Mobile routing in elastic optical networks

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Plan of presentation

- Introduction
- Problem statement
- Solutions
- Simulation results
- Conclusion

Background

- Mobile traffic has increased manyfold and will increase further.
- Hundreds of Mb/s - client download data rates in LTE-Advanced
- Elastic optical networks (EONs) are very likely to succeed.
- Currently optical subcarriers have the 6.25 GHz channel spacing.

Motivation

- Gb/s - planned client download data rates for 5G
- Optical subcarriers with narrow channel spacings could directly support mobile clients.
- A client can be an emergency vehicle, a train or a bus.
- Objective: support for mobile routing in EONs

Problem statement

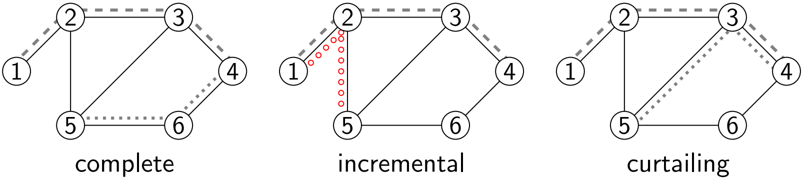
- An EON services a given number of mobile clients.
- There is an optical connection established for a mobile client.
- As the client roams, the source node of the connection changes, while the remote node stays the same.
- Client roaming requires optical link reconfigurations.
- Link reconfigurations are critical, because they can take a long time, and can cause service disruption.
- Objective: design a reconfiguration algorithm to limit the number of link reconfigurations.

Reconfiguration algorithms studied

- Complete (baseline algorithm):
  - find a shortest path between the new source node and the remote node;
  - no constraints needed.
- Incremental (baseline algorithm):
  - find a bridging path between the new source node and the previous source node;
  - spectrum continuity constraint applies.
- Curtailing (our contribution):
  - find a bridging path with the smallest number of hops between the new source node and any of the nodes of the already-established path;
  - spectrum continuity constraint applies.

Examples

An already-established connection (dashed line) between the previous source node 1 and the remote node 4 has to be reconfigured. The new source node is node 5. Reconfigured connection is painted dotted-gray.



- Complete: no links reused, two new links to configure.
- Incremental: fails, requires the dotted-red bridging path, but link 1-2 already has the required subcarriers taken by this connection.
- Curtailing: one link reused, one new link to configure.

Simulation setting

- Simulations carried out to compare the performance of the three routing algorithms and two spectrum allocation policies.
- Spectrum allocation policies used:
  - first available - subcarriers with the lowest number are chosen,
  - fittest available - a smallest fragment of subcarriers is chosen which can still accommodate the demand.
- Random networks with 50 nodes, 200 edges, and 400 subcarriers.
- The number of clients varied from 500 to 10000 with step 500, which produced loads from light to heavy, respectively.
- Clients change their states between active and idle. When active, a client attempts Poisson($\lambda_t = 7$) reconfigurations every Poisson($\lambda_{stay} = 1$) hours, and then goes idle for Poisson($\lambda_{idle} = 16$) hours.
- A client requests Poisson($\lambda_{sc} = 2$) subcarriers.

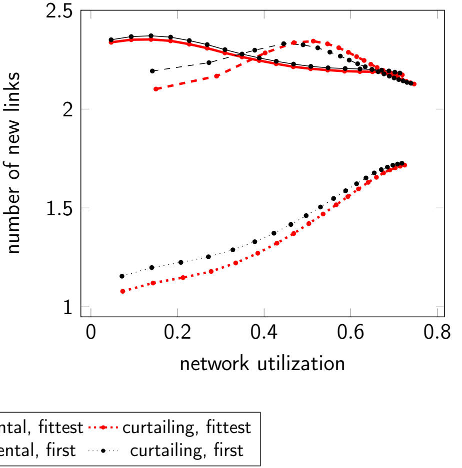
Simulation results

- There are 120 samples (20 loads x 3 algorithms x 2 policies)
- Each sample had 10 runs, resulting in 1200 simulation runs.
- The relative standard error of the results is below 1%.
- A data point in plots (which follow) corresponds to a sample.
- Key measured values:
  - number of new links to configure,
  - probability of establishing a connection,
  - probability of completing a connection.
- There are six data sets in plots (3 algorithms x 2 policies):

complete, fittest	incremental, fittest	curtailing, fittest
complete, first	incremental, first	curtailing, first

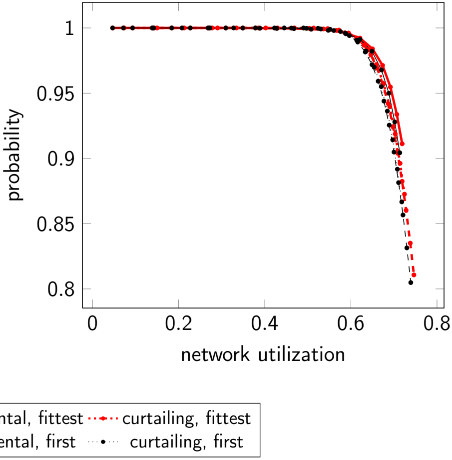
Number of new links to configure

- The number of new links to configure during reconfiguration.
- The curtailing algorithm outperforms the other two algorithms.
- Spectrum allocation policy makes little difference.



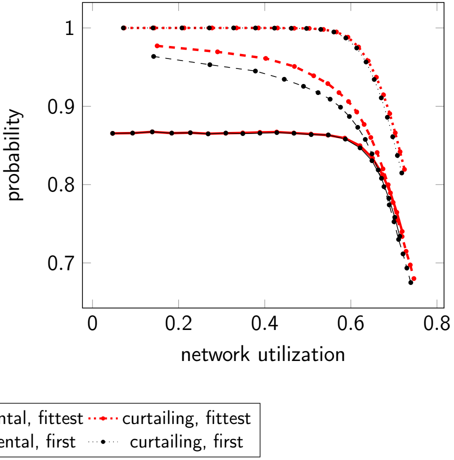
Probability of establishing a connection

- Refers to a new connection.
- All three algorithms perform in a similar way.



Probability of completing a connection

- The probability that a client makes a number Poisson($\lambda_t = 7$) of successful reconfigurations.
- The curtailing algorithm performs best.
- Again, spectrum allocation policy makes little difference.



Conclusion

- We proposed a mobile routing algorithm for elastic optical networks.
- We achieved the key objective of lowering the number of new links to configure, which is required by reconfiguration.
- The proposed algorithm achieves high probabilities of establishing and completing connections.
- The algorithm could be also used in link restoration in EONs.