# Data Centric Directed Diffusion Based On Weighted Grover's Quantum Algorithm In Wireless Sensor Network

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*Abstract*— **Wireless sensor networks (WSN) have various application in various fields such as military, disaster management, and many other civic uses. Improving the performance and reliability of the network is the prime area of concern. Majority of Wireless sensor networks use data-centric protocol called directed diffusion. The existing protocol gives an optimal solution by finding the shortest path between source and sink. Finding shortest path does not ensure long lifetime of wireless sensors. Quantum Computing approach is used to propose a protocol, that will modify the original one by applying the weighted Grover's quantum algorithm to select the best path back to the sink . The proposed solution may speed up the data transmission process as well as reduce the power consumption which may result in increase in the lifetime of the network.**

*Index Terms*— Directed Diffusion, Grover's Quantum Algorithm, Weighted Grover's Algorithm, Wireless Sensor Networks

## I. INTRODUCTION

Wireless sensor networks have been considered as a subtype of ad hoc networks. However, they differ from each other in the case of energy and bandwidth limitation. So the routing protocols ADOV and DSR are used in ad-hoc networks cannot be applied because of their high power consumption. Because of this limitation led to develop many protocols for wireless sensor networks to increase the lifetime of the network also for increasing the overall performance of the network the energy efficient routs has the first priority [1]. These protocols are classified into three types which are data-centric protocols, hierarchal protocols, and location based protocols. Data centric protocols are called as flat because all nodes in this type of structure are equal that means they play the same role. Whereas, in hierarchal routing protocols, nodes are divided into groups called as clusters and each cluster assigns a head cluster which is responsible for aggregation and data forwarding. The third type is the location based protocols, which are utilizing the location information to be based on the region rather than considering the whole network [2]. In this paper we will focus on a data centric protocol called directed diffusion. Quantum computing studies the concept of theoretical computation systems (quantum computers) that make the direct use of quantum-mechanical phenomena, such as superposition and entanglement, which perform operations on data. Quantum computers are different from digital computers which are based on transistors. Whereas digital computers require data in the form of binary digits (bits), each of which is always either 1 or 0 definite states, quantum computation uses quantum bits (qubits), which is in superposition of states. A Quantum turing machine is theoretical model of this type of computer, and is known as the universal quantum computer. Quantum computers share the theoretical similarities with non-deterministic and probabilistic computers.

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## II. Related Work

### A. Sensor Protocol for Information via Negotiation (SPIN):

SPIN is a protocol which was designed for data-centric information dissemination in sensor networks. Rather than the blindly broadcasting sensor data throughout the whole network, nodes receiving/generating data first and advertise this data through short ADV messages. The ADV messages are simply consist of an application-specific meta data description.

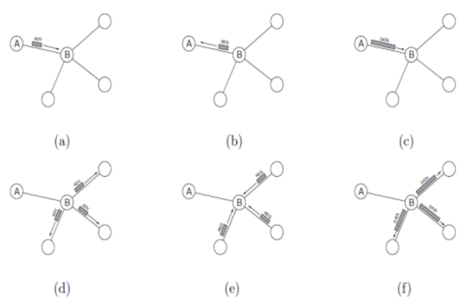


Fig 1. Illustration of message exchange in the SPIN protocol.

(a) Nodes advertise their data with an ADV messages. (b) Any node interested in receiving the data replies with REQ message, (c) To which the source node replies with transmission of the actual data. (d) The receiving node then advertises this new data (e, f) the processes continues .

This meta-data can be describe such a aspects as the type of data and the location of its origin. Nodes that are interested to send the data request from the ADV sender through REQ messages. Finally, the data is disseminated to the interested nodes with data information through DATA messages. This procedure is illustrated in fig 1. The advantage of SPIN over a blind flooding or gossiping data dissemination methods which avoids three costly problems: overlap, implosion and resource blindness. In highly connected networks, implosion occurs that employ flooding and thus each sensor receives various redundant copies of the data shown in fig 2. For large data messages wastes of energy takes place. on the other hand, in SPIN, short ADV messages will face the implosion problem, but the costly transmission of data messages is greatly reduced. Overlapping occurs due to the redundant nature of sensor data. Thus two sensors with some common data will send their data and causing redundancy in data transmission and therefore energy waste takes place shown in fig 2. By naming data, SPIN solve this problem so that sensors only request the data or parts of data that they are interested in receiving. In SPIN, there are mechanisms in which a sensor which is running low on energy level will not be advertise its data in order to save dwindling energy resources. SPIN solves the resource blindness problem by sensors make decisions based on the current level of available resources [3].

