Introduction

Wireless electricity or witricity is the transfer of electric energy or power over a distance without the use of wires. In order for the energy to be transferred safely coupled resonators are used. Coupled resonators are two objects of the same resonant frequency that exchange energy efficiently without much leakage. Minimizing energy leakage is very important because the goal is to have as much energy as possible be transferred from one object to another. The first experiment to successfully wirelessly transfer energy consisted of two copper coils that were each a self-resonant system. One of the coils was connected to an AC power supply and acted as the resonant source. The second coil acted as the resonant capturing device and was connected to a 60-watt light bulb. The power source and the capturing device were about 2.5 meters apart and the light bulb was able to light up. This technology is very useful both in everyday life and for military usage. An example of a military usage includes sensors on a battlefield that can detect motion. The sensors would send their information to a base station and the soldiers can use this information to sense possible attacks. This could give them enough time to move or keep safe. This would be very beneficial, however; replacing batteries in the sensors can be dangerous and time consuming. Using witricity there would be no need to replace batteries because energy could be transferred from one sensor to another. Once a sensor has reached a predetermined threshold it would "shout" for help from a neighboring sensor. If the neighboring sensor had above the determined threshold it would transfer the necessary amount of energy to the sensor in need. An optimization model has been created through researching this topic. One optimization solution is as follows; a matrix represents the amount of energy to transfer from all WiTricity devices to all WiTricity devices, which combines multiple power transmissions with multi-hop WiTricity charging as a response to multiple charging requests. Current research is focusing on solving various optimization problems on WiTricity charging protocols in wireless sensor networks. Through the use of the CPLEX program a java simulation will be created in order to find an optimal way to transfer energy with minimal energy leakage.

Questions to be Addressed

This research is going to address the following questions and hypotheses. What kinds of optimization problems will be useful to solve in the wireless electricity charging protocol for wireless sensor networks? How each of the optimization problems can be modeled using mixed integer programming? How each of the optimization models can be solved using an optimization tool such as CPLEX? The following assumptions must be made to further investigate the proposed hypotheses: Each sensor has a wireless sensor in the device to capture and send wireless electricity. The wireless sensor network is a multi-hop wireless sensor network; the sensors are expected to be an end node as well as and intermediate node. Sensors use multi-directional transmission and all the sensors within the transmission range can be reachable. Sensors will use adjustable transmission power so that the number of reachable neighbors can be changed for a static network topology and energy consumption of a sensor can be managed.

Conditions

In order for witricity charging to be able to be used there are some conditions that are necessary. The first condition necessary is that charging must be able to occur through physical objects. If the witricity cannot be passed through physical objects then the charging can only occur in a perfect unobstructed environment. This is not realistic because there are objects all around us that can interfere with the transmission of the energy. Research thus far has found that witricity can be transmitted through wood, gypsum wallboard, plastics, textiles, glass, brick, and concrete. The second condition necessary is that charging must be safe and not pose any sort of threat or safety hazard to humans or animals. Since this type of energy transfer is non-radioactive it is safe for humans and animals. The third condition necessary is that witricity charging must be able to provide electricity to remote objects without the use of wires. Therefore, the energy must be transferable from the transmitter to the capturing device over a certain distance. For example, traditional magnetic induction that is used in an electric toothbrush needs physical contact, or their needs to be a fairly short distance between the energy transmitter and the energy receiver. Thus, magnetic induction is not a suitable technology for witricity transfer. According to WiTricity, a company that has developed the wireless electricity technology, the distance between the power source and the capturing device can range from a centimeter to several meters between the power source and the capturing device, depending on the size of the device, how efficient the transfer is desired, and the amount of power that needs to be transferred. According to a team of researchers at MIT, two resonant objects of the same resonant frequency tend to exchange energy more efficiently while dispersing little energy to off-resonant objects, and a power transfer can be multi-directional and efficient. The team also calculated the efficiency of wireless power transfer using strong coupled magnetic resonators to be the amount of useable electrical energy at the power receiving device over the amount of energy sent by the power sources. The fourth condition necessary is that the witricity is able to transfer a meaningful amount of energy, or else it would defeat the purpose of the energy transfer. WiTrcity.com states their technology is able to transfer energy ranging from miliwatts to several kilowatts of power. The fifth condition necessary is that the witricity technology should not use a lot of memory. In order for a program to be loaded on the sensors it cannot take a lot of memory, since the sensors have limited memory capacity. The final condition necessary is that the witricity charging technology should be affordable to be able to be apart of a sensor.

Parameters

Witricity charging protocols have many parameters. The first parameter is the degree of charging. There are three different degrees in which a sensor can be charged. The first is perfect charging, this type of charging charges all the batteries of the sensors until they are all full. This is achieved by using an external power source such as a base station or using designated power supply devices. The second way is limited charging, this type of charging charges the batteries of the sensors that are at or above a certain threshold. It could have an external power source, but if it does not it will try to maximize the network lifetime without creating a blind spot in the wireless sensor network. The network lifetime is measured by the amount of data transmissions necessary until the WSN has its first blind spot or until the WSN has a given percentage of the WSN field in a blind spot. The third type of charging is no charging this is a wireless sensor network without charging.

The second parameter is the type of charging algorithm. There are two different charging algorithms; distributed and centralized. The distributed algorithm calculates the amount of energy that needs to be transferred between a node and its direct neighbor based on information received from its direct neighbor. The centralized algorithm calculates the amount of energy that needs to be transferred between all the sensors in the network. The amount of energy that needs to be transferred is represented in a matrix. In a two-dimensional WSN with n sensors, the matrix is n x n for a three-dimensional WSN with n sensors the matrix is n x n x n.

The third parameter is the type of power supply. There is a base station and either all of the sensors or some of the sensors are indicated as a percentage between 0 and 100%. It also allows the base station to select a set of certain sensors. There are also designated power supply devices that are non-sensor power supply devices that are deployed in the WSN. The next parameter is the type of power capturing device. There is a base station and the sensors are indicated as percentages too, the difference is the devices and base station might be a power capturing device or act as an intermediate power relay device. Another parameter is the mobility of the base station. The base station can either be stationary or mobile which has a velocity and direction. The mobility of designated power supply devices is another parameter. The power supply devices can either be stationary or mobile also with velocity and direction, or a combination of both. The mobility of the sensors is another parameter. The sensors can be stationary, mobile with velocity and direction, or a combination of both.

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