

# Quantum Communication Methods Based On The Nodes' Connectivity

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**Abstract---** Many studies have been published in quantum communication focused on the natural law of communication depend on the entanglement between the Qubit. This review paper focused on the architecture (p2p, multi nodes to a single node and multi nodes to multi nodes), this paper has shown when connected two nodes they use entanglement method, for multi-users must connect by another type of connecting such as multi-quantum lines links such as in fixed network when connected one server two multi nodes. p2p method is best for security purpose such as in peer to a server connected for login authentication or for sending the encrypted password, multi-users(nodes) method is best for security purpose to quantum key distribution, the other methods connect two nodes (p2p) for sending and receiving data such as in quantum satellite, quantum radar, and quantum sensor. Another different type of communication inside of the quantum computer established by using quantum gates.

**Keywords---** Quantum bite, quantum communication, per to per, quantum computer, quantum radar, quantum algorithm

## I. INTRODUCTION

The classical communication between nodes depend on a bit, whatever the mechanism that will use to represent the bits such as 5 voltage or 0 voltage, It contains either 0 or 1, any information in the world contain from it if someone writes login, this in bits represented

(01101100 01101111 01100111 01101001 01101110) this is in classical information, but in Quantum word all things different, the one of any quantum bit can represent many classical bits, one of Qubits type is the electron, to understand the work for any Quantum device first should know about the Qubit, in figure 1.a, an atom with two exciting stages, ground excited stage within  $|0\rangle$  and first excited stage  $|1\rangle$ , in the classical world the movement between the two-stage is 0 or 1 in like this the data is processing but in the quantum world different the electron is between these exciting states but in superposition[1],[2], in all places in the same time no one can know the exact location of it but when the observer wants to see the location of the electron all of sudden the electron will be in any one of two exciting states, therefore no one can measure the location of the electron even the Quantum computer just Qubit know the state this makes the security one of the best application of Qubit (Heisenberg's uncertainty principle

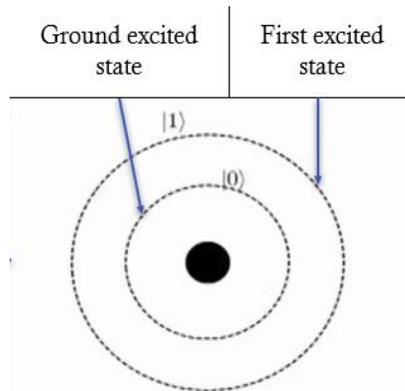
$\sigma^2 A \sigma^2 B \rangle = \left(\frac{1}{2} \langle [\hat{A}, \hat{B}] \rangle\right)^2 \dots (1)$  [3], therefore, the Qubit is uncopyable, this makes it more secure than the

classical bit. this in a two-dimensional world, in the world the movement or the superposition of the electron will be in any place of the sphere, sees fig 1.b, this cipher called Bloch sphere referring to Felix Bloch [4],[5],  $\Psi = \alpha|0\rangle + \beta|1\rangle \dots (2)$ .

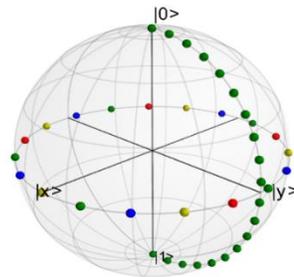
where alpha and beta are complex numbers  $|\alpha|^2 + |\beta|^2 = 1 \dots (3)$ .

the movement of the electron in all place of superposition this is the processing of the data and when the electron takes place in one of the excited states this represents the information result, for this kind of Qubit inside the quantum computer there is a quantum logic gate to communicate with each other. other Qubit type uses photon spinning, this type uses for QKD quantum key distribution in some of the point to point connection by calculating the angle and the spinning direction[6]–[9]. see figure 1.c.

other phenomena, if two Qubits have entanglement between each other wherever they find in split places if one of the process data the other one instantly processes the same information no matter the distance between them. therefore, anyone wants to know the information inside the one Qubit the other one told (by changing its state) us about it[10].



**Figure 1.a, a simpler atom.**



**Figure 1.b, 3D atom modular explain electron position depend on quantum mechanics.**

**Fig 1 electron and the atom explain quantum bit [10].**

This paper reviewed many of connection type between two or more nodes and then discuss this types to give an overview of the communication and when we can use it and how we can combine between them to give the researchers enough information to work in any type or make a new one more efficient, there are other review papers but those discuss the communication in a physical way, the paper discusses the communication as applied engineering methods in real-world applications.

The paper divided into three parts, related works to show the other work in this field, review papers on the work of others in each part related to the title of the paper, the third part will be discussing and the correlation between the types of connection then the conclusion.

