合肥学院
HEFEI UNIVERSITY

Optimization Algorithms

1. Introduction

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Outline

1. Transportation Planning Example
2. Optimization Problems
3. Example Framework Scenario: Smart Manufacturing
4. Exact vs. Heuristic Algorithms
5. Summary and Outlook

What is Optimization?

- In this unit, we want to get a rough feeling about what optimization is.

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- In this unit, we want to get a rough feeling about what optimization is.
- So let us start by looking at some examples for optimization problems.

Transportation Planning Example

Transportation Planning: Task

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- What does this mean?

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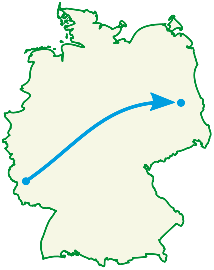
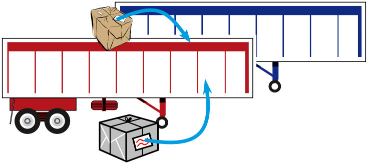
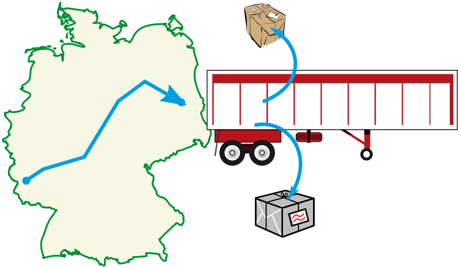
    1. Find routes on the map



Transportation Planning: Task

- Build a system which tells a logistics company what it needs to do to fulfill all transportation orders at minimum costs.[3–7]
    1. Find routes on the map and assignments of orders to containers





Transportation Planning: Task

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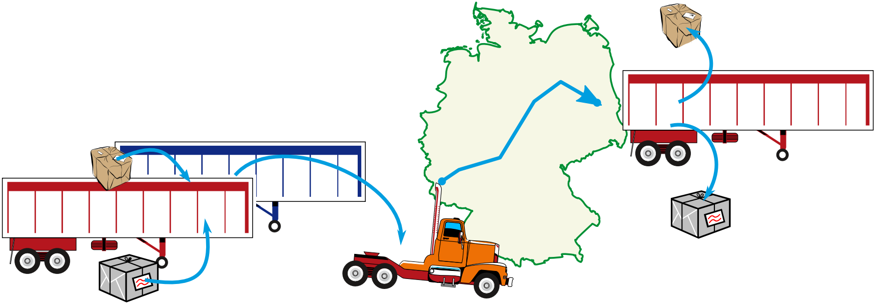
    1. Find routes on the map and assignments of orders to containers and containers to trucks



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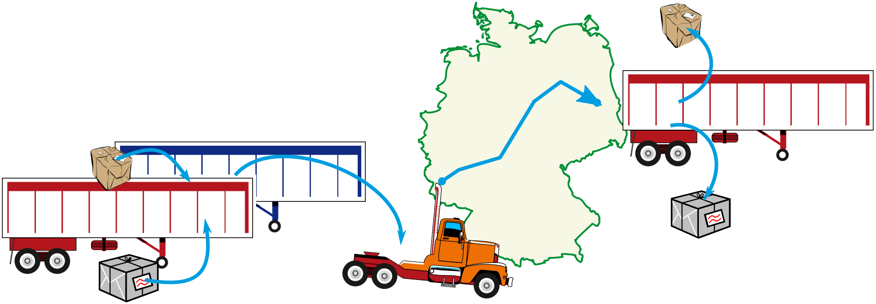

Transportation Planning: Task

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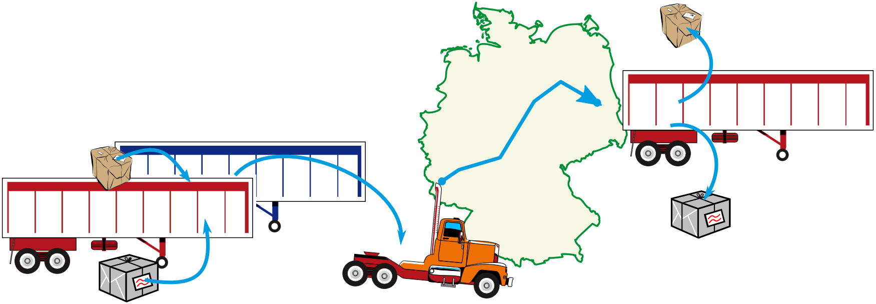

