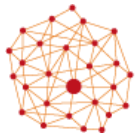


LocalSolver

Designing and optimizing an LNG supply chain using LocalSolver

Thierry Benoist, Frédéric Gardi, Romain Megel, Clément Pajean
Innovation 24 & LocalSolver, Paris

Michel Ben Belgacem, Delphine Leblanc, Frédéric Legrand, Sławomir Pietrasz
ENGIE Lab CRIGEN, Saint-Denis

VEROLOG 2016, Nantes

Who we are

Bouygues, one of the French largest corporation, €33 bn in revenues

http://www.bouygues.com

Innovation24

Operations Research subsidiary of Bouygues
20 years of practice and research

http://www.innovation24.fr

LocalSolver

Mathematical optimization solver developed by Innovation 24

http://www.localsolver.com

Clients

- Construction
- Medias & Advertising
- Telco & Retail
- Large Industry
- Energy
- Banking & Finance
- Transportation
- Logistics
- Food & Agribusiness
- Aerospace & Defense
- IT Services

ENGIE

Multinational electric and gas utility company, €70 bn in revenues

http://www.engie.com

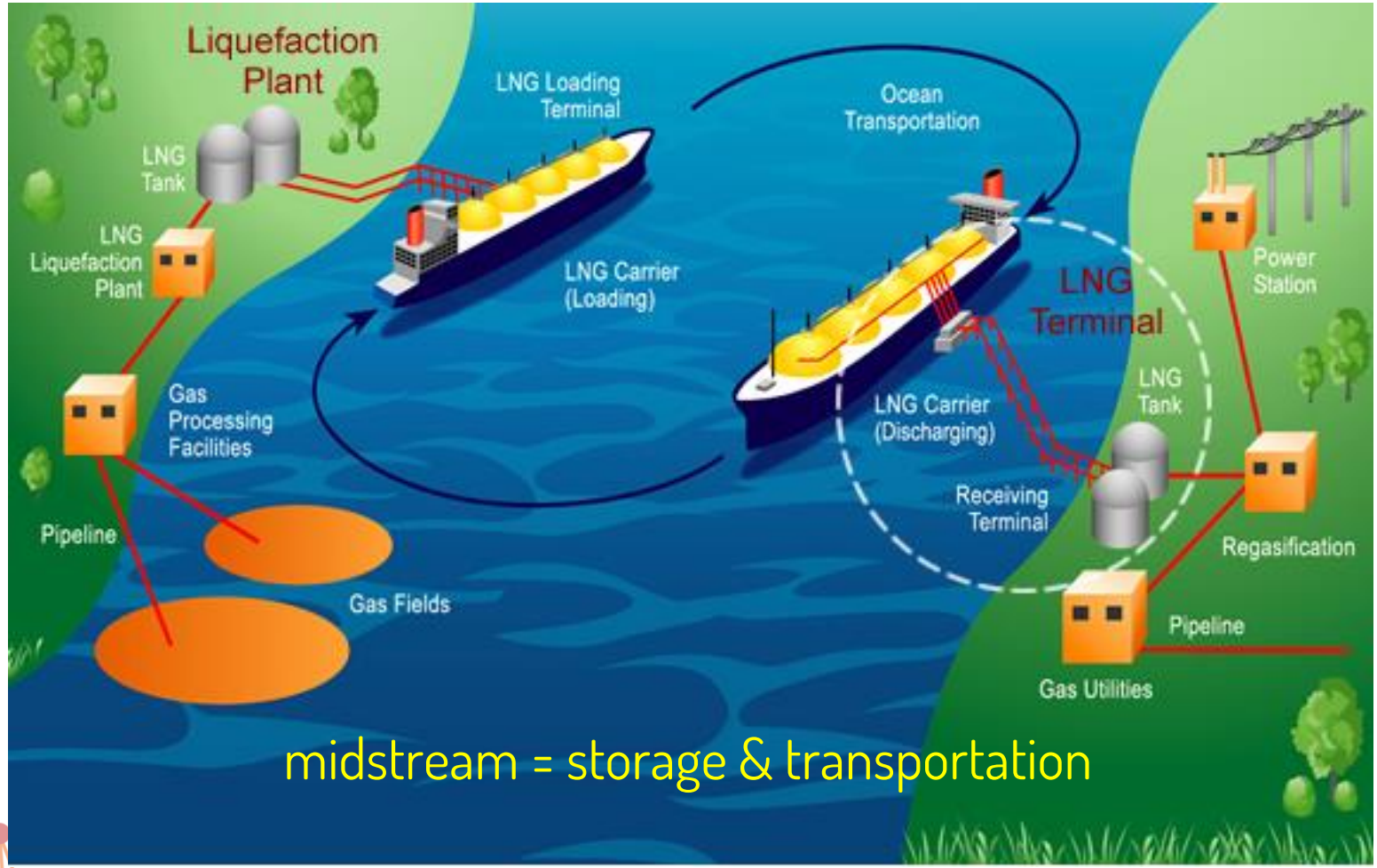
ENGIE is a major gas agent in Europe

- No. 2 buyer
- No. 1 transport and distribution network manager
- No. 1 storage operator
- No. 1 in Liquefied Natural Gas (LNG)

CRIGEN = ENGIE French historical R&D center on gas, new energy sources, and emerging technologies, with 350 people

