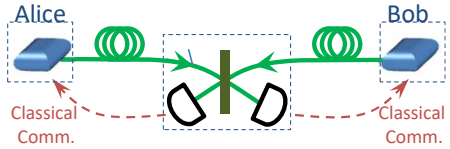
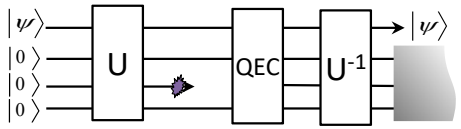
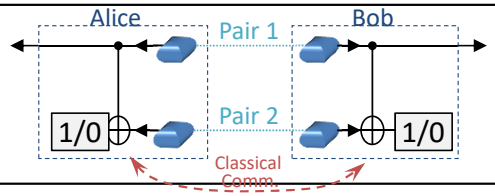
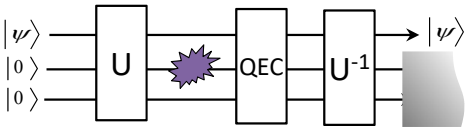
Quantum Networking Protocols

- Goal of Quantum Networking?
  - Provide a backbone support for various applications
  - Characterized in terms of e-bits
  - Resources: temporal, physical, & limited by imperfections (memory, gate errors)
- Protocols at different layers
  - Physical Layer
  - Link Layer
  - Network Layer (routing)

Quantum Repeater Protocols

Various Types of Quantum Repeaters

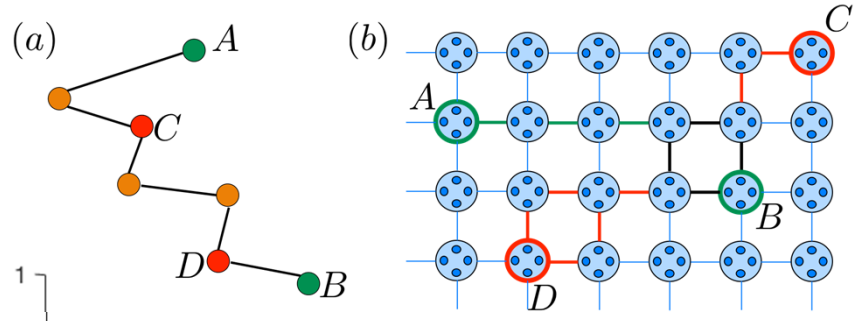
Challenges	Approaches	Examples	1G-QR	2G-QR	3G-QR
Loss Error	Heralded Entanglement Generation (HEG) [two-way signaling]		✓	✓	
	Quantum Error Correction (QEC) [one-way signaling]				✓
Operation Error	Heralded Entanglement Purification (HEP) [two-way signaling]		✓		
	Quantum Error Correction (QEC) [one-way signaling]			✓	✓
		Rate:	$\sim \frac{c}{L_{tot}}$	$\sim \frac{c}{\eta^2 L_0}$	$\sim \frac{1}{\tau_{opr}}$

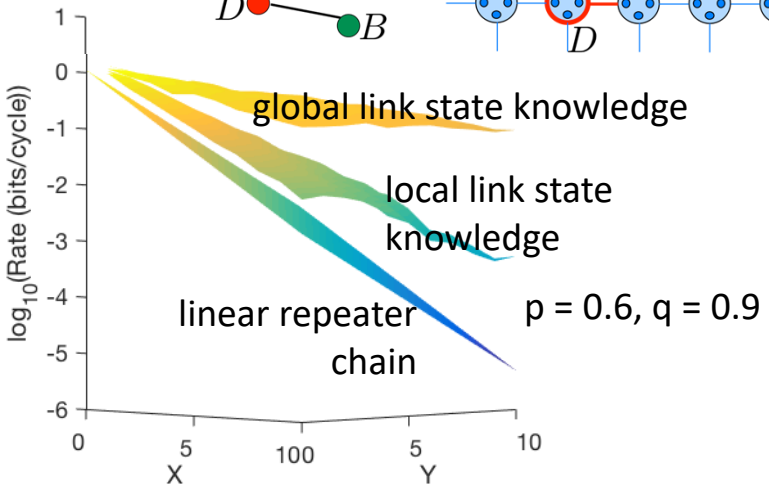
Muralidharan, Li, Kim, Lütkenhaus, Lukin, L.J., Scientific Reports 6, 20463 (2016)

Quantum Network
-- Beyond 1D Quantum Repeaters

Multi-path and multi-flow entanglement routing in a quantum network

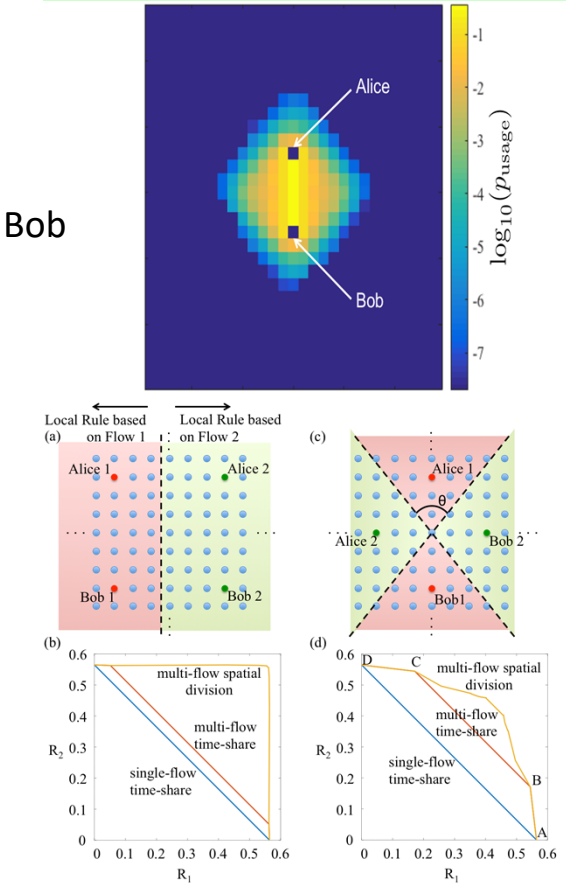
- What are optimal local connection rules for the repeater nodes?
  - **Single flow, multi-path**: local vs. global link state information





Even with only local information, Multi-path routing over a 2D repeater network can outperform a linear repeater chain

Which repeaters are most important for a given flow?



Quantum Network Algorithms
(Computing, sensing, …)