## II. RELATED WORK AND MOTIVATION

All work that includes communication review in the quantum world was on physics or chemical or other fields this paper reviewed the quantum communication in the networking field combines the most effective type in this field.

The most relevant work is [11], they made a competitively paper between classical communication and quantum communication.

In the classical model of communication complexity, its often allowed for two nodes to share random variables, does not important if make sense from a mathematical way, node 1 assumed made a random bit( integer or string), according to some specific distribution or even though random real number when node 1 tells node 2 the outcome of this bit in an initialization phase, this type of communication is not the complexity of the protocol because it takes the position before nodes are given their inputs. when the correctness of the protocol is analyzed for a given input, probabilities are taken through success choice of the random numbers, this method has an error with probability  $\epsilon$  with the only  $k = \lceil \lg 1/\epsilon \rceil$  bits of communication but can be solved the quality testing, the value of  $s$ . in initialization phase the two nodes share  $k$  random bit integer,  $r_1, r_2, \dots, r_k$ , the length is  $n$ , once each of the nodes receives their input  $x$  and  $y$ , node 1 computes  $b_i = x \cdot a_i$  for each  $i$ . where  $a$ ,  $x$  is the inner product, between bit string  $x$ ,  $a$ , node 2 transmits  $b_1, b_2, \dots, b_k$  to node 1 who verifies whether or not  $b_i = y \cdot a_i$  for each  $i$ . now the probability of error of this strategy is  $2^{-k} \leq \epsilon$  because it is  $1/2$  independently for each  $i$ .

Quantum communication complexity, if we assume there is no error in Quantum communication that's mean this type exponentially better than the classical one, Quantum computer of google company (supremacy) has 52 Qubit means can run 252 steps in parallel, therefore can solve a problem more than  $4 \cdot 10^{15}$  steps and equal to 4.5 quadrillion classical computers run in parallel to solve the same problem, Google's quantum computer has solved problem take 10,000 years for normal computer solve [12], [13].

## III. QUANTUM NETWORK CONNECTING

Quantum communication, depending on the photon between the sender and receiver for key distribution or communication between two nodes or more for a short distance or long, the photon travels for long distance in free space but in the optic medium lost, therefore the photon needs for a refreshing device, here the repeater used for QKD or communicate between nodes.

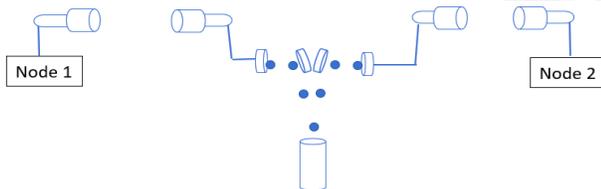
### A. Peer to Peer Connection

When two nodes connect or communicate with each other such as user to the bank server.

- 1) fixed, used for security purpose to QKD, the using repeater to make the photon travels for long-distance,

to make entanglement between two nodes, the repeater put in distance between two nodes then node 1 send Qubit(photon) same for node 2 send photon inside the repeater make entanglement after that the whole path between two nodes will be entangled and the two nodes can communicate or used for security login server-node connection, this method fixed by using guided medium (fiber optic), this method suggest by QuTech Academy[10].

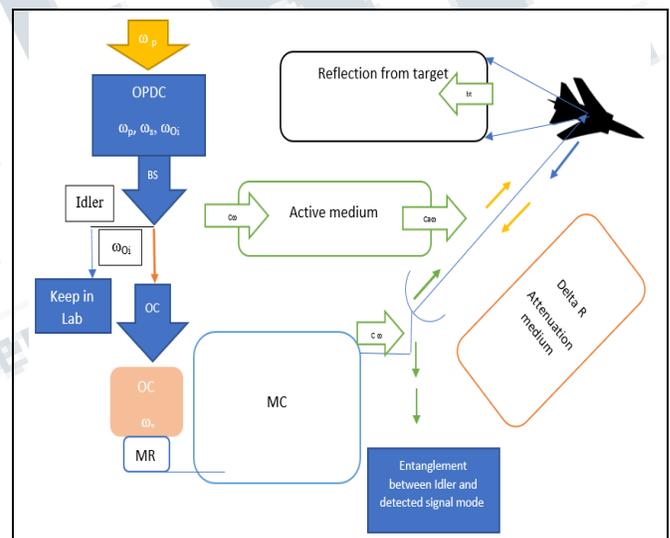
- 2) wireless the repeater some time is the quantum key maker and distributing by generating two or more entanglement photons then distributing them to two nodes and can these nodes communicate suavely, this approach depends on Qubit generator then send by reflecting them in a mirror then send using the telescope to node1, node 1 receives the Qubit also, by telescope then directed it to the node, same procedure doing node 2, after that, all entangled photons can communicate or send or receive without any needing for a medium like optic[14], [15], see figure 2 [16].