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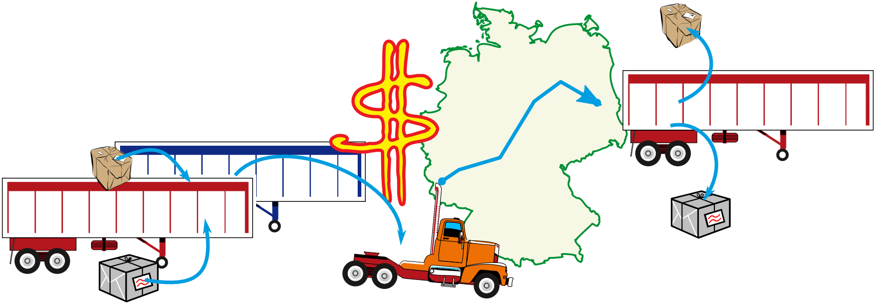

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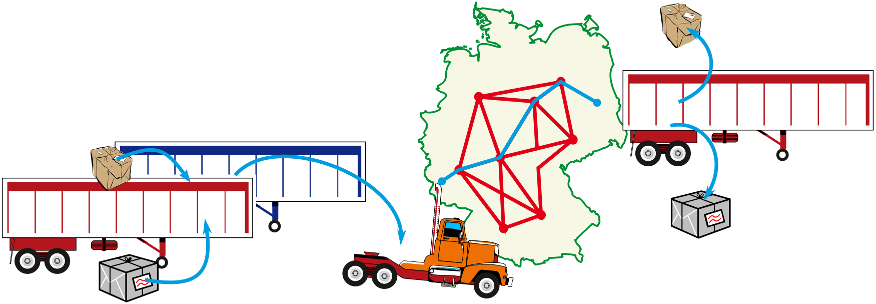

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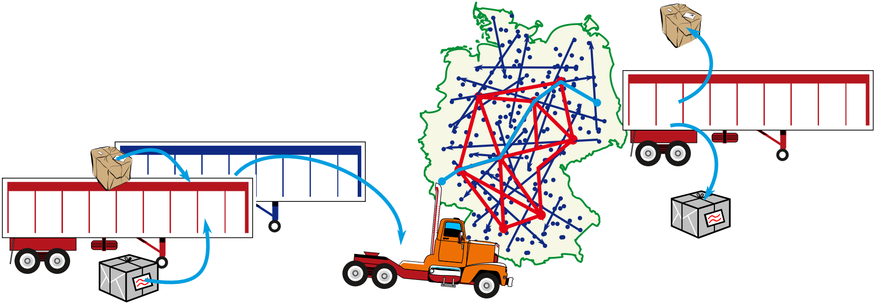

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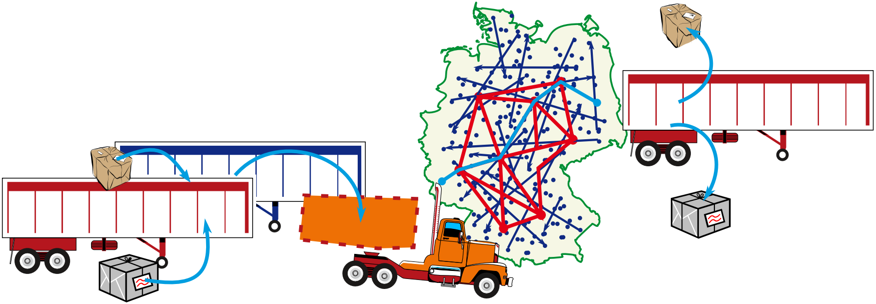

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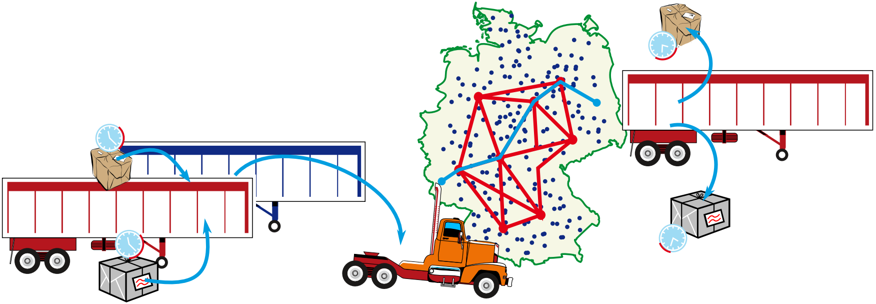

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  6. Time limit for optimization: 1 day

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- Before the problem was solved by hand, by manual planning with Excel sheets. . .
- With an optimization algorithm, we can get better solutions than that.
- In this course, you will learn how we can do such a thing.

