

Energy-efficiency vs. resilience

Code for optimization procedures and simulations

P. Cholda and P. Jaglarz

To reproduce the steps of the algorithm presented in the paper, save attached files to a common directory and provide required tools.

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SOFTWARE REQUIREMENTS

- CPLEX (including OPL Interpreter): <http://www-01.ibm.com/software/commerce/optimization/cplex-optimizer/>
- MATLAB (including MATLAB Compiler): <http://www.mathworks.com/products/matlab/>

NR-GERMANY.DAT

This CPLEX file presents data necessary to find the optimal optical flows if energy profiles in links are concave. The recovery option used by all the demands is a lack of recovery NR. The energy profiles are approximated with linear segments. The data is related to the German network

```

1 // *****/
2 // OPL 12.6.0.0 Model
3 // Author: Piotr Cholda, AGH University of Science and Technology
4 // Creation Date: 28 April 2014 at 12:07:15
5 // *****/
6
7 Nodes = {Hannover,
8         Frankfurt,
9         Hamburg,
10        Norden,
11        Bremen,
12        Berlin,
13        Muenchen,
14        Ulm,
15        Nuernberg,
16        Stuttgart,
17        Karlsruhe,
18        Mannheim,
19        Essen,
20        Dortmund,
21        Duesseldorf,
22        Koeln,
23        Leipzig};
24
25 Arcs = {<Berlin,Hamburg>, <Berlin,Hannover>,
26        <Berlin,Leipzig>, <Bremen,Hamburg>,
27        <Bremen,Hannover>, <Bremen,Norden>,
28        <Dortmund,Essen>, <Dortmund,Hannover>,
29        <Dortmund,Koeln>, <Dortmund,Norden>,
30        <Duesseldorf,Essen>, <Duesseldorf,Koeln>,
31        <Frankfurt,Hannover>, <Frankfurt,Koeln>,
32        <Frankfurt,Leipzig>, <Frankfurt,Mannheim>,
33        <Frankfurt,Nuernberg>, <Hamburg,Hannover>,
34        <Hannover,Leipzig>, <Karlsruhe,Mannheim>,
35        <Karlsruhe,Stuttgart>, <Leipzig,Nuernberg>,
36        <Muenchen,Nuernberg>, <Muenchen,Ulm>,
37        <Nuernberg,Stuttgart>, <Stuttgart,Ulm>};
38
39 Demands = {<Hannover,Muenchen>, <Hannover,Ulm>,
40            <Hannover,Nuernberg>, <Hannover,Stuttgart>,
41            <Hannover,Karlsruhe>, <Hannover,Mannheim>,
42            <Hannover,Koeln>, <Hannover,Leipzig>,
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44            <Frankfurt,Norden>, <Frankfurt,Muenchen>,
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53            <Bremen,Hannover>, <Bremen,Frankfurt>,
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62            <Berlin,Muenchen>, <Berlin,Ulm>,
63            <Berlin,Nuernberg>, <Berlin,Stuttgart>,
64            <Berlin,Karlsruhe>, <Berlin,Mannheim>,

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98     <Leipzig,Nuernberg>,
99     <Leipzig,Stuttgart>, <Leipzig,Mannheim>;
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    ↵ 2 4 2 2 6 4 6 10 4 4 2 2 4 2 2 8 8 6 6 6 12 4 4 2 4 4 2 2 10 12 6 4 4 4 4 2 6 8 6 6 8 ↵
    ↵ 4];
102
103 Path = 10;
104
