A Review on Integration of Quantum Processor Services with Recursive Quantum Network in Cloud System

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Abstract

Index terms—

1 Introduction

loud computing is globalization for internet computing. It is a revolutionary system but still faces some vulnerability in many cases. Many threats such as, data loss, privacy issue, data theft, vendor security, data locality etc. has shown up. Using most powerful encryption system or secured medium to transfer data over cloud is not properly safe yet.

Because intruders have a chance to eavesdrop client's information at any time in this classical system. Cloud computing is 50 year old business model, which still needs to expand and overcome limitations that prevent the full use of its potential. [1] Clouds must be able to define computational risk management tactics to identify, assess, and manage risks involved in the execution of applications with regards to service requirements and customer needs. [2] Secure cloud computing concerns some issues like secure cryptographic key distributions, strong network system, fast processing etc.

All these system are based on classical method, they are electronically and virtually safe. However, they are not safe enough to rely because advancement of technology and method is a hint of upcoming problem. However, new concept of quantum physics for information technology is making a way to make safe and faster cloud system. All we need to integrate the quantum network system with cloud system. In order to established Quantum internet networks using classical optical technology it needs storage to store quantum information and quantum repeater as amplifier for long distribution of entanglement.

As we know, there is a possibility of QCaaS (Quantum Computing as a Service) in cloud system. [17] In here our paper is reviewing the model of integration cloud with recursive quantum internet for further more secured and faster cloud computing.

At first, we will know about some facts aboutcloud, classical networks and quantum networks, entanglements as well as recursive quantum repeater network for our further review on integrating quantum internet with cloud. a) Cloud System Understanding basic system of how cloudcomputing works in network is important. It consist two layers; user interface layer and backend layer consist of hardware and software services. This cloud uses a network layer to connect users' endpoint devices. Present network architecture of cloud system consist router, firewall, Ethernet switch, fiber channel switch, Server Load balancing etc. Fig. 1 **??**3] shows present architecture of cloud computing network. However, these architecture cloud change based on different service module. This complex structure is costly and has different vulnerabilities. As we see, each part is connected to the internet at a time so making the network system more secure and faster is one of the challenges. This why we will review a new model of cloud system integrated with recursive quantum internet. Entanglement happens when a pair of particles interacts physically. Entangled photon particles spin vice-versa even if we observe it from a far distance. Fig. **??** shows a simple view of entanglement for a pair of photon particle. It shows if we observe one of the photon from the pair then we can assume easily the other one's spin status not matter how far they are. This is a key technique for instant data teleportation in Quantum networks system. c) Recursive Networking In classical network system can be used or add all over the network topology so that the complex subnet structure stay hidden and it can reuse single protocol for different layers in a protocol stack. In Here the black dot represents simple repeater, red dot represents router and blue dot represents nodes in request states.

[4] Fig. **??** : Entangled Photons A recursive network architecture reuses single flexible protocol for the different layer of protocol stack to avoid recapitulation of implementation and dynamic composition of services. [5] Before we introduce recursive quantum network with cloud system it's essential to know why new network architecture like RNA is needed. Current classical internet architecture has been remodeled by adding different extension layer, protocol and facilities such as, SHIM6, HIP, SCTP, TLS, BEEP etc. [6] But in many cases these extensions affects the nature of conventional protocol stack and sometimes it repeats services which are available at existing layer. That is why recursive network model unifies basic properties of protocols and reuses components services to avoid these shortcomings. Another similar classical network recursion is shown in Fig. **??**, a simple recursive classical network where the embedded subnet works as router at the higher level, this embedding could happen in many times, on top of its existing embedding and that's how it works like a recursive network. [7] Fig. **??** The Quantum Internet is a concept of information travels to the end users in a quantum state through an optical fiber link using entanglement. The main thing to create a quantum internet is the capability to encrypt information on single photons of light that can be produced on demand. There is no quantum communication scheme so that is why we use a classical communication scheme to transmit quantum information using infrared photon through optical fiber. However, photons decay exponentially as they propagate so a quantum repeater is used to amplify the transmission as long as possible. Simple quantum network structure using entanglement is shown in Fig. 5. Just like in classical perspective amplifiers is used to extend the data communication we use here quantum repeater to pass data through one fiber links to another fiber links. Our main concern for Quantum repeater is to ensure that the whole system is compatible with standard fiber optical communication system for long distance transmission.

