

Comparing discrete optimisation solvers

How to make a fair comparison

Prof. dr. Frank Phillipson



Maastricht University

TNO innovation
for life

TNO innovation
for life

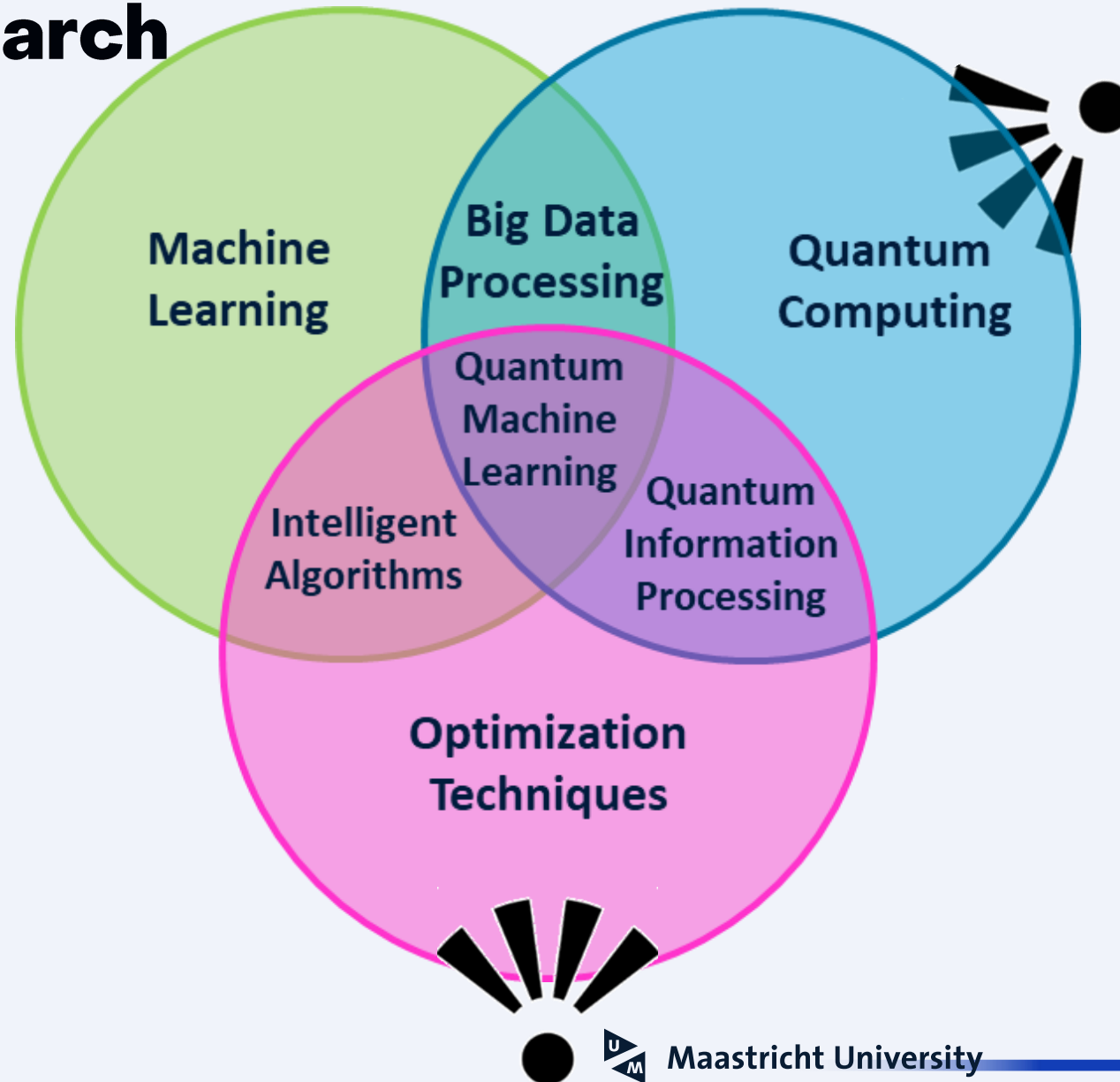


Agenda



1. About me, TNO, NATO
2. About RTG NATO SET-IST-339 & METRICS
3. View on METRICS for combinatorial optimisation problem solvers
4. Conclusions

Area or research



QUANTUM @ TNO

MILITARY & SECURITY APPLICATIONS
OF QUANTUM TECHNOLOGY



ALGORITHMS – COMPUTING APPLICATIONS
QUANTUM CRYPTOGRAPHY – PQC – MIGRATION
QUANTUM (INTER)NETWORKS AND COMMUNICATION
ECOSYSTEM DEVELOPMENT AND STRATEGY CONSULTING

