

Optimization and Operations Research

Motivation

Michel Bierlaire

Introduction to optimization and operations research



Operations Research: a short history

17th-18th centuries

Decision problems involving uncertainty



D. Bernoulli



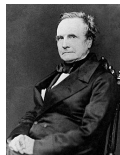
C. Huygens



B. Pascal

19th century

- ▶ Invented the first mechanical computer.
- ▶ Worked on transportation problems.

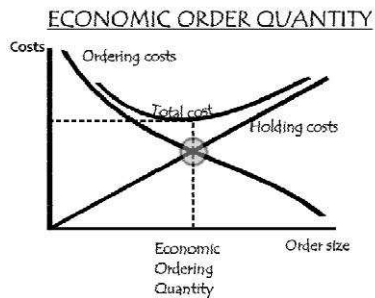


Ch. Babbage

Operations Research: a short history

Harris (1913)

Inventory management, optimization.



Operations Research: a short history

Patrick Blackett (1897–1974)

- ▶ Military operations.
- ▶ Organization of convoys.



George Dantzig (1914–2005)

Simplex algorithm (1945)



Key concepts

Modeling

Translation of real problems into mathematical formulation.

Optimization

Identification of the best possible configuration of a system.

Simulation

Imitation of the operations of a complex system in a computer.

Concrete research in our laboratory

Airlines

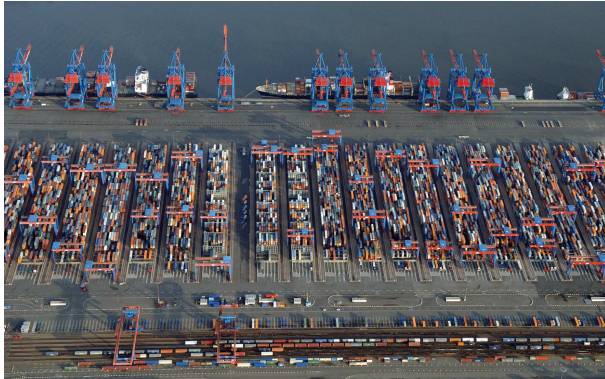


- ▶ Crew assignment.
- ▶ Re-optimization after a major disruption.

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Port operations

- ▶ Port of Gioia Tauro, Italy.
- ▶ Port of Ras-Al-Khaima, UAE.



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Urban traffic

- ▶ Traffic light optimization.
- ▶ Mitigation of congestion.



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Vehicle routing

- ▶ School bus.
- ▶ Parcel delivery.
- ▶ Collection of recycled waste.



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Train timetable

- ▶ Passenger-centric timetable.
- ▶ Disposition timetable in case of major disruption.



	18. 00	Wankdorf	Lyss		BIEL / BIEL
	18. 02	Zürich HB	Zürich Flughafen →	Winterthur	ROMANSHOF
S	18. 02	Felsenau Tiefenau	Worblaufen		UNTERZOL
S	18. 02	Ausserholligen	Kehrsatz		BELP
	18. 04	Thun	Spiez	Interlaken West	INTERLAKEN
	18. 04	Olten			BASEL SB
	18. 04	Fribourg	Romont	Lausanne Gare	GENEVE - A
Express	18. 05	Jegenstorf	Bätterkinden	Biberist	SOLOTHUR
S	18. 06	Ausserholligen	Köniz		SCHWARZENBACH
	18. 07	Thun	Spiez	Visp	BRIG
	18. 07	Burgdorf	Herzogenbuchsee	Langenthal	OLTEN
S	18. 08	Worblaufen			BOLLIGEN
S	18. 08	Bümpliz Nord	Brünau Westside	Ermensee Karsen	NEUCHÂTE
Express	18. 12	Münchenbuchsee	Lyss		BIEL / BIEL
S	18. 12	Wankdorf	Gümligen	Konolfingen	LANGNAU

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Electric bus

- ▶ TOSA: catenary-free electric bus
- ▶ Fast charging at bus stop.
- ▶ Which bus stops must be equipped?



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Accelerated moving walkways

- ▶ Post-car world: car-free cities.
- ▶ Promotion of walking.



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Clip-Air: a modular aircraft

- ▶ Capsules can be transferred on road or rail.
- ▶ For passengers, freight, or fuel.



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Activity-based models: an optimization approach

- ▶ In collaboration with SBB/CFF/FFS
- ▶ Reproduce the scheduling of a full day.



Course structure

Seven topics

1. Linear optimization: from geometry to algebra.
2. Linear optimization: the simplex algorithm.
3. Duality.
4. Networks and transshipment.
5. Shortest paths
6. Integer optimization — Branch and bound.
7. Unconstrained nonlinear optimization — Newton's method and line search.

Textbook

