Crosstalk-Aware Anycast Routing and Wavelength Assignment in Optical WDM Networks

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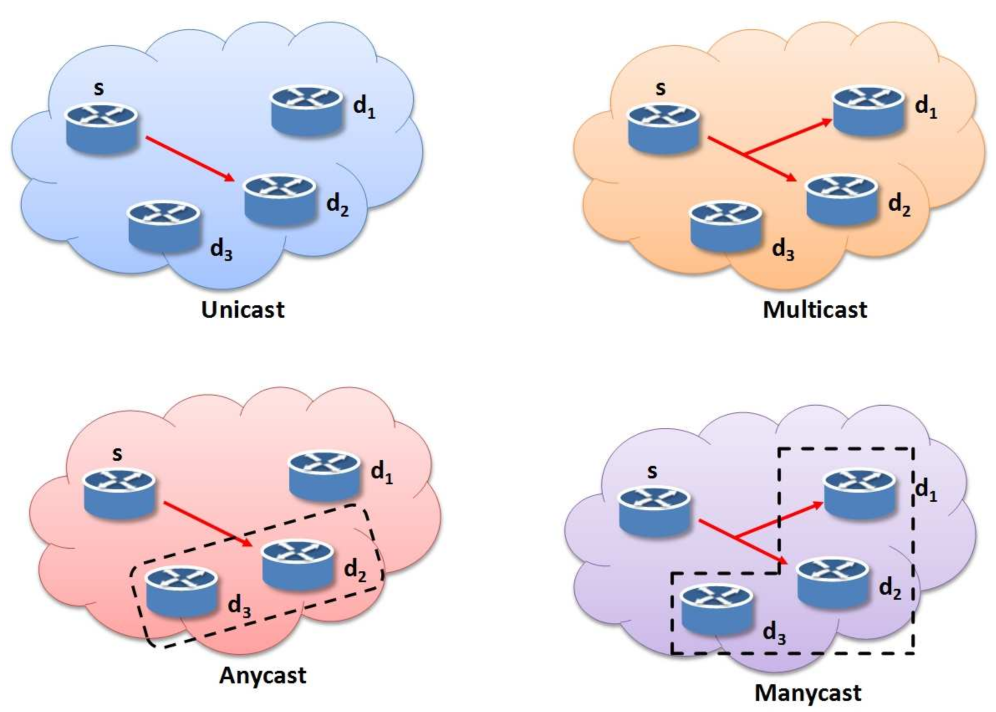
Summary

- We discuss the performance of physical-layer impairment-aware anycast communication over transparent optical networks.
- The simulation results show, that the proposed anycast routing algorithms can significantly decrease the request loss due to impairments, such as crosstalk and ASE noise.

Anycast: Definition and Applications

- The anycast communication paradigm is a variation of unicast, where the source node has a choice of selecting a destination from a candidate set.
- Anycast can be used by a client (source) to find an appropriate server (destination) when there are multiple servers.



- Anycasting can be used for applications such as,
  - Grid Computing,
  - Content distribution,
  - Network storage.

Problem Definition

- For a given source node s and the candidate destination set $D_s = \{d_1, d_2, \ldots, d_m\}$ with a cardinality $|D_s| = m$,
  - A source node s can choose any one among m destinations (C_1^m).
  - Anycast configuration is denoted as $m/1$.
  - Request is denoted by $(s, D_s, 1)$.