QUANTUM COMPUTING ENGINEERING
QUANTUM COMMUNICATION (IN SPACE)
QUANTUM SENSING



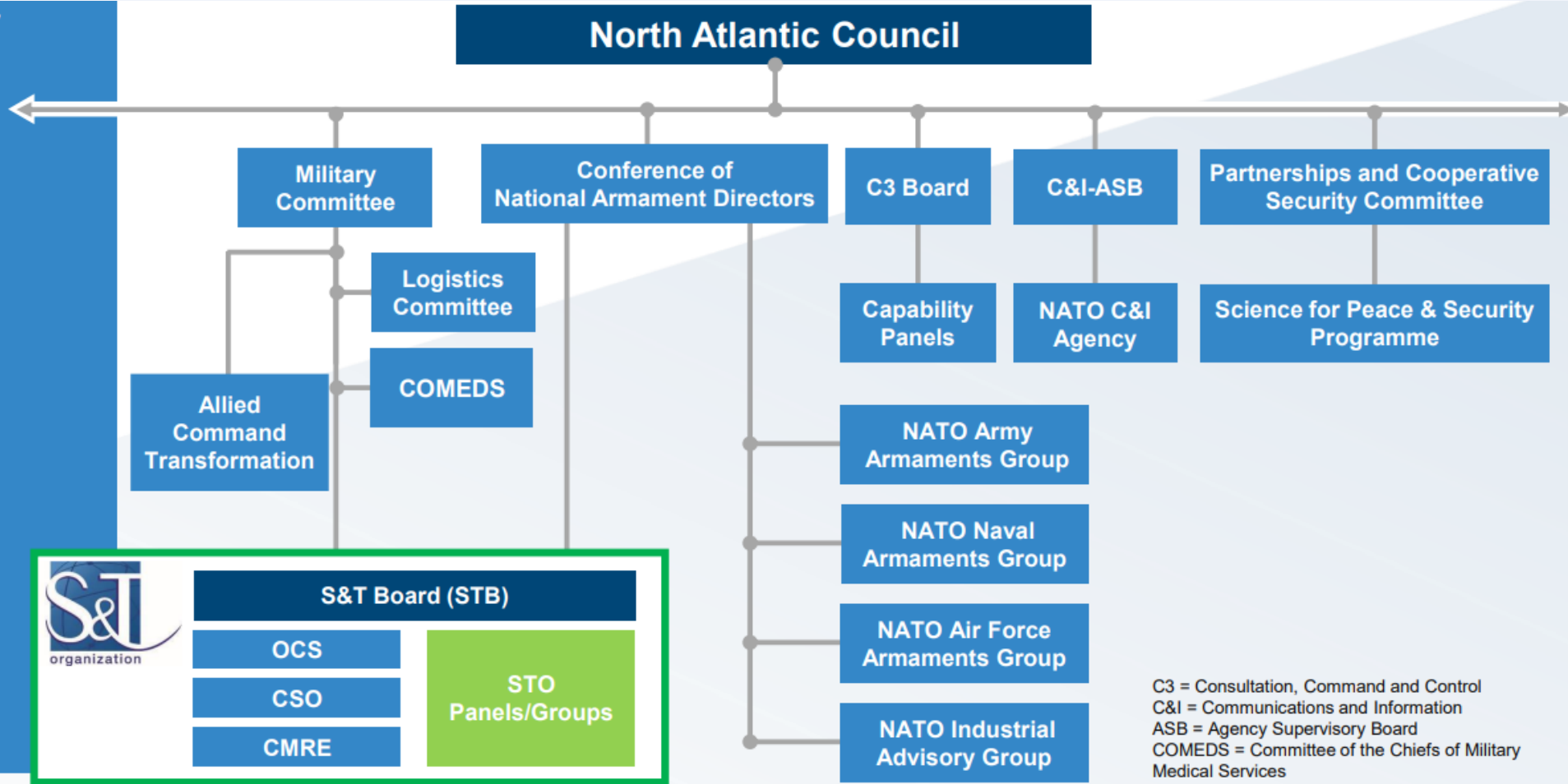
NATO ORGANISATION


The NATO Science & Technology Organization (STO) is a NATO subsidiary body to the North Atlantic Council (NAC).

The STO reports through the Conference of National Armaments Directors and NATO's Military Committee to the NAC and liaises with other relevant organizations within the Alliance.

NATO STO's strategic goals are to

- Accelerate Capability Development;
- Deliver Timely, Targeted Advice; and
- Build Capacity through Partnerships.





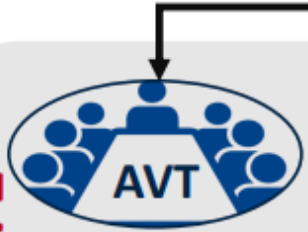
S&T Board (STB)	
OCS	STO Panels/Groups
CSO	
CMRE	

Level 2

Level 3

governance ↓

↑ reporting and advice



Applied Vehicle Technology Panel



Human Factors & Medicine Panel



Information Systems Technology Panel



NATO Modeling & Simulation Group



System Analysis & Studies Panel



System Concepts & Integration Panel



Sensors & Electronics Technology Panel



Collaboration Support Office



STO Collaborative Programme of Work (CPoW)

scientific knowledge and capability development in Nations

support

RTG NATO SET-IST-339 > GOALS

Investigations of Military Applications of Quantum Computing

ACTIVITIES:



Overview of state
of the art



Development of
Novel Quantum
Algorithms



Prototype
Implementations
and Experimental
Demonstrations

GOALS:



