An Agile Optical Spectrum Management Algorithm For Mixed-grid Network

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Motivation

- Emergence of technologies such as HDTV on demand, edge computing, cloud computing, metropolitan datacenters, smart city, self driving vehicles are in need of a underlying network infrastructure which will be able to drive them smoothly on top.
- International Telecommunication Union (ITU-T) has already standardized the new scalable and flexible spectrum grid (close to the ideal “gridless” to assign ”just enough” bandwidth) which can support beyond 100 Gb/s rate and frequency slices have smaller bandwidth (e.g., 12.5 GHz), such that distance-adaptive transceivers can scale using spectral resources as needed to serve the client demand.

Motivation

- As of now, research is being going on how flex-grid core network is able to cope with the advanced applications running on top, however, before analyzing a all flex-grid scenario we should consider a practical scenario of mixed fixed and flex-grid.
- Resource allocation, route selection, modulation format adaptation is highly impacted by the underlying technologies. Therefore, the strategies of a mixed-grid network will differ from all fixed or all flex-grid ones.
- Here, our study will shed light on the most possible strategies of resource allocation in a mixed-grid network. Our goal is to propose a agile optical spectrum management system in order to more effective spectrum occupation and spectral efficiency.

Objective

- In our study we evaluate the effect of the choice of different modulation format and different channel bandwidths satisfying the reach requirements.
- Our aim is to find an optimal selection technique of modulation format and channel bandwidth for a mixed-grid network.

