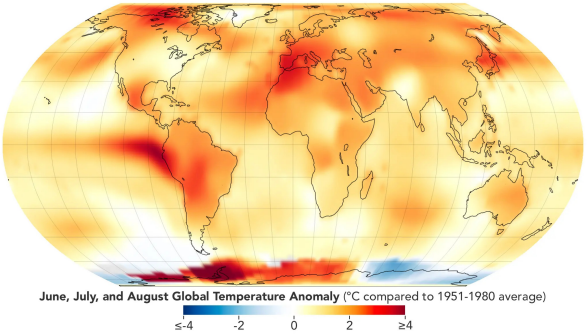
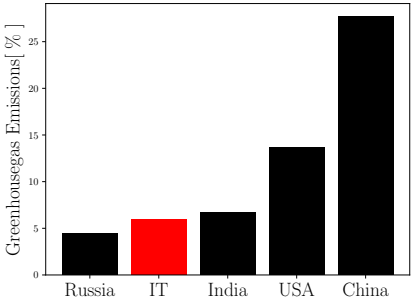
Green Segment Routing
Enhancing Energy Efficiency in Backbone Networks

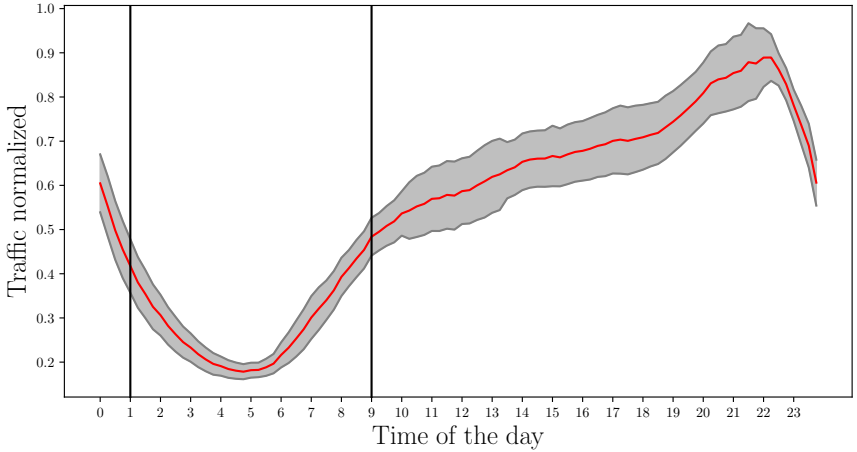
Daniel Otten

Ripe Meeting
10.2024





https://climate.nasa.gov/news/3282/ https://theshiftproject.org/en/article/lean-ict-our-new-report/

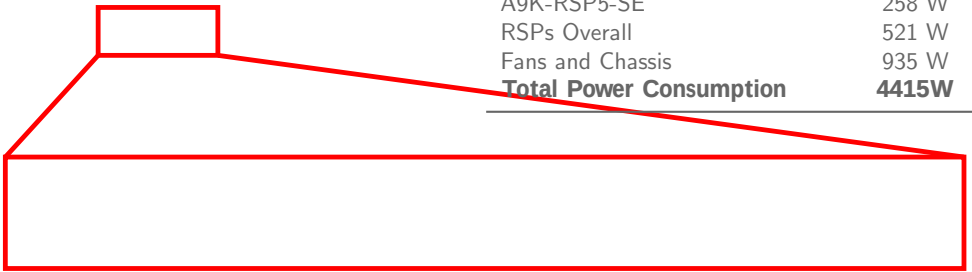


The maximum is four times higher than the minimum.

Parts of the infrastructure are not always needed.