Improved Data
Analysis and
Intelligence
Analysis

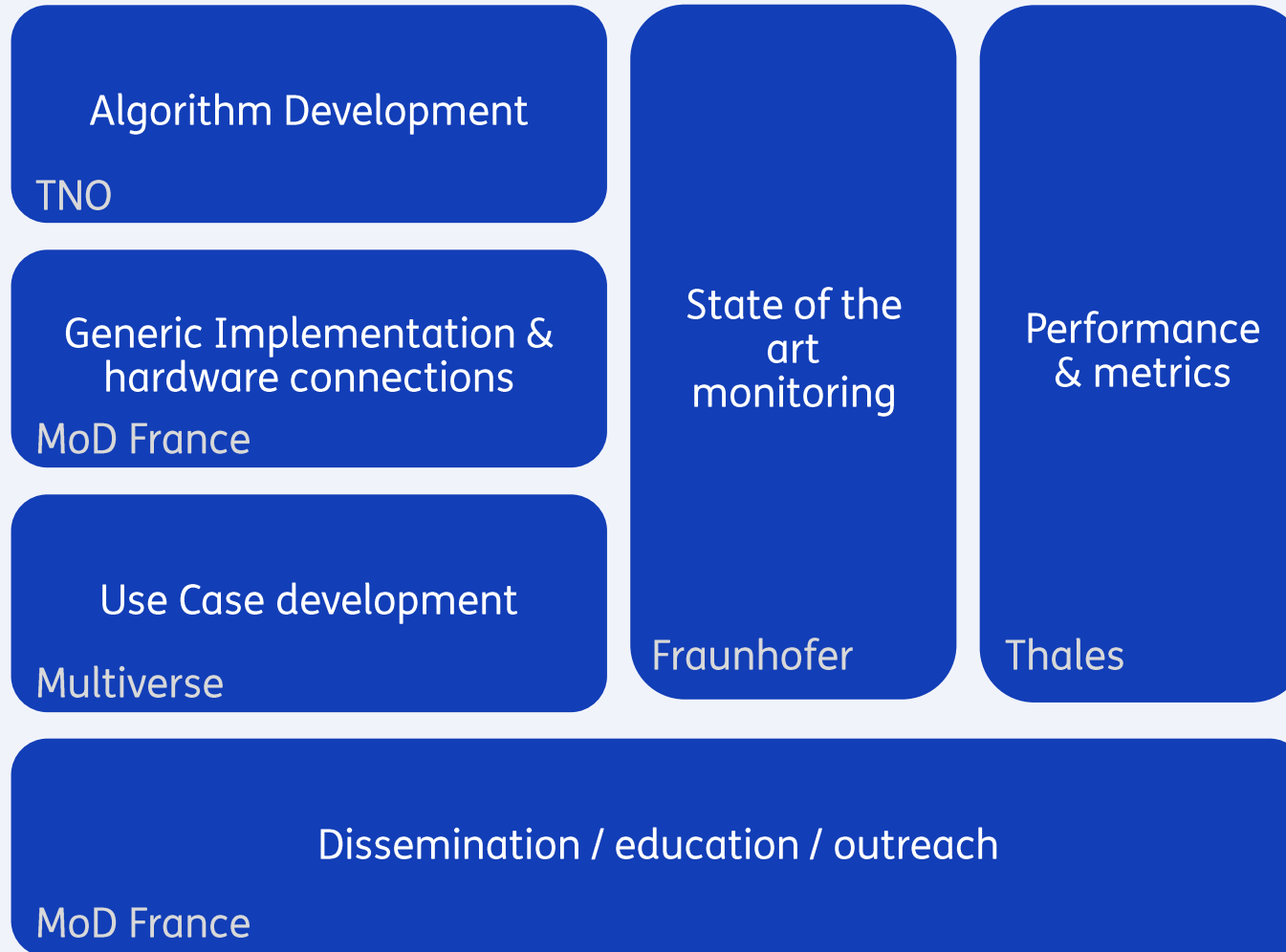


Enhanced Military
Decision-Making



Demonstration of
Quantum
Speedup and
Benefits

RTG NATO SET-IST-339 > PROJECT



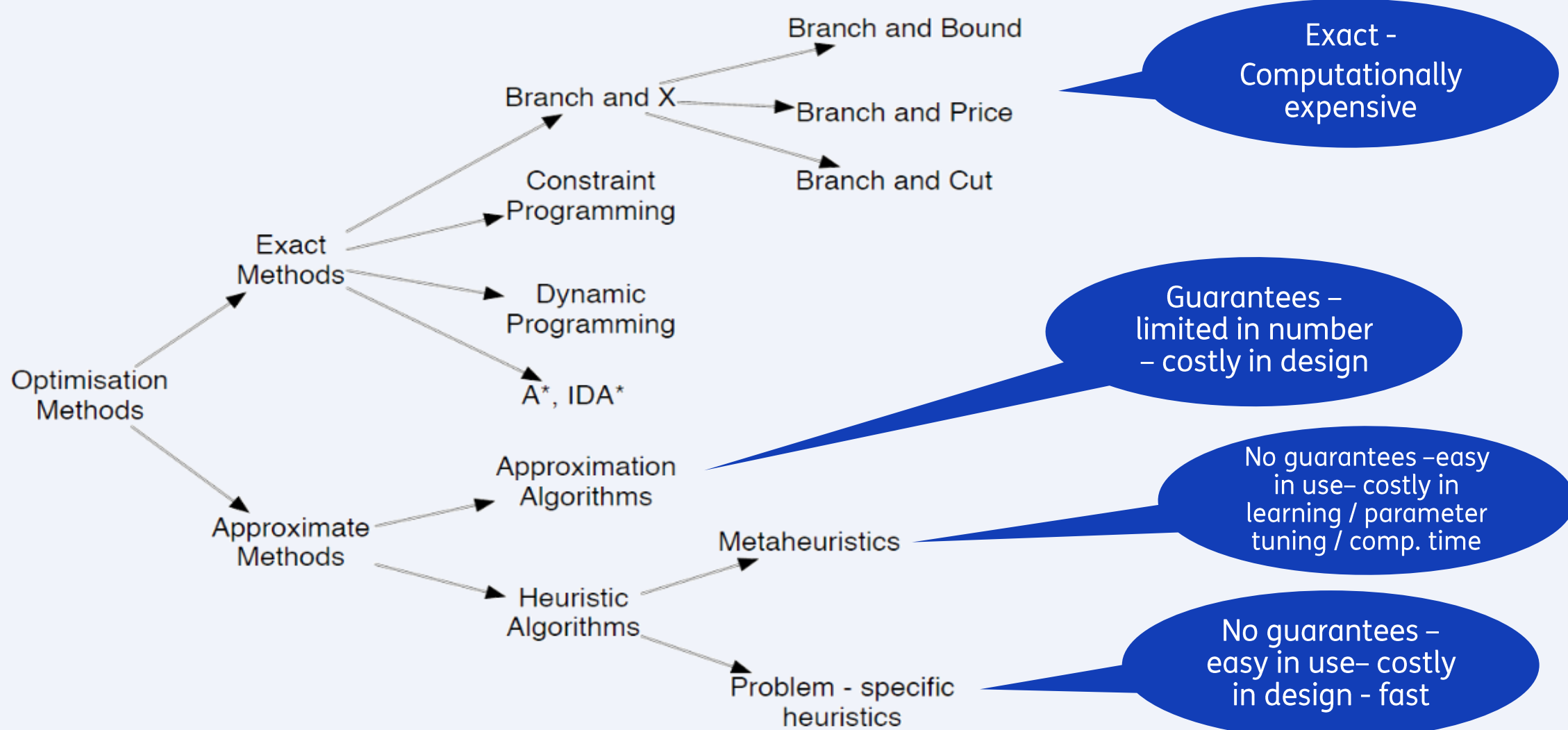
Performance & Metrics Overview

- Goals:
 - Standardize NATO QC benchmarks.
 - Provide robust and adaptable QC benchmarks.
- Description:
 - Overview of performance metrics
 - Survey and adapt QC benchmarks for NATO military applications
 - Develop user-oriented multi-criteria benchmark.
 - Create hardware-agnostic compiler benchmark.
 - Run benchmarks on QPUs.
 - Recommend standardized benchmarks for NATO QC efforts.