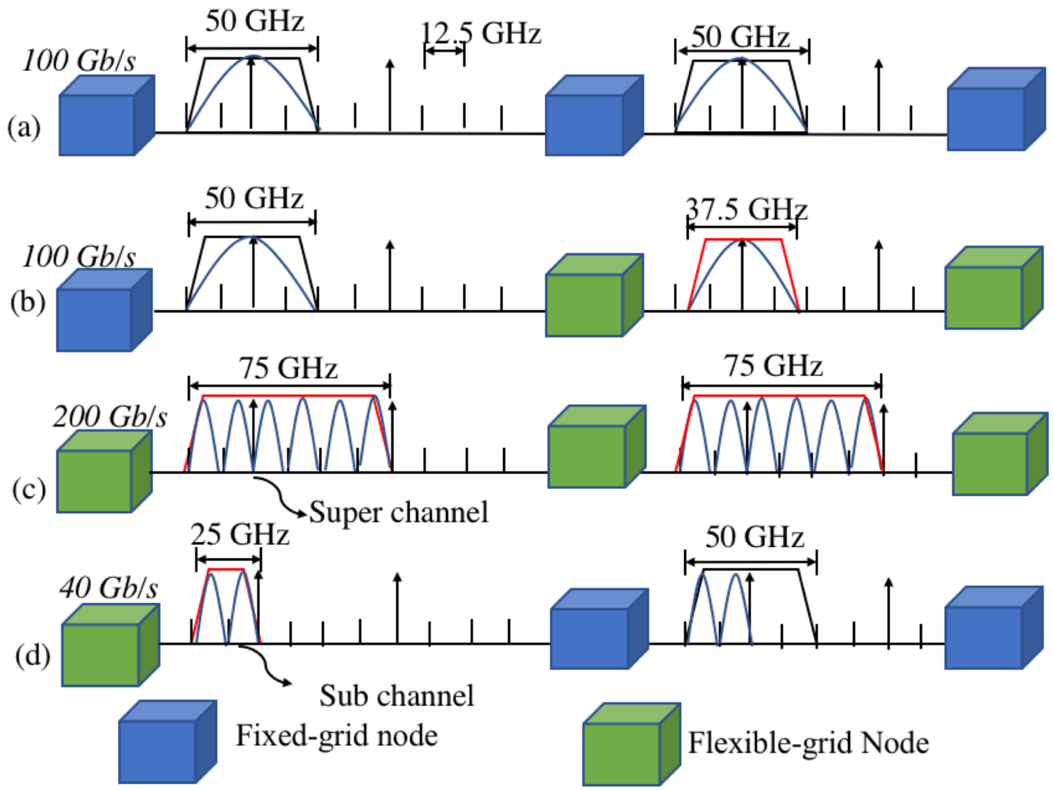
Constraints

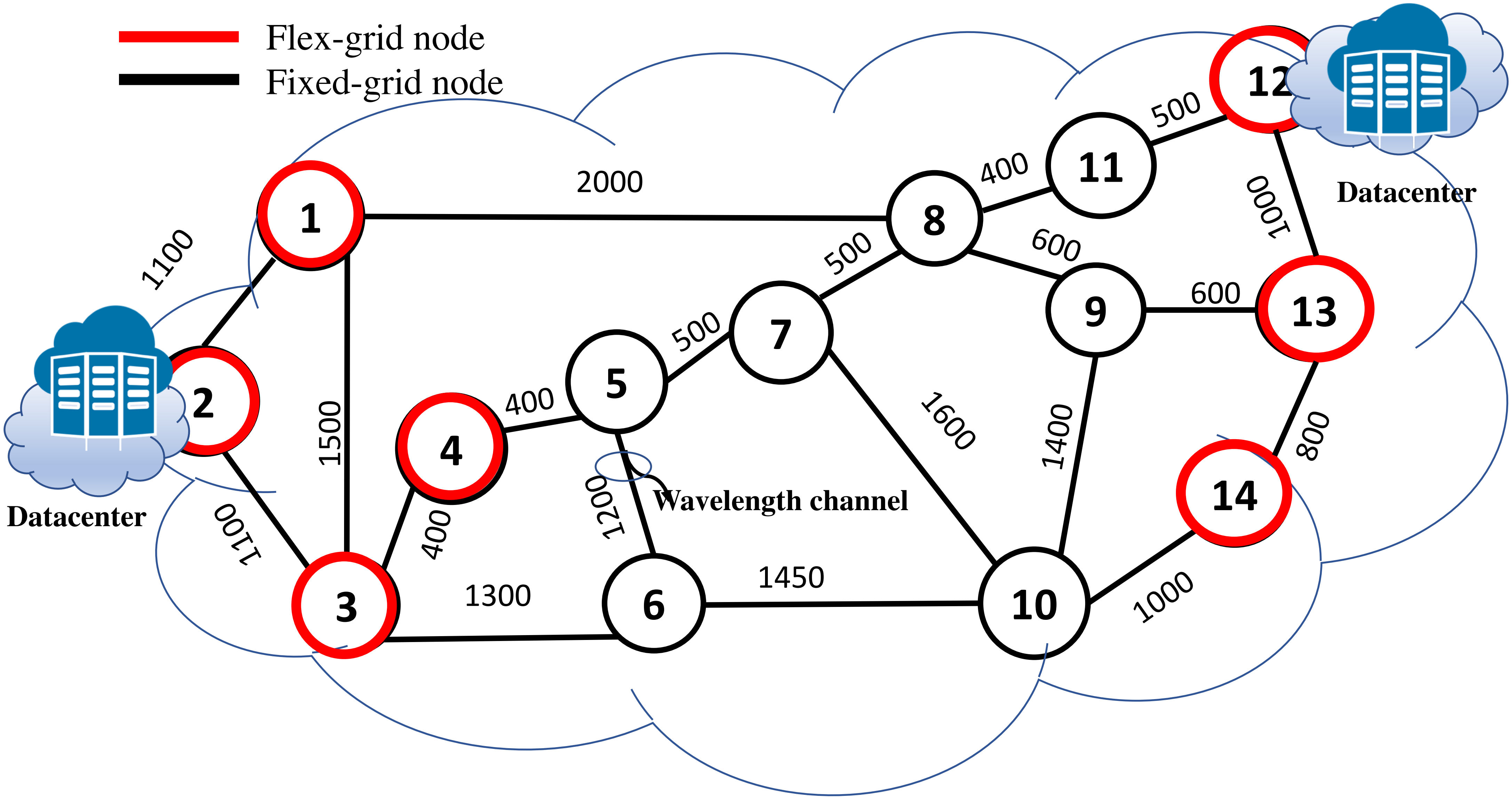
- We have fixed nodes, Flexible nodes along the network and transmission should be seamless in terms of modulation level, spectrum occupation and capacity (Gb/s)
- Maintain spectrum contiguity (Flex-grid) , spectrum continuity (Flex-grid) and wavelength continuity (Fixed-grid)
- Minimize O-E-O conversion