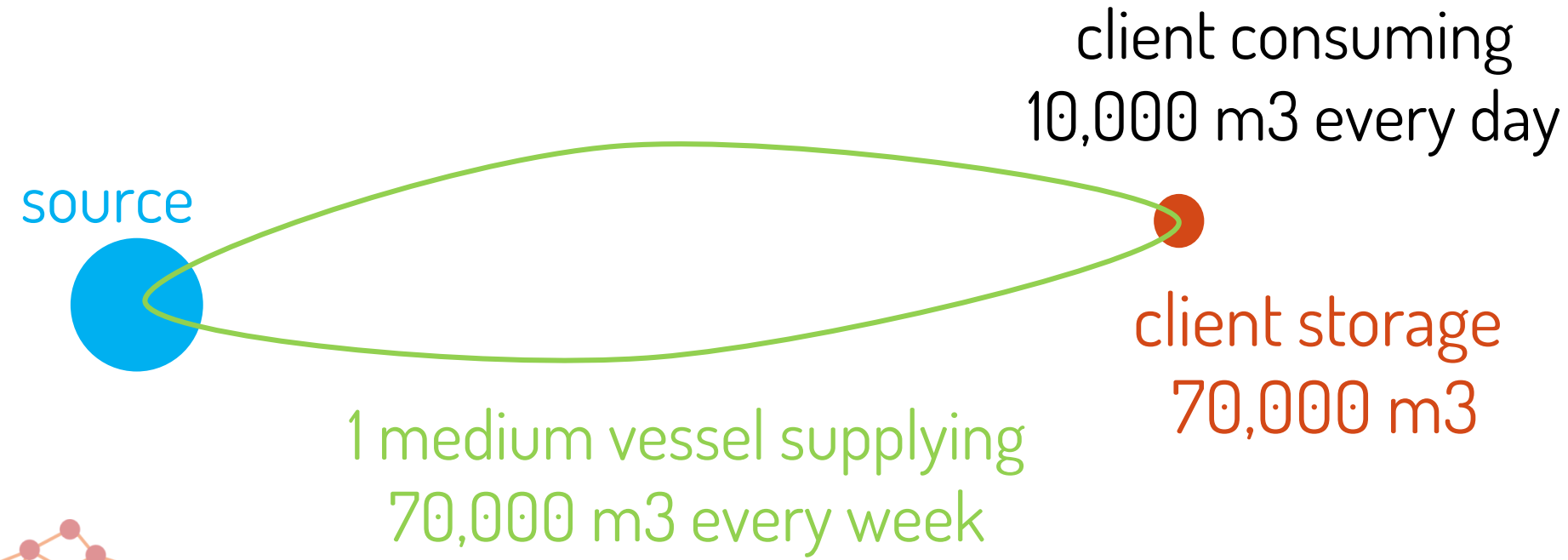
LNG value chain

upstream → midstream → downstream

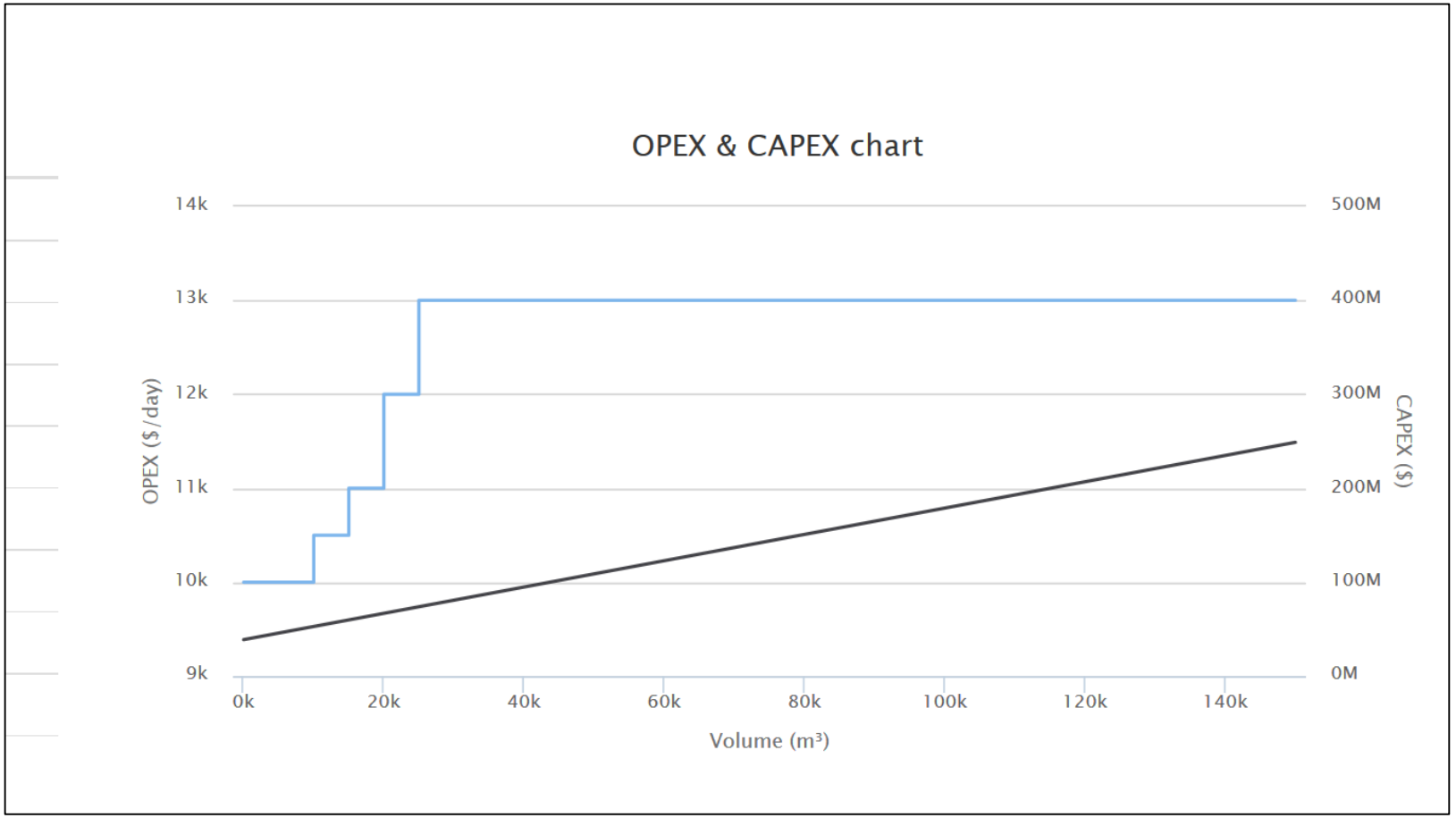


Dimensioning storage & transportation assets

→ Periodic, stationary, long-term replenishment planning of client storages by trailers (vessels or trucks)