2   Recursive Quantum Repeater Network

In 2011, a team of Van Meter, Joe Touch and Clare Horseman presented a better quantum internet system by adopting classical recursive network. As we know classical network forward the data packet on towards its destinations but quantum internet does not sends the data rather than it recreate quantum states by requesting for the execution of operation. In the(QRNA) Quantum Recursive Network Architecture system the developer team contributes a solution for 4 major scaling problem such as: ensuring interoperability among technologies that are heterogeneous (at both the physical and logical levels), reconciling the competing needs and policies of independent organizations (including the desire to keep information about the network internals private), choosing a technical approach for the routing, naming, and resource discovery problems that is robust in the face of this heterogeneity and federated operation and managing communication requests using incomplete, out-of-date information about the dynamic state of the network, including availability of resources and topological change occurring as nodes join and leave, and network links go up and down. [8] This model gives quantum internetwork system a possibility in large-scale deployment which is essential for world-wide cloud computing services.

IV. Recursive Quantum Repeater Network and Quantum Processor Services in Cloud

In 2015, the Cloud Security Alliance formed a new working group called the Quantum-Safe Security Working Group (QSSWG). [9] So secured cloud computing is a provocative question at present. Judging this facts unify present fiber network technology with Quantum physics features we could build a strong repetitive and large network system, so that cloud data passing and storing will more secured and reliable. Our approach is to unify different progress in Quantum internetwork system in recent years and propose a minimum view of model to integrate cloud with Quantum internet.

One of the greatest challenges for implementing a globally distributed quantum computer or a quantum internet is entangling nodes across the network. [10] Building peer-to-peer small quantum network system is not so hard. However, in the case of large quantum network there are difficulties to deal with decoherence and photon decay. Therefore, there is a method to build large quantum network using photon entanglement by distributing quantum state. In this system, the network nodes are Quantum repeaters, which are equivalent to classical internet routers. In entanglement, behavior pair of entangled particle is called Bell pair. This entanglement increases the photon transmission distance through networks. Research on the physical mechanisms for transmitting quantum states typically assumes transmission through a fiber, but free-space optical links and even satellite links can also be used, with repeater nodes at each end of the link. [11] Since our present technology is not fully quantum specialized and the quantum computer still not available so we have to take help from classical network control system to design a unified Quantum Repeater. A unified architecture proposed by Van Meter, Joe and Horsman team to build classical recursive network concepts to extend data distribution. This system claimed to be very useful to build arbitrary distributed states such as Bell pairs and GHZ, W and Cluster state. [12] In order to safely long-distance Distribute Quantum Key through a large network system there must be an error proof requestresponse protocol. The request naturally produced in the nodes and processed through a set of protocol software modules. [13] In their proposed system, the building block for distributed algorithm is a core group of entangled states, which supports direct distributed execution of any quantum algorithm. In quantum repeater, network recursion is natural model because of purification, entanglement, swapping and Calderbank-Shor-Steane (CSS) [14] Fig. 6shows a simple structure of Quantum repeater network, which can distribute QKD over approximately 50km to 3000km where each Quantum Repeater node contains Error correction purification, Entanglement distribution, initialization and measurements. Another progress in Quantum internet system is to add a quantum SIM chip in

cloud architecture so that anyone can process any quantum algorithm application in web browser using internet. A group of scientist in University of Bristol, UK has already done this part experimentally. According to their claim a small quantum chip connected to the internet will works by guiding two photons through a series of optical channels. As the photons pass through the 2-Qubit chip, they become entangled, meaning that a measurement on one influences the outcome when measuring the other. Programming the computer involves tweaking the extent of this entanglement to produce different computations. [15] However, this is a limited version of Quantum processor service; we need to implement it in large scale for public. And that's why we propose to unite recursive quantum repeater network system for large-scale communication with the quantum cloud chip services.

Because of QKD is vulnerable to distance and loss factor so we could use recursive quantum repeater network model with an extra layer of Quantum chip service so that anyone can process Quantum algorithm over the internet using existing fiber optical technology.

In our proposed approach, we could add the Quantum chip service in our physical layer of present network architecture thatprovides users a secured and faster quantum processing over internet. The quantum SIM chip we are using is actually open web interface simulator. This high-level application interface helps us to do experiments on various quantum application theory. This API could integrate in Application layer of QRNA.We merge the recursive quantum repeater system in physical layer so that processed Quantum encrypted key could travel through internet to the end user in cloud system in large-scale. This integrated approach will increase the performance the Quantum internet over cloud system.Fig. 7 is a simple structure for our proposed model how the end user cloud use Quantum processor which is interconnected with recursive Quantuminternet system over cloud.