Modulation Format Facts

- Higher Modulation offers higher bit rate (speed)
- Higher modulation offers low reach
- Higher modulation offers higher spectral efficiency
- Spectral occupancy is computed by summing the channel bandwidth and the guard bands of all the optical channels traversing every link of the network
- Spectral efficiency is bit/symbol, higher the modulation format greater the spectral efficiency

Traffic Demand (Gb/s)	Fixed Grid		Flex Grid	
	Bandwidth(GHz)	#slots	Bandwidth(GHz)	#slots
40	50	1	25	2
100	50	1	37.5	3
200	100	2	75	6
400	200	4	125	10




Flex-grid node
Fixed-grid node
1
2
3
4
5
6
7
8
9
10
11
12
13
14
2000
1100
1100
1500
400
400
1300
500
500
1200
1450
1600
400
600
500
1000
600
1400
800
1000
Wavelength channel
Datacenter
Datacenter

Optical Reach

Gbps	BW (GHZ)	Reach in km				
		QPSK	8-QAM	16-QAM	32-QAM	64-QAM
40 Gbps(BPSK)	25	3050	1010	495	197.5	138
	37.5	3200	1140	540	205	142
	50	3500	1400	630	220	150
	75	4100	1920	810	250	166
	125	5300	2960	1170	310	198
100 Gbps(QPSK)	25	3050	1010	495	197.5	138
	37.5	3200	1140	540	205	142
	50	3500	1400	630	220	150
	75	4100	1920	810	250	166
	125	5300	2960	1170	310	198

Optical Reach

Gbps	BW (GHZ)	Reach in km				
		QPSK	8-QAM	16-QAM	32-QAM	64-QAM
200 Gbps(8QAM)	25	3050	1010	495	197.5	138
	37.5	3200	1140	540	205	142
	50	3500	1400	630	220	150
	75	4100	1920	810	250	166
	125	5300	2960	1170	310	198
400 Gbps(16QAM)	25	3050	1010	495	197.5	138
	37.5	3200	1140	540	205	142
	50	3500	1400	630	220	150
	75	4100	1920	810	250	166
	125	5300	2960	1170	310	198

Strategies

1. **Shortest path**
2. **Maintain the requested reach**
3. **For requested reach select the lowest spectrum occupation**
4. **For requested reach and lowest spectrum occupation select the highest modulation**

Case Studies

Scenario 1: 10-14-13-12 (Fixed to Flex Island) 100 Gbps request, Distance = 1800 km

a. Modulation format unaware technique: 50 GHz-fixed & **37.5 GHz**-Flex, 3500 KM, **QPSK**

b. Modulation format aware technique: 50 GHz- Fixed & **25 GHz** - Flex, 3050 KM, **QPSK**

Scenario 2: 1-3-4 (All Flex grid) 200 Gbps request, Distance = 1900 km

a. Modulation format unaware technique: **75 GHz** Flex, 4100 KM , **QPSK**

b. Modulation format aware technique: **25 GHz** Flex, 3050 KM, **QPSK**

Case Studies

Scenario 3: 3-4-5-7 (Flex to Fix Island) 100 Gbps request, Distance = 900 km

a. Modulation format unaware technique: 50 GHz-fixed & **37.5 GHz**-Flex, 3200 KM, **QPSK**

b. Modulation format aware technique: 50 GHz- Fixed & **25 GHz** – Flex, 1010 KM, **8 QAM**