Nonlinear costs



Vessel OPEX function in blue | Vessel CAPEX function in black

Toy example

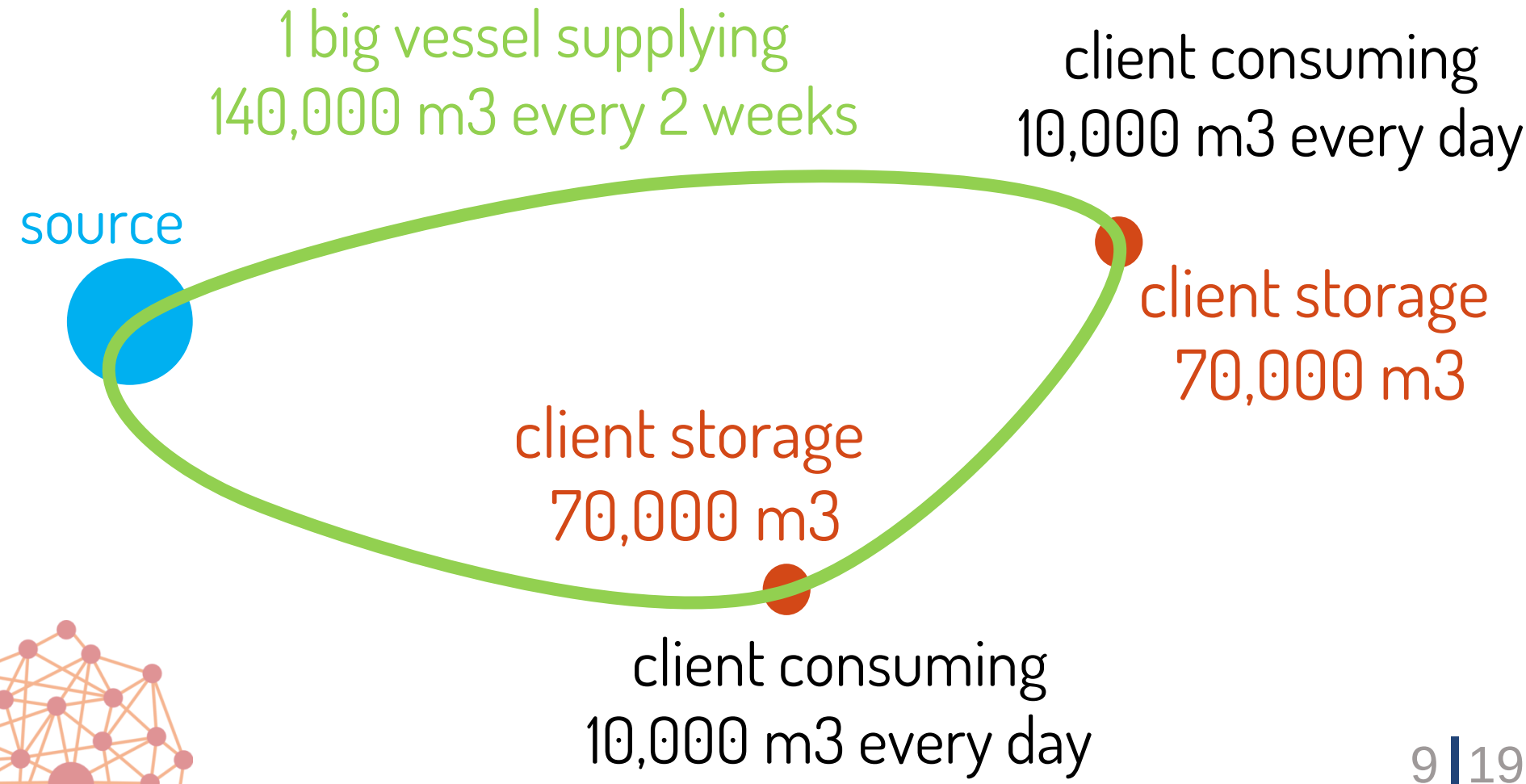
client consuming
10,000 m3 every day

source

client storage
140,000 m3

1 big vessel supplying
140,000 m3 every 2 weeks

Toy example


1 big vessel supplying
140,000 m3 every 2 weeks
client consuming
10,000 m3 every day
source
client storage
70,000 m3
client storage
70,000 m3
client consuming
10,000 m3 every day

