NETPLAN Architecture

Multiobjective algorithm
- Select front of solutions
- Generate new generation

Cost Minimization

Investment Portfolio

Sustainability Metrics

Resiliency Metrics

Search and selection

Evaluation (fitness functions)
What V1 does

- Written in C++

- Optimizes using
  - Multiobjective: NSGA-II
  - Cost Minimization: Cplex and Benders

- Three objectives:
  - Cost
  - CO2 Emissions
  - Electrical reserve margin
What V1 does

- Data Driven:
  - Network topologies and attributes defined by data
- Scalable
- Multistep
- Modeling
  - Energy transport
  - Transportation energy demand
  - DC Power Flow
V1 Structure

Input data

Preprocessor

Parameters

NSGA-II Optimizer
Minimum Investment Enforced

MPS file

Minimum Cost Optimizer

Results
NETPLAN: Under the hood

- Previously presented goals, model and equations

- [http://home.eng.iastate.edu/~eibanez/netplan/](http://home.eng.iastate.edu/~eibanez/netplan/)
  - Cplex and C++ tutorial
  - References
  - Source code for V1.32

- Please: Use url internally (work in progress)
NETPLAN folders and files

- **Folders**
  - “data”: contains all problem data
  - “prepdata”: used to store temporary files and solution information
  - “src”: NETPLAN source code
  - “src/nsga2”: C++ version of the NSGA-II algorithm

- Obtained and modified from:

- Original code found here:
  [http://www.iitk.ac.in/kangal/codes.shtml](http://www.iitk.ac.in/kangal/codes.shtml)
NETPLAN folders and files

- **Source code is divided into**
  - Main files (programs that you run)
  - Libraries (auxiliary code for programs)

- **Libraries:**
  - “read.cpp”: Functions that read files
    - Global parameters
    - Networks (arcs, nodes, transportation)
    - Properties…
  - “write.cpp”: Write files (solutions, temporary…)
NETPLAN folders and files

- Libraries (II):
  - “global.cpp”: Common global definitions
  - “netscore.h”: Common tasks and misc.
  - “node.cpp”:
    - Declares a special class to store node information
    - Functions to read, modify and write node data
  - “arc.cpp”:
    - Similar but for arcs
  - “step.cpp”:
    - Functions related with time and time steps
NETPLAN folders and files

- **Libraries (III):**
  - “index.cpp”:
    - Special variables to store order of arcs and nodes
    - Useful for recovering information
  - “solver.cpp”:
    - Functions to solve a problem
    - Includes Benders decompositions, not completely integrated
  - In the future: “metrics.cpp”
    - To store calculation of metrics
NETPLAN folders and files

- **Main files:**
  - “preprocessor.cpp”:
    - Takes information from “data” folder
    - Creates MPS and temporary files
  - “postprocessor.cpp”:
    - Takes MPS files and solves problem
    - Writes solution in files
    - Future base for reporting module

- **NSGA-II works similarly to postprocessor**
Defining a problem

- In the “data” folder
  - “parameters.csv”: General properties
    - Used by ReadParameters() in “read.cpp”, lines 40-55
  - “nodes_List.csv”: Define list of nodes
  - “arcs_List.csv”: Define links (between valid nodes)
  - “trans_List.csv”: Create transportation network
  - “nodes_X.csv”: Node properties
    - List of X and default values defined in ReadParameters() in “read.cpp”, lines 83-96
  - “arcs_X.csv”: Arc properties
    - List of X and default values defined in ReadParameters() in “read.cpp”, lines 98-124
Data Input

- Comma Separated Value (CSV) files

```
| code  | const | y1m1   | y1m2   | y1m3   | y1m4   | y1m5   | y1m6   | y1m7   | y1m8   | y1m9   | y1m10  | y1m11  | y1m12  | y2     | y3     | y4     | y5     | y6     | y7     | y8     |
|-------|-------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| C, 0  |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| E, 0  |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| EO, x |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| EI, x |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 1, 0  |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 2, 0  |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| 3, 0  |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| EL01  | 8869015 | 31 | 8080031 | 56 | 8759049 | 17 | 7845790 | 69 | 443447  |       |        |        |        |        |        |        |        |        |        |        |        |
| EL02  | 1467974 | 38 | 1249458 | 34 | 12647206 | 77 | 11583319 | 15 | 1       |       |        |        |        |        |        |        |        |        |        |        |
| EL03  | 5796343 | 35 | 5263321 | 69 | 5179249 | 33 | 5982476 | 33 | 81085   |       |        |        |        |        |        |        |        |        |        |        |
| EL04  | 4877454 | 42 | 4262787 | 24 | 4556901 | 07 | 4181482 | 55 | 43594   |       |        |        |        |        |        |        |        |        |        |        |
| EL05  | 15591927 | 4 | 13332347 | 4 | 14340535 | 59 | 13110047 | 56 | 12      |       |        |        |        |        |        |        |        |        |        |        |
| EL06  | 13758722 | 96 | 12834544 | 08 | 12138213 | 28 | 12390365 | 63 | 1       |       |        |        |        |        |        |        |        |        |        |        |
| EL07  | 18514401 | 66 | 16569731 | 45 | 17492393 | 14 | 17604894 | 42 | 2       |       |        |        |        |        |        |        |        |        |        |        |
| EL08  | 13486160 | 91 | 13102083 | 4 | 13385960 | 69 | 11380519 | 65 | 12      |       |        |        |        |        |        |        |        |        |        |        |
| EL09  | 46251847 | 68 | 40462194 | 91 | 39449315 | 39 | 37031969 | 99 | 3       |       |        |        |        |        |        |        |        |        |        |        |
| EL10  | 8072669 | 55 | 7695402 | 37 | 719577 | 28 | 7217027 | 95 | 923154  |       |        |        |        |        |        |        |        |        |        |        |
| EL11  | 8915583 | 27 | 8833914 | 28 | 8306225 | 51 | 7954102 | 47 | 97596   |       |        |        |        |        |        |        |        |        |        |        |
| EL12  | 15985311 | 99 | 13872321 | 62 | 11355108 | 14 | 11110974 | 42 | 1       |       |        |        |        |        |        |        |        |        |        |        |
| EL13  | 13375773 | 88 | 12689900 | 69 | 10363863 | 9 | 10288909 | 68 | 14      |       |        |        |        |        |        |        |        |        |        |        |
| EL14  | 11776240 | 48 | 9923388 | 56 | 1101840 | 63 | 11001047 | 36 | 12      |       |        |        |        |        |        |        |        |        |        |        |
| EL15  | 15049885 | 99 | 13550359 | 28 | 12906488 | 52 | 11731183 | 26 | 1       |       |        |        |        |        |        |        |        |        |        |        |
| EL16  | 4739408 | 86 | 4509934 | 08 | 4977012 | 75 | 4029921 | 52 | 5018C   |       |        |        |        |        |        |        |        |        |        |        |
| EL17  | 4084647 | 21 | 424670 | 91 | 4558171 | 83 | 5501530 | 54 | 49161   |       |        |        |        |        |        |        |        |        |        |        |
| GA, 0 |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| GS01  | 474212000 |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
| GS02  | 1048048000 |       |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |        |
```

National Energy Transportation Sustainability, Cost, & Resiliency

NETSCORE21
Research Project

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Basic use

- Refer to tutorial for more details on C++ and CPLEX

- In the “pluto” server, position yourself in the NETPLAN folder and type:
  - `make` (compile programs)
  - `./prep` (run preprocessor)
  - `./post` (run postprocessor)
  - `./nsga2` (run NSGA-II solver)
NETPLAN in depth

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