### B. Directed Diffusion:

Directed Diffusion is a data centric protocols which is commonly used in wireless sensor networks. It consists of several elements that are interests, gradients, data messages and reinforcements. An interest is a request, which specifies the desired data, sent by sink node to the sensor nodes in fig 2. A gradient is a response link to neighbour from which the interest was received shown in fig 3. Therefore, by using the interest and gradients, routes are established in between sensor nodes and sink node. Various routes can be set so that one of them is selected according to the rate. Data messages are events generated from one or more sensor nodes in response to requests sent by base station. Interests and gradients are described by the attribute-value model. When the sink node requires a data, it broadcasts an interest which contains several fields that depend on the application, like the type of required data, the rate of desired data and the time to live an interest.

An interest message consists of object name, data rate, duration and geographical area. In return the gradient message will consists of object name, duration, data rate, timestamp and many other parameters that related to the object type.

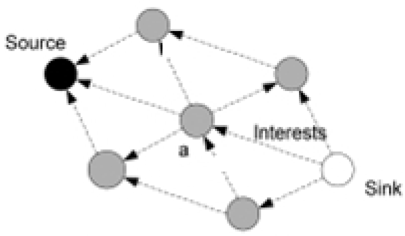


Fig. 2: Interest Propagation [4]

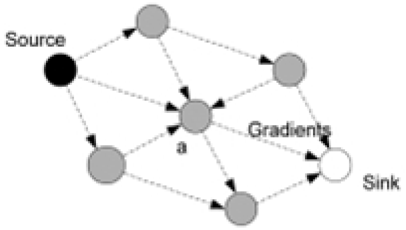


Fig. 3: Gradients setup [4]

## III. Proposed Work

In the proposed protocol, original one protocol will be modify by applying the weighted Grovers quantum algorithm. The first two steps are very similar to classical directed diffusion protocol. Firstly the sink will broadcast a service request. The request is going to be flooded in between sensor nodes until it reaches the desired node, which in this case is the source node. Second, source will replay back by sending replay message using the same routes back to the sender or sink only if it is able to satisfy the required service. Once the connection established between source node and sink node, the source will have different paths to choice from it. In the original protocol the best path is picked on the basis of how short is it? The best path in the proposed protocol is based on four different factors which are distance in between source node and candidate node for next hop, power consumption, remaining energy candidate node and buffer size available.

### A. Grover's Algorithm

1. The point at which we terminate the Grover's algorithm and measure the result which is critical
2. It has been shown that the optimum number of iterations is ≈ _ 4qNM, where M = number of solutions [5].
3. It has also been shown that this is the best way that any quantum search algorithm can do
4. It's much better than classical search algorithms which take $\Theta(N)$ steps
5. So there are huge potential benefits when searching very large data sets

Note that we could solve any problem where finding answers is hard, but recognising them is easy

As long as we can construct a Grover's algorithm

### B. Quantum Computer

Quantum Computer is proved to be very effective when used for factoring large numbers. It was found that it could decrypt codes within 20 minutes which took billions of years with classical computers. This is a great motivation for focusing on this latest topic. A quantum computer allows quantum bit or qubit to have three states - 0, 1, and -1. The last state (-1) is the coherent state. This enables an operation to be performed on two different values at the same time. However, this brings out a problem of de-coherence. As of 2015, the development of actual quantum computers is still in its provisional step, but experiments have been carried out in which quantum computational operations were executed on a very small number of qubits. Both theoretical and practical research continues, and many national governments and military agencies are funding to the quantum computing research in an effort to develop quantum computers for civilian, trade, business, and national security purposes, such as cryptanalysis.

### C. Wireless Sensor Network

Wireless Sensor Network (WSN) technology provided the availability of small and low-cost sensor nodes with capability to sens different types of physical and environmental conditions, data processing, and wireless communication. Variety of sensing capabilities results in a profusion of application areas. To achieve the desired aim it is very necessary to improve the overall performance of the network.

In WSN, the sensor nodes have limited transmission range, and also the processing and storage capabilities as well as the energy resources are limited. Routing protocols in wireless sensor networks are responsible to maintain the routes in the network and have to ensure the reliable multi-hop communication under these conditions, one of the most famous protocols that to use in wireless sensor networks is the Directed Diffusion protocol.