Optimization Problems

What is optimization?

So what actually is optimization?[1 2 8]

What is optimization?

So what actually is optimization?[1,2,8]

What is optimization?

So what actually is optimization?[1 2 8]

What is the cheapest way to get from Hefei to Beijing?

What is optimization?

So what actually is optimization?[1] [2] [8]

What is the fastest way for our team to finish all the work?

What is optimization?

So what actually is optimization?[1,2,8]

How can I package these products using the fewest boxes?

What is optimization?

So what actually is optimization?[1 2 8]

How do I arrange the components on a circuit board so I need the shortest electrical cable length?

What is optimization?

So what actually is optimization?[1 2 8]

Definition (Optimization Problem: Economical View)

An optimization problem is a situation which requires deciding for one choice from a set of possible alternatives in order to reach a predefined/required benefit at minimal costs.

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Definition (Optimization Problem: Simplified Mathematical View)

Solving an optimization problem requires finding an input value $y^{\star} \in \mathbb{Y}$ from a set $\mathbb{Y}$ of allowed values for which a mathematical function $f : \mathbb{Y} \mapsto \mathbb{R}$ takes on the smallest possible value.

More Examples

- Many questions in the real world are optimization problems

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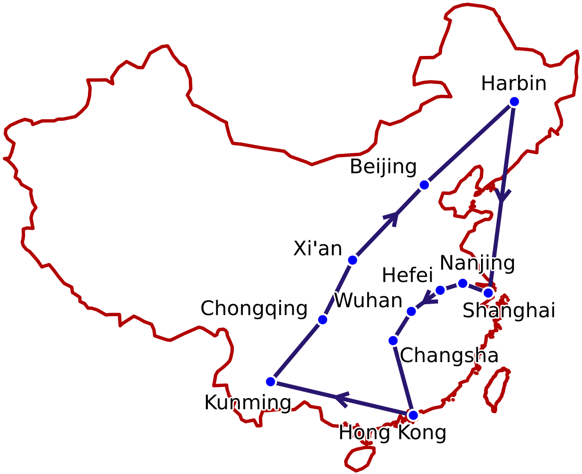
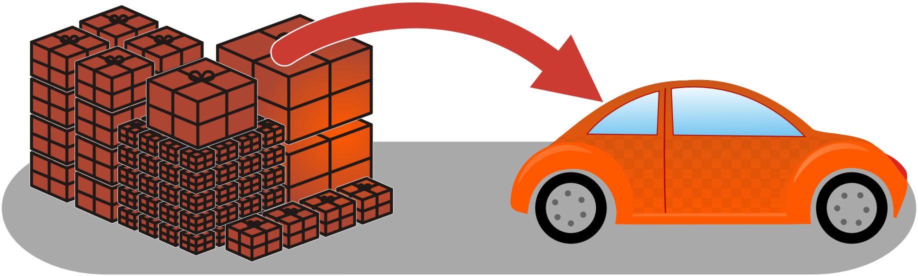
  - Find the shortest tour for a salesman to visit a certain set of cities in China and return to Hefei!



More Examples

- Many questions in the real world are optimization problems, e.g.,
  - Find the shortest tour for a salesman to visit a certain set of cities
  - I need to transport n items from here to another city but they are too big to transport them all at once. How can I load them best into my car so that I have to travel back and forth the least times?



More Examples

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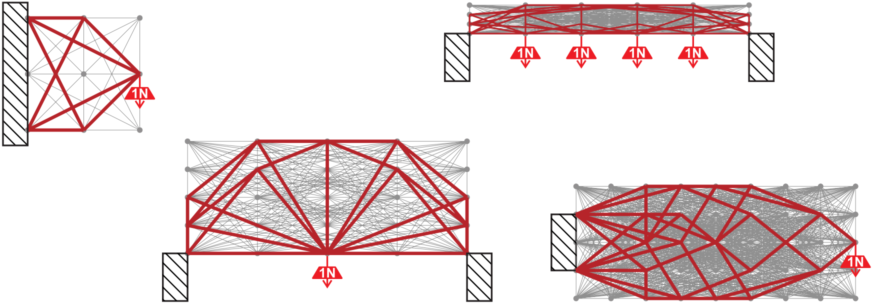
  - Find the shortest tour for a salesman to visit a certain set of cities
  - I need to transport n items from here to another city
  - How can I construct a truss which can hold a certain weight with at most a certain amount of iron?