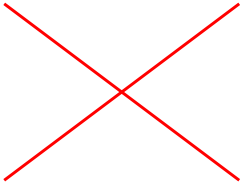
Power consumption of an ASR-9912 router

Component	Power Consumption
A9K-MOD400-TR	524 W
A99-8X100GE-TR	810 W
A99-8X100GE-TR	813 W
A99-8X100GE-TR	812 W
Linecards Overall	**2959W**
A9K-RSP5-SE	263 W
A9K-RSP5-SE	258 W
RSPs Overall	521 W
Fans and Chassis	935 W
Total Power Consumption	**4415W**



Courtesy of Cisco Systems, Inc. Unauthorized use not permitted , 22.09.2023, www.cisco.com/c/en/us/products/collateral/routers/asr-9000-series-aggregation-services-routers/datasheet-c78-737393.html

Turning routers o



Turning ports o

Turning linecards o

Otten et al., \On Modelling the Power Consumption of a Backbone Network", GreenNet Workshop in Cooperation with the ICC, 2023
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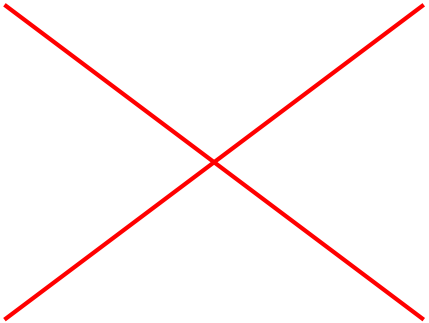


Turning a router off

- The routers take about 30 minutes to reboot.
- Hardware defects can occur.
- Peering with customer networks.

Method

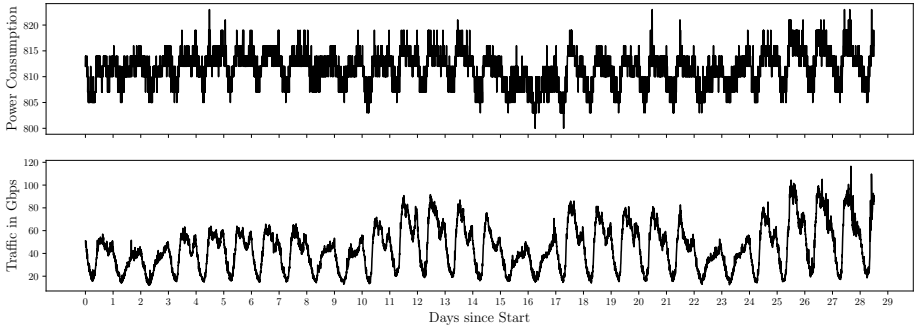
Measuring Power consumption via Cronjob

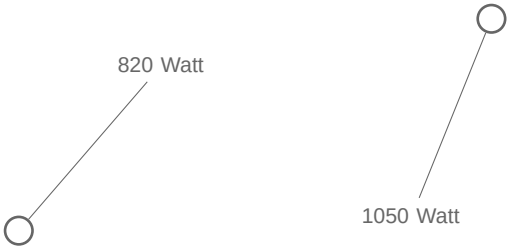
Measuring the amount of Traffic via Prometheus

Runtime: four weeks

Linecard 0: A9K-MOD400-TR

Linecard 1-3: A99-8X100GE-TR





Power consumption varies by just 200 Watt.

To reduce power consumption, parts must be switched o .

Measurement ASR9904

- Measurement using Tra c Generator
- Power Consumption in di erent scenarios

50 G per Port or 100 G on 16 Ports?

Processing 32 X 50 Gbps Tra c: 915 Watt

Processing 16 X 100 Gbps Tra c, 16 Ports on: 912 Watt

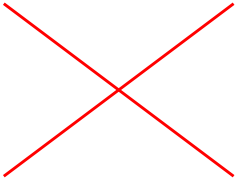
Processing 16 X 100 Gbps Tra c, 16 Ports o : 875 Watt

