Goal: Provisions routes for dynamic, heterogeneous traffic ensuring maximum spectrum utilization and minimum bandwidth blocking.

Fig. 1 Co-existing fixed/flex-grid in NSFNet topology.
Spectrum Allocation in Mixed-grid Network

Table I: Spectrum occupation for various bit rates.

<table>
<thead>
<tr>
<th>Traffic Demand (Gb/s)</th>
<th>Fixed-Grid</th>
<th>Flex-Grid</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bandwidth (GHz)</td>
<td>#slots</td>
</tr>
<tr>
<td>40</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>100</td>
<td>50</td>
<td>1</td>
</tr>
<tr>
<td>200</td>
<td>100</td>
<td>2</td>
</tr>
<tr>
<td>400</td>
<td>200</td>
<td>4</td>
</tr>
</tbody>
</table>

RSA algorithm needs to be aware of the source/destination node, intermediate nodes, and corresponding spectrum usage.
Example

In Fig. 1, let us consider a 100 Gb/s traffic demand from source node 10 to destination node 12.

**Path1**, 10-14-13-12 (one fixed and three flex nodes): \((50+37.5*2) \text{ GHz} = 125 \text{ GHz}\)

**Path2**, 10-9-13-12 (two fixed and two flex nodes): \((2*50+37.5) \text{ GHz} = 137.5 \text{ GHz}\)

**Path3**, 10-9-8-11-12 (four fixed and one flex nodes): \((4*50) \text{ GHz} = 200 \text{ GHz}\)
Finding the value of $k$
Spectrum-Efficient Dynamic Routing and spectrum Assignment (SEDRA) is a route selection/prioritization scheme which finds the route with least spectrum consumption among the other possible routes with first-fit slot search mechanism.
Bandwidth Blocking Ratio Comparison (Profile 3)

• **Offered load**

  \[ \text{Offered load} = \text{arrival rate} \times \text{avg request size} \times \text{avg holding time} \times \frac{\text{Avg path length}}{\text{Network Capacity}} \]

• **Network Capacity**

  \[ \text{Network Capacity} = \#\text{fixed node} \times \text{channel capacity in GHz} \times \text{Spectral Efficiency of fixed grid} + \#\text{flex node} \times \text{channel capacity in GHz} \times \text{Spectral Efficiency of flex-grid} \]

  Spectral Efficiency of fixed grid = 100/50 = 2 bits/sec/Hz

  Spectral Efficiency of fixed grid = 100/37.5 = 2.6 bits/sec/Hz

  Channel capacity = 5000 GHz (C Band)

  \#fixed node = 16 \hspace{0.5cm} \#flex node = 4
Result 2: Carried Load vs Offered Load

Carried Load = \[\frac{\text{Sum of Spectrum Occupied by all incoming connection requests for a given time period} \times \text{(that time period)}}{\text{Total Spectrum Capacity of the network} \times \text{simulation duration}}\]

\[= \frac{\sum_{i=1}^{N} \text{Spectrum Occupied by } i^{th} \text{ connection request} \times \text{duration of } i^{th} \text{ connection request}}{\text{total of links} \times \text{no of slots per link} \times \text{simulation duration}}\]

\(N = \text{no of connection request}\)

Carried load is always less than the offered load because of the blocking. SEDRA carries more load compare to SP-FF as it has better spectrum efficiency.
Result 3: Avg Hop count vs offered load

Here, we observe that when the offered load is low SP-FF and SEDRA both has lower avg hop count (around 2.4). However, when the load starts to get higher SEDRA goes through longer paths so its avg hop count increases. Finally, when the network starts to get congested both algorithm can only serve request with shorter path lengths.
In general SEDRA serves more connection requests than SP-FF for the same offered load. As previous results suggested SEDRA takes longer paths, here we see SEDRA serves more connections as well as longer paths.
Result 4: Connection request arrived per second vs connection request served per second

<table>
<thead>
<tr>
<th>Arrival rate</th>
<th>SP-FF</th>
<th>SEDRA</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.33</td>
<td>3.115</td>
<td>3.12</td>
</tr>
<tr>
<td>8.33</td>
<td>7.75</td>
<td>7.74</td>
</tr>
<tr>
<td>13.33</td>
<td>12.23</td>
<td>12.39</td>
</tr>
<tr>
<td>18.33</td>
<td>16.1</td>
<td>16.61</td>
</tr>
<tr>
<td>23.33</td>
<td>18.80</td>
<td>20.04</td>
</tr>
<tr>
<td>28.33</td>
<td>21.28</td>
<td>22.69</td>
</tr>
<tr>
<td>33.33</td>
<td>23.72</td>
<td>24.64</td>
</tr>
</tbody>
</table>

SEDRA serves more connection requests than SP-FF
Result 6: No of request blocked in percentage vs traffic demand in Gbps (75% Load)

Profile 3 has 0% of 40 Gbps, 40% of 100 Gbps, 40% of 200 Gbps and 20% of 400 Gbps. We observe how different traffic requests were blocked in SEDRA and SP-FF. It is shown that, SP-FF blocks more no of requests for all 3 request types than SEDRA. Obviously, for large traffic demands as 400 Gbps, more number of contiguous slots are required which can be hard to find every time. So, 400 Gbps gets block more often compare to small demands as 100 Gbps.
Result 7: Observing fix-grid and flex-grid link usage for profile 3(75% load)

0,2,3,4,18,19 are flex-grid links
Bandwidth Blocking Ratio Comparison (Profile 1)

Bandwidth Blocking vs Offered Load

Bandwidth Blocking vs Offered Load (logarithmic)
Result 4: No of path length served (75% offered Load) Profile 1

In general SEDRA serves more connection requests than SP-FF for the same offered load. As previous results suggested SEDRA takes longer paths, here we see SEDRA serves more connections as well as longer paths.
Result 7: Observing fix-grid and flex-grid link usage for (75% load) Profile 1

0, 2, 3, 4, 18, 19 are mostly flex-grid links
Observing fix-grid and flex-grid link usage (75% load)

Profile 3

Profile 1

0,2,3,4,18,19 are flex-grid links
Result 3: Avg Hop count vs offered load

Profile 3

Profile 1
Questions?