Comparing solvers for combinatorial optimisation problems



CATEGORIES OF SOLVERS



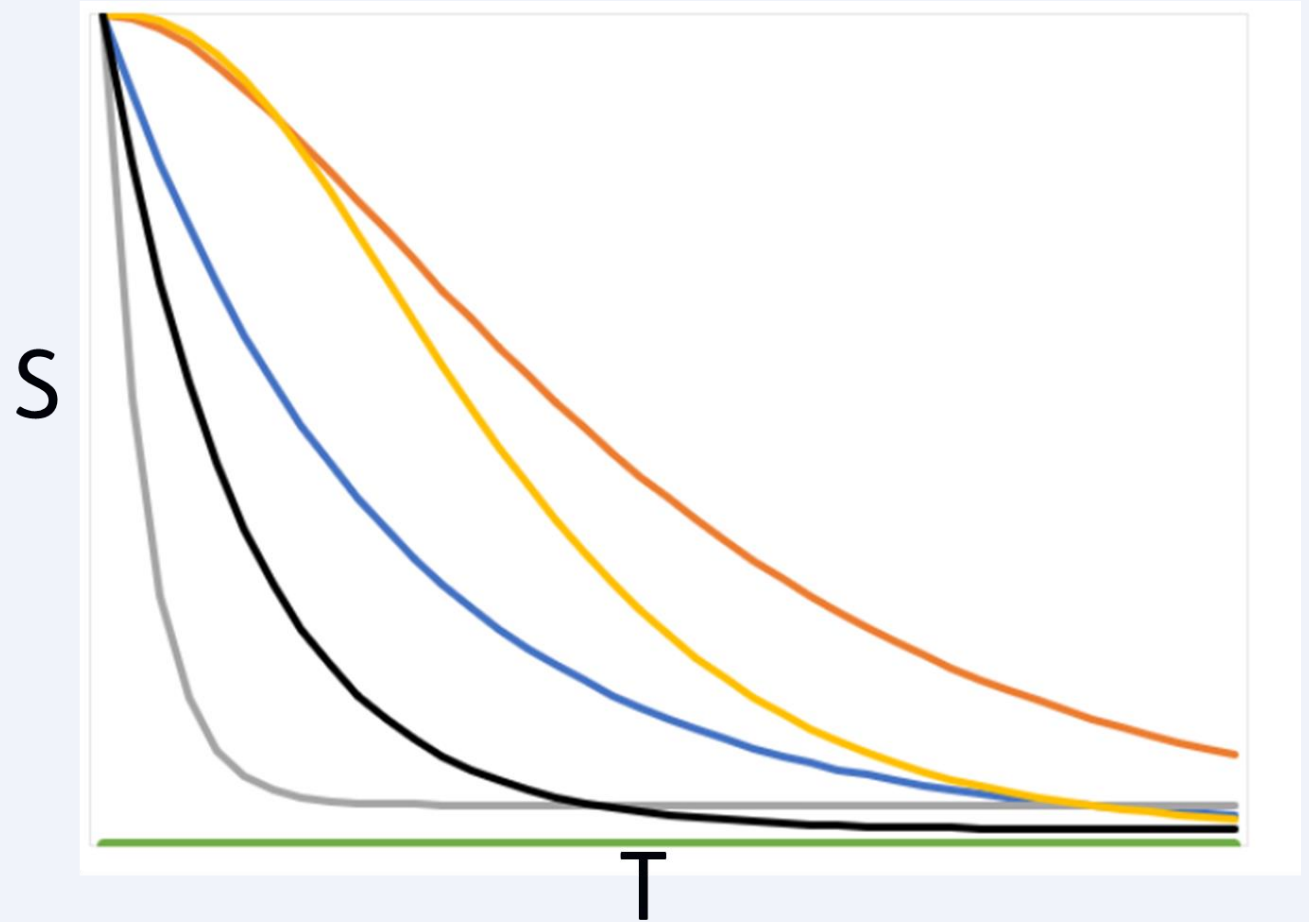
Comparison

- Solution quality
- Running time
- Preparation time
- Design time

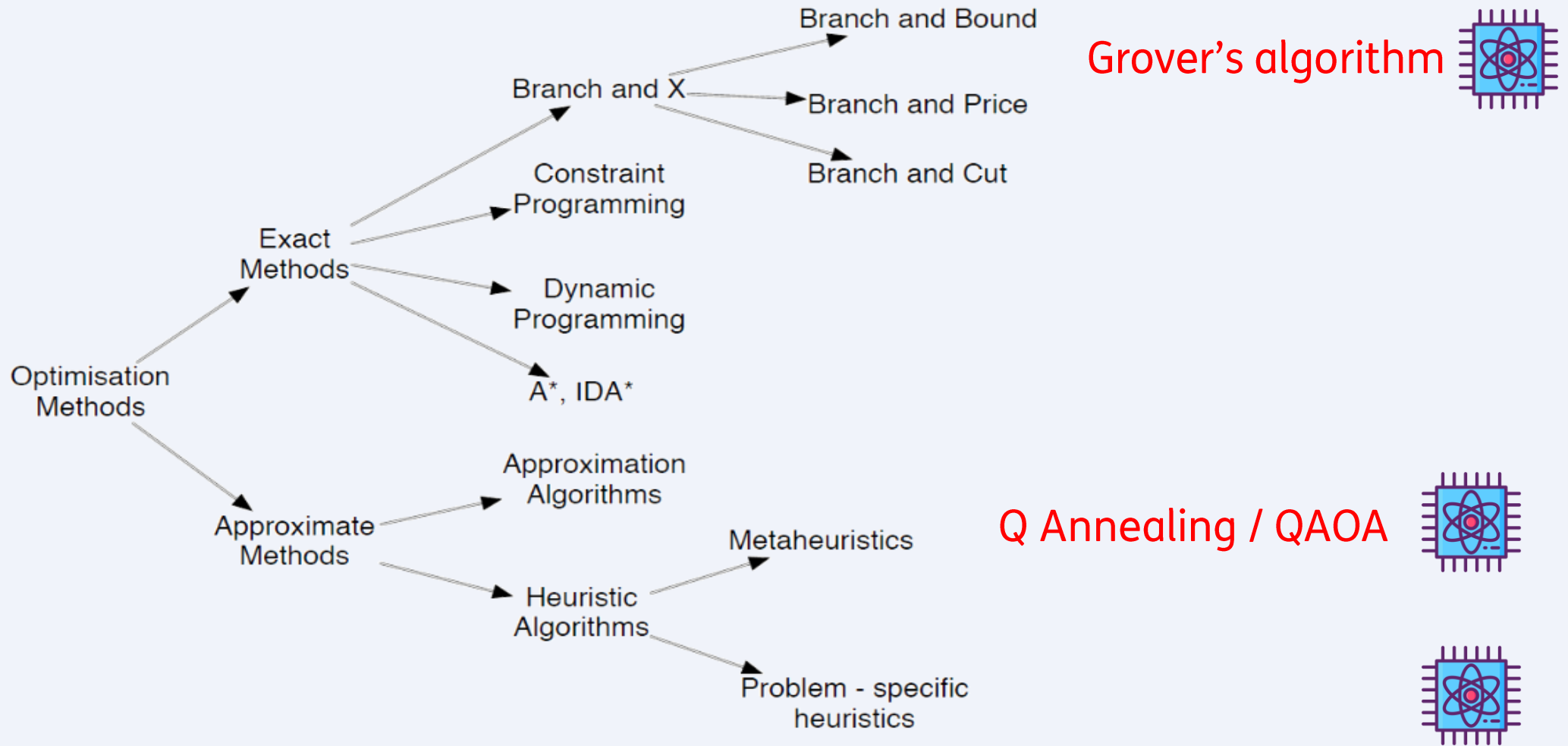
	Solution	Design	Preparation	Running
Exact	+++	++	++	--
Approximation	++	--	+	+
Metaheuristics	0	+	--	0
Problem Specific heuristics	+	-	+	++