Scenario 4: 4-5 (Flex to Fix) 100 Gbps request, Distance = 400 km

a. Modulation format unaware technique: **37.5 GHz** Flex, 3200 KM , **QPSK**

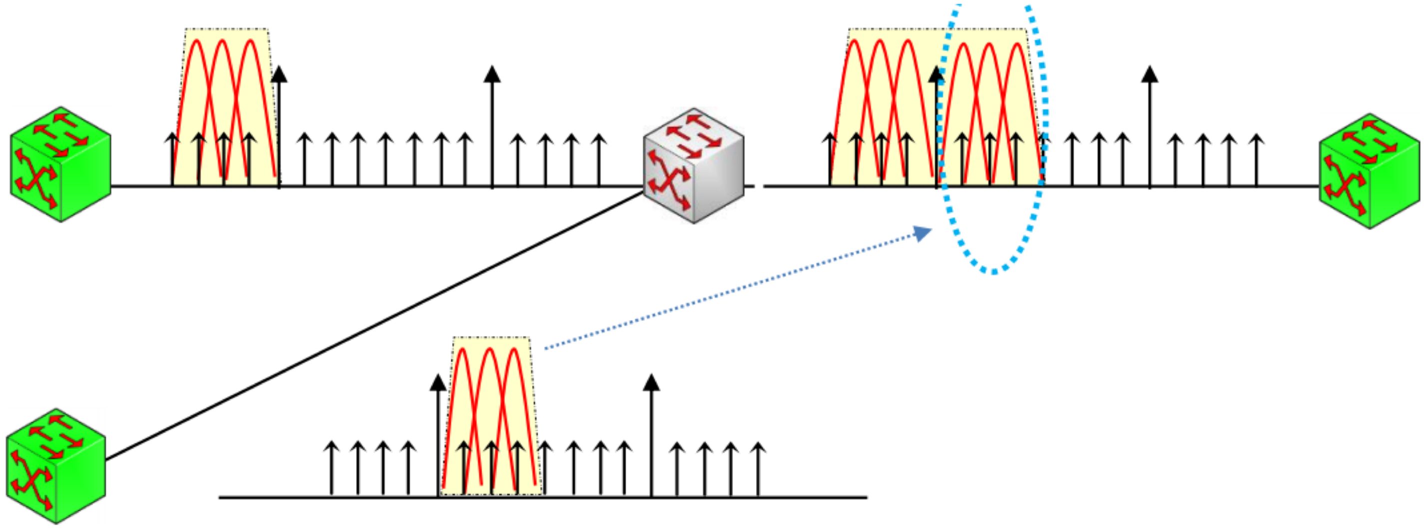
b. Modulation format aware technique: **25 GHz** Flex, 495 KM, **16 QAM**

Case Studies

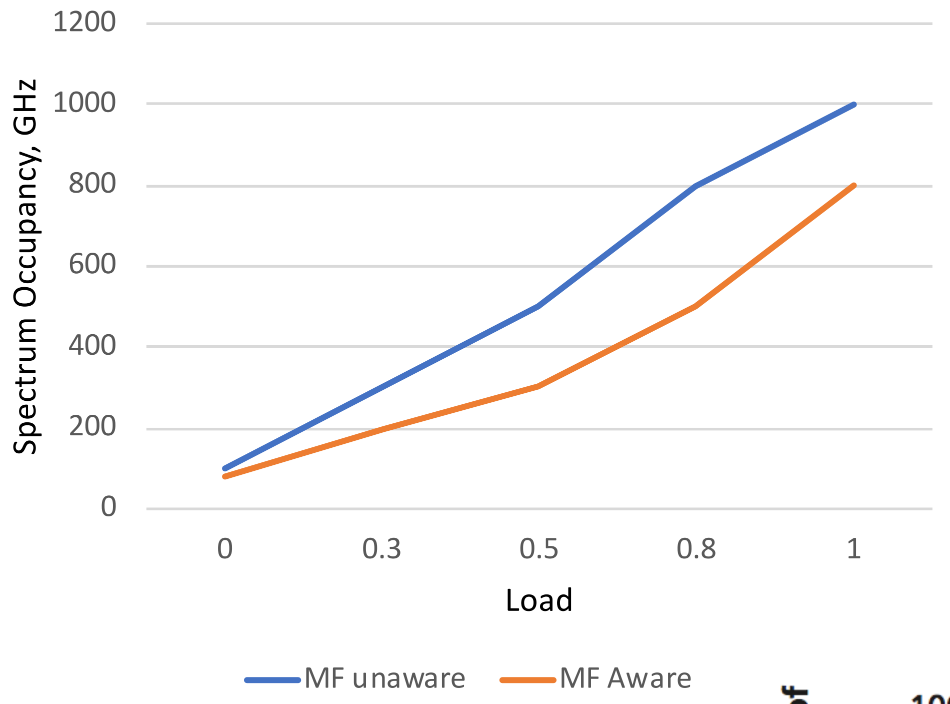
Scenario 5: 5-7-8-11 (All Fixed) 40 Gbps request, Distance = 1400 km

