DEFENCE ACQUISITION OPTIMISATION USING QUANTUM ALGORITHMS

PROBLEM

In the financial world, portfolio optimisation is used to select a diverse set of assets that maximises investment return. A similar approach can be used within the defence domain, where return may be considered in terms of the military capabilities that the investment provides. (See, for example, Harrison et al., 2020.) Therefore, it may be even more challenging because there is no clearly defined analogue to profit when compared to portfolio selection for financial investments. Therefore, the planning of defence acquisition is a complex process, where optimisation of Defence's investment portfolio is required to maximise national security whilst constrained by a finite budget. We will assume that we can model this portfolio as a quadratic knapsack problem (QKP). QKP is a combinatory problem, which means that as the number of projects on the portfolio grows, it becomes increasingly difficult to compute numerically. The typical approach to this problem is using a meta-heuristic algorithm to find a possible solution. However, the optimality is not guaranteed because those algorithms tend to converge to local optima. We wish to investigate the prospective advantages of quantum algorithms to maximise the likelihood that a global optimum is obtained.

NEED/RELEVANCE TO DEFENCE

There is an ongoing need to minimise the uncertainty and risks in the investment/divestment decisions in planning the Defence portfolio and ensure Defence is ready for any possible threat. It may not be the solution for the entirety of the problem, but it attempts to improve existing disruptive technologies. This quantum algorithm research will help bring Australia Defence into line with critical partners, the UK and USA, who heavily invest in this field.

RESEARCH QUESTION

The problem can be divided into two main parts. First, it needs to explore whether a version of the Quantum Algorithm can outperform the leading classical algorithms to solve the quadratic knapsack problem with scheduling. This part of the research is aligned with a research project on logistic and supply chain problem that has recently targeted by a collaboration between Entropica labs, BMW team group and Honeywell Quantum solutions.

Suppose the first part of the problem presents favourable results towards quantum computation. In that case, we will investigate what would be needed to solve the problem and if there are ways to solve the problem using a local cluster of quantum computers instead of a cloud whilst maintaining the performance.

EXPECTED OUTCOMES

- Demonstration of an improvement over the decision-maker software tool (NITRO) that Defence currently uses to guide the investments needed to build Defence readiness. The algorithm potentially can be applied for several optimisation problems, such as the distribution of sensors and radars and communication problems.
- Bring a new science and technology capability to Defence by the study of quantum meta-heuristic algorithms.

METHODOLOGY/ APPROACH

The methodology to be applied will:

- assess the feasibility of developing a hybrid classical-quantum meta-heuristic algorithms to solve those minor problems;
- develop an example of such an algorithm,
- find ways to define a knapsack problem in minor problems mathematically, and
- compare the algorithm's performance with state-of-the-art classical algorithms.