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  - Find the shortest tour for a salesman to visit a certain set of cities
  - I need to transport n items from here to another city
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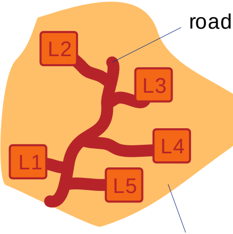
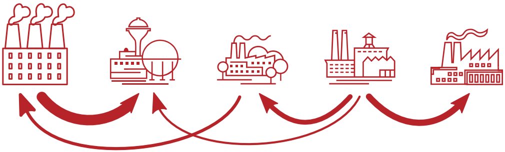
  - I want to build a large factory with n workshops. I know the flow of material between each two workshops and now need to choose the locations of the workshops such that the overall running cost incurred by material transportation is minimized.



the land with 5 locations



the 5 workshops which need to be assigned to the 5 locations and the different material flows between them

More Examples

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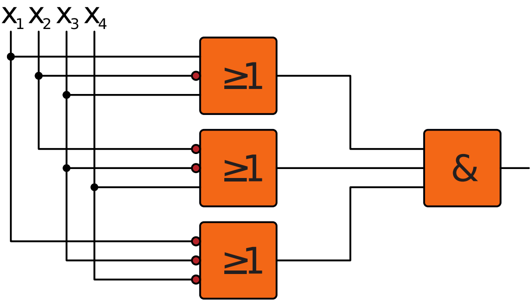
  - Find the shortest tour for a salesman to visit a certain set of cities
  - I need to transport n items from here to another city
  - Construct a truss which can hold a certain weight
  - Assign workshops to locations
  - Which setting of x_1, x_2, x_3, and x_4 can make $(x_1 \vee \neg x_2 \vee x_3) \wedge (\neg x_2 \vee \neg x_3 \vee x_4) \wedge (\neg x_1 \vee \neg x_3 \vee \neg x_4)$ become true?



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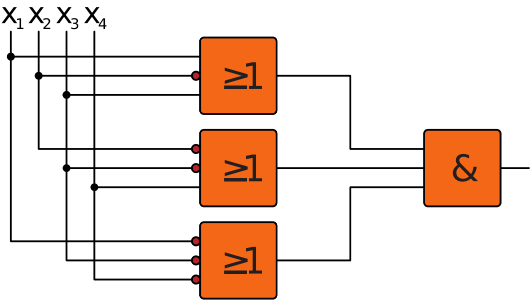

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  - I need to transport n items from here to another city
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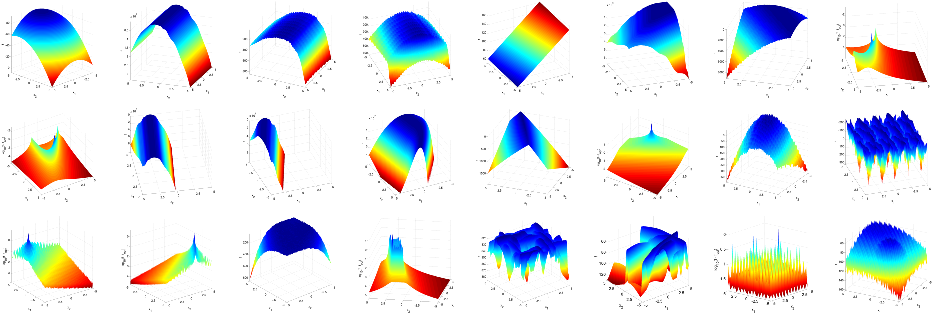
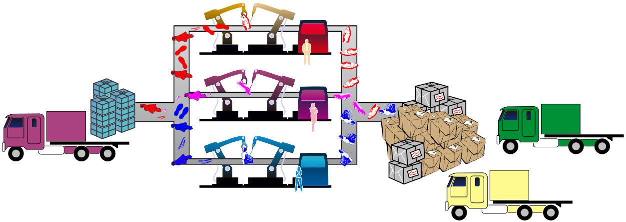
  - Satisfy Boolean formula
  - Find the minima of complex, multi-dimensional mathematical formulas



Example Framework Scenario: Smart Manufacturing

What is Smart Manufacturing?