105 delta = [[ [0 0 0 0 1 0 0 0 1 0] [0 0 0 0 1 0 0 0 1 0] [0 0 0 0 1 0 0 0 1 0] [0 0 0 0 0 1 ↵
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↵ -01  1.387779e-01  1.291713e-01  1.213203e-01  1.147476e-01  1.091399e-01  1.042819e-01
↵ 1.000200e-01  9.624155e-02  9.286148e-02  8.981434e-02  8.704882e-02  8.452405e-02
↵ 8.220700e-02  8.007066e-02  7.809269e-02  7.625444e-02  7.454020e-02  7.293662e-02
↵ 7.143229e-02  7.001737e-02  6.868334e-02  6.742277e-02  6.622917e-02  6.509679e-02
↵ 6.402059e-02  6.299606e-02  6.201920e-02  6.108642e-02  6.019451e-02  5.934055e-02
↵ 5.852195e-02  5.773631e-02  5.698149e-02  5.625552e-02  5.555661e-02  5.488313e-02
↵ 5.423355e-02  5.360651e-02  5.300073e-02  5.241503e-02  5.184833e-02  5.129963e-02
↵ 5.076798e-02  5.025253e-02  4.975247e-02  4.926704e-02  4.879556e-02  4.833735e-02
↵ 4.789182e-02  4.745838e-02  4.703650e-02  4.662568e-02  4.622544e-02  4.583533e-02
↵ 4.545493e-02  4.508385e-02  4.472172e-02  4.436817e-02  4.402288e-02  4.368552e-02
↵ 4.335580e-02  4.303344e-02  4.271817e-02  4.240972e-02  4.210786e-02  4.181236e-02
↵ 4.152299e-02  4.123954e-02  4.096183e-02  4.068965e-02  4.042282e-02  4.016118e-02
↵ 3.990455e-02  3.965278e-02  3.940571e-02  3.916321e-02  3.892513e-02  3.869134e-02
↵ 3.846171e-02  3.823612e-02  3.801445e-02  3.779660e-02  3.758245e-02  3.737190e-02
↵ 3.716485e-02  3.696120e-02  3.676087e-02  3.656375e-02  3.636978e-02  3.617885e-02
↵ 3.599091e-02  3.580586e-02  3.562364e-02  3.544417e-02  3.526739e-02  3.509323e-02

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↵3.492162e-02	3.475250e-02	3.458582e-02	3.442152e-02	3.425953e-02	3.409981e-02	↵
↵3.394230e-02	3.378696e-02	3.363373e-02	3.348256e-02	3.333342e-02	3.318625e-02	↵
↵3.304101e-02	3.289766e-02	3.275616e-02	3.261648e-02	3.247856e-02	3.234238e-02	↵
↵3.220790e-02	3.207508e-02	3.194389e-02	3.181430e-02	3.168628e-02	3.155978e-02	↵
↵3.143479e-02	3.131127e-02	3.118920e-02	3.106855e-02	3.094928e-02	3.083138e-02	↵
↵3.071481e-02	3.059956e-02	3.048559e-02	3.037289e-02	3.026143e-02	3.015118e-02	↵
↵3.004214e-02	2.993427e-02	2.982755e-02	2.972196e-02	2.961749e-02	2.951411e-02	↵
↵2.941181e-02	2.931056e-02	2.921035e-02	2.911117e-02	2.901298e-02	2.891579e-02	↵
↵2.881956e-02	2.872429e-02	2.862996e-02	2.853655e-02	2.844404e-02	2.835244e-02	↵
↵2.826171e-02	2.817184e-02	2.808283e-02	2.799466e-02	2.790731e-02	2.782078e-02	↵
↵2.773504e-02	2.765010e-02	2.756592e-02	2.748252e-02	2.739986e-02	2.731795e-02	↵
↵2.723677e-02	2.715630e-02	2.707655e-02	2.699749e-02	2.691912e-02	2.684143e-02	↵
↵2.676441e-02	2.668805e-02	2.661234e-02	2.653727e-02	2.646283e-02	2.638902e-02	↵
↵2.631581e-02	2.624322e-02	2.617122e-02	2.609981e-02	2.602898e-02	2.595873e-02	↵
↵2.588904e-02	2.581991e-02	2.575133e-02	2.568330e-02	2.561580e-02	2.554883e-02	↵
↵2.548238e-02	2.541645e-02	2.535103e-02	2.528611e-02	2.522168e-02	2.515775e-02	↵
↵2.509430e-02	2.503133e-02	2.496883e-02	2.490679e-02	2.484522e-02	2.478410e-02	↵
