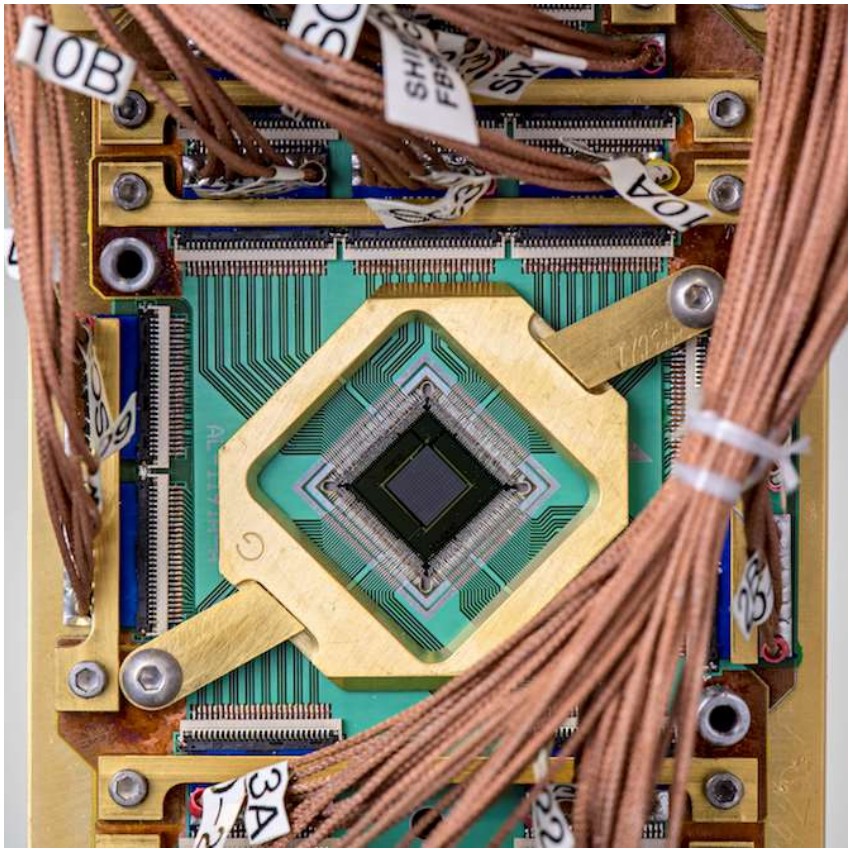
Scaling Asset Sustainment to Industrial Size

Aussie Schnore, Annarita Giani
GE Research

Qubits North America
09/24/2020



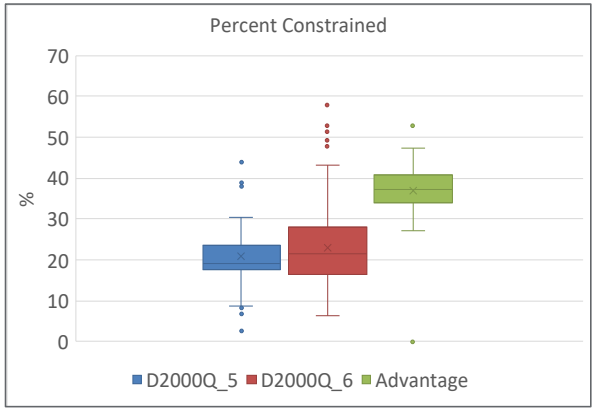
Industrial Scale

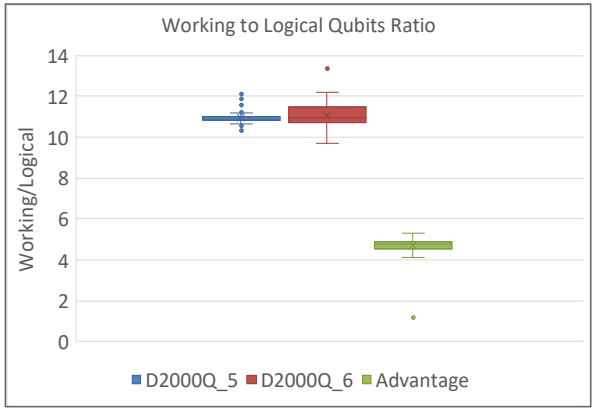
Domain	Number of Entities	Alternatives	Timeliness	Relative Value
Resource Allocation	15,000	$\sim 10^{6,500}$	1 day - 1 hours	$100M+/year
Scheduling	39,129	$\sim 10^{110,000}$	30 days - 6 hours	$100M+/year
Configuration	260	$\sim 10^{250}$	months	$100M+/year