Smart Manufacturing[9] . . .



Intelligent
Decisions
by
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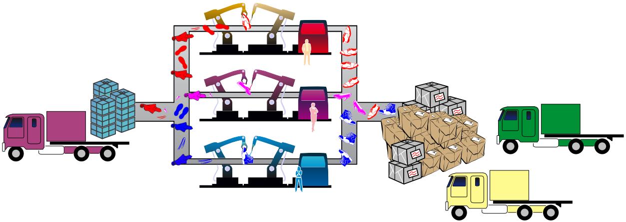
Smart Manufacturing[9]...

- has the goal of optimizing development, production, and logistics.



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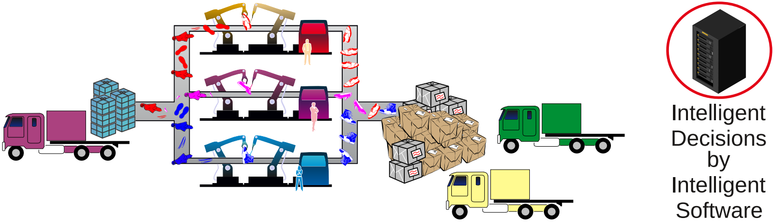

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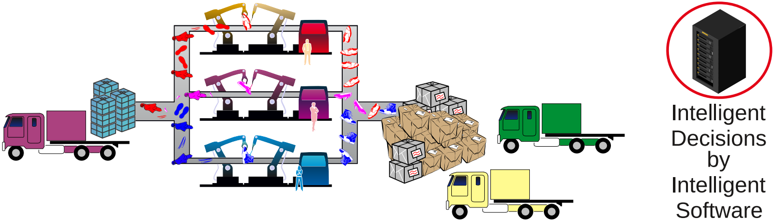
- utilizes advanced information and manufacturing technologies to enable flexibility in production processes to address a dynamic market.



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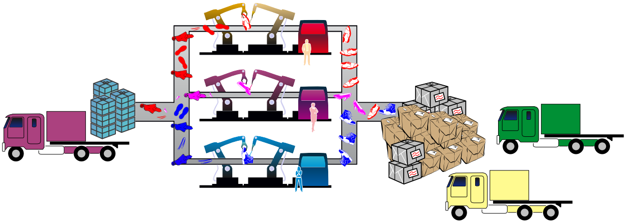
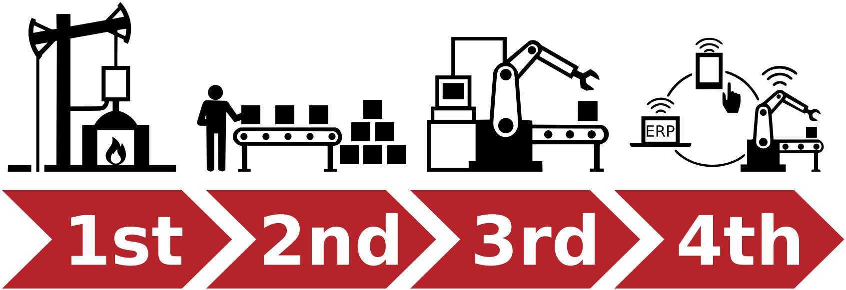
- requires increased workforce training for flexibility and use of the technology instead of simple repetitive tasks as in traditional manufacturing.



Intelligent Decisions by Intelligent Software

Industry 4.0[10]



mechanization	mass production	automation	intelligent production
water power	assembly line	computer	networks
steam power	electricity	electronics	cyber physical systems
waving loom			internet of things

Involved Technologies

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Relationship with Smart Manufacturing

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- No enterprise can waste money

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- All kinds of the previously mentioned problems can occur in manufacturing.
- For example, logistics exist inside and outside a company, and even on the factory floor!