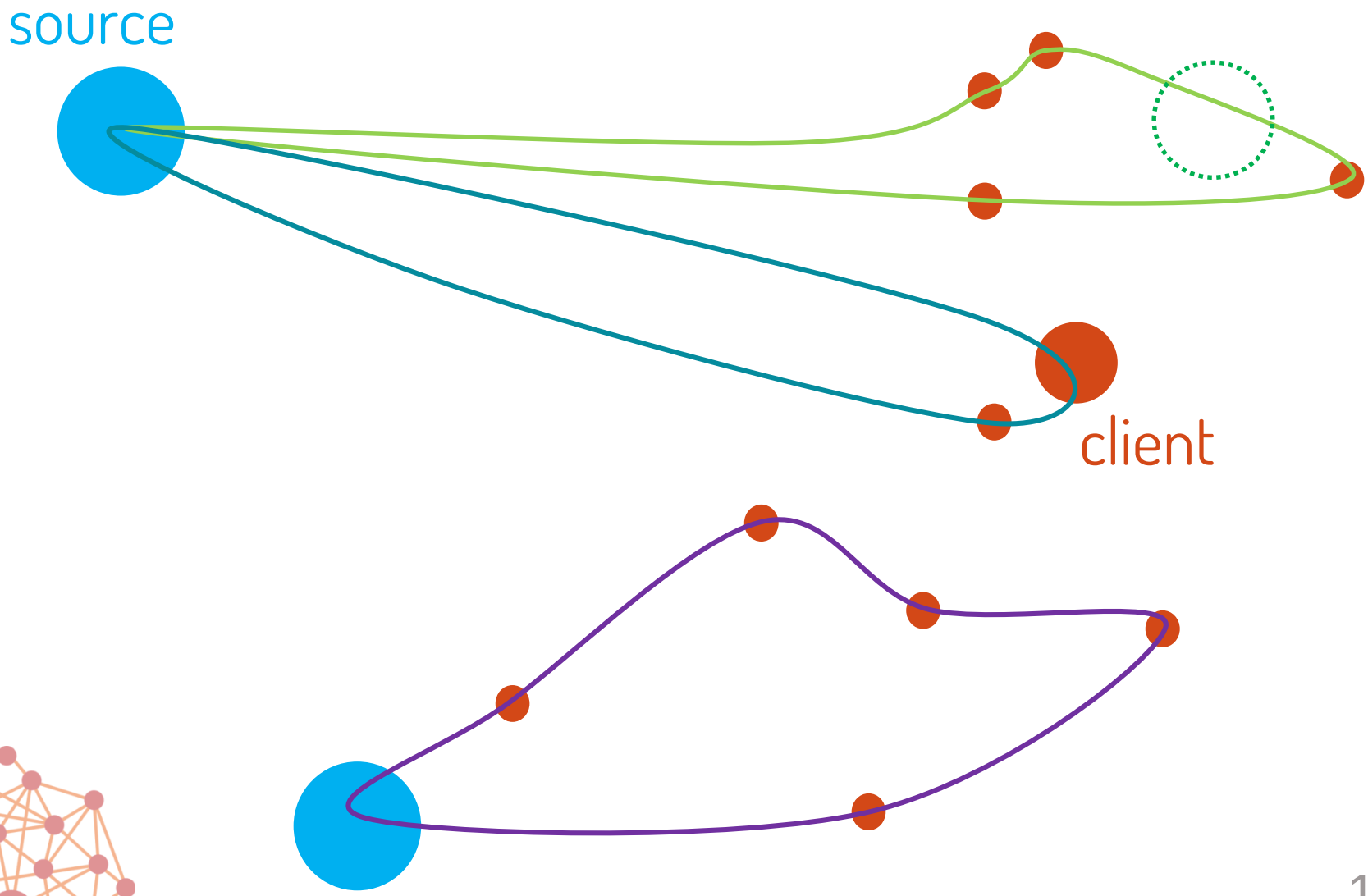
Hubs

source

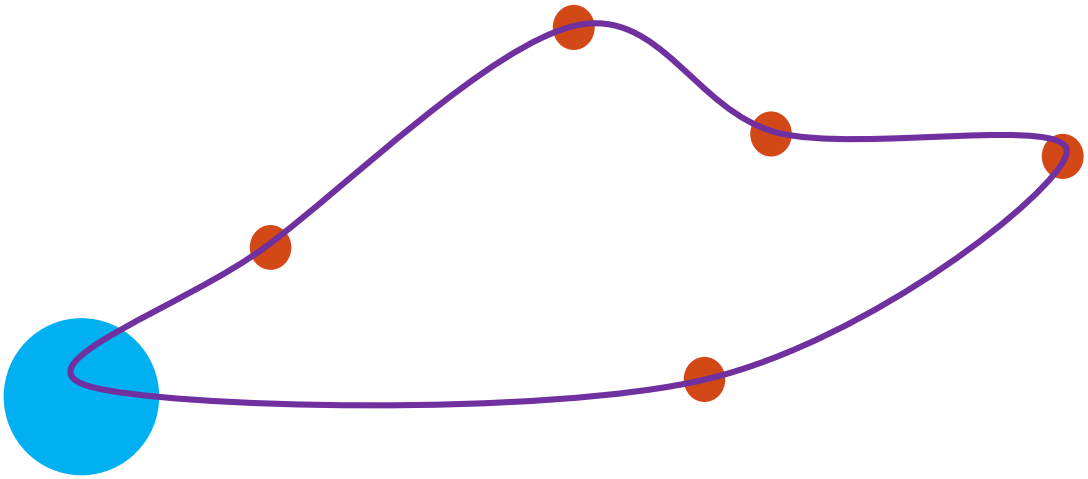
hub

client

Hubs



Hubs



Core optimization model

Decisions

- Which periodic routes to supply clients over the long run?
- What size for site storages? What size for trailers? How many ones?

Constraints

- Site storage and trailer sizes between min/max capacities
- Storage level dynamics: no runout, no overflow
- Trailer/site compatibilities

+ a number of real-life, business ingredients
Ex: all trailers delivering hubs must have the same size

Objective: minimize the Total Cost of Ownership (= CAPEX + OPEX)
of site storages and trailers over the operating horizon, generally 20 years

Resolution

Scale of the instances

- 5 sources
- 20 hubs
- 100 clients
- 10 type of trailers

Technical conditions of use

- Default running time: 90 seconds
- Modern but standard server: 8-core Intel Xeon, 2.70 GHz, 8 GB RAM

→ Direct resolution through LocalSolver

LocalSolver 6.0

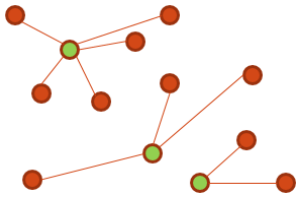
All-terrain optimization solver

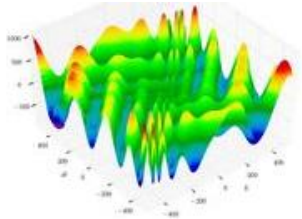
For combinatorial, numerical, or mixed-variable optimization

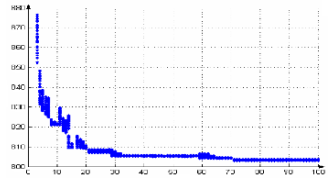
Suited for tackling large-scale problems

Quality solutions in minutes without tuning

The « Swiss Army Knife » of mathematical optimization







free trial with support – free for academics – rental licenses from 590 €/month – perpetual licenses from 9,900 €

