



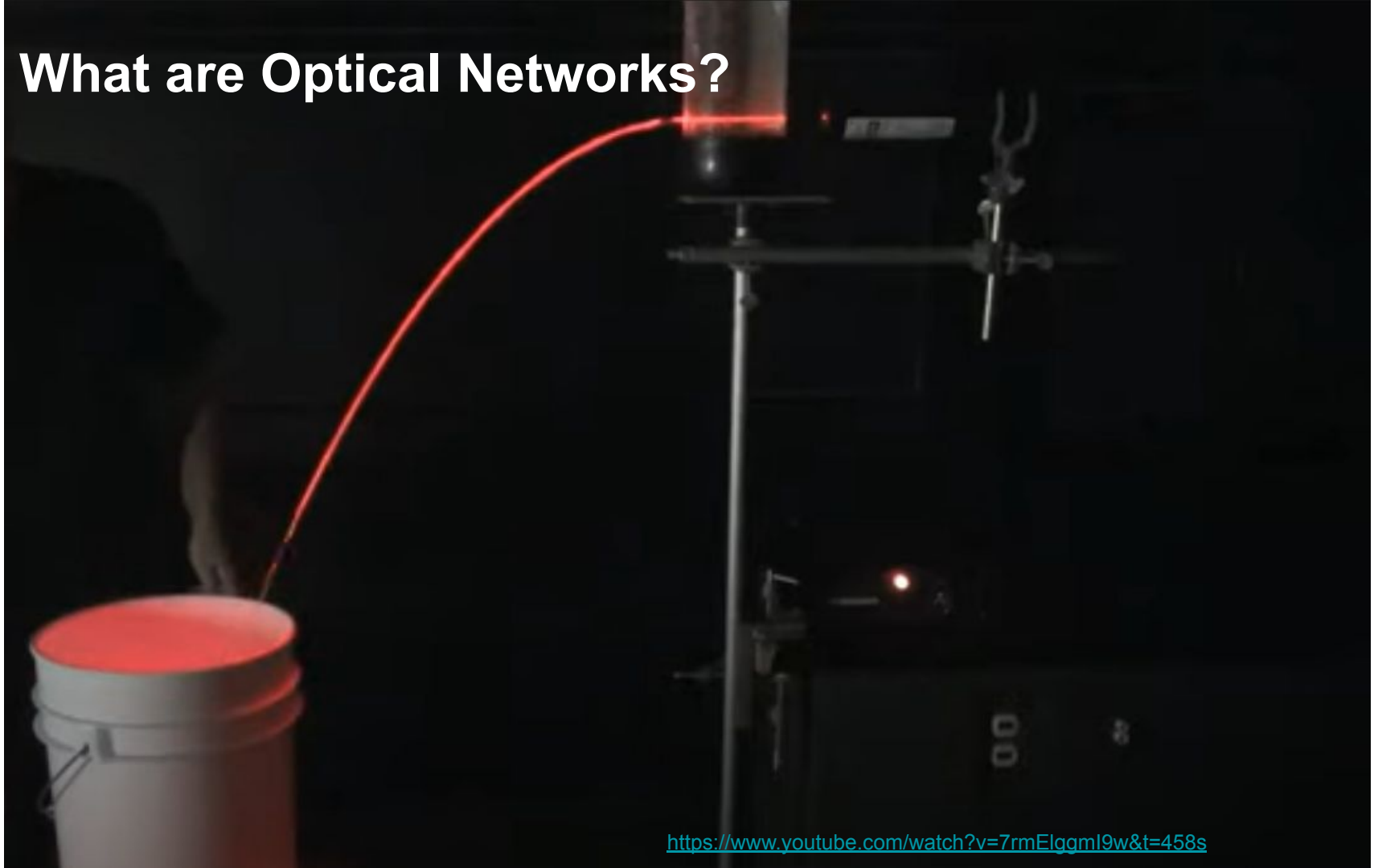
# Optical Networks and Optimization

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# Presentation Outline

- What are optical networks?
- Why do we care about optimization in optical networks?
- What is RMSA and what roles do these features play?
- Algorithms: SPF and AMRA
- How is q-learning used in optical networks?
- What areas have been identified for future research, what have we selected to focus on in our project?

