

Fair Routing and Wavelength Assignment in All-Optical Networks

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Overview

- ▷ Introduction
- ▷ Adaptive QoS-aware RWA
- ▷ Validation by simulation
- ▷ Conclusions

Introduction

- ▷ All-optical networks with no wavelength conversion
- ▷ Crosstalk impairs the QoS of lightpaths
 - typically we want to keep $BER \leq 10^{-9}$ at all times, for each lightpath
- ▷ Design Routing and Wavelength Assignment (RWA) algorithms to mitigate crosstalk effects
 - wavelength continuity constraint and QoS constraint
 - adaptive RWA is a class of RWA with low blocking probability due to the wavelength continuity constraint

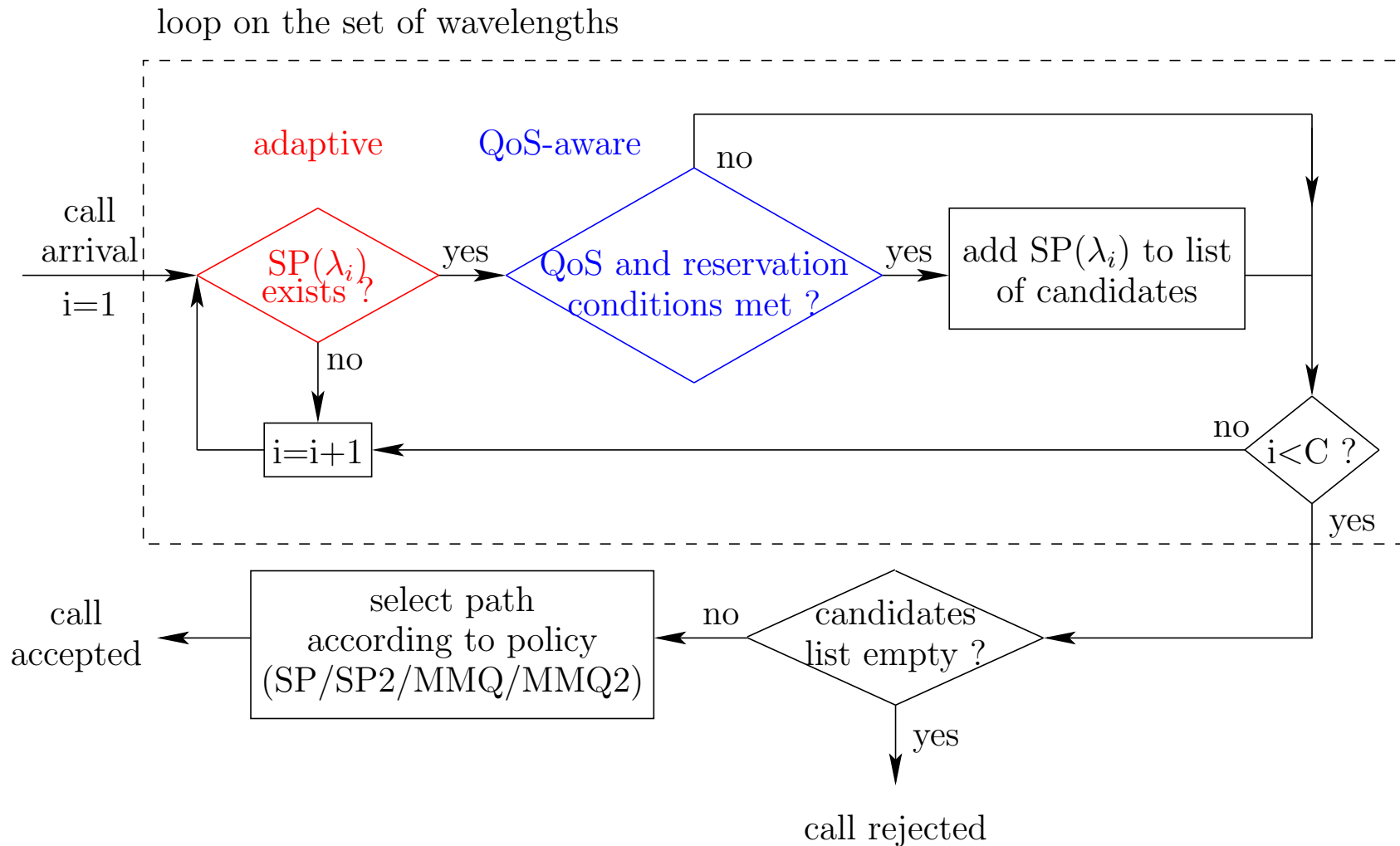
Metrics

- ▷ Average call blocking probability (BP): keep low
- ▷ Bit-error rate (BER)
 - a margin allows for greater scalability, flexibility, robustness, fewer retransmissions at higher layers
- ▷ Fairness: $0 \leq f(X) = E_S[X]^2 / E_S[X^2] \leq 1$
 - here, S is the set of all (source, destination) pairs and X is either BP or BER
- ▷ BP fairness: all clients should have equal access to the network
