Quantum Annealing at Google: Recent Learnings and Next Steps
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Recently we studied optimization problems with rugged energy landscapes that featured tall and narrow energy barriers separating energy minima. We found that for a crafted problem of this kind, called the weak-strong cluster glass, the D-Wave 2X processor achieves a significant advantage in runtime scaling relative to Simulated Annealing (SA). For instances with 945 variables this results in a time-to-99%-success-probability $10^9$ times shorter than SA running on a single core. When comparing to the Quantum Monte Carlo (QMC) algorithm we only observe a pre-factor advantage but the pre-factor is large, about $10^6$ for an implementation on a single core. We should note that we expect QMC to scale like physical quantum annealing only for problems for which the tunneling transitions can be described by a dominant purely imaginary instanton. We expect these findings to carry over to other problems with similar energy landscapes. A class of practical interest are k-th order binary optimization problems. We studied 4-spin problems using numerical methods and found again that simulated quantum annealing has better scaling than SA. This leaves us with a final step to achieve a wall clock speedup of practical relevance. We need to develop an annealing architecture that supports embedding of k-th order binary optimization in a manner that preserves the runtime advantage seen prior to embedding.