Master's Thesis (Academic Year 2023)

Link Management For Quantum Network

Keio University Graduate School of Media and Governance Makoto Nakai

#### Abstract of Bachelor's Thesis - Academic Year 20xx

#### Link Management For Quantum Network

I can't write English.

Keywords:

1. Thesis, 2. RG, 3. Jun Murai Lab., 4. LATEX

Keio University Graduate School of Media and Governance Makoto Nakai

## Contents

Int	Introduction	
1.1	.1 Background	
1.2	.2 Research Contribution	
1.3	.3 Thesis Structure	
Ba	Background	
2.1	2.1 Quantum Bit	
	2.1.1 Definition	
	2.1.2 Bloch Sphere	
2.2	2.2 Quantum Operations	
	2.2.1 X Gate	
	2.2.2 Y Gate	
	2.2.3 Z Gate	
	2.2.4 H Gate	
	2.2.5 CNOT Gate	
	2.2.6 Measurement	
2.3	2.3 Quantum Circuit	
2.4	2.4 Quantum Entanglement	
	2.4.1 Bell Pair	
	2.4.2 Multipartite Entanglement	
	2.4.3 CHSH Inequality	
	2.4.4 Quantum Teleportation	
	2.4.5 Entanglement Swapping	
	2.4.6 Entanglement Purification	
2.5		
	2.5.1 Quantum Node	
	2.5.2 Quantum Repeater	
	2.5.3 Quantum Link	
	2.5.4 Major Applications of Quantum Networking .	
${ m Re}$	Related Works	
3.1		
3.2		

4	Pro	blem Definition	5			
	4.1	Problem Definition				
5	Proposal: Link Management For Quantum Network					
	5.1	Overview	6			
	5.2	Requirements	6			
	5.3	Link Allocation Policy	6			
	5.4	Link Allocation Policy Negotiation	6			
	5.5	Link Allocation Timing Negotiation	6			
	5.6	Resource Allocation	6			
	5.7	Link Management Finite State Machines	6			
	5.8	Link Management Finite State Events	6			
	5.9	Type of Messages	6			
	5.10	Relationship With Connection Setup	6			
	5.11	Relationship With Connection Teardown	6			
6	Sim	nulation	7			
	6.1	Overview of QuISP (Quantum Internet Simulation Package)	7			
	6.2	Major Components	7			
	6.3	BSA Controller	7			
	6.4	EPPS Controller	7			
	6.5	Bell Pair Store	7			
	6.6	RuleEngine	7			
		6.6.1 Link Allocation Policy Negotiation	7			
		6.6.2 Link Allocation Timing Negotiation	7			
		6.6.3 Resource Allocation	7			
		6.6.4 Connection Teardown	7			
	6.7	Connection Manager	7			
		6.7.1 LinkAllocationUpdateNotifier	7			
		6.7.2 Connection Teardown	7			
_	Б		0			
7		lluation	8			
	7.1	Experiment				
		7.1.1 Two Node Network With an MM Link	8			
		7.1.2 Two Node Network With an MIM Link	8			
		7.1.3 Two Node Network With an MSM Link	8			
8		nclusion	9			
	8.1	Conclusion	9			
	8.2	Future Works	9			
$\mathbf{A}$	App	pendix	LC			
	A.1	hoge	10			
A	knov	wledgement	L1			

# List of Figures

# List of Tables

# Introduction

- 1.1 Background
- 1.2 Research Contribution
- 1.3 Thesis Structure

## Background

0 1	<b>^</b>	D.
2.1	Quantum	Bit

- 2.1.1 Definition
- 2.1.2 Bloch Sphere
- 2.2 Quantum Operations
- 2.2.1 X Gate
- 2.2.2 Y Gate
- 2.2.3 Z Gate
- 2.2.4 H Gate
- 2.2.5 CNOT Gate
- 2.2.6 Measurement
- 2.3 Quantum Circuit
- 2.4 Quantum Entanglement
- 2.4.1 Bell Pair
- 2.4.2 Multipartite Entanglement
- 2.4.3 CHSH Inequality
- 2.4.4 Quantum Teleportation
- 2.4.5 Entanglement Swapping
- 2.4.6 Entanglement Purification
- 25 Quantum Notworking

## Related Works

- 3.1 RuleSet-Based Quantum Network
- 3.2 Quantum Recursive Network Architecture

## **Problem Definition**

#### 4.1 Problem Definition

# Proposal: Link Management For Quantum Network

- 5.1 Overview
- 5.2 Requirements
- 5.3 Link Allocation Policy
- 5.4 Link Allocation Policy Negotiation
- 5.5 Link Allocation Timing Negotiation
- 5.6 Resource Allocation
- 5.7 Link Management Finite State Machines
- 5.8 Link Management Finite State Events
- 5.9 Type of Messages
- 5.10 Relationship With Connection Setup
- 5.11 Relationship With Connection Teardown

### **Simulation**

- 6.1 Overview of QuISP (Quantum Internet Simulation Package)
- 6.2 Major Components
- 6.3 BSA Controller
- 6.4 EPPS Controller
- 6.5 Bell Pair Store
- 6.6 RuleEngine
- 6.6.1 Link Allocation Policy Negotiation
- 6.6.2 Link Allocation Timing Negotiation
- 6.6.3 Resource Allocation
- 6.6.4 Connection Teardown
- 6.7 Connection Manager
- 6.7.1 LinkAllocationUpdateNotifier
- 6.7.2 Connection Teardown

## Evaluation

- 7.1 Experiment
- 7.1.1 Two Node Network With an MM Link
- 7.1.2 Two Node Network With an MIM Link
- 7.1.3 Two Node Network With an MSM Link

## Conclusion

- 8.1 Conclusion
- 8.2 Future Works

# Appendix A Appendix

A.1 hoge

# ${\bf Acknowledgement}$

## Reference

[1] Satoshi Nakamoto. Bitcoin: A peer-to-peer electronic cash system. http://www.cryptovest.co.uk/resources/Bitcoin%20paper%200riginal.pdf, 2008.