www.localsolver.com

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Who we are

Bouygues, one of the French largest corporations
Construction, telecom, media, transport, energy
€32 bn in revenues, 120,000 employees

http://www.bouygues.com

LocalSolver

Operational Research subsidiary of Bouygues
10 people, 20 years of practice and research

Mathematical optimization solver

http://www.localsolver.com

Swiss Army Knife for math optimization

All-Terrain & All-In-One

Discrete, Numerical, Black-Box

Fast & Scalable

Innovative Resolution Technology

Differentiators

Easier to use than any other solver

- Model & Run optimization solver
- Natural math modeling formalism through user-friendly interfaces
- Models can be: non-linear, non-convex, non-smooth
- Models can be: black-box, noisy, nondeterministic
- No need to pass derivatives
- One-click resolution: no need of complex tuning

New-generation optimization technology

- All-in-one: combines many different optimization techniques
- Innovative: integrates unique heuristic search techniques

→ Automating the resolution of mathematical optimization problems arising in industry

LocalSolver

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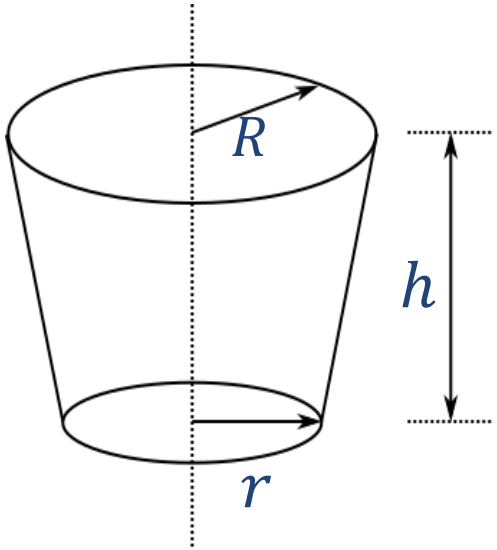
Quick tour

Parametric optimization (analytical)

Maximize the volume of a bucket with a given surface of metal



$$V = \frac{\pi h}{3}\left(R^2 + Rr + r^2\right)$$

$$S = \pi r^2 + \pi(R + r)\sqrt{(R - r)^2 + h^2}$$

```
function model() {

  R <- float(0,1);
  r <- float(0,1);
  h <- float(0,1);

  V <- PI * h / 3.0 * (R*R + R*r + r*r);
  S <- PI * r * r + PI*(R+r) * sqrt(pow(R-r,2) + h*h);

  constraint S <= PI;
  maximize V;
}
```

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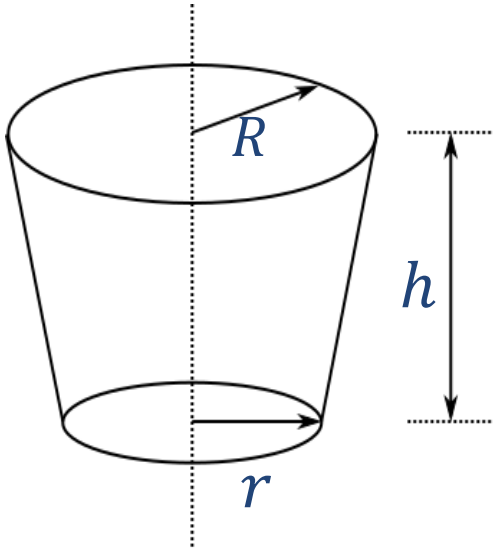
Mathematical operators

Decisional	Arithmetical			Logical	Relational	Set-related
bool	sum	sub	prod	not	eq	count
float	min	max	abs	and	neq	contains
int	div	mod	sqrt	or	geq	at
list	log	exp	pow	xor	leq	indexOf
	cos	sin	tan	iif	gt	disjoint
	floor	ceil	round	array + at	lt	partition
	dist	scalar		piecewise		

+ operator call : to plug any external function
Can be used to implement your own (black-box) operator