# What are Optical Networks?



<https://www.youtube.com/watch?v=7rmElggml9w&t=458s>

# Why Do WE Care?

- The Internet is expanding!
- Traditional Wavelength Division Multiplexing (WDM) have show to have limitations
- Elastic Optical Networks seems to be a strong candidate for the future!
- RMSA algorithm for EONs

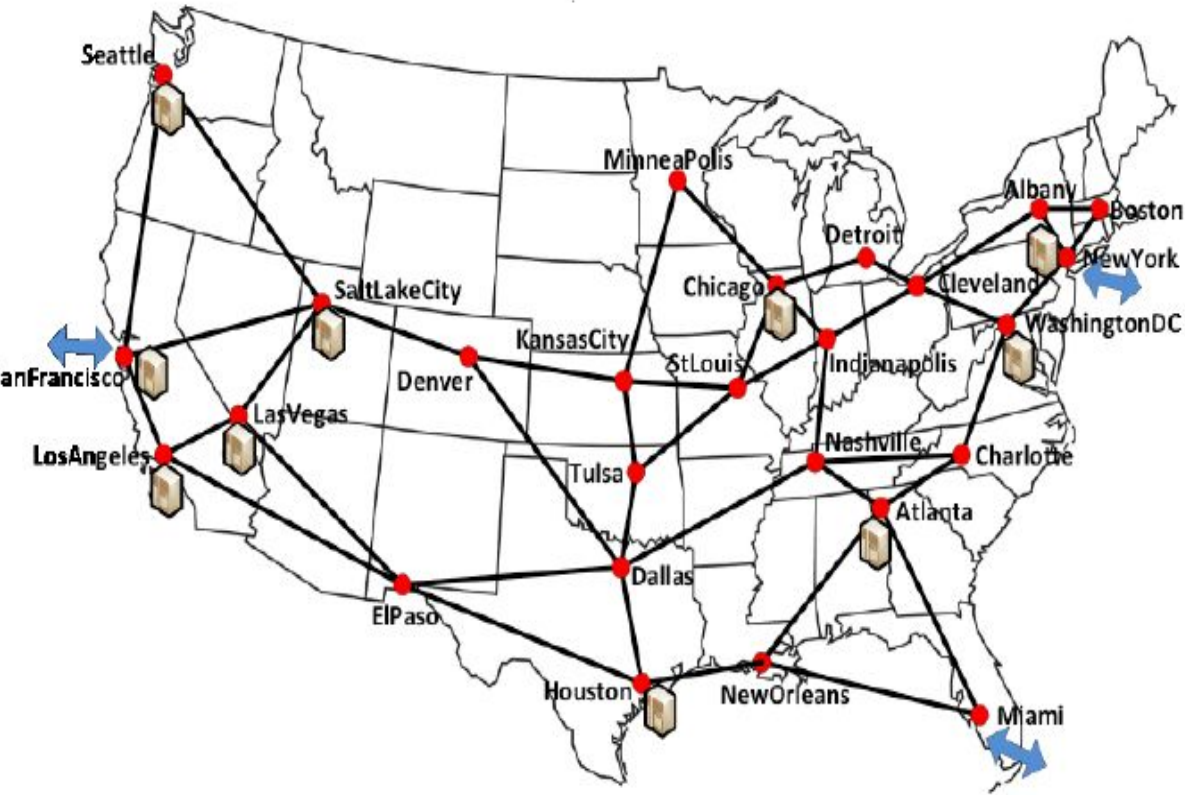
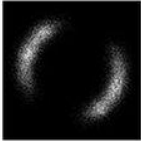
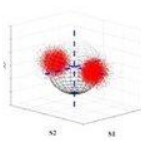
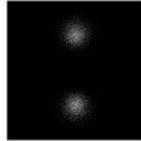
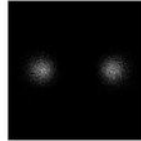
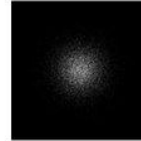
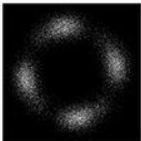
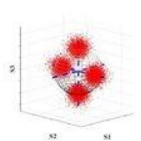
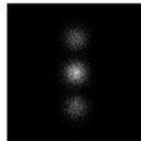
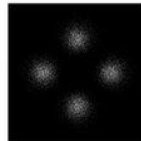
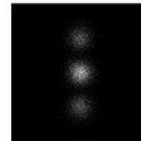
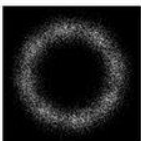
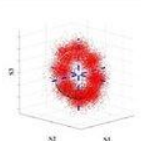
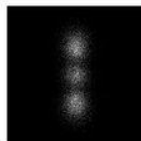
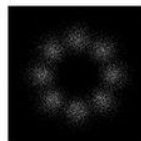
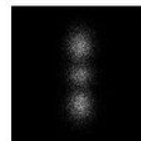
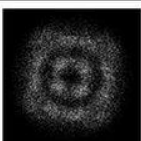
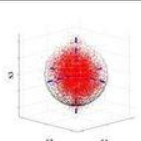
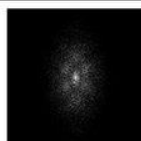
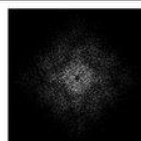
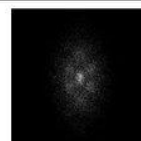
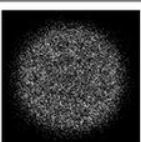
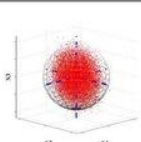
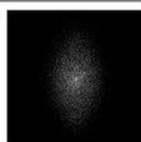
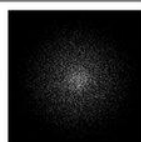
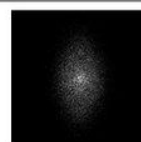
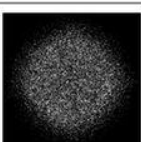
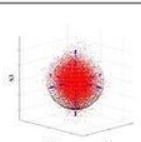
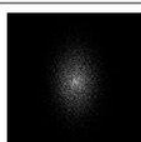
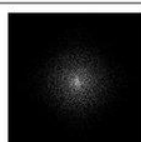
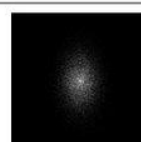