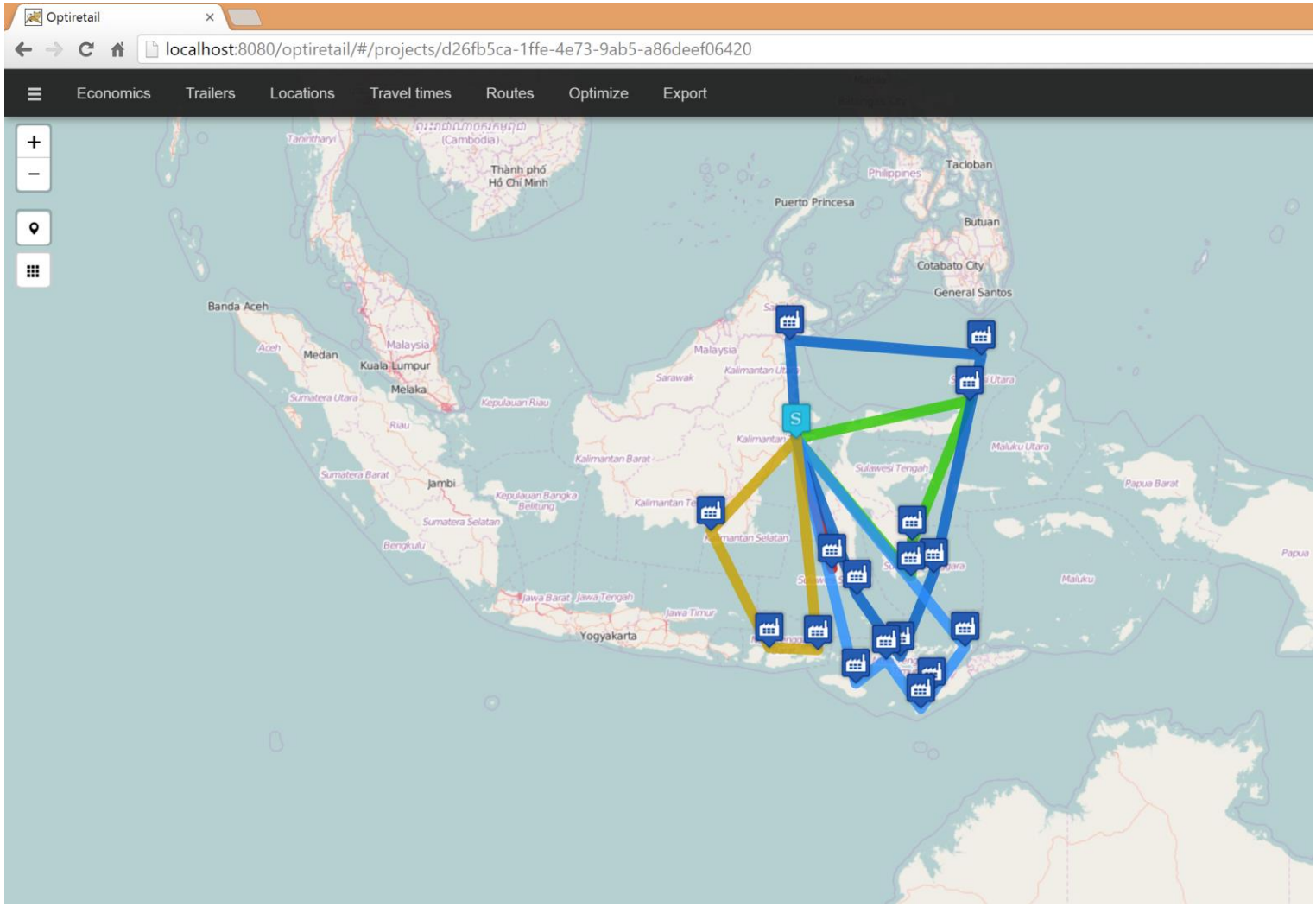
www.localsolver.com

Mathematical operators

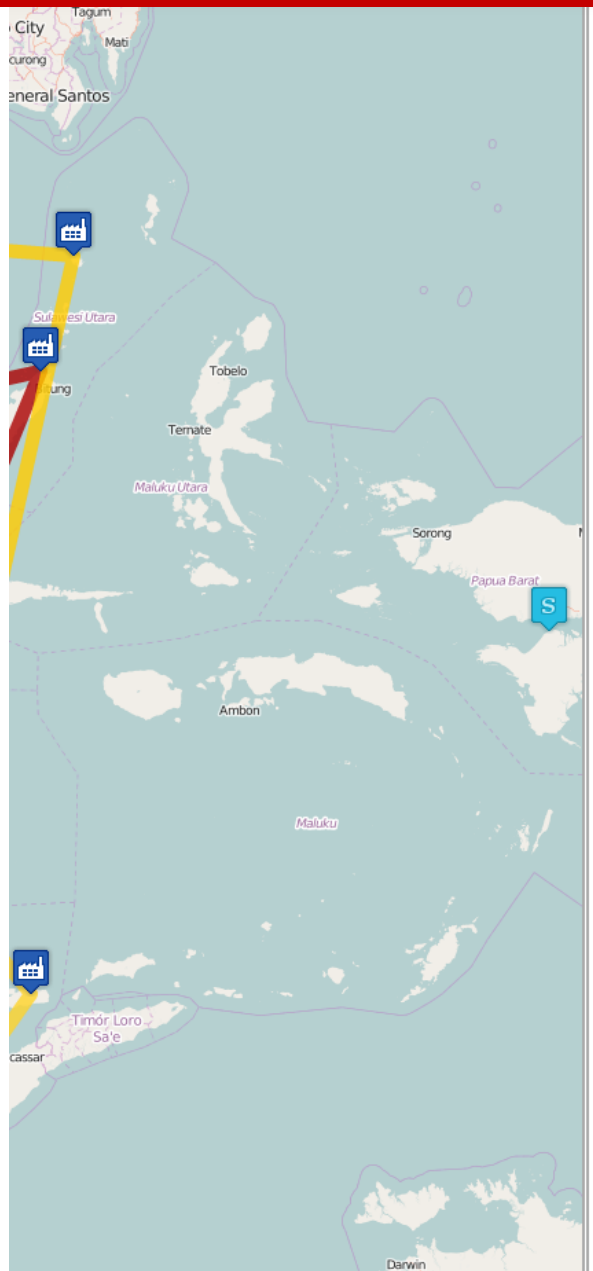
Decisional	Arithmetical			Logical	Relational	Set-related
bool	sum	sub	prod	not	eq	count
float	min	max	abs	and	neq	at
int	div	mod	sqrt	or	geq	indexof
list	log	exp	pow	xor	leq	partition
	cos	sin	tan	iif	gt	disjoint
	floor	ceil	round	array + at	lt	
	dist	scalar		piecewise		