3   Conclusion

A cloud system is all over the world is truly a large-scale system. In classical networking approaches data moves through network using source applications, but in normal quantum networking system it creates distributed entangled quantum states as well as transport the data one to another places. In advance, Quantum recursive Network system it asks a node or network to contribute vigorously in the view of large state network. Therefore, the major issue of large-scale distributed computing could be solved using QRNA. We hope within next few years, hybrid technology of quantum internet will deploy. So that Quantum processor with quantum storage system in cloud system will add with microwave-optical transducers for longdistance optical communication. [16] In our paper we have showed a simple view and recent progress of integrated quantum network system with quantum processor chip in cloud, but there could be more of it. Not only a single quantum chip but also all the major cloud application could be attached with recursive quantum network so

4   Quantum Processor Service

Recursive Quantum RepeaterNetwork End User that distributed quantum computing gets availability all over the internetwork system. We hope QCaaS (Quantum Computing as a Service) would be more efficient with the integration with recursive quantum repeater networks.
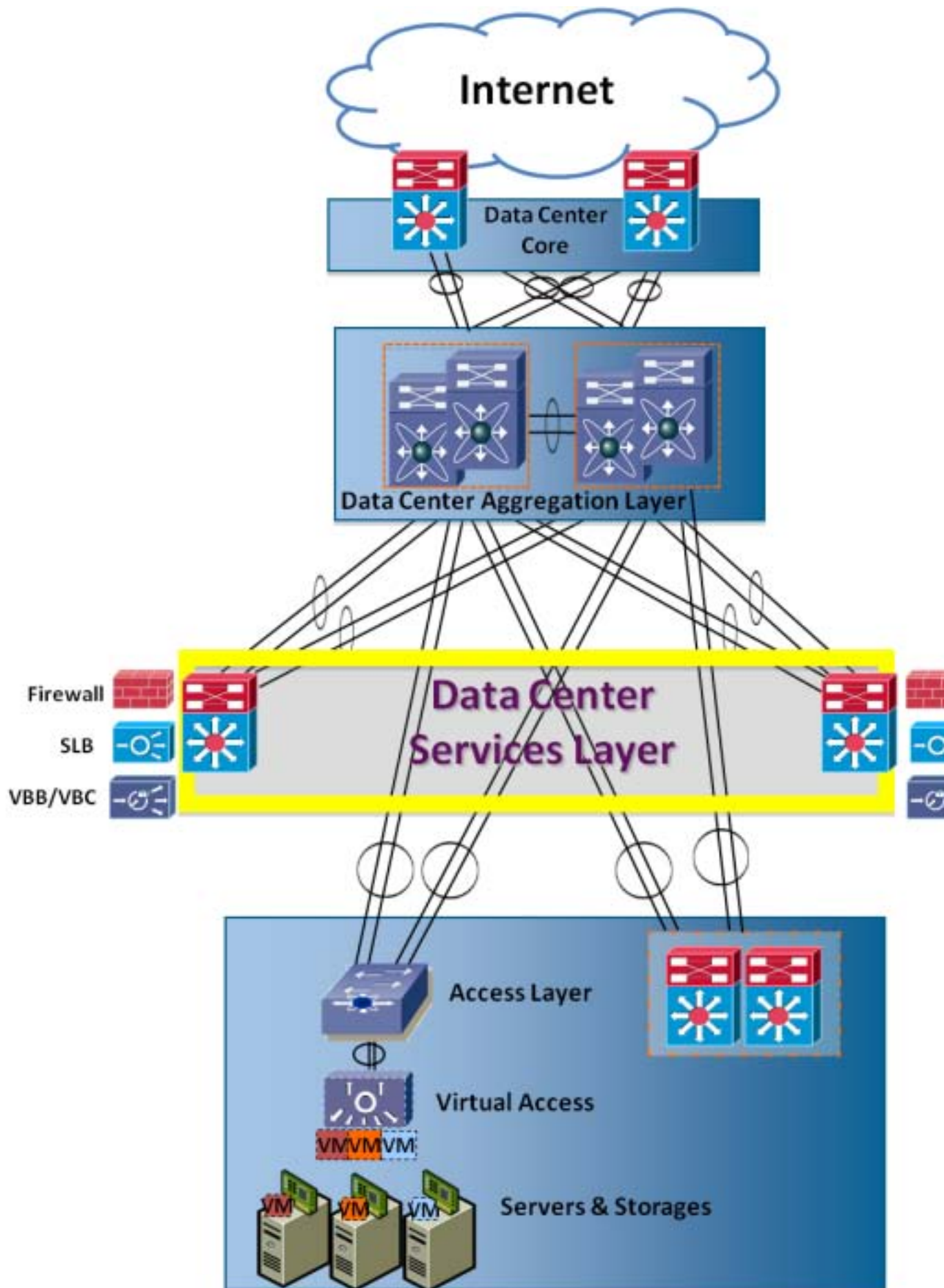
Figure 1: A

Figure 2 : Fig. 1 :

Figure 3:

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Figure 4: Fig. 4 : 1 BA

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Figure 5: Fig. 5 :

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Figure 6: Fig. 6 :

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Figure 7: Fig. 7 :

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Figure 8: 1 BA

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