**Fig 2, quantum repeater for long-distance relay on free space medium [16].**

One of the best examples of wireless communication is the radar, figure 3 i showing Quantum radar with some information, the process starts with the communication if laser that has high intensity through a nonlinear to made entangled photon[17],[18]. the mediator makes the entanglement between photons, the mediator establishes it with backscattered photons. Passing through the optical pressure applied to the oscillator the excited OC by the signal to the couple MR, by changing the capacitance of MC of the oscillation by which frequency of the cavity is changed. the system of three components, its found the OC, MC, to the MR modes couple one to each other which means the modes are affected the contributed. the engineering of the tripartite systems has been shown that the correlation in nonclassical can be established to the modes between them[19]–[24]. know it illustrates the OC and MC entangled. so, the output of the MC is  $C\omega$ , with the optical is entangled by cavity mode, the amplifies is first step  $\nu_0 = i\alpha$  active medium and after that propagate to the atmosphere for a detect target. the medium active

approach that shows in figure 3. it contains K of(BS) beam-splitters for considered as components amplification in the same active medium. regarding to the theory of quantum electrodynamics, the excited photons that thermally invested intensify at each BS incoming photon[25]. so,  $C\omega$  is the output of the active medium, the OC studied with the entanglement of  $C\omega$ . the result has shown ka (gain) of the active medium properties, with medium length effect strongly the entanglement behavior. the second, of the activity of medium mode  $C\omega$ , must transmit into the medium (atmosphere) for propagating, the medium modeled with K discrete components by which photon that propagates will be changed in amplitude and phase. the output showed the nodes of the medium ca is affected most of the length of the channel R and imaginary of a minority of the wave vector the delivered by the excited state of the attenuation medium. another parameter critical in the medium attenuation varying to the atmospheric conditions like the pressure and temp[26].



**Figure 3, Quantum radar operation[27]**

### B. Peer to multi-point connection

It depends on the medium if it is fixed which means the photon travel through fiber and for long-distance must have a repeater for refreshing the signal (photon) and so on, of there is no medium the photon travel through the air to reach the destination.

- 1) Fixed as what in the previous said the fixed that's meaning must the network has medium to travel the photon through what over the distance because there are refreshing points for the photon, but the photon travel from the server to reach the multi nodes.

- 2) wireless the communication here because for multi-use the photon(single) will be split by beam-splitter but, must emerge in a correlated state with the output modes. the measurement of determent the output modes which one occupies will always show the result in only one just whose occupied, there is occupation prosperity of determining the coupler coefficients, for the fiber tests[28]–[33]. the laser diode of highly attenuated usually used for the single-photon source, the single-photon features at couplers are avoiding problems of entanglement of single photons[15], [34].
- 3) Quantum computer, there are some common and famous quantum algorithms such as Shor's algorithm for finding the prime factor, the communication inside the quantum computer makes it is strong or fast to solve this problem by running in polynomial time[35]. another algorithm for searching in a huge database with various applications called Gover search algorithm[36], [37], this method of search is quadratic fast then the classical one that's run in a classical computer, it's a fancy algorithm for quantum computer[38], it has a brunch application for this type of computer[39], [40], all these algorithms have been shown on variety platform[41]–[47][48]. all these algorithms or other algorithms in the future will be prosed depend on one thing, the communication inside the quantum computer, this type of communication flows the type of circuit design inside the quantum computer itself such as that's run within the IBM quantum computer[49].

**IV. DISCUSSION AND CORRELATION**

The connections types can be combining between them to make one of the best applications in Quantum devices or one of the best benefits of using quantum devices, the quantum internet to use all these connections work with each other but this work wants more time and effort to establish. For security issue as what the paper is showing the best type of communication not like the classical one for point to point is better then the multi-point or user in quantum communication all connecting is same its power because the security depends on the natural quantum physics not on mathematical function, see table1.

Type of connection	Type of medium	Type of structure
P2P	Fixed and wireless	Using fiber some time laser
Point to multi-point	Wireless some of the design such as radar, fixed Quantum computer at home[50]	Photon and fiber
Quantum computer	Quantum gate	Depend on the producer

**Table 1 summarizes the connections**

**V. CONCLUSION AND FUTURE WORK**

As the paper explained the type of connecting between nodes, the type of connection some time depending on the type of the quantum bit that's used such as fixed and wireless communication. for multi-user to multi-user communication, the laser photon sprayer can be used to spray between them and make communication between each other for security (quantum key distribution) or normal communication. For future work, we will make a study on the types of Qubits and how they produced them, and which type suitable for p2p network or multipoint in two fields wireless or fixed network. Also, we will make a study of the security effect on the type of communication.

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