Freeing half of the NPUs or 2 Ports per NPU

Processing 16 X 100 Gbps Tra c, 16 Ports on: 906 Watt

Processing 16 X 100 Gbps Tra c, 16 Ports o : 872 Watt

Turning routers o



Turning ports o

Turning linecards o

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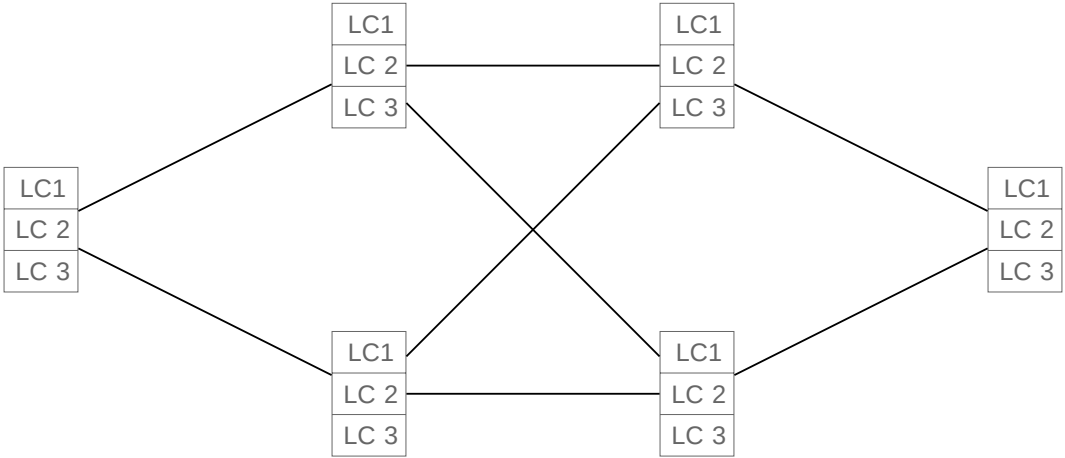
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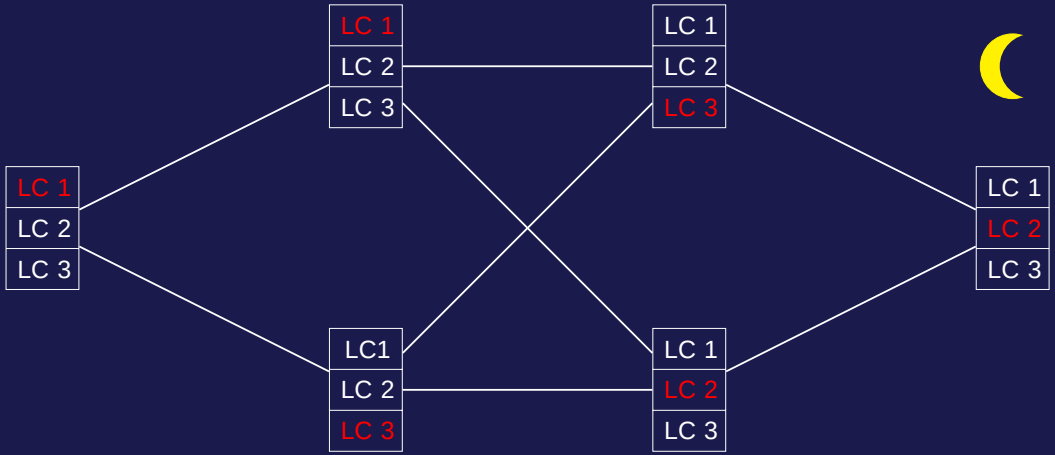
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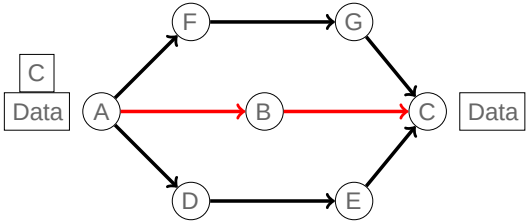
Segment Routing

- Source Routing Architecture.
- De ne interim destinations.
- Using the IGP to reach waypoints.
- Reducing algorithmic complexity.
- Already implemented.



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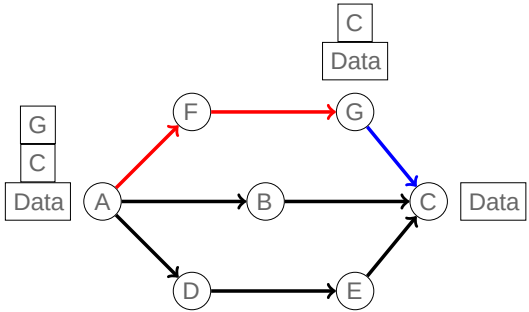