S-T diagram

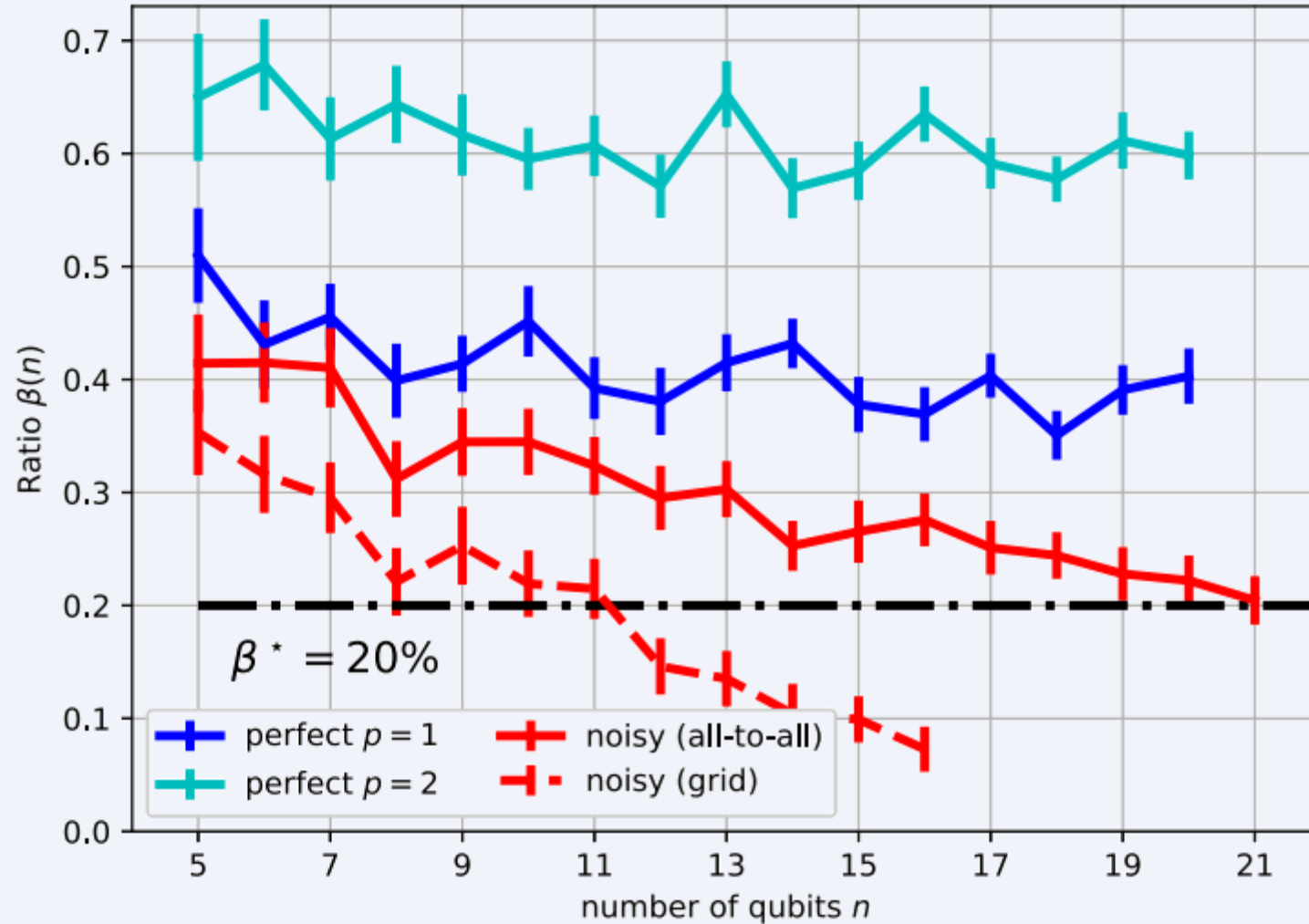
- For given problem instance (size)
- In practice:
 - Data quality / completeness low
 - Interaction needed
 - How often do you solve this?
 - How useful is learning/parameter tuning?