Parametric optimization (black-box)

Maximize the volume of a bucket with a given surface of metal



$$V = \frac{\pi h}{3}\left(R^2 + Rr + r^2\right)$$

$$S = \pi r^2 + \pi(R + r)\sqrt{(R - r)^2 + h^2}$$

```
function model() {

  R <- float(0,1);
  r <- float(0,1);
  h <- float(0,1);

  V <- volume(r, R, h); // volume function call
  S <- surface(r, R, h); // surface function call

  constraint S <= PI;
  maximize V;
}
```

User-friendly APIs

Python

Java

C#

C++

Matlab

R

```
########## optimal_bucket.py ##########

import localsolver
import sys

with localsolver.LocalSolver() as ls:

    PI = 3.14159265359

    #
    # Declares the optimization model
    #
    m = ls.model

    R = m.float(0,1)
    r = m.float(0,1)
    h = m.float(0,1)

    # Surface constraint
    # surface = PI * r^2 + PI*(R+r) * sqrt ((R-r)^2 + h^2)
    surface = PI*r*r + PI * m.sqrt((R-r)**2 + h**2) * (R+r)
    m.constraint(surface <= PI)

    # Maximize volume
    # volume = PI * h/3 * (R^2 + R*r + r^2)
    volume = PI * h/3 * (R**2+ R*r + r**2)
    m.maximize(volume)

    m.close()

    #
    # Param
    #
    ls.param.nb_threads = 2
    if len(sys.argv) >= 3: ls.create_phase().time_limit = int(sys.argv[2])
    else: ls.create_phase().time_limit = 6

    ls.solve()
```

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Success stories

100+ clients worldwide

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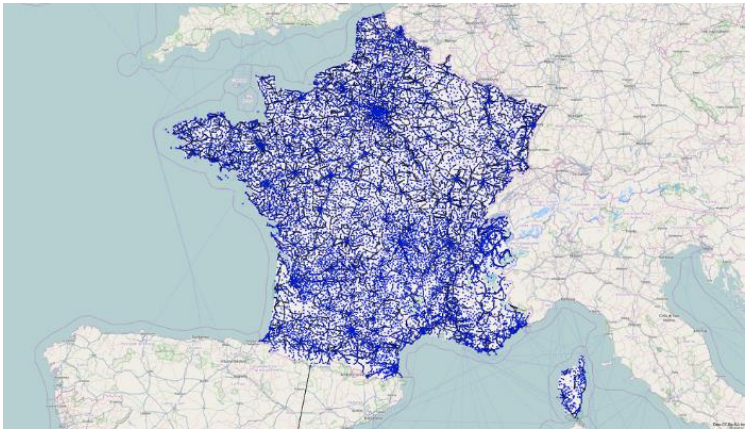
Application panorama

- TV media planning
- Railway operations planning
- Logistic clustering and routing
- Road maintenance planning
- Network deployment planning
- Loan assembling optimization
- Designing sailboat weathervanes
- Airline network management
- LNG supply chain design
- Optimal fertilization of agricultural parcels

Telecom network optimization

ADSL network expansion planning

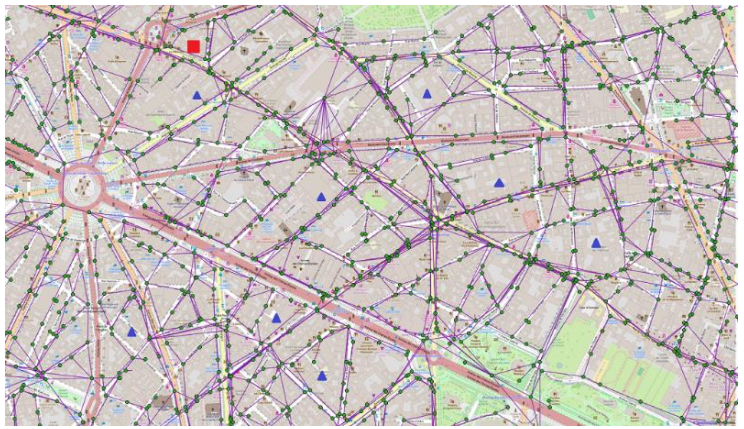


Context

- Choose remote concentrator units to unbundle
- Local and global constraints. Ex: forbid paths with too much clients to limit impacts of an incident