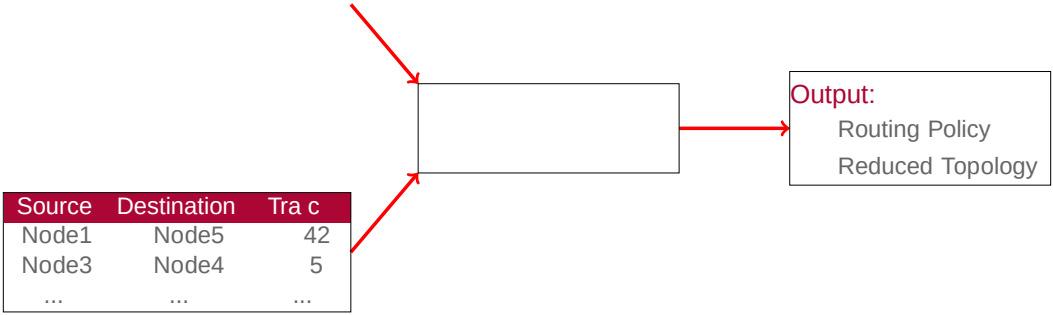
Output:
Routing Policy
Reduced Topology
Source Destination Tra c
Node1 Node5 42
Node3 Node4 5
... ...

MCF-LC

- Target Function: Minimize the number of active linecards
- Every Path is allowed
- Upper bound for the link utilization: 70 %
- Theoretical upper bound

2SR-LC

- Target Function: Minimize the number of active linecards
- Paths are limited to all 2-SR Paths
- Upper bound for the link utilization: 70 %

Repetita Instances [2]

- 21 Random Instances.
- Reduced the tra c by 50 %.
- Usage of the A99-8X100GE-TR linecard is assumed.

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- Reduced the tra c by 50 %.
- Usage of the A99-8X100GE-TR linecard is assumed.

Real-World Instances

- Includes tra c and topology.
- One Snapshot from every month of 2020 and 2022.
- All snapshots were taken at 1:00 a.m.
- Usage of the A99-8X100GE-TR linecard is assumed.

(a) Solution of 2SR-LC compared with MCF-LC (b) Run time of 2SR-LC compared with MCF-LC

Nearly optimal results

Signi cantly reduced computation time

Otten et al., \Green Tra c Engineering by Line Card Minimization", In Proc. of the 2023 LCN