a. Modulation format unaware technique: 50 GHz-fixed , 3500 KM, **QPSK**

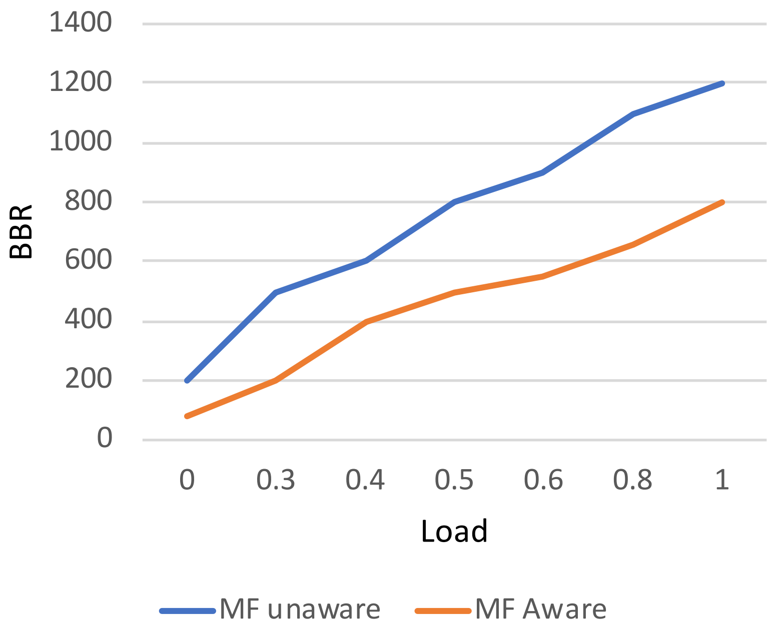
b. Modulation format aware technique: 50 GHz- Fixed, 1400 KM, **8 QAM**



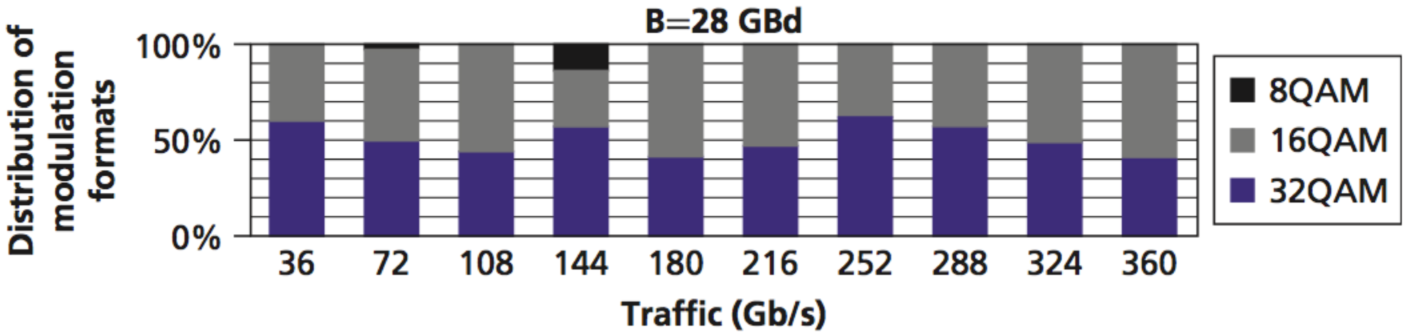
Results



1200
1000
800
600
400
200
0
Spectrum Occupancy, GHz
0
0.3
0.5
0.8
1
Load
MF unaware
MF Aware



1400
1200
1000
800
600
400
200
0
BBR
0
0.3
0.4
0.5
0.6
0.8
1
Load
MF unaware
MF Aware



B=28 GBd
Distribution of modulation formats
100%
50%
0%
36
72
108
144
180
216
252
288
324
360
Traffic (Gb/s)
8QAM
16QAM
32QAM