Examples from Smart Manufacturing

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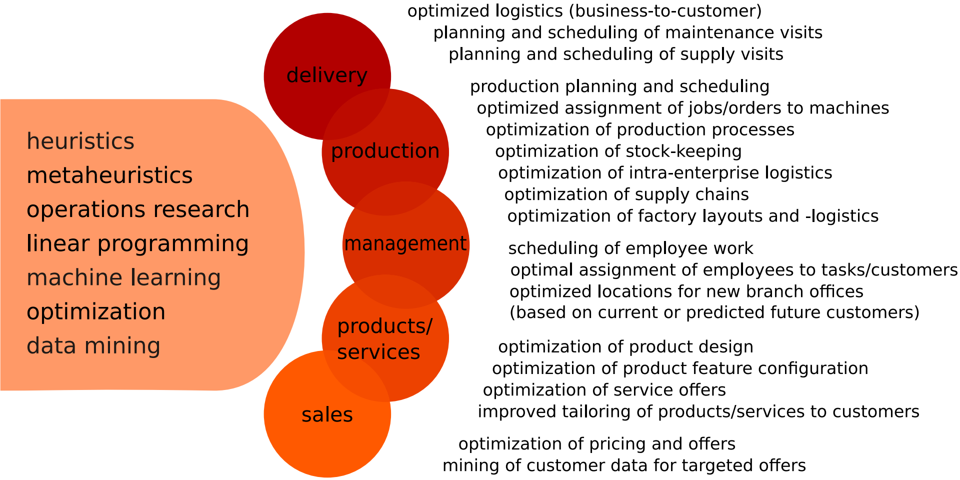

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  1. Developing and implementing a good algorithm that can solve the problem at hand and
  2. integrating this implementation into the existing software ecosystem.
- We focus only on the first of the two issues: optimization algorithms and their implementation.

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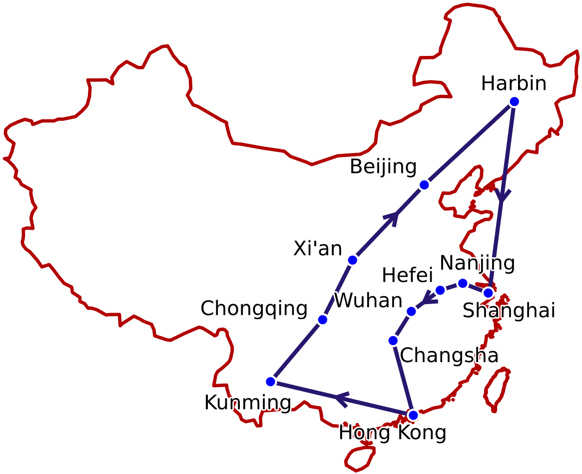

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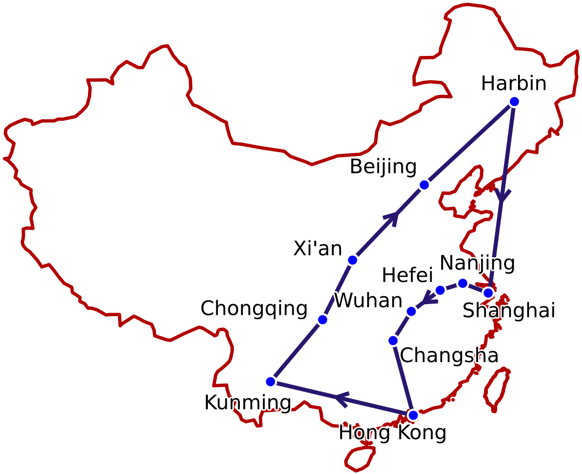

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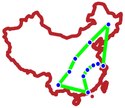

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    - Theory proofs that the time to find this tour may grow exponentially with the number of cities we want to visit in the worst case.[16–20]

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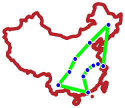

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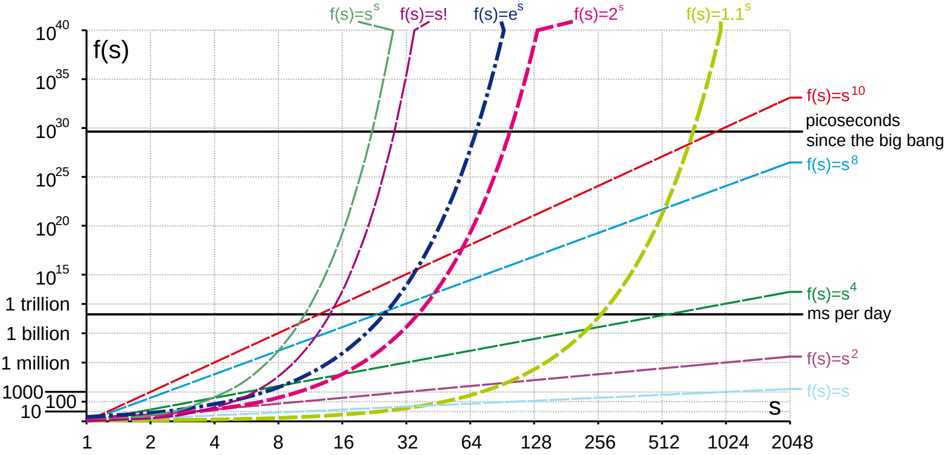