Prize collecting Steiner forest problem

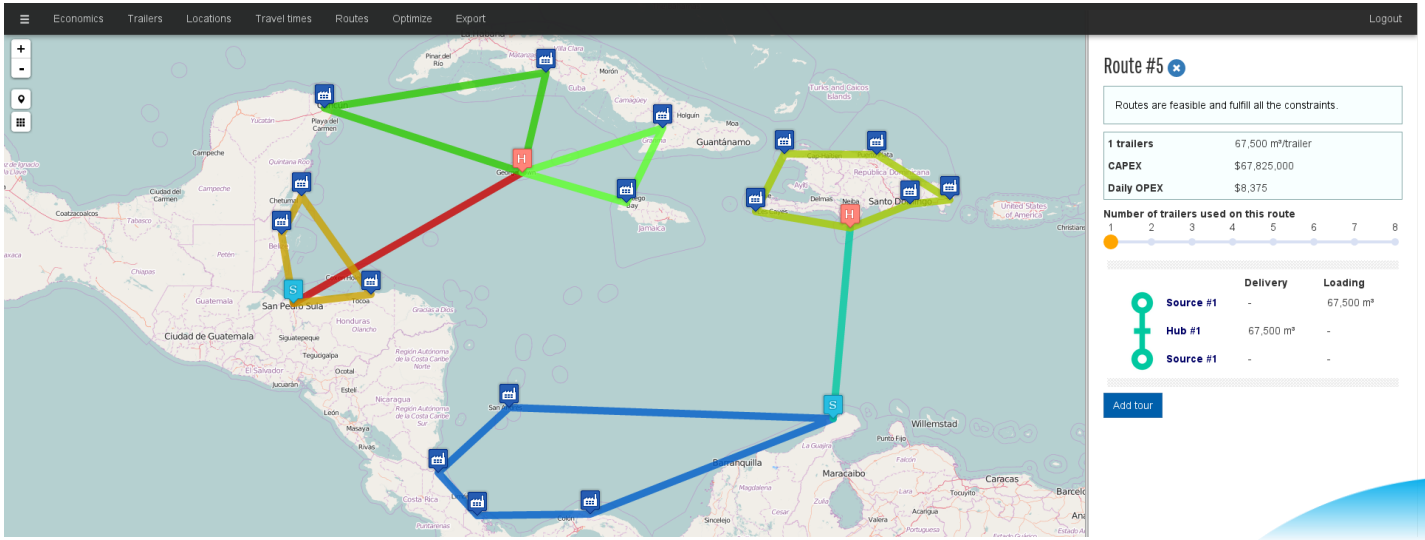
- Network: 14,000 nodes, 180,000 edges
- Resulting model: 1.4 million variables
- Required resolution time: minutes



Supply chain optimization

LNG supply chain design

- Sizing trailers and client/hub storages
- LNG routes: sources/hubs → hubs/clients
- 100+ clients to be replenished



ENGIE

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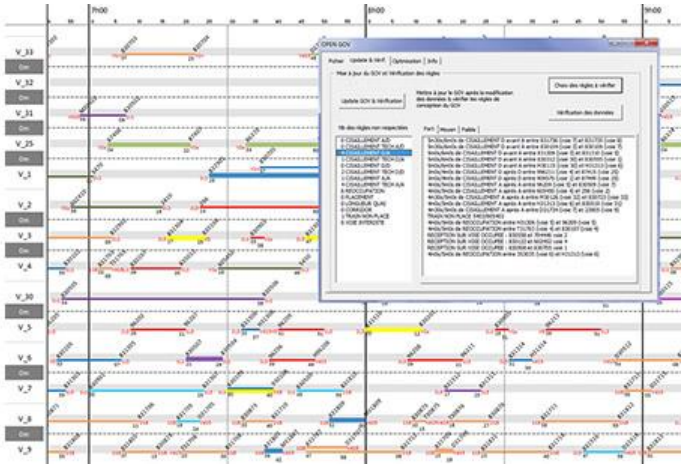
Railway operations optimization