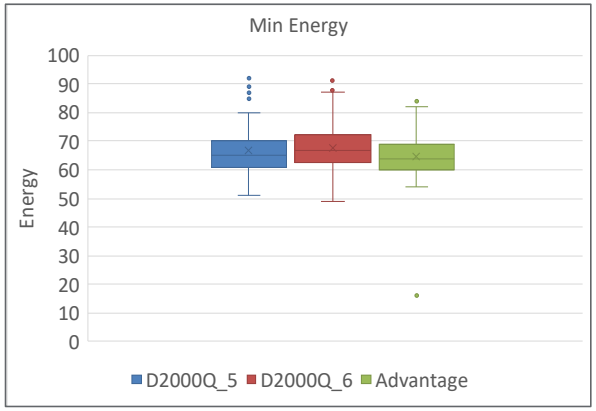
Classical computing is doing very well so you need to go after the tough problems.
Not a lot of low hanging fruit.

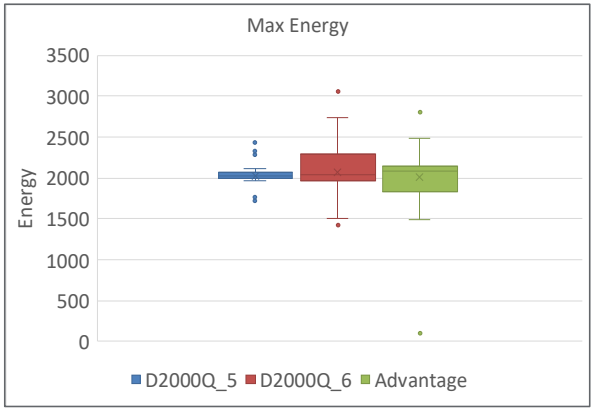
Advantage – Improved Access to Qubits

We had to tell our visitors that you couldn't use all the qubits to solve the problem







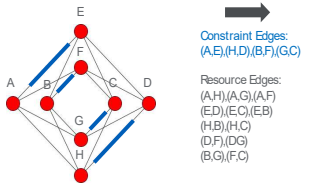


Perfect Embedding

At Qubits 2019

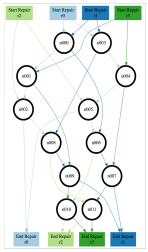
Working Backward to Full Scale Problem

Started with small perfect embedding



Constraint Edges:
(A,E),(H,D),(B,F),(G,C)

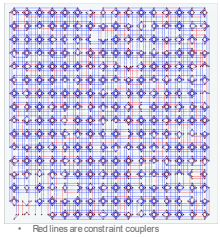
Resource Edges:
(A,H),(A,G),(A,F)
(E,D),(E,C),(E,B)
(H,B),(H,C)
(D,F),(DG)
(B,G),(F,C)



$2^4 = 16$ answers

Creating a problem with perfect embedding

Big Problem



- Red lines are constraint couplers
- Blue lines are resource sharing
- Used 1854 qubits (~90%) and 4917 couplers

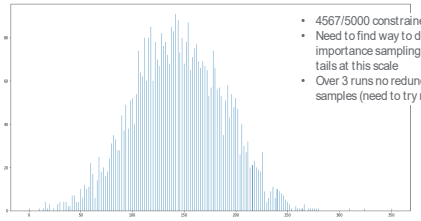
927 repairs
Two paths each

$2^{927} =$

Answers
$\sim 10^{279}$

Creating a problem with perfect embedding

Sampled distribution from $\sim 10^{297}$ answers



- 4567/5000 constrained samples
- Need to find way to do importance sampling to focus on tails at this scale
- Over 3 runs no redundant samples (need to try more)