↵2.472343e-02	2.466320e-02	2.460341e-02	2.454405e-02	2.448512e-02	2.442662e-02	↵
↵2.436853e-02	2.431085e-02	2.425358e-02	2.419671e-02	2.414024e-02	2.408417e-02	↵
↵2.402848e-02	2.397318e-02	2.391826e-02	2.386371e-02	2.380954e-02	2.375573e-02	↵
↵2.370229e-02	2.364920e-02	2.359647e-02	2.354409e-02	2.349206e-02	2.344038e-02	↵
↵2.338903e-02	2.333802e-02	2.328734e-02	2.323698e-02	2.318696e-02	2.313725e-02	↵
↵2.308787e-02	2.303880e-02	2.299004e-02	2.294159e-02	2.289344e-02	2.284560e-02	↵
↵2.279805e-02	2.275080e-02	2.270384e-02	2.265717e-02	2.261079e-02	2.256470e-02	↵
↵2.251888e-02	2.247334e-02	2.242808e-02	2.238309e-02	2.233836e-02	2.229391e-02	↵
↵2.224972e-02	2.220579e-02	2.216212e-02	2.211871e-02	2.207555e-02	2.203264e-02	↵
↵2.198999e-02	2.194757e-02	2.190541e-02	2.186348e-02	2.182180e-02	2.178035e-02	↵
↵2.173914e-02	2.169816e-02	2.165741e-02	2.161689e-02	2.157660e-02	2.153653e-02	↵
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↵2.103517e-02	2.099803e-02	2.096110e-02	2.092436e-02	2.088781e-02	2.085145e-02	↵
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↵2.039543e-02	2.036158e-02	2.032790e-02	2.029438e-02	2.026103e-02	2.022784e-02	↵
↵2.019482e-02	2.016195e-02	2.012925e-02	2.009670e-02	2.006432e-02	2.003208e-02	↵
↵2.000001e-02	1.996808e-02	1.993631e-02	1.990469e-02	1.987322e-02	1.984190e-02	↵
↵1.981073e-02	1.977970e-02	1.974882e-02	1.971808e-02	1.968749e-02	1.965703e-02	↵
↵1.962672e-02	1.959655e-02	1.956652e-02	1.953662e-02	1.950686e-02	1.947724e-02];

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Coeff_b = [0 8.284271e-01 1.101021e+00 1.312678e+00 1.493025e+00 1.653158e+00 1.798767e+00 1.933259e+00 2.058875e+00 2.177183e+00 2.289338e+00 2.396215e+00 2.498499e+00 2.596739e+00 2.691381e+00 2.782795e+00 2.871292e+00 2.957134e+00 3.040548e+00 3.121729e+00 3.200848e+00 3.278054e+00 3.353481e+00 3.427245e+00 3.499453e+00 3.570199e+00 3.639569e+00 3.707640e+00 3.774481e+00 3.840159e+00 3.904731e+00 3.968252e+00 4.030771e+00 4.092334e+00 4.152985e+00 4.212761e+00 4.271701e+00 4.329838e+00 4.387205e+00 4.443830e+00 4.499743e+00 4.554969e+00 4.609533e+00 4.663458e+00 4.716767e+00 4.769480e+00 4.821616e+00 4.873195e+00 4.924233e+00 4.974747e+00 5.024753e+00 5.074266e+00 5.123301e+00 5.171871e+00 5.219988e+00 5.267667e+00 5.314917e+00 5.361751e+00 5.408179e+00 5.454212e+00 5.499859e+00 5.545131e+00 5.590036e+00 5.634583e+00 5.678780e+00 5.722637e+00 5.766159e+00 5.809355e+00 5.852233e+00 5.894799e+00 5.937059e+00 5.979021e+00 6.020690e+00 6.062073e+00 6.103175e+00 6.144002e+00 6.184559e+00 6.224853e+00 6.264887e+00 6.304667e+00 6.344197e+00 6.383483e+00 6.422528e+00 6.461337e+00 6.499915e+00 6.538265e+00 6.576391e+00 6.614297e+00 6.651988e+00 6.689466e+00 6.726735e+00 6.763799e+00 6.800661e+00 6.837324e+00 6.873791e+00 6.910066e+00 6.946152e+00 6.982051e+00 7.017767e+00 7.053301e+00 7.088658e+00 7.123839e+00 7.158847e+00 7.193684e+00 7.228354e+00 7.262858e+00 7.297199e+00 7.331380e+00 7.365401e+00 7.399266e+00 