Assigning trains to platforms

while respecting crossing constraints

Mechanical system design

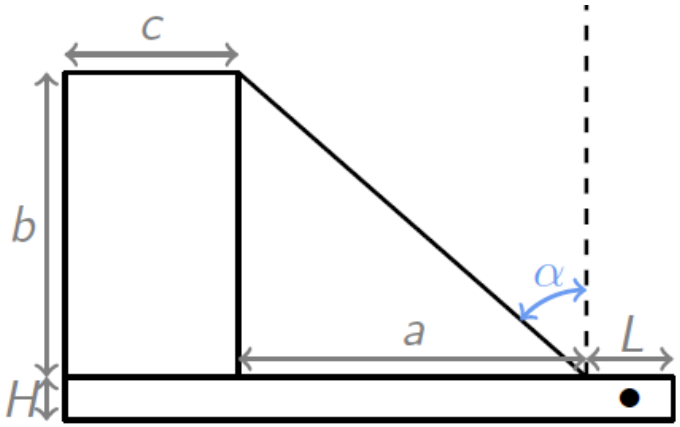
Designing sailboat weathervanes

Context

- Used to measure the wind, to drive sailboats
- Custom C++ code to simulate the physical behavior of the weathervane (time consuming)

Heterogeneous variables

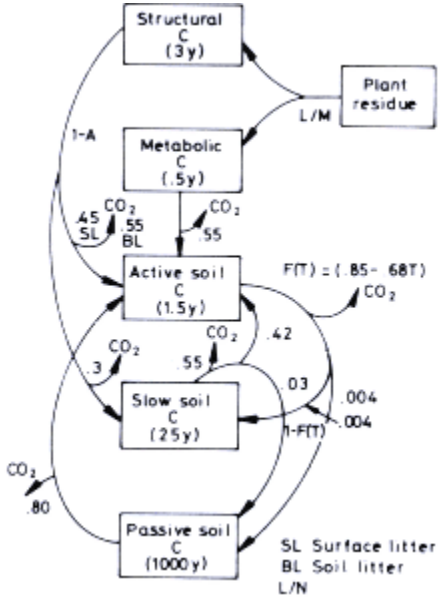
- Continuous decisions
- Boolean & integer decisions
- Black-box objectives/constraints



Agronomic system optimization

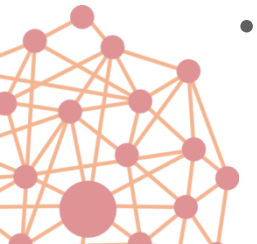
Optimal fertilization of agricultural parcels

How to best fertilize soils from mineral and organic fertilizers?



Highly-nonlinear dynamic system

- Nonlinear dynamics of N, C, K over time
- 1000+ on/off and continuous decisions
- Analytical or simulation-based



LocalSolver

Why being here?

Being close to industrial needs

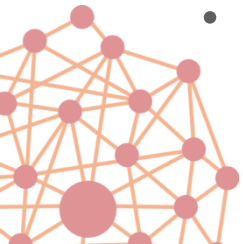
- Understanding the current needs in optimization in industry (at large)
- Benchmarking LocalSolver on business cases (newest, hardest ones)

Being close to scientific excellence

- Being on the edge of (& advancing) the state of the art
- Sourcing EU talents in maths & computer science
- Fostering interactions between discrete and numerical maths

Contributing to publicize industrial math successes

- At a EU level
- To industry itself ;-)
- To society
- To engage youngers in industrial maths



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