Quantum Global Public Goods Implementation on Qiskit

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Equal preservation of GPG: A universal call to action protect the planet.

- **Motivation**: use quantum technologies to tackle SDGs.
- Assimilation of SDGs as Global Public Goods (GPG) ; a good which cannot be replaced with any other good, and that no one can be theoretically excluded from.

If a nation is able to enjoy the benefit of the GPG without paying for it, we end up at the free-rider problem.

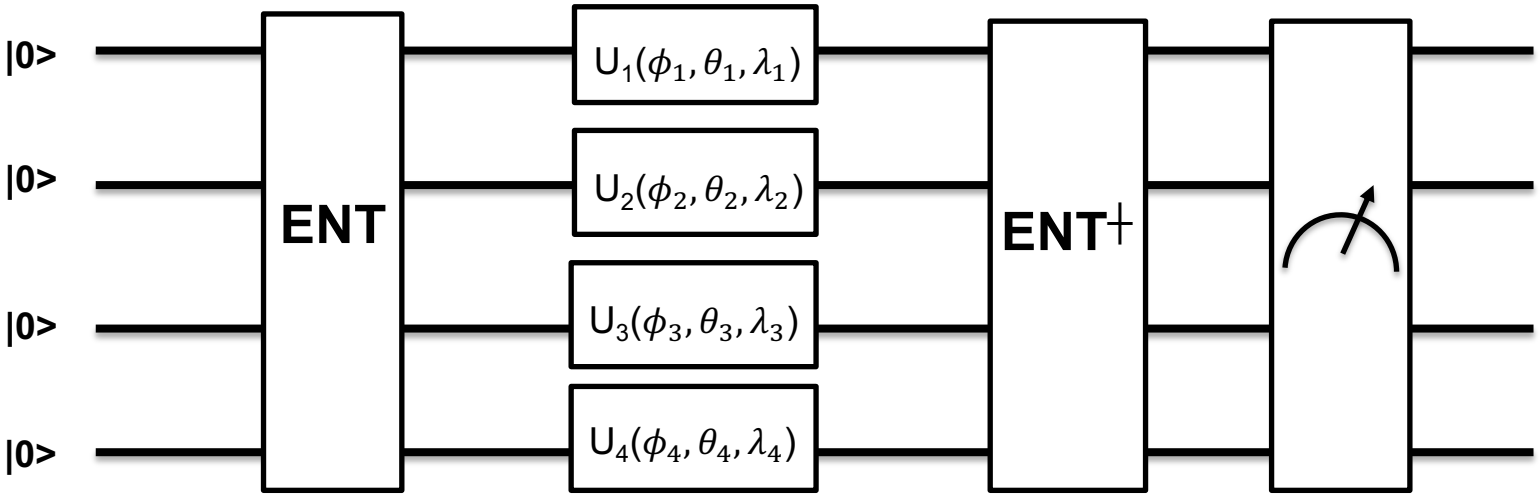
Can we… efficiently combine quantum protocols with Game Theory to address free riding countries in international environmental agreements?

Prisoner's dilemma

		Country 2	
		cooperation	non-cooperation
Country 1	cooperation	(-1; -1)	(-10; 0)
	non-cooperation	(0; -10)	(-5; -5)

Implementation of Quantum strategies :

Each country may apply arbitrary unitaries (n countries)



Entanglement operator (Creation of GHZ state)

Quantum advantage : Individual strategies now **correlated**

What to do with the output?

- Sampling circuit ouput -> **returns a global mixed strategy**
- Possibility to estimate each country's payoff
- Plug this state in **cost function** defined by given constraints on the problem

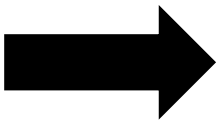
Iterate classically on all possible quantum strategies

- Once cost function is evaluated, iterate over all quantum strategies to find an optimal distribution of payoffs.

Goal : minimize cost function value

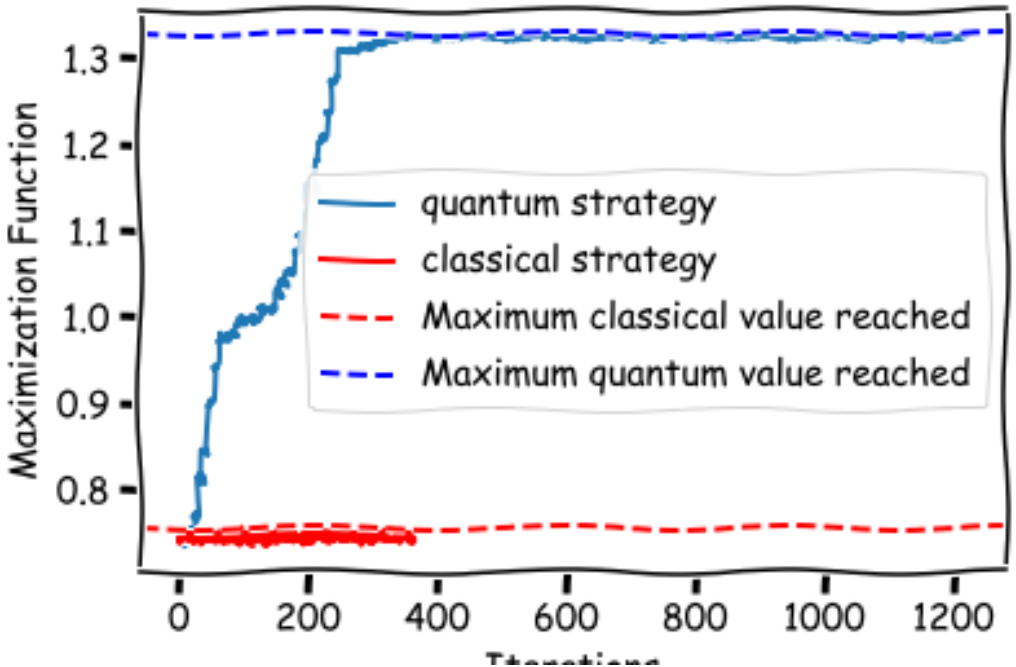
How can we define it?

- To preserve the Public Good : potential need to symmetrize efforts, the payoff should be the same amount for everyone
- Each country should have a positive payoff



Obtain $\min_{\boldsymbol{\theta}} \boldsymbol{\sigma}(\boldsymbol{\theta}) - \|\boldsymbol{\theta}\|_{\mathbf{1}}$ $\qquad \boldsymbol{\theta} \in \mathbb{R}^{\boldsymbol{3N}}$

Quantum strategy advantage over best classical one



- New optimum found using quantum strategy.
- Since minimum values are negative, absolute values are considered here

Further possibilities of improvement

Enhancing this approach with Quantum Meta-Learning	Defining better cost function and payoff matrix	Modifying the entanglement type to study more complicated dynamics

References

- http://vixra.org/pdf/1911.0151v1.pdf
- https://arxiv.org/pdf/quant-ph/0301013.pdf
- http://documents.worldbank.org/curated/en/480391468764142631/pdf/multi0page.pdf

Modeling efficiently the problem : Building Payoff matrix

Critical to perform realistic optimization, it should put constraints linked to real social and political issues over each countries :

Example of GHG emissions :

One should consider :

- abatement costs for each country
- Cost of potential damages linked to failure of containing climate change impacts
- Etc…