+ operator call : to call an external native function
which can be used to implement your own (black-box) operator

OptiRetail software



OptiRetail software



Route #2

Routes are feasible and fulfill all the constraints.

1 trailers	18,724 m³/trailer
Capex	$65,113,184
Daily opex	$11,000

Number of trailers used on this route

1 2 3 4 5 6 7 8 9 10

	Delivery	Loading
source1	-	12,732 m³
site16	1,251 m³	-
site3	4,982 m³	-
site10	626 m³	-
site8	1,251 m³	-
site14	1,993 m³	-
source1	-	-
source1	-	13,262 m³
site9	1,251 m³	-
site6	4,982 m³	-
site17	626 m³	-
site7	2,479 m³	-
site2	1,251 m³	-
source1	-	-

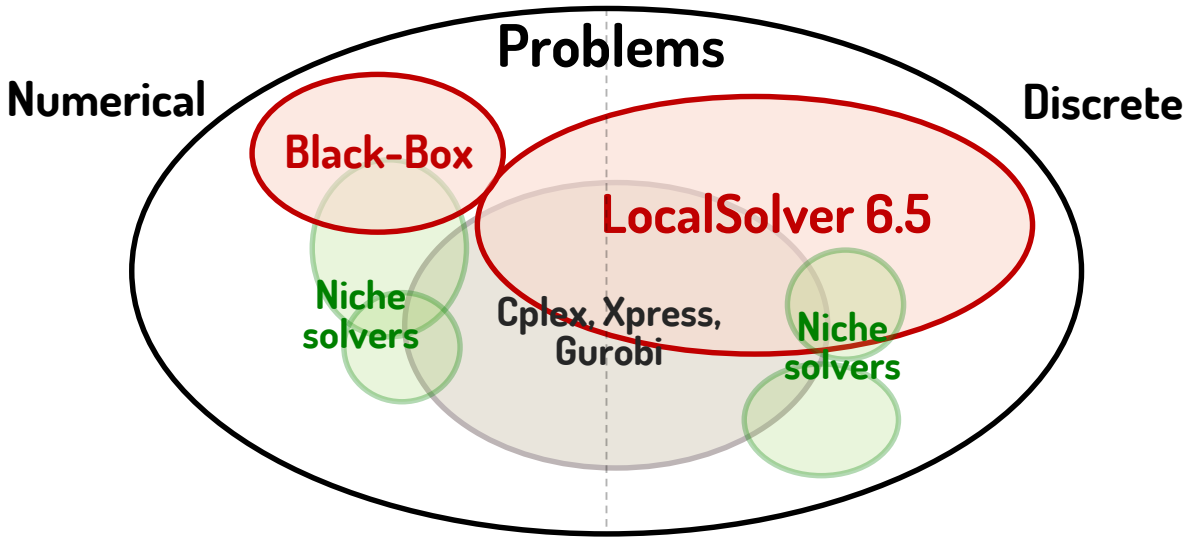
Add tour

LocalSolver 6.5

Major features

- Integration of the power of LP/MIP techniques into LocalSolver
- Performance improvement of set-based modeling features

→ Release planned for July 2016



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