### D. Grover's algorithm: How it works

Grover's algorithm begins with quantum register of n quantum bits, where n is the number of qubits necessary to represent the search space of size $2^n = N$, all initialized to $|0\rangle$:

$$|0\rangle \quad n = |0\rangle \quad \otimes \qquad (1)$$

The first step is to put the system into equal superposition states, achieved by applying the Hadamard transform $H^{\otimes n}$, which requires $\Theta(\lg N) = \Theta(\lg 2n) = \Theta(n)$ operations, n is an applications of the elementary Hadamard gate:

$$|\psi\rangle = H^{\otimes n}|0\rangle^{\otimes n} 1/\sqrt{2n}\sum_{x=0}^{2n-1}|X\rangle \qquad (2)$$

The next series of transformations is often referred to the Grover iteration, and performs the amplitude amplification mentioned

  

earlier, the bulk of the algorithm. The Grover iteration will be repeated
$\Pi/4=\sqrt{2n}$ times.

According to Grover , in order to achieve optimal probability that the state that we ultimately observe is the correct one, we want the overall rotation of the phase to be $\Pi/_4=$ radians, which will occur on average after $\Pi/_4\sqrt{2n}$ iterations.

The first step in the Grover iteration is a call to a quantum oracle $\Theta$ that they will modify the system depending on whether it is in the configuration we are searching for. An oracle is a black-box function, and this quantum oracle is a quantum black-box, meaning it can observe and modify the system without collapsing it to classical state, that will recognize if the system is in the correct state. If the system is indeed in the correct state, then the oracle will rotate the phase by $\prod$ radians, effective mark the correct state for further modification by subsequent operations. Remember that such a phase shift of oracle leaves the probability of that system being correct state the same, although the amplitude is negated. Quantum oracle implementations will often use an extra scratch qubit, but in this implementation the extra qubit is unnecessary, so the oracle's effect on |X> may be written simply:

$$|X\rangle \xrightarrow{0} (-1)^{f(x)}|x\rangle \qquad (3)$$

Where f(x) = 1 if x is a correct state, otherwise f(x) = 0. The exact implementation of the f(x) is dependent on particular search problem.

Grover refers to next part of iteration as diffusion transform, which performs inversion of the average, transforming the amplitude of each state so that it is above the average and below the average prior to the transformation, and vice versa. This diffusion transformation consists of other application of the Hadamard transform $H^{\otimes}$ followed by a conditional phase shift that shifts every state except |X> by -1, followed by yet another Hadamard transform. The conditional phase shift can be represented by the unitary operator $2|0\rangle\langle 0| - I$:

$$|[2|0\rangle\langle 0|-I]|0\rangle=2|0\rangle\langle 0|0\rangle-I=|0\rangle \qquad (4a)$$
$$[2|0\rangle\langle 0|-X]0\rangle=2|0\rangle\langle 0|X\rangle-I=|x\rangle \qquad (4b)$$

Giving the entire diffusion transform, using the notation |ψ> from equation 2:

$$H^{\otimes}[2|0\rangle\langle 0|-I]H^{\otimes n}=2H^{\otimes n}|0\rangle\langle 0|H^{\otimes n}-I=2|\psi\rangle\langle\psi|-I \qquad (5)$$

And the entire Grover iteration:

$$[2|\psi\rangle\langle\psi|-I]\Theta \qquad (6)$$

In considering the runtime of the Grover iteration, the exact runtime of the oracle depends on the implementation and specific problem, so a call to $\Theta$ is viewed as one elementary operation. The total runtime, then, of a single Grover iteration is $\Theta(2n)$,from the two Hadamard transforms, plus the cost of applying O(n) gates to perform the conditional phase shift , is O(n). It follows that the runtime of Grover's entire algorithm, performing $\Theta(\sqrt{N})=\Theta(\sqrt{2n})=\Theta(2^{n/2})$ iterations each with a runtime of $\Theta(n)$, is $\Theta(2^{n/2})$ Once the Grover iteration has been performed an adequate number of times, then the classical measurement is performed to determine the result, which will be correct with probability $\Theta(1)$ completing the execution of the algorithm [6].

## IV. Conclusion

The quantum computing techniques can improve the performance of many algorithms due to the provided parallelism. For this reason, these techniques are applied to various areas such as Wireless Sensors Networks (WSN) which has become core of many critical applications. Project demonstrates an improvement to Directed Diffusion Protocol by using the Quantum Weighted Grover's search algorithm. The parallelism provided by this type of algorithm will decrease the complexity of searching from N to $N^{1/2}$. In order to enhance the Directed Diffusion Protocol a modification to the original protocol is conducted by applying the weighted Grovers search algorithm to select the best path from the source to the sink based on different proposed factor. The proposed solution also helps to reduce end-to-end delay and power consumption of the WSN due to the speed up of finding the best path.

## V. Future Scope

1. Selecting the factors will be based on a known benchmark.
2. Sing different factors such as transmission rate , increasing available buffer size.
3. Increase the number of candidate nodes.

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