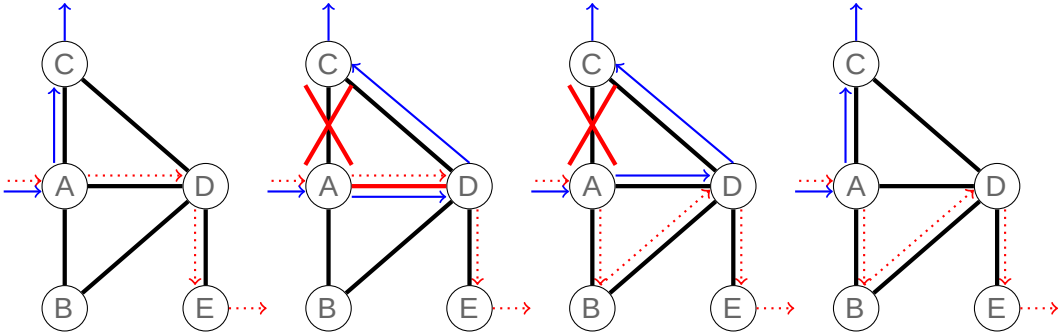
(a) Evaluation of 2020

(b) Evaluation of 2022

Overall Energy Consumption (theoretically) reduced by 50 %

Heuristic works on bigger instances

Otten et al., \Green Tra c Engineering by Line Card Minimization", In Proc. of the 2023 LCN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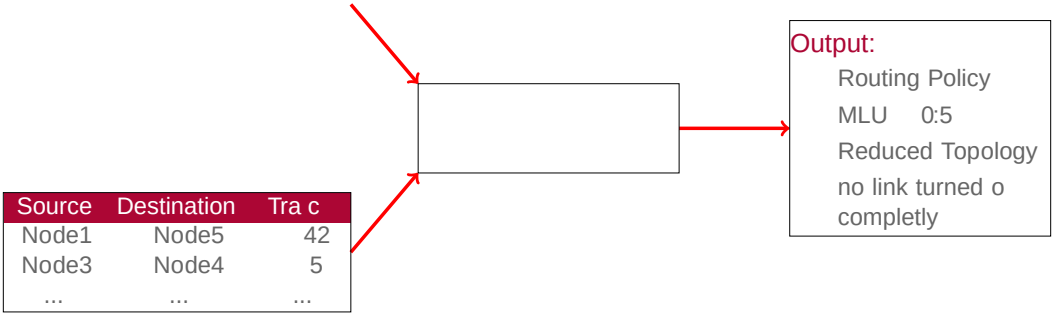
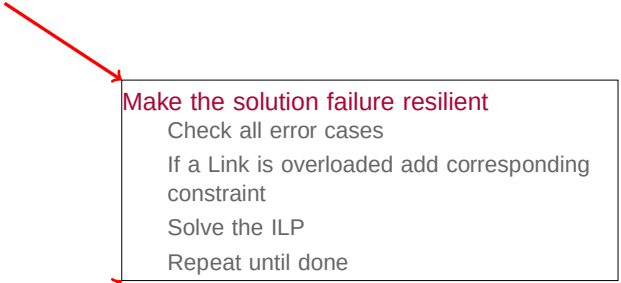

Source Destination Tra c
Node1 Node5 42
Node3 Node4 5
... ...
Output:
Routing Policy
MLU 0:5
Reduced Topology
no link turned o
completly

Result Step 1



Source	Destination	Tra c
Node1	Node5	42
Node3	Node4	5
...	...	...

Real-World Instances

- Includes tra c and topology.
- One snapshot from six months of 2022.
- All snapshots were taken at 1:00 a.m.
- Usage of the A99-8X100GE-TR linecard is assumed.

Failure Scenarios

- All Single Link Failures.
- Shared Risk Link Group (SRLG) Failures.

More than 50 % of all errors are critical

At most 21 Iterations are needed

Only a small fraction of all possible constraints added per iteration.

E ective reduction of computational overhead.

Initial decrease in deactivated linecards during the process

Only a small extra amount of linecards is needed to solve all errors

Otten and Aschenbruck, \Failure Resilient Green Tra c Engineering", In Proc. of the 2024 LCN

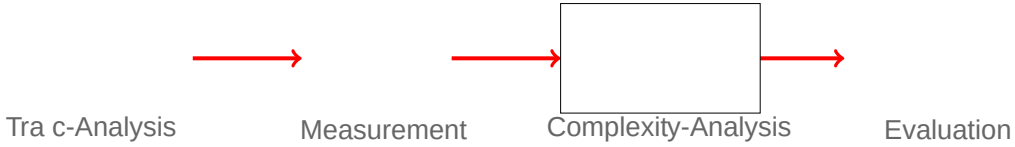
[1] Daniel Otten et al. \On Modelling the Power Consumption of a Backbone Network". In: Proc. of the IEEE International Conference on Communications Workshops (ICC Workshops) 2023.

[2] S. Gay et al. \REPETITA: Repeatable Experiments for Performance Evaluation of Tra c-Engineering Algorithms". In: ArXiv e-prints (2017). arXiv: 1710.08665.

[3] Daniel Otten et al. \Green Tra c Engineering by Line Card Minimization". In: Proc. of LCN 2023. doi : 10.1109/LCN58197.2023.10223344.

[4] Daniel Otten and Nils Aschenbruck. \Failure Resilient Green Tra c Engineering". In: Accepted for the LCN 2024.

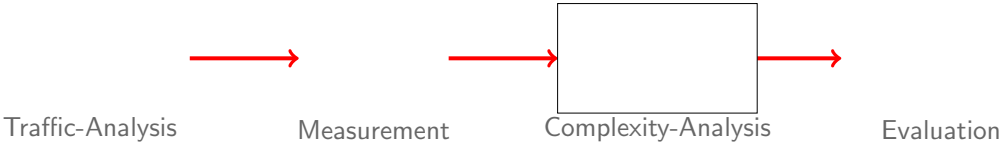
Contributions and Findings:



Future Work:

- Reducing the number of policies
- Considering additional constraints

Contributions and Findings:



Future Work:

- Reducing the number of policies
- Considering additional constraints

Time's up? Find me at
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or contact me directly:
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