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State Diagrams and Tree Tensor Networks

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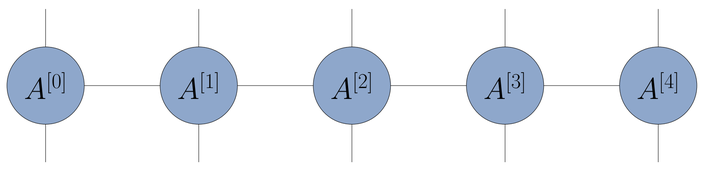
Motivation

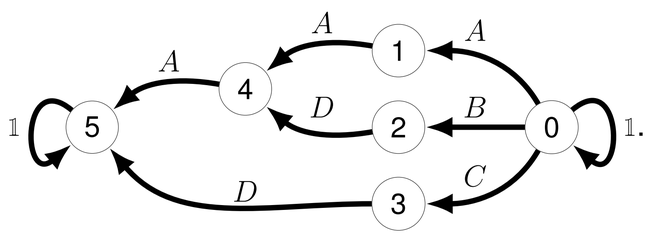
Many relevant Hamiltonians and operators have the following form

$$H = \sum_{i=1}^{K} \bigotimes_{s \in Q} A_i^{[s]},$$

