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Multi Qubit Transmission in Quantum Channels Using Fibre Optics Synchronously and Perform Error Correction

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Abstract : *A quantum channel can be used to transmit classical information as well as to deliver quantum data from one location to another . Classical information theory is a subset of Quantum information theory which is fundamentally richer, because quantum mechanics includes so many more elementary classes of static and dynamic resources. Quantum information theory contains many more facts other than described here, including the study of quantum data processing, manipulation and Quantum data compression. Here we consider quantum channel as Bosonic channels, which are a quantum-mechanical model for free space or fibre optic communication. In this paper the overview of theoretical scenario of quantum networks in particular to multiple user access to the quantum communication channel is considered. Multiple qubits are generated in different system, the proper alignment of qubits is a must it can be first come first serve or round robin fashion. The received data are grouped into codewords each of n qubits and quantum error correction is performed. These codewords are agreed between the transmitter and the receiver before transmitting over the quantum channel known as valid codewords.*

Keywords*: Bosonic channel, Entanglement, Quantum error correction, Quantum memory, Qubits*

I. Introduction

Quantum information in the form of Qubits exploits the quantum nature of information. It offers fundamentally new solutions in the field of communication and computer science that extends the possibilities to a level that cannot be imagined in classical computer networks or data communication systems. For quantum communication channels, many new capacity definitions were developed in comparison to classical counterparts. The unique properties of quantum states are it is impossible to copy because of no cloning theorem also they cannot be perfectly distinguished this is quantified by the Holevo bound [1]. Recent work on determining the channel capacity of optical channels is extended in several ways. Classical capacity is derived for a class of Gaussian Bosonic channels represent the quantum version of classical Gaussian-noise channels [4]. The proof is strongly motivated by the standard technique of whitening Gaussian noise used in classical information theory. Minimum output entropy problems related to these channel capacity derivations are also considered [11]. These single-user Bosonic capacity results are extended to a multi-user scenario by deriving capacity regions for single-mode and wideband coherent-state multiple access channels. An even larger capacity region is obtained when the transmitters use non-classical Gaussian states, and an upper bound on the capacity region is also acceptable. The main goal of quantum information theory is evaluating the information capacities an important factor of bosonic communication channels. Currently, exact transmission capacity are known for only a handful of quantum channels. Here we consider the classical capacity *C* of Bosonic channels with isotropic Gaussian noise [2].

Coherent Quantum information and transmission of valid codewords

The entropy exchange S_e measures the amount of information that is exchanged between the system Q and the environment E during their interaction. If the environment is initially in a pure state the entropy exchange is just the environments entropy after the interaction that is $S_e = S(\rho^{E'})$ where $\rho^{E'}$ is the final state of E. The entropy here is just the ordinary Von Neumann entropy of a density operator, $S(\rho)=-\mathrm{Tr}(\rho\log\rho)$[1][2]. The entropy exchange is entirely determined by the initial state ρ^{Q} of Q and the channel dynamics super operator ε^{Q} that is the entropy exchange is a property 'intrinsic' to Q and its dynamics. The coherent information I_e, Is given by $I_e = S(\rho^{Q'}) - S_e$ .It has many properties that suggest it as the proper measure of the quantum information conveyed from sender to receiver by the channel. For example, I_e can never be increased by quantum data processing performed by receiver on the channel output and perfect quantum error correction of the channel output is possible for receiver if and only if no coherent information is lost in the channel[3].The coherent information are also related to the capacity of a quantum channel to convey quantum states with high fidelity. The reliable transmission of quantum information can be measured by the fidelity of entanglement or fidelity of quantum information [5].

Quantum Fidelity of Transmission of Quantum Information

The fidelity for two pure quantum states is defined as [5]

$F(|\varphi\rangle,|\Psi\rangle) = |\langle \varphi|\Psi\rangle|^2$

The fidelity is the measure of quantum states describes the relation of sender's pure channel input state $|\Psi\rangle$ and receiver's mixed quantum system $\sigma = \sum_{i=0}^{n-1} pi\rho i$ at the channel output as $F(|\Psi\rangle,\sigma)=\langle\Psi|\sigma|\Psi\rangle|= \sum_{i=0}^{n-1} pi\, |\langle\Psi\, |\Psi i\rangle|^2$[5]

A quantum system denoted by **A** and a reference system **P**. Initially the quantum system **A** and the reference system **P** are in a pure entangled state, denoted by $|\Psi^{PA}\rangle$[5].