Results

Next Pegasus

With
- 5640 qubits
- 40484 couplers

Based on a calculated embedding with 94% qubit utilization

2674 repairs with two paths each sharing 37810 resources

$2^{2674} =$

Answers
$\sim 10^{804}$

Estimate based on 90% utilization
1692 repairs with three paths each

$3^{1692} =$

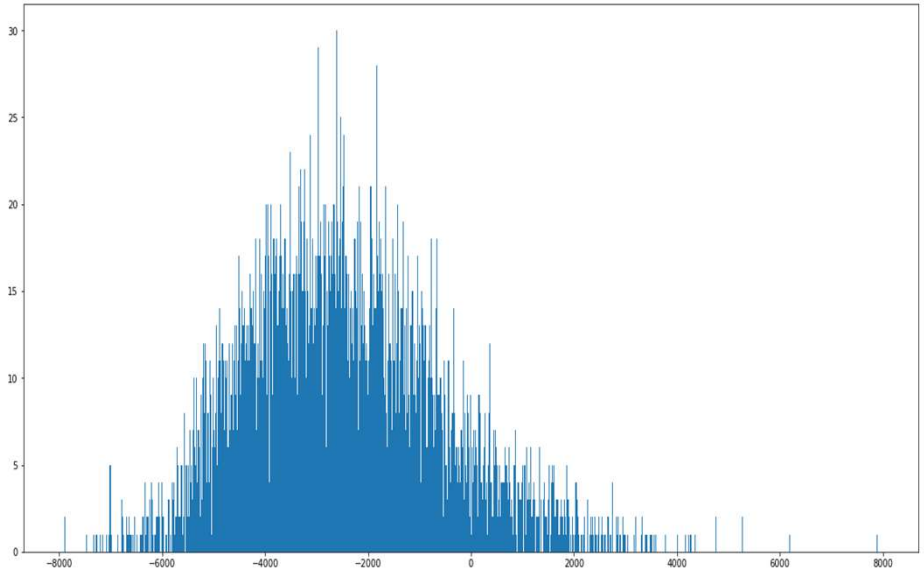
Answers
$\sim 10^{807}$

Perfect Embedding in Pegasus

Perfect Pegasus Embedding and DQM

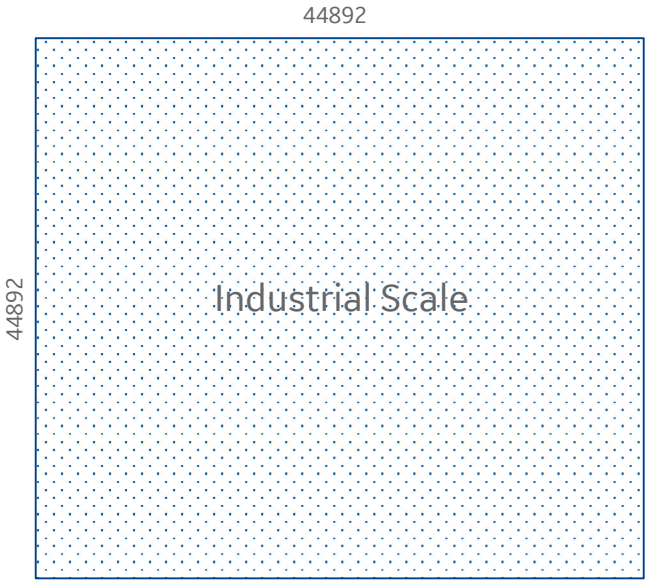
Perfect Embedding- scaling to the qubit limit:

~2615 Repairs with 2 repairs path
Sharing over 31,000 resources
Constrained answers: ~10^{787}



DQM- scaling beyond the qubit limit:

~15,000 Repairs with ~3 repairs path
Sharing over 6000 resources
Constrained answers: ~10^{6500}



The answer ->

Challenge: How to motivate change

Mechanical Calculator → Electrical Calculator → • Digital Computers → • Analog • Quantum

Machine	Algorithm	Application
GPP	▲	●
GPU	▲	●
FPGA	▲	●
Quantum	▲	●

Thank you for your time

Questions?