

# Contents

Abstract	page
Acknowledgements	i
Contents	iii
List of Figures	v
List of Tables	vii
List of Symbols	viii
List of Abbreviations	ix
<b>Chapter 1: Introduction</b>	<b>1</b>
1.1 Data center	1
1.2 Challenges for latency critical applications	4
1.3 Meeting user interactivity deadlines	4
1.4 Traffic in Data center Network	5
1.5 Issues with Traditional TCP in Data center networking	7
1.5.1 Data Copy	7
1.5.2 Time Scale of RTT and RTO	7
1.5.3 Small BDP	8
1.5.4 Designing Goal	8
1.5.5 Delayed Convergence	8
1.5.6 Heavy Congestion Control	8
1.6 Multipath Routing in Data center	8
1.7 Overview of Thesis	10
1.8 Thesis Roadmap	11
<b>Chapter 2: Related Work</b>	<b>13</b>
2.1 Topologies for Data center Network	13
2.1.1 Classification of data center topologies	15
2.1.2 Proposals in literature	17
2.2 Data Transport Protocols	22
2.2.1 Classification of data center protocols	23
2.2.2 Proposals in literature	24
2.3 Multipath load-balancing Protocols	33
2.3.1 Classification of multipath protocols	33
2.3.2 Proposals in literature	36
<b>Chapter 3: Topology Aware Flow Prioritization</b>	<b>47</b>
3.1 Introduction	47
3.2 pFabric	47
3.3 Motivation	47
3.4 Flow Prioritization	49
3.4.1 TAP	49
3.4.2 TP-SRSF	50
3.5 Evaluation	50
3.5.1 Simulation Setup	51
3.5.2 Simulation Results	52
3.5.3 TP-SRSF	53
3.6 Summary	56
<b>Chapter 4: Adapting Jumbo Frames in Data center</b>	<b>63</b>
4.1 Introduction	63
4.2 Motivation	63
4.2.1 Data center Topology	63
4.2.2 Jumbo frames in Ethernet	64
4.2.3 Latency Vs Packet Size	64
4.3 JFEPM: Jumbo Frame Enabled Packet Merge	65
4.4 Analytical Characterization	67
4.4.1 Processing time without Jumbo frame (Original size)	69
4.4.2 Processing time with Jumbo frame (JFEPM)	69

4.5	Argument on the Approach of Packet Merge	70
4.6	Evaluation	71
	4.6.1 <i>Simulation Setup</i>	71
	4.6.2 <i>Simulation Results</i>	71
4.7	Summary	79
<b>Chapter 5: Flow-level Adaptive Routing in Data center</b>		<b>81</b>
5.1	Introduction	81
5.2	Motivation	81
	5.2.1 <i>Data center Topology</i>	81
	5.2.2 <i>Adaptive Routing in Data center</i>	82
	5.2.3 <i>Naive path selection schemes</i>	83
5.3	FlowFurl Design	83
	5.3.1 <i>FlowFurl-Basic</i>	84
	5.3.2 <i>FlowFurl-Complete</i>	89
5.4	Evaluation	90
	5.4.1 <i>Simulation Setup</i>	91
	5.4.2 <i>Simulation Results</i>	92
5.5	Summary	99
<b>Chapter 6: Conclusion</b>		<b>101</b>
6.1	Summary	101
6.2	Future Work	102
<b>Chapter A: Data Distribution over Multipath</b>		<b>103</b>
A.1	Introduction	103
A.2	MPTCP	103
A.3	Motivation	103
	A.3.1 <i>Problem with Current Scheduler</i>	104
A.4	Proposed Algorithm	105
A.5	Evaluation	108
	A.5.1 <i>Simulation Setup</i>	108
	A.5.2 <i>Simulation Results</i>	108
	A.5.3 <i>Our Contribution</i>	110
A.6	Summary	111
<b>References</b>		<b>115</b>