Figure 5.2: The US26 network topology

# What is RMSA?

**Routing** will be determined by factors like the routing algorithm and topology

Modulation Format (OSNR = 18dB)	Images				
	Jones	3D Stokes	$(s_1, s_2)$	$(s_2, s_3)$	$(s_1, s_3)$
BPSK					
QPSK					
8PSK					
US-16QAM					
US-32QAM					
US-64QAM					

# What is RMSA?

## Images of Modulation Constellations

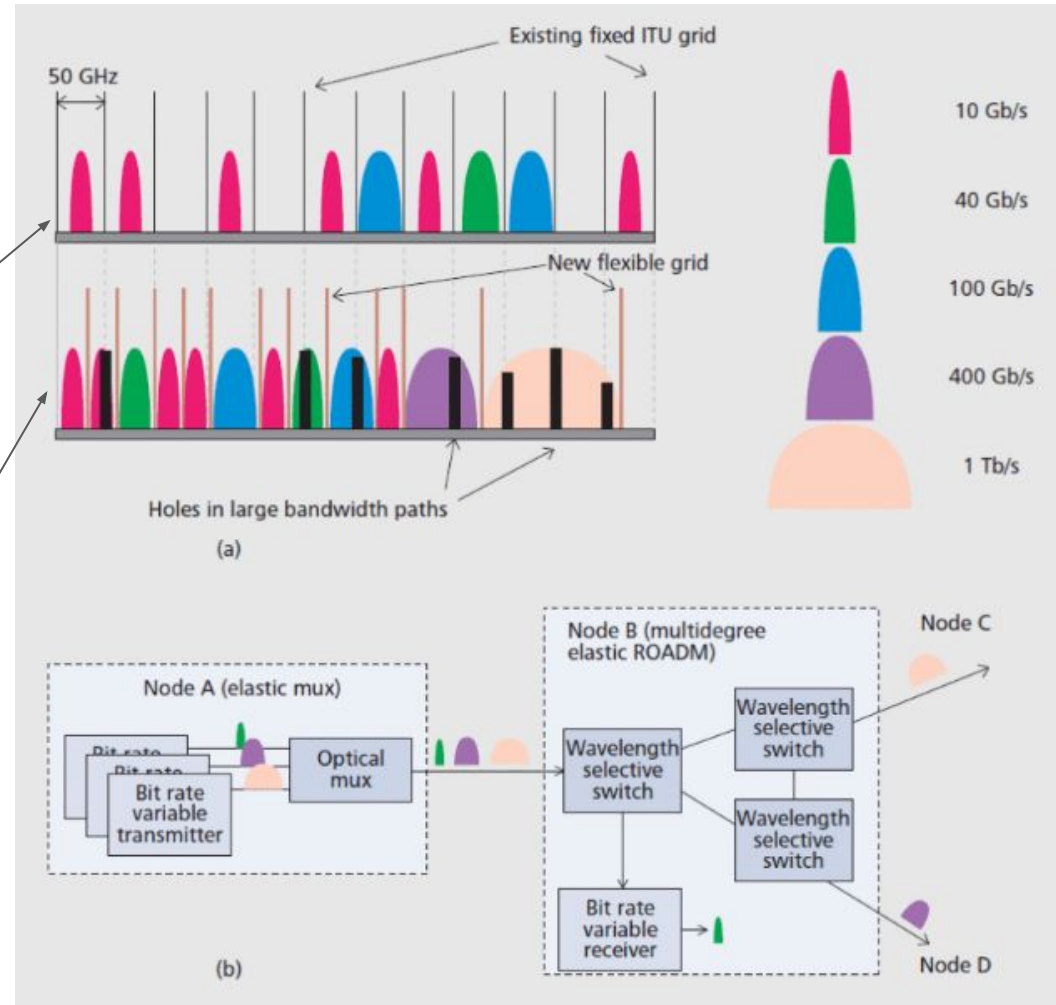
[https://www.researchgate.net/figure/Images-of-20-000-symbols-of-BPSK-QPSK-8PSK-US-16QAM-US-32QAM-US-64QAM-signals-in-2D\\_fig3\\_338334026](https://www.researchgate.net/figure/Images-of-20-000-symbols-of-BPSK-QPSK-8PSK-US-16QAM-US-32QAM-US-64QAM-signals-in-2D_fig3_338334026)

