Quantum Annealing for Traffic Application in Thailand

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1. Motivation and target application

Traffic issues like road congestion are major problems which bother efficiency of daily life in Thailand. Real-time optimization by using quantum annealing (QA) machine could create attractive applications for intelligent transportation system (ITS). Based on probed location data from commercial application T-Square in Thailand[1], evaluation of taxi allocation was done by using D-Wave 2000Q.

<System>

Requirement example @ 7:30AM-7:45AM at Bangkok
Number of request : 259,000 taxis and 660 request
Response time: less than 10 sec.

2. Modeling

<Hamiltonian>

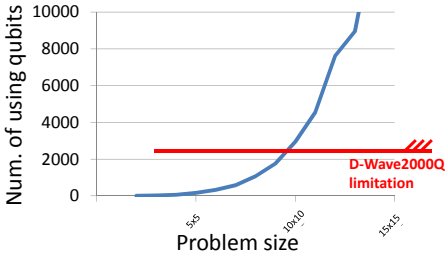
$$E=\sum_{v=1}^{M}\sum_{i=1}^{N}h_{v,i}\sigma_{v,i}+\lambda\left\{\sum_{v=1}^{M}\left(1-\sum_{i=1}^{N}\sigma_{v,i}\right)^2+\sum_{i=1}^{N}\left(1-\sum_{v=1}^{M}\sigma_{v,i}\right)^2\right\}$$

Minimization of total distance

Constrained condition of 1 for 1 matching

$h_{v,i}$ [fixed value]: Distance between taxi v and customer i
$\sigma_{v,i}$ [variable]: Selection of combination taxi v and customer i

<Num. of using qubits>

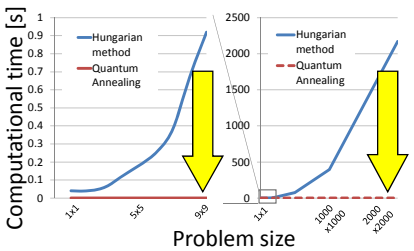


[Num. of taxis x num. of customers]

Problem size is limited up to 9 x 9 for D-Wave 2000Q by using minor embedding.

3. Performance evaluation

<Computational time>

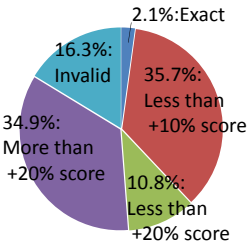


[Num. of taxis x num. of customers]

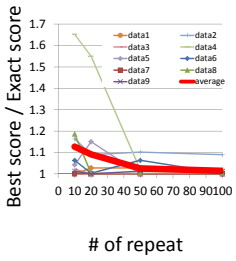
QA is faster than legacy machine with Hungarian algorithm[2] even in small size of problems.

<Accuracy>

Rate of accuracy @9,000 trial



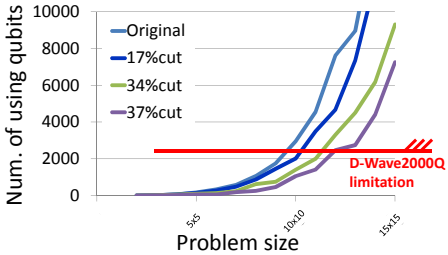
Dependence on # of repetition



QA has good accuracy less than +10% score when number of repetition is more than 20 times.

4. Improvement

<Num. of using qubits by pruning of candidates>



[Num. of taxis x num. of customers]

By cutting 37% of candidates, 11 x 11 problem was implemented on D-Wave 2000Q.

5. Conclusion & future plan

- These results show even in small size of problems, QA machine has good performance in speed and accuracy.
- For finding killer applications, continue to evaluate various practical application in mobility & factory IoT domains.

Reference: [1] https://www.rtic-thai.info/tsquare/traffic-application/, [2] H. Kuhn, Naval Research Logistics Quarterly (1955)

DENSO Crafting the Core

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