisions of the algorithm for future idle periods. There have been a number of adaptive strategies proposed in literature [13, 14]. Stochastic approaches make probabilistic assumptions about usage patterns and exploit the nature of probability distribution to formulate an optimization problem, the solution to which drives the DPM strategy. In [6], the authors proposed an OS-directed power management technique to improve the energy efficiency of sensor nodes. It is event-based power management policy for a single a node, but not an effective policy for whole system. First, it may cause event-missed situation due to the operation system isolates the node in the deepest state and it is awakened until a specific sleeping interval goes by. Second, the authors only considered that an event occur can wake up the sleeping node. In addition, predictive techniques have limitation: they cannot provide an accurate tradeoff between energy saving and performance degradation.

A stochastic policy has been proposed in [15] to overcome these limitations. The considered system is proposed of a service provider, a service requester, a power manager and a request queue. In this case, the optimal policy strictly depends on how the system is modeled and on the abstractions that have been made.

III. Dynamic Power Management

The power consumption of a wireless sensor network [1] is a major problem because of the scarcity of energy. Whereas energy is a scarce resource in every wireless device, the problem in WSNs is amplified for the following reasons:

1. Compared to the complexity of the task they carried out-namely sensing, processing, self-management and communication-the nodes are very small in size to accommodate high capacity power supplies.

2. Ideally, a WSN consists of a large number of nodes. This makes manually changing, replacing or recharging batteries almost impossible.

3. The failure of a few nodes may cause the entire network to fragment prematurely.

The problem of power consumption can be approached from two angles: one is to develop energy-efficient communication protocols (self-organization, medium access and routing protocols).The other is to identify activities in the networks that are both wasteful and unnecessary and mitigate their impact. Most inefficient activities are, however, results of non-optimal configurations in hardware and software components. For example, a considerable amount of energy is wasted by an idle processing or a communication subsystem. A radio that aimlessly senses the media or overhears while neighboring nodes communicate with each other consumes a significant amount of power.

A dynamic power management (DPM) strategy ensures that power is consumed economically. The strategy can have a local or global, or both. A local DPM strategy aims to minimize the power consumption of individual nodes by providing each system with amount of power that is sufficient to carry out a task at hand. When there is no task to be processed, the DPM strategy forces some of the systems to operate at the most economical power mode or puts them into a sleeping mode. A global DPM strategy attempts to minimize the power consumption of the overall network by defining a network-wide sleeping state.

There are different ways to achieve this goal. One way is to let individual nodes define their own sleeping schedules and share these schedules with their neighbors to enable a coordinated sensing and an efficient inter-node communication. This is called synchronous sleeping. The problem with this approach is that neighbors need to synchronize time as well as schedules and the process is energy intensive. Another way is to let individual nodes keep their sleeping schedules to themselves; and a node that initiates a communication should send a preamble until it receives an acknowledgment from its receiving partner. This approach is known as asynchronous sleeping schedule and avoids the needs to synchronize schedules. But it can have a latency side-effect on data transmission.

Once the design time parameters are fixed, a dynamic power management (DPM) strategy attempts to minimize the power consumption of the system by dynamically defining the most economical operation conditions. This condition takes the requirements of the application, the topology of the network, and the task arrival rate of the different subsystems into account.

Whereas there are different approaches to a DPM strategy, they can be categorized in one of the following three approaches:
> 1. Dynamic operation modes.
> 2. Dynamic scaling.
> 3. Task Scheduling.

1.Dynamic Operation modes:

The subsystems of a wireless sensor node can be configured to operate in different power modes, depending on their present and anticipated activity. In general, a subcomponent can have n different power modes. If there are x hardware components that can have n distinct power consumption levels, a DPM strategy can define $x \times n$ different power mode configurations, Pn. Hence, the task of the DPM strategy is to select the optimal configuration that matches the activity of a wireless sensor node. There are, however, two associated challenges in selecting a specific power configuration.

1. Transition between the different power configurations costs extra power.
2. A transition has an associated delay and the potential of missing the occurrence of an interesting event.
In this approach of Dynamic Power Management (DPM) technique [3],basic idea is to keep active only those units which are really necessary to perform the sensor network task which yields good saving.
Once the system has been designed additional energy saving can be done using Dynamic Power Management. However, it is not easy to decide which nodes should sleep and which should be active at in given time.
Dynamic operation mode technique can be discussed through two policies:

A. Power-Aware sensor node model
B. Sleep state transition policy

A. Power Aware sensor node model

Every sensor node consists different components like processor to process the incoming data, memory in order to store the data, sensor component to sense the data from environment and radio in order to transmit or receive or for both transmission and receive purpose.

Depending on the different states of components there exist different states that are shown in table1. If all the components are in active state, that state is called active state which is represented as S0.In order to reduce the power consumption some of the components should be turn off. In sleep state S4,all the components kept into off state. So this state is called as deepest sleep state. Deepest sleep state takes very less power compare with all other sleep states because all components in off state in this.

State	Processor	Memory	Sensor	Radio
S0	Active	Active	On	
S1	Idle	Sleep	On	RX
S2	Sleep	Sleep	On	RX
S3	Sleep	Sleep	On	Off
S4	Sleep	Sleep	Off	Off

Table 1-Different state of component

B. Sleep state transition policy

In the previous section, we defined the different sleep states according to power consumption. But in this section we will discuss how and when these sleep states will be selected to save the energy and also we will see at what value of threshold, transition from one sleep state to another sleep state happens.
Assume an event is detected by node k at some time. The node finishes processing the event at t1 and the next event occurs at a time t2=t1+ti, where ti is idle time. At time t1,node k decides to transition to sleep state Sk from the active state S0.Each state Sk has power consumption Pk,and the transition times to it from the active state and back are given by $\tau(d,k)$ and $\tau(u,k)$.By definition of node sleep state, $Pj > Pi, \tau(d,i) > \tau(d,j)$ and $\tau(u,i) > \tau(u,j)$ for any i>j.

Now we derive a set of sleep time thresholds{T(th,k)} corresponding to states{Sk}, where k lies between 0 to N,for N sleep states. Transitioning to sleep state Sk from state S0 will result in a net energy lose if idle time *ti*< T(th,k) because of the transition energy overhead. The energy saving from a state transition to sleep state is given by

$$E_{save,k} = P_0 t_i - \{(P_0+P_k)/2\}$$
$$\{\tau(d,k)+\tau(u,k)\} - P_k(t_i - \tau(d,k))$$

Such a transition is only justified when $E_{save,k}$>0.The transition from one state to another is useful when energy saved must be greater than energy consumed. So the energy saving must be greater than energy expended by the sensor node for certain threshold value of time.
$$T(th,i) = [\tau(0,i)+\{(P0+Pi)/(P0-Pi)\}\tau(i,o)]$$
An accurate event arrival model enables a DPM strategy to decide for the right configuration that has a long duration and minimal power consumption.

2.Dynamic scaling
Dynamic voltage scaling (DVS) and dynamic frequency scaling (DFS) are complementary approach of DPM. These two approaches aim to adapt the performance of the processor core (as well as the memory unit and the communication buses) when it is in the active state.

3. Task scheduling:
In a dynamic voltage and frequency scaling, the DPM strategy aims to autonomously determine the magnitude of the biasing voltage (*Vdd*) and the clock frequency of the processing subsystem. The decision for a particular voltage or

frequency is based on several factors, including the application latency requirement and the task arrival rate. Ideally, these two parameters are adjusted so that a task is completed "just in time". This way, the processor does not remain idle and consume power unnecessarily.

IV. CONCLUSION& FUTURE SCOPE

The main goal is to prolong the wireless sensor network life time and preventing connectivity degradation through aggressive power management as the most of the devices have limited battery life .So we should follow power conservation techniques in order to the save the energy by improving the existing protocol or algorithm.

References

[1].Book:[Wiley 2010]Fundamental of wireless sensor netwoks Theory and Practice.

[2].Survey on wireless sensor network lan F.Akyildiz,Weilian, Yogesh Sankarasubramaniam and Erdal Cayirci Georgia Institute of Technology.

[3].Optimal power management in wireless sensor nrtworks for enchanced life time,journal of Global Research.

[4] M.Perillo and W.Heinzelman, "Sensor management and routing protocols for prolonging network lifetime.

[5] J. Hill, R. Szewczyk, A. Woo, S. Hollar, D.E.Culler, and K.S.J. Pister, "System architecture directions for networked sensors," Architectural Support for Programming Languages and OperatingSystems, http://webs.cs.berkeley.edu.

[6].A. Sinha and A. Chandrakasan, "Dynamic power management in wireless sensor networks," IEEE Design & Test of Computers.

[7] B. Brock and K. Rajamani, "Dynamic power management for embedded systems," IEEE SOC Conference, 2003.

[8] J.Hui, Z.Ren, B.H. Krogh, ―Sentry-based Power Management in Wireless Sensor Networks,‖ Second International Workshop on Information Processing in Sensor Networks, pp. 458-472, April, 2003.

[9] B.Calhoun, A. P. Chandrakasan, "Standby Power Reduction Using Dynamic Voltage Scaling and Canary Flip-Flop Structures," IEEE Journal of Solid-State Circuits, Vol. 39, No. 9, September, 2004.

[10] Rodrigo M. Passos, Claudionor J. N. Coelho Jr., Antonio A. F. Loureiro, Raquel A. F. Mini, ―Dynamic Power Management in Wireless Sensor Networks: An Application-Driven Approach,‖ Second Annual Conference on Wireless On-demand Network Systems and Services (WONS'05), pp. 109-118, January, 2005

[11]."Dynamic Power Management with Scheduled Switching Modes" by Paulo Sergio Sausen,jose Renato de Britosouse,Macro Aurelio spohn,AngeloPerkuich, 2008.
 [12] T.A. Henzinger, ―The Theory of Hybrid Automata,‖ Eleventh Annual IEEE Symposium on Logic in Computer Science (LICS), pp. 278-292, July, 1996. C.-H. Hwang, A. C.-H. Wu, ―A Predictive System Shutdown Method for Energy Saving of Event-driven Computation,‖ IEEE/ACM International Conference on Computer-Aided Design

[13] L. Benini, A. Bogliolo, G. Paleologo, and G. D. Micheli.Policy optimization for dynamic power management.IEEE Transactions on Computer-Aided Design of Integrated Circuits and Systems.

[14] E. Y. Chung, L. Benini, A. Bogliolo, and G. D. Micheli. Dynamic Power Management for Non-Stationary Service Requests.

[15]. L. Benini, A. Bogliolo, G. A. Paleologo, and G. De Micheli, ―Policy Optimization for Dynamic Power Management.