# What is RMSA?

**Spectrum Assignment** will be where in the spectrum we select to send our signal

Fixed Grid WDM

Flexible grid allocation in EON



## **SPF (Shortest Path first) Algorithm**

Just focus on routing as an avenue for optimizing, without considering the spectrum or modulation

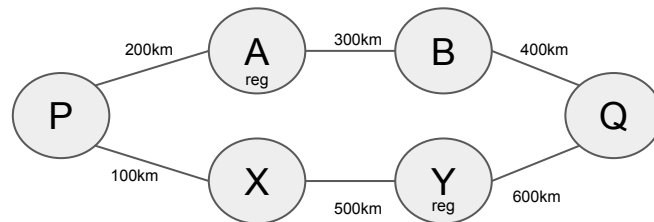
## **AMRA (Adaptive Modulation and Regenerator Aware) Dynamic Routing Algorithm**

Consider number of regenerators (to amplify signal)

Change the modulation method (we can do this when there are regenerators)



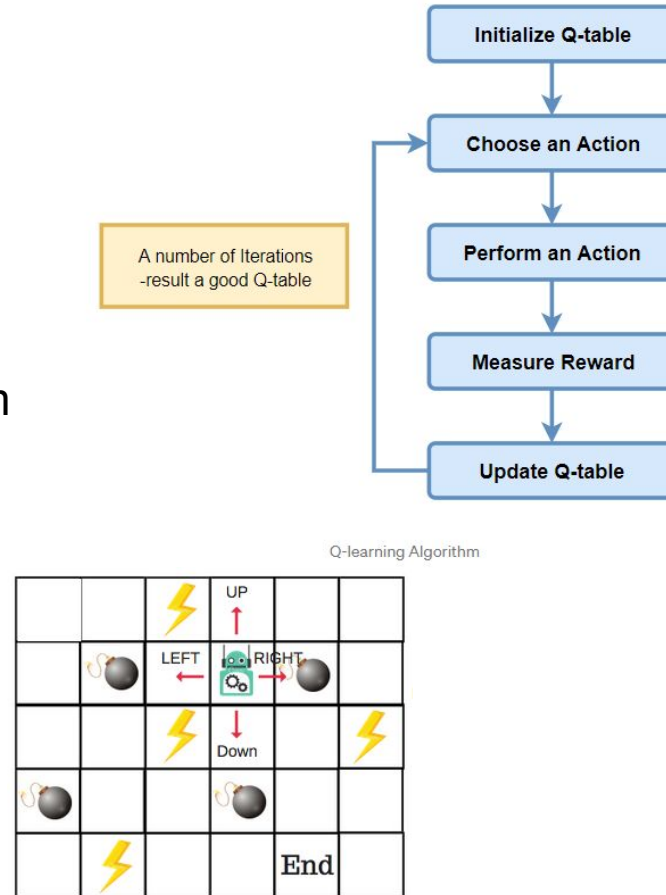
# SPF vs AMRA



SPF	AMRA
Base on path length (km) between nodes	Base on network utilisation, number of regenerators, number of frequency slices
No change in modulation along the path	Able to change modulation between edges to maximize the utilisation
Regenerators are used for amplifying signal only	Regenerators are used for amplifying signal, or change modulation and spectrum
Routing only	Routing, Modulation Selection, Spectrum Selection

# Q-learning

Reinforcement Learning: an action/state table of values is updated as the algorithm Q-learning is an off policy reinforcement learning algorithm as it learns from acts outside the existing policy by doing all possible actions



## Our Project Goal

Implement a reinforcement learning algorithm for the RMSA problem such that the bandwidth blocking percentage is minimized (or at least lower than the SPF in the simulation).