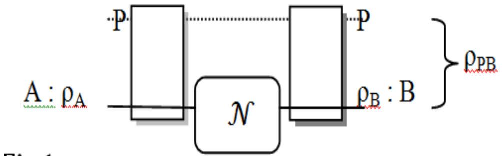

Fig.1

In Fig.1 ρ_A will be transmitted through the quantum channel $\mathcal{N}$, while the reference state **P** is isolated from the environment, hence it is not modified after the transmission. After the quantum system ρ_A is transmitted through the quantum channel, the final state will be, [5]

$\rho_{PB} = (I^P \otimes \mathcal{N}^A)\,(|\Psi^{PA}\rangle|\langle\Psi^{PA}|)$.

Von – Neumann entropy [1]: Shannon entropy measures the uncertainty associated with a classical probability distribution quantum states are described in a similar fashion with density operators replacing probability distributions. Generalizing the definition of the Shannon entropy of a quantum state ρ by the formula $S(\rho)\equiv -tr(\rho \log \rho)$. If λ_x are the eigen values of ρ then von neumanns definition[1] re expressed as $S(\rho) = -\sum \lambda_x \log \lambda_x$.

Bosonic channel that carries quantum code words

The main intention of any channels is the reliability of the channel that is whatever the information that is carried through the channel to the receiver side must be the same what has been transmitted at the sender side. The data being transmitted in any medium will undergo loss in fibre optics the error is 1 out of 10^{17} which is very low compared to any channel.

Bosonic channel capacity decreases with the increase in λ [12].The exact Bosonic upper bound channel capacity is derived with physics quantum electrodynamics. The trade offs for chains of qubits and bosons should not be different as the physics of spin wave propagation is closely related to the physics of wave propagation in the muti mode bosonic channel. The entanglement need not increase the overall channel capacity, but do provide the correlation between sender and receiver which are exchanging information.

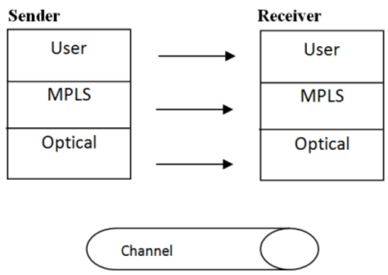

Fig.2

In Fig 2 Multiprotocol λ switching and optical networking is shown through a layered model [15].The data in the form of qubits,a group of qubits called as Qpackets uses the label swapping operation to transfer a labelled information from an input to an output. The data plane uses a switching to connect an optical channel from a sender to receiver.

Quantum Error Correction

It is shown that the resulting code which is invalid can correct the errors of weight less than d/2. The parameters of the quantum code are thus [[n, 2k − n, d]][6,7,8].

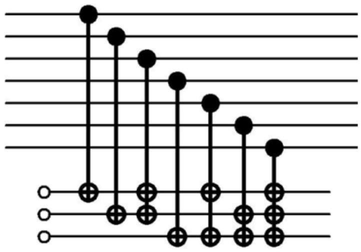

Fig. 3

The Fig.3 shows Syndrome extraction operation for [[7, 1, 3]] CSS code.

II. Conclusion

A bosonic channel is used for transmission of quantum information, the optimization must be allowed for both the transmitted quantum code and the receivers quantum measured data. In particular it is not appropriate to immediately restrict consideration to coherent state transmitters and coherent detection or direct detection receivers[13][14]. Recently there are much progress in determining the classical and quantum communication capacities of bosonic channels. The protocol corrects virtually all errors in quantum memory, but requires little measure of quantum states. The ideal quantum error correction code would correct any errors in quantum data, but until now researchers at MIT could correct only limited number of errors roughly equal to the square root of the total number of qubits. Knill and Laflame[9] and Bennett[10] provided a more general theoretical framework, describing requirements for quantum error correcting codes and measure the fidelity of corrected states.

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