- ▷ BER fairness: more fair \Rightarrow need FEC for fewer paths

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Generic QoS-aware adaptive RWA algorithm



Reference policies: SP, SP2

- ▷ SP is the traditional Shortest Path policy
- ▷ SP2 is SP with protecting threshold – single-hop paths accepted only if 2 or more wavelengths are available
- ▷ Insight: put aside wavelengths for longer paths, which are more likely to be blocked due to both wavelength continuity and QoS constraints
- ▷ SP and SP2 are found in the literature and serve as reference algorithms

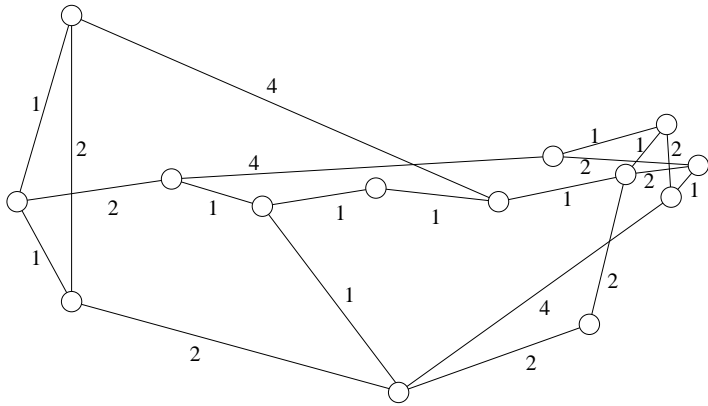
Our novel policies: MMQ, MMQ2

- ▷ Inserting a new lightpath (LP1) in the network changes the BER for all LPs that cross LP1; MMQ maximizes (over the set of wavelengths) the minimum BER (over the set of LPs that cross each candidate lightpath)
- ▷ MMQ2 additionally implements the protecting threshold technique
- ▷ Insight: optimize QoS by selecting the path that manages the largest QoS margin in the network
- ▷ MMQ/MMQ2 are QoS-enhanced but may waste resources compared with SP2