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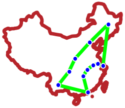

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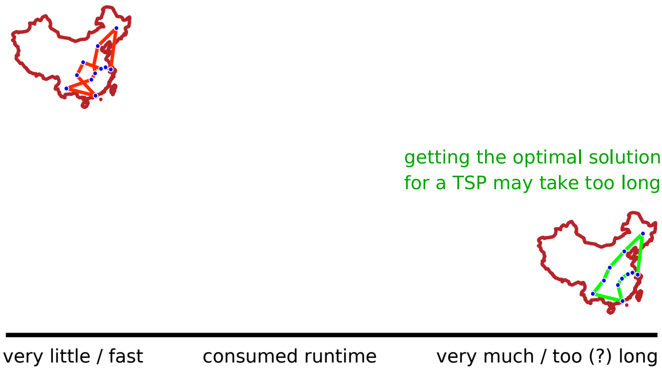

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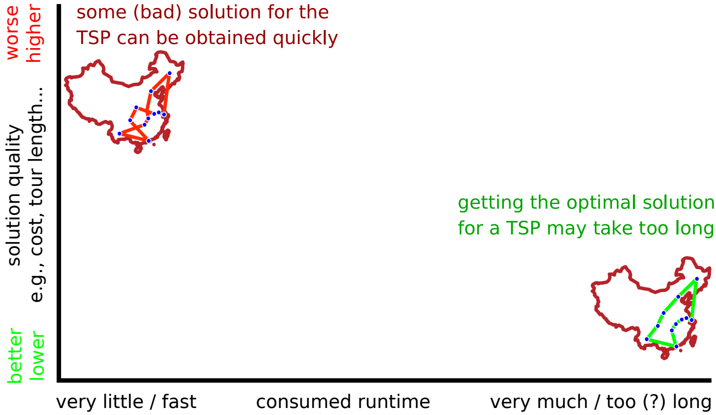

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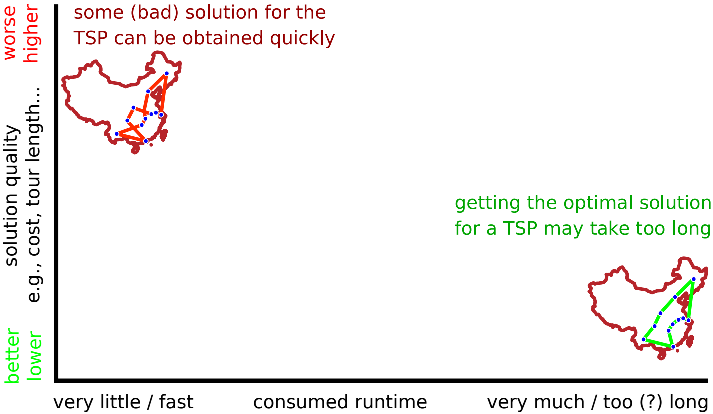

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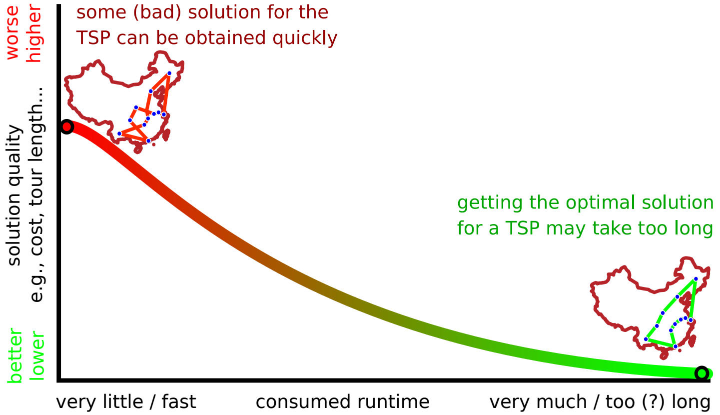