Crosstalk Aware Anycast Algorithms (CAAR)

Input : Anycast Request: $(s, D_s) = (s, \{d_1, d_2, \ldots, d_m\})$
Output : Request Successful: *TRUE*/*FALSE*

begin
$D'_s \leftarrow SORT[D_s]$
while $D'_s \neq \emptyset$ **do**
  $PATH \rightarrow (s, d'_i)$ where $d'_i \in D'_s; 1 \leqslant i \leqslant |D'_s|$
  while $\Lambda_A \neq \emptyset$ **do**
    for $h \in PATH(d'_i)$ **do**
      $PWR(h, \lambda_i) \leftarrow PWR(h-1, \lambda_i) - LOSS(h, \lambda_i)$
      $ASE(h, \lambda_i) \leftarrow ASE(h-1, \lambda_i) + ASE.SW(\lambda_i)$
      $XT(h, \lambda_i) \leftarrow XT(h, \lambda_i) + XT.SW(\lambda_i)$
    end
    $OSNR(d'_i, \lambda_i) = \frac{PWR(d'_i, \lambda_i)}{(ASE(d'_i, \lambda_i) + XT(d'_i, \lambda_i))}$
    if $OSNR(d'_i, \lambda_i) \geqslant OSNR_{th}$ **then**
      $CONFIG.SD(s, d'_i)$
      $REQ.ID(s, D_s) \leftarrow TRUE$
      exit
    end
    else
      $\Lambda_A \leftarrow \Lambda_A \backslash \{\lambda_i\}$
    end
  end
  if $\Lambda_A == \emptyset$ **then**
    $UPDATE.DES$: $D'_s \leftarrow D'_s \backslash \{d'_i\}$
    if $D'_s == \emptyset$ **then**
      $REQ.ID(s, D_s) \leftarrow FALSE$
      $DROP.OSNR \leftarrow DROP.OSNR + 1$
    end
    else
      $CREATE.SD$: (s, d'_{i+1})
    end
  end
end
end

Results

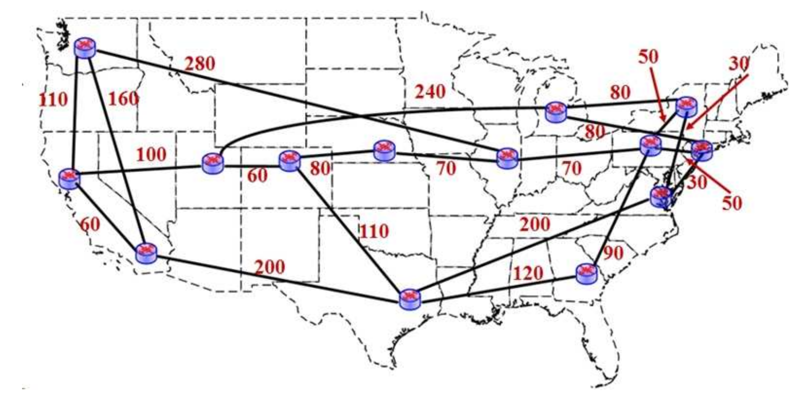


Figure: Scaled NSFNET topology.

Parameter	Value
Channel bit rate	10 Gb/s
Optical bandwidth	7 GHz
Electrical bandwidth	10 GHz
Input signal power	1 mW (0 dBm)
Switch crosstalk ratio	25 dB
OSNR threshold for BER 10^{-9}	7.4 dB
Number of requests	10^6
Wavelengths	8

Table: Parameters used for computation of OSNR.

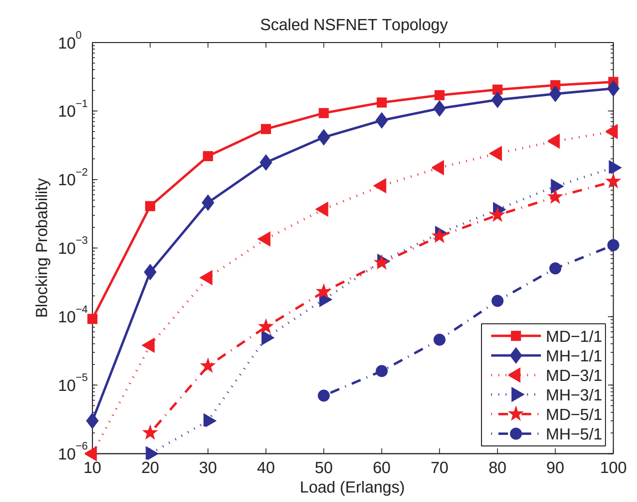


Figure: Comparison of blocking probability for various anycast scenarios.