CATEGORIES OF SOLVERS (with QUANTUM)

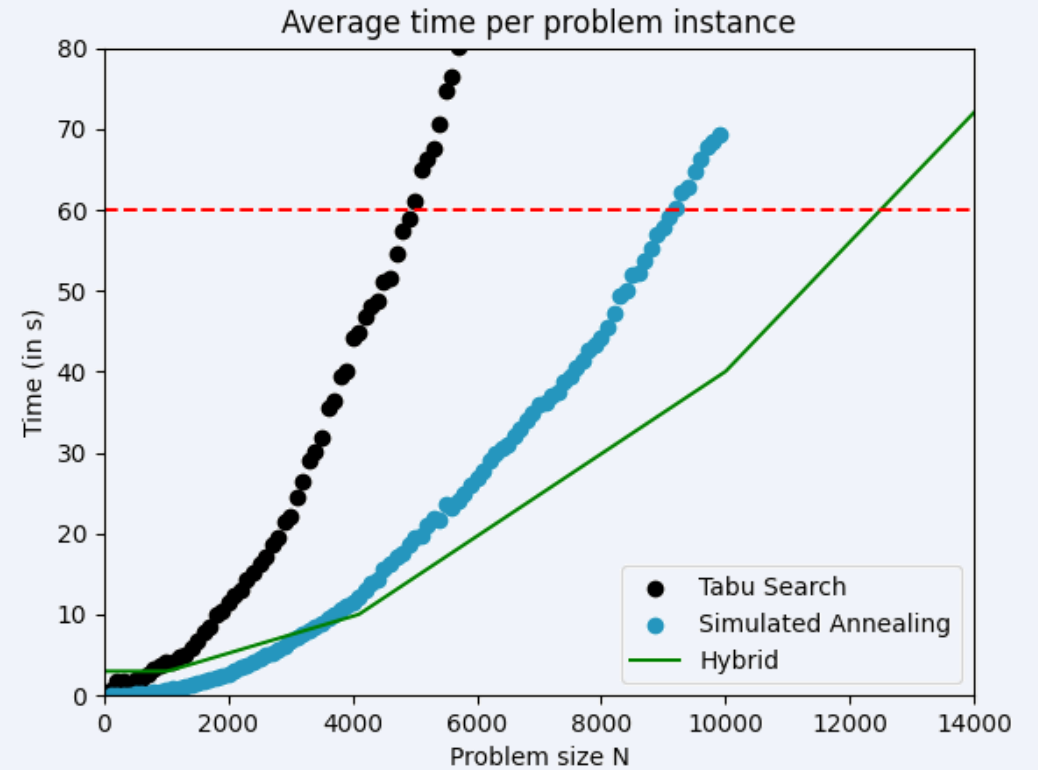
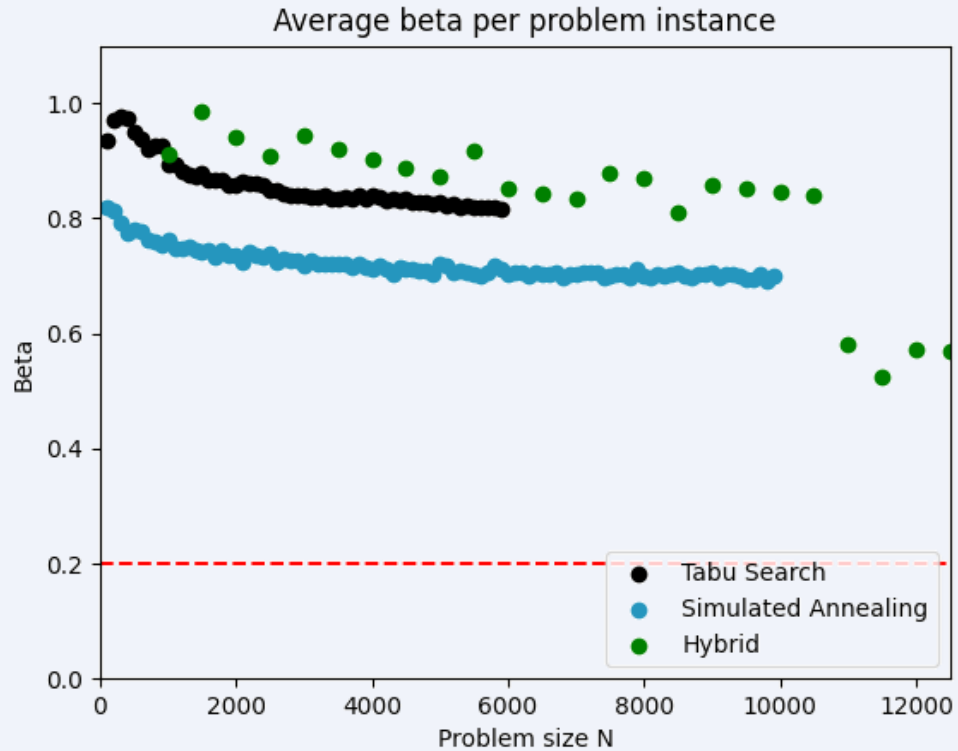