7.432977e+00 7.466536e+00 7.499944e+00 7.533205e+00 7.566319e+00 7.599289e+00 7.632116e+00 7.664803e+00 7.697351e+00 7.729762e+00 7.762037e+00 7.794179e+00 7.826189e+00 7.858069e+00 7.889819e+00 7.921443e+00 7.952940e+00 7.984314e+00 8.015564e+00 8.046693e+00 8.077703e+00 8.108593e+00 8.139367e+00 8.170024e+00 8.200567e+00 8.230997e+00 8.261314e+00 8.291521e+00 8.321618e+00 8.351606e+00 8.381488e+00 8.411263e+00 8.440933e+00 8.470499e+00 8.499962e+00 8.529323e+00 8.558584e+00 8.587745e+00 8.616807e+00 8.645772e+00 8.674640e+00 8.703412e+00 8.732089e+00 8.760673e+00 8.789163e+00 8.817562e+00 8.845869e+00 8.874086e+00 8.902214e+00 8.930253e+00 8.958204e+00 8.986068e+00 9.013846e+00 9.041539e+00 9.069147e+00 9.096672e+00 9.124113e+00 9.151472e+00 9.178750e+00 9.205946e+00 9.233063e+00 9.260100e+00 9.287059e+00 9.313939e+00 9.340742e+00 9.367468e+00 9.394119e+00 9.420694e+00 9.447194e+00 9.473620e+00 9.499973e+00

↳9.526252e+00	9.552460e+00	9.578595e+00	9.604660e+00	9.630654e+00	9.656578e+00	↵
↳9.682433e+00	9.708218e+00	9.733936e+00	9.759585e+00	9.785168e+00	9.810684e+00	↵
↳9.836133e+00	9.861517e+00	9.886836e+00	9.912090e+00	9.937280e+00	9.962406e+00	↵
↳9.987469e+00	1.001247e+01	1.003741e+01	1.006228e+01	1.008710e+01	1.011185e+01	↵
↳1.013654e+01	1.016118e+01	1.018575e+01	1.021027e+01	1.023472e+01	1.025912e+01	↵
↳1.028346e+01	1.030774e+01	1.033197e+01	1.035614e+01	1.038025e+01	1.040431e+01	↵
↳1.042831e+01	1.045225e+01	1.047614e+01	1.049998e+01	1.052376e+01	1.054749e+01	↵
↳1.057117e+01	1.059479e+01	1.061836e+01	1.064188e+01	1.066535e+01	1.068876e+01	↵
↳1.071212e+01	1.073544e+01	1.075870e+01	1.078191e+01	1.080507e+01	1.082819e+01	↵
↳1.085125e+01	1.087426e+01	1.089723e+01	1.092015e+01	1.094302e+01	1.096584e+01	↵
↳1.098861e+01	1.101134e+01	1.103402e+01	1.105665e+01	1.107924e+01	1.110178e+01	↵
↳1.112428e+01	1.114673e+01	1.116914e+01	1.119150e+01	1.121381e+01	1.123609e+01	↵
↳1.125831e+01	1.128050e+01	1.130264e+01	1.132474e+01	1.134679e+01	1.136880e+01	↵
↳1.139077e+01	1.141270e+01	1.143458e+01	1.145642e+01	1.147822e+01	1.149998e+01	↵
↳1.152170e+01	1.154338e+01	1.156502e+01	1.158662e+01	1.160817e+01	1.162969e+01	↵
↳1.165117e+01	1.167260e+01	1.169400e+01	1.171536e+01	1.173668e+01	1.175796e+01	↵
↳1.177920e+01	1.180041e+01	1.182158e+01	1.184271e+01	1.186380e+01	1.188485e+01	↵
↳1.190587e+01	1.192685e+01	1.194779e+01	1.196870e+01	1.198957e+01	1.201040e+01	↵
↳1.203120e+01	1.205196e+01	1.207268e+01	1.209337e+01	1.211403e+01	1.213465e+01	↵
↳1.215523e+01	1.217578e+01	1.219630e+01	1.221678e+01	1.223723e+01	1.225764e+01	↵
↳1.227802e+01	1.229836e+01	1.231867e+01	1.233895e+01	1.235919e+01	1.237941e+01	↵
↳1.239958e+01	1.241973e+01	1.243984e+01	1.245992e+01	1.247997e+01	1.249999e+01	↵
↳1.251997e+01	1.253992e+01	1.255984e+01	1.257973e+01	1.259959e+01	1.261942e+01	↵
↳1.263921e+01	1.265898e+01	1.267871e+01	1.269841e+01	1.271809e+01	1.273773e+01	↵
↳1.275734e+01	1.277692e+01	1.279647e+01	1.281599e+01	1.283549e+01];	↵