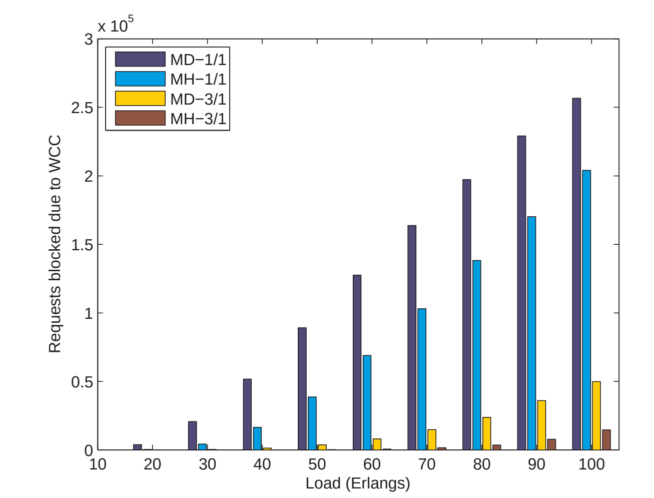


Figure: Comparison of requests blocked due to wavelength continuity constraint for unicast and 3/1 anycast.

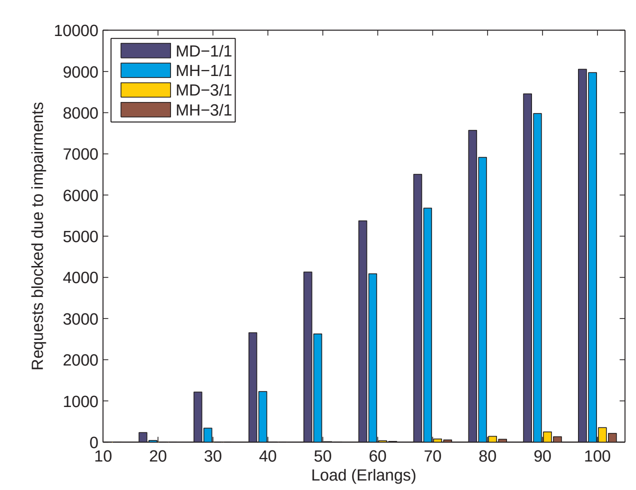


Figure: Comparison of requests blocked due to transmission impairments (dominated by XT) for unicast and 3/1 anycast.

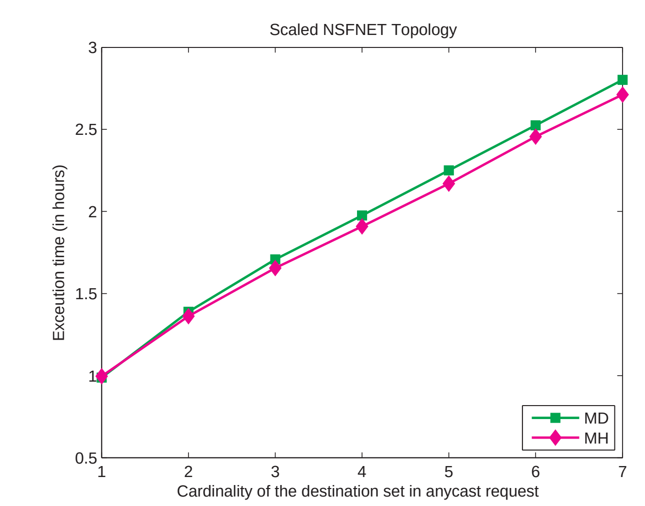


Figure: Execution time for simulation of 10^6 requests for each anycast configuration at a network load of 100 Erlang.

Conclusion

Our work presents a novel approach to provide required transmission quality on the WDM layer for content distribution, storage area, and data center networks.

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