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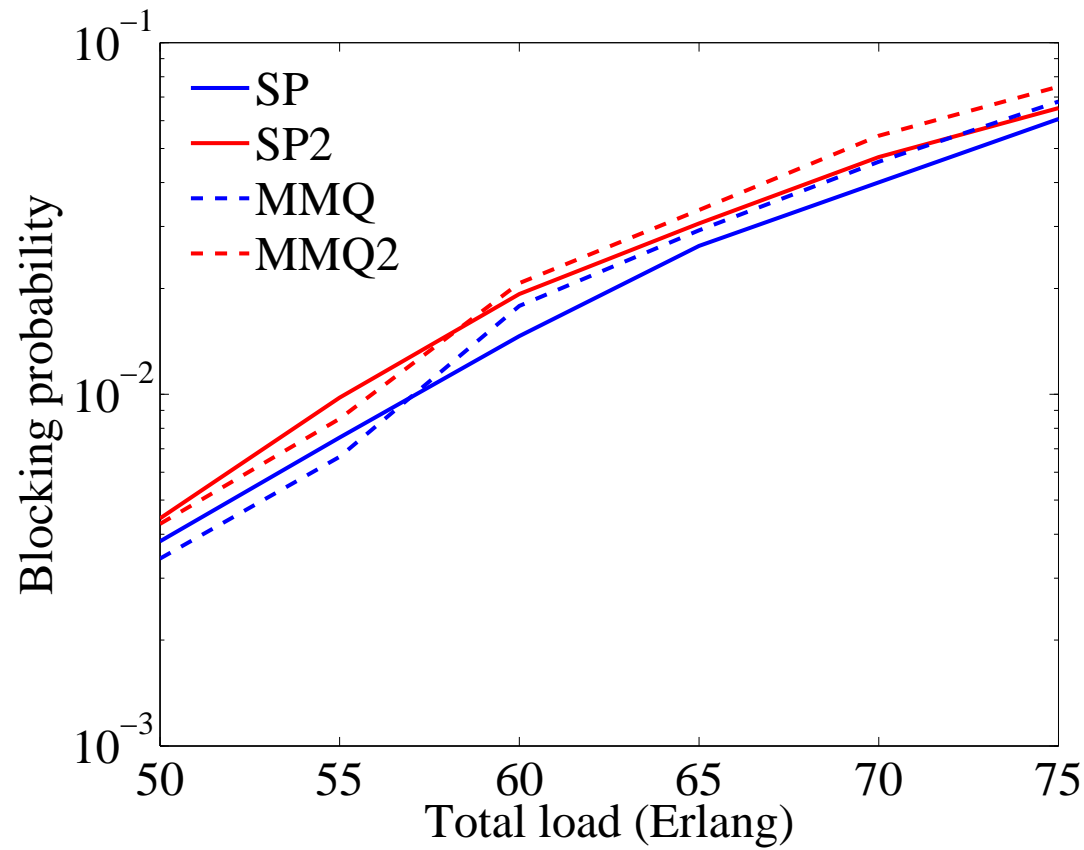
Topology and physical parameters



Downscaled NSF topology;
the weights are the number
of spans.

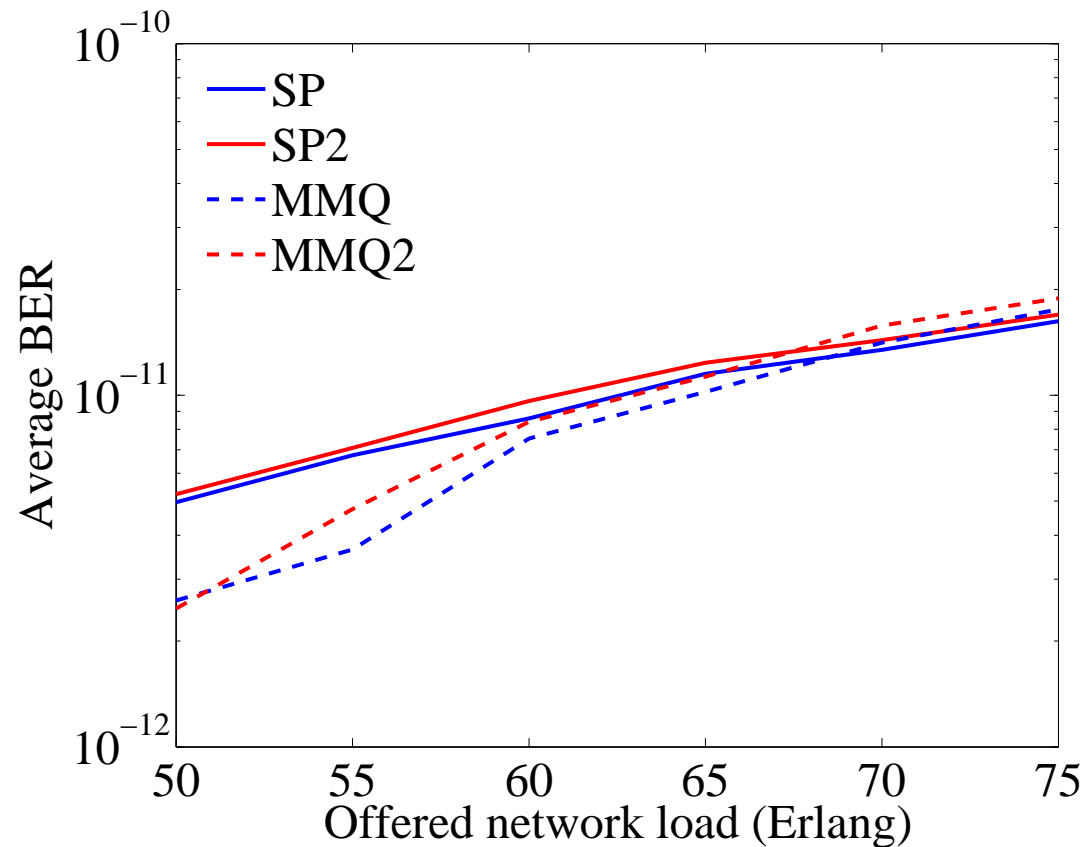
Description	Value
Span length	70 km
Signal peak power	2 mW
Bit rate	10 Gbps
Pulse shape	NRZ
Fabric crosstalk	-40 dB
Adj. port crosstalk	-30 dB
Non adj. port crosstalk	-60 dB
Fiber type	SMF
Dispersion compensation	100% post-DC
Noise factor	2
Receiver elec. BW	7 GHz
Number of WL	8
Maximum BER	10^{-9}