Q-Score

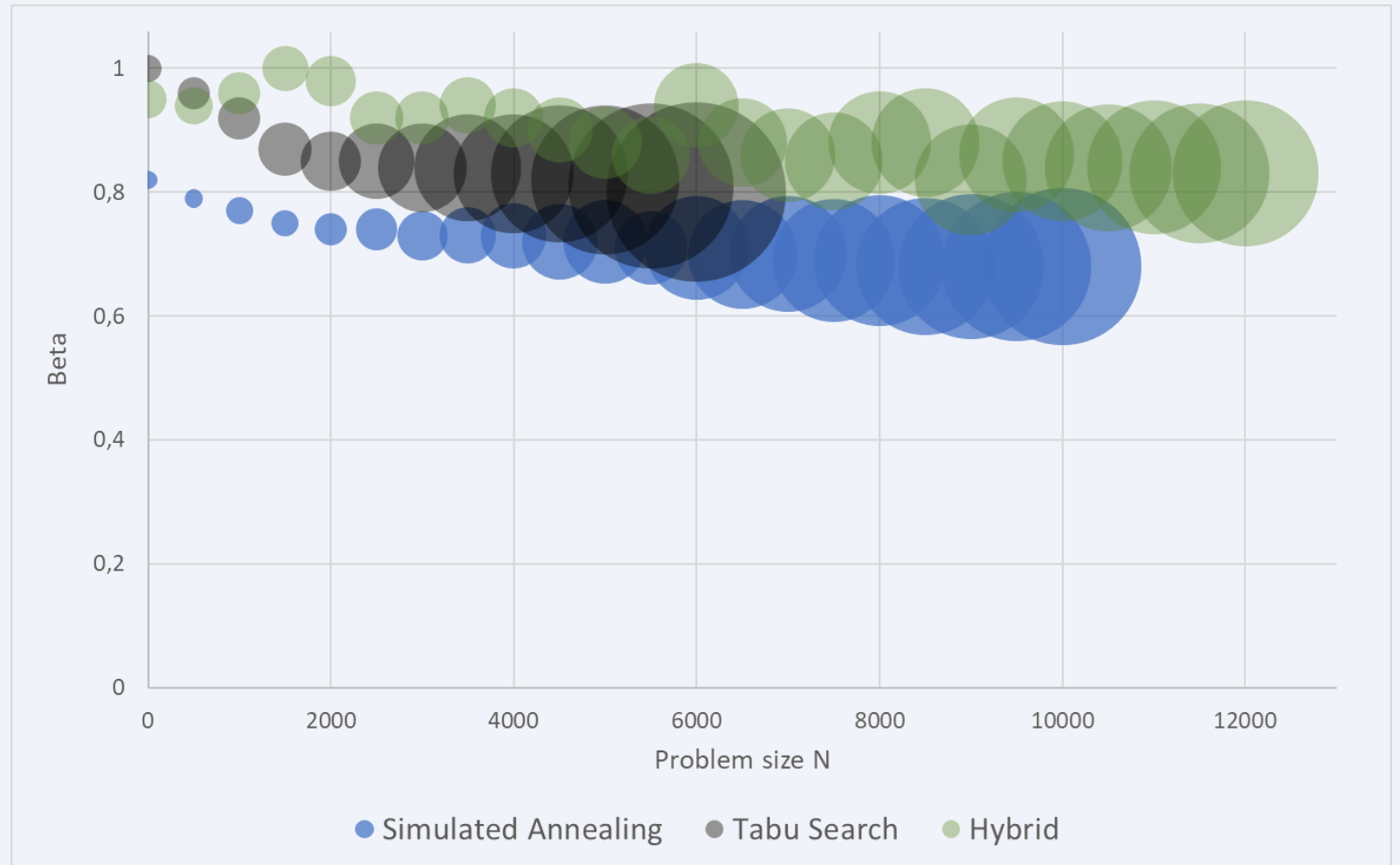
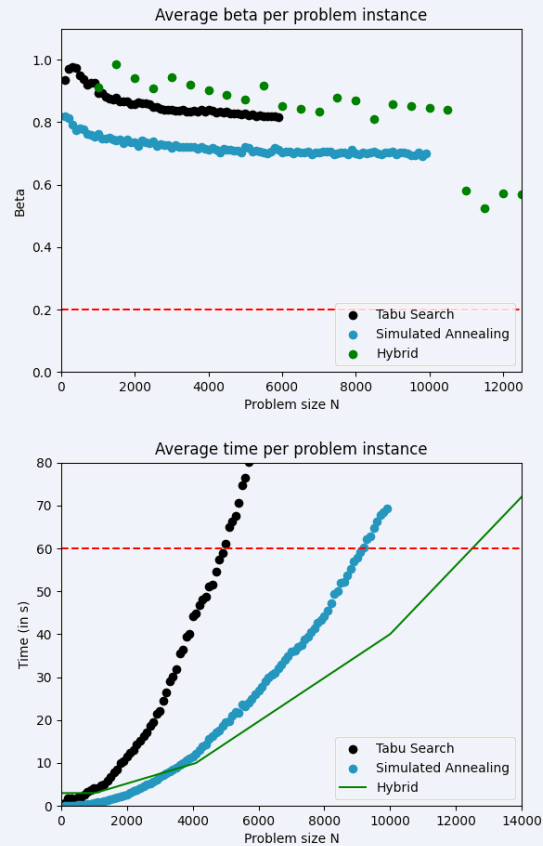


“naive randomized algorithm and an exact solver”

Q-Score (time dependent)



Q-Score (time dependent)



Attention points

- What kind of algorithm?
- What kind of instances?
 - Random
 - Random within boundaries
 - Real use case
- Guarantees?
- Intermediate results accessible?
- Sharp upperbound?
- How much work does it take in which phase?

Recommendations

- Add time...
- Define clearly what times are included.
- Define clearly what bounds are taken (“naive randomized algorithm and an exact solver”).
- Avoid (too much) interpretations possibilities.