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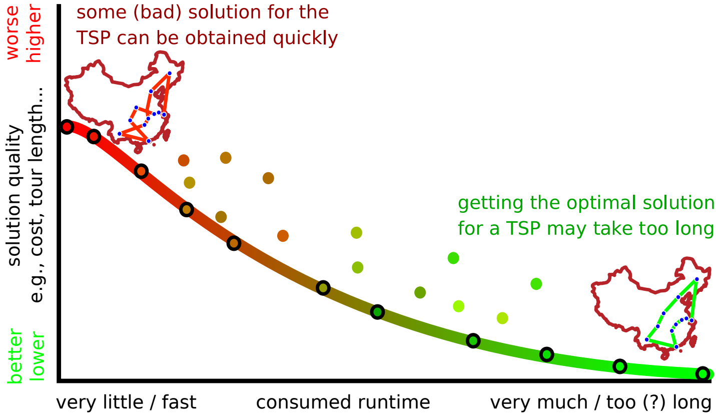

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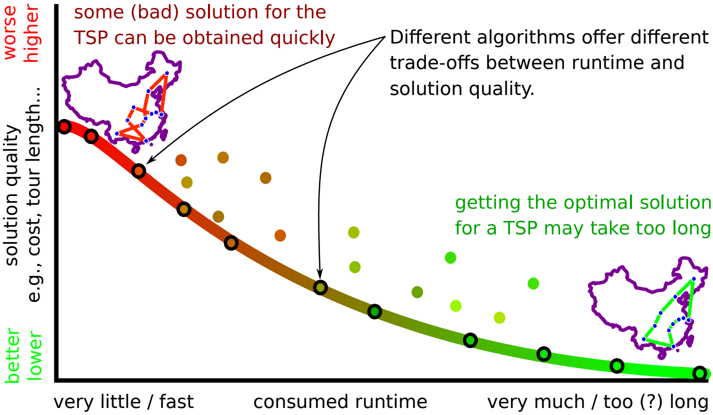

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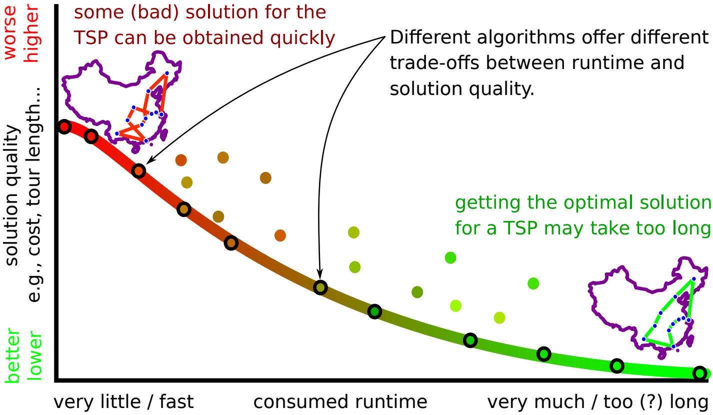

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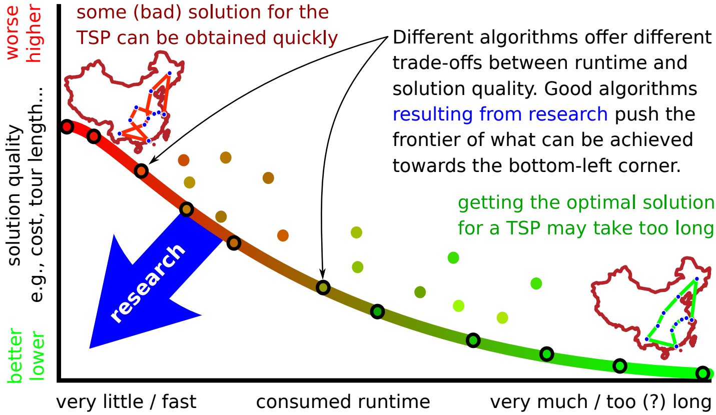

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- We will try to get a good perspective and understanding of the very basics needed to navigate in the domain of optimization.
- The goal is to be able to recognize and identify optimization problems as they occur in many fields, especially in Intelligent Manufacturing scenarios, and to develop basic algorithms to solve them.

谢谢

Thank you

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