Blocking Probability



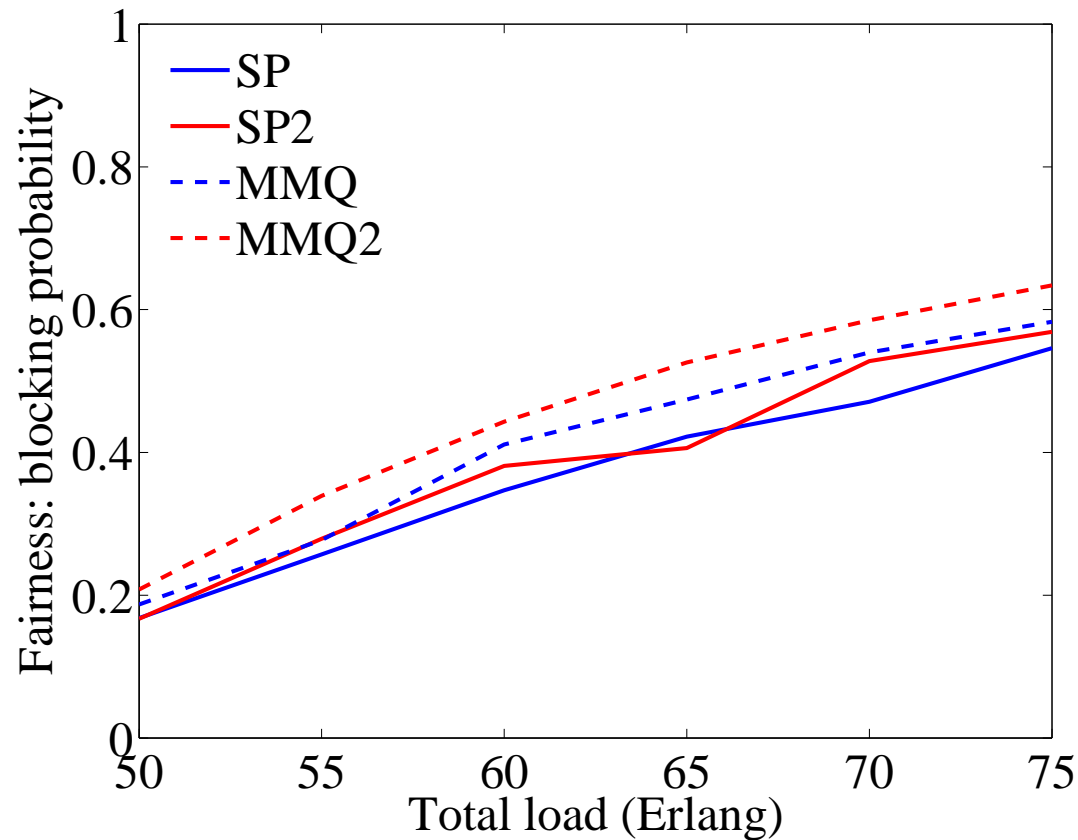
▷ BPs are equivalent for all algorithms

BER



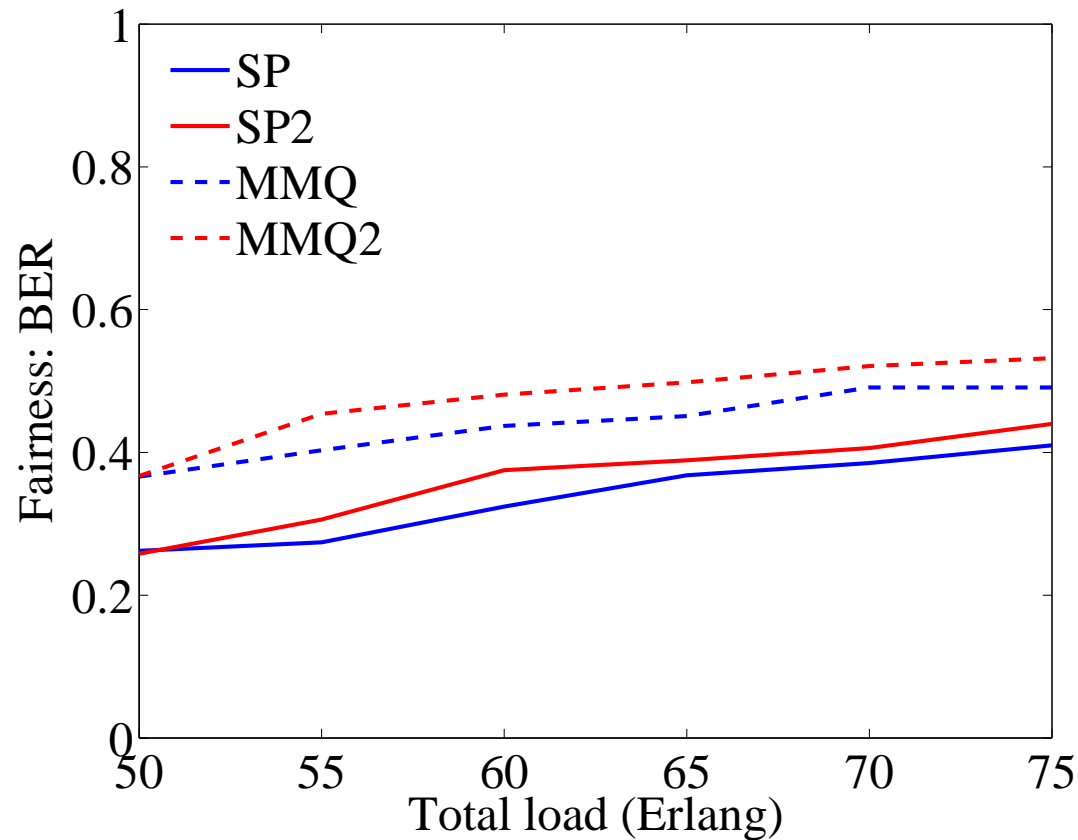
- ▷ Our QoS-enhanced RWA algorithms perform better for BER than SP/SP2

Fairness: Blocking Probability



▷ MMQ2 exhibits high BP fairness

Fairness: BER



▷ MMQ/MMQ2 exhibit high BER fairness

Conclusions

- ▷ Presented two new QoS-enhanced RWA algorithms based on adaptive RWA (MMQ) with protecting threshold (MMQ2)
- ▷ Introduced new metrics to evaluate RWA algorithms
- ▷ Perform well in terms of BP
- ▷ Perform better than others in terms of QoS and fairness