**Proposed Wireless Sensor Network Design for Monitoring**

**Water Quality in Irish Reservoirs**

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**Assignment 1**

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## Introduction

With the introduction of water charges citizens are questioning the quality of Irish drinking water. Irish Water wants to reassure the public that Irish drinking water reservoirs are safe. The company is looking to implement a service where the reservoirs can be monitored by the company and also by the public through a website. The following proposal will be an outlay of the best implementation of a wireless sensor network for monitoring water quality. The sensors must be able to measure pH, light, oxygen levels and have the capability to float. Irish Water want to have the most up to date information on any drop in water quality and as per specification need to monitor water quality in fifteen minute intervals.

## Related Work

The research community has been active in designing and implementing wireless sensor networks for monitoring water quality. Exploring this topic Zhuiykov (2012) points out that with increased urbanization and water pollution that complex and continuous monitoring is needed to ensure water safety. Zhuiykov (2012) discusses in detail various solid-state sensors for on-line monitoring of water quality parameters such as pH, conductivity, turbidity, dissolved organic carbon (DOC) and dissolved metal ions. The area of detailed analyses will help to identify the best sensors for measuring pH, light and oxygen levels for Irish Water. Faustine, Anthony et.al (2014, p. 281) and Guobao, Xu et.al (2014, p. 16932) describe water pollution increasing in a similar manner to Zhuiykov (2012). These papers identify the need for fast and accurate water quality monitoring while assessing current technologies. Faustine, Anthony et.al (2014) work is of particular interest to the scope of this proposal as a wireless sensor network is critically analyzed, implemented and tested in a similar outlay to what Irish Water are requesting. These papers offer applicable research to the scope of what Irish Water are preparing to implement.

## System Analysis

**Network topology** - is of crucial importance to the design of this wireless sensor network. The topology suggested will take into account the application and environment that the network will function in. Guobao, Xu et.al (2014, p. 16936) discusses the star topology, cluster/tree topology and mesh topology. There are other topologies such as the ring topology, bus topology and a fully connected network topology but these topologies are not relevant to this work. As Guobao, Xu et.al (2014, p. 16936) has analyzed the star, cluster/tree and mesh topology in a similar scenario of water monitoring the proposal will outlay the advantages and disadvantages of these three.

***-The Star topology – Advantages/Disadvantages***
Due to the single-hop architecture this topology offers the advantage of using the least amount of power to run the network. Another advantage is that failure in one node does not effect the entire network. A major disadvantage of the star topology is that if the central hub fails then the entire network fails. This rules out a star topology as updates are required every 15 minutes, with a failing central hub this would not be possible.

***-The Mesh topology – Advantages/Disadvantages***
The mesh topology is a one to many multi-hopping architecture and offers advantages of increased transmission range, decreased loss of data and increased self healing (Guobao, Xu et.al 2014). Moreover, Faustine, Anthony et.al (2014, p. 285) implement a point to multipoint topology in sleeping-mode to reduce latency in communication with their proposed design. Higher latency and power consumption is a disadvantage in this topology but this is not as detrimental as the star topology issue of a failing central hub.

***-The Cluster/Tree topology – Advantages/Disadvantages***
As Guobao, Xu et.al (2014, p. 16936) states the cluster/tree topology offers the low power consumption and the simple design of the star topology. The topology also utilizes the fault tolerance of a mesh network. The main disadvantage of this design is similar to the star topology whereby if the central hub/sink node fails the entire network fails.

*Proposed Topology* **-** From the analysis above and to fit with the scope of Irish Waters requirements it is recommended to use a Mesh Topology for increased fault tolerance and the built in redundancy of a self healing network.

**Network lifetime** – is very important for the scope of the proposed design. Some key points mentioned in the project proposal such as getting up to the minute information at regular 15 minute intervals and the fact that finding failed sensors may be difficult means the network needs to be robust and each mote needs a long lifetime. To extend network lifetime the following should be taken into consideration during the network design. The management of local power consumption and components of motes should be chosen for minimal power consumption and the implementation of energy-scavenging capabilities. As Yang, (2000, p. 64) states energy efficiency can be managed by turning off the power whenever possible or switching the sensor system to a low power state. Faustine, Anthony et.al (2014, p. 285) discuss the process and benefits of utilizing a low power state in their network design. As each mote will be in the water and the lifetime needs to be maximized in the network, each mote should have efficient recharging methods. It's important that the mote can still function during the recharge process. Guobao, Xu et.al (2014, p. 16937) implement Photovoltaics as an energy scavenging technique in their network. Although dependent on the weather when used outdoors the technique can have a power density of 15 $mW/cm^2$ to 150 $\mu W/cm^2$ and can potentially power the mote components with a stable output of 0.6V.

**Data gathering -** for the network requires a combination of methods for the best efficiency. Zhuiykov (2012) discusses sensors in detail and offers a good reference to sensor types but the detail of analysis is too extensive for this proposal. As Guobao, Xu et.al (2014, p. 16936) point out the mote needs a sensing module to gather data, a CPU for data processing and a wireless transceiver to send data wirelessly. Both Guobao, Xu et.al (2014, p. 16936) and Faustine, Anthony et.al (2014 p. 284) utilize ZigBee 802.15.4 for wireless communication and this will be implemented for Irish Water due to the specification that small amounts of data need to be sent on a regular basis. Faustine, Anthony et.al (2014, p. 284) mote design utilizes four sensors including one to measure PH. The mote design is scalable and allows for additional sensors which is ideal for Irish Waters specifications.

**Deployment** – From analysis of Irish Waters proposal and my research I suggest the deployment method discussed by Yang (2000, p. 131) of two sink nodes with multiple random motes. The reason I suggest two sink nodes is to speed up the acquisition of data from the motes. Depending on the size of the reservoir Irish Water may need two or more sink nodes to enable efficient data transfer. For example, if the water changes quality and becomes below standard at one end of the reservoir and this data cannot transfer in time the public supply could then be affected. As mentioned above scattered motes should also be implemented. The change in water quality can occur anywhere within the reservoir and these changes cannot be pin-pointed. The only logical solution is to deploy enough motes to cover the reservoir in it's entirety.

**Quality of Service** - The network needs to be reliable as any change in water quality must be available to stakeholders and the public. Irish Water are trying to reassure the public of water quality so it is of upmost importance that the network delivers quality information with a consistent service. The network must also be responsive to time intervals and have the capability of measuring pH, light and oxygen levels. Faustine, Anthony et.al (2014, p. 287) have shown a mote design that is scalable, works with timed intervals and captures a dataset that can be accessed quickly. In addition, the end user does not need to download specific software to obtain clear visualizations of the data. Following these guidelines will be cost effective and offer a quick and tested method of implementing a high quality streamlined service.

**Fault tolerance** – The network handles individual node failure by utilizing the mesh topology. Faustine, Anthony et.al (2014, p. 287) and Guobao, Xu et.al (2014, p. 16936) utilize and discuss the advantages of the mesh topology. Implementing this topology increases fault tolerance and robustness of Irish Waters proposed network. Events can be detected by multiple nodes, this means if one node fails another node in range will still pick up the data. Implementing two sink nodes as suggested by Yang (2000, p. 131) offers an extra layer of fault tolerance whereby there is always an extra sink node in the event of failure. Although this is not the primary purpose of an additional sink node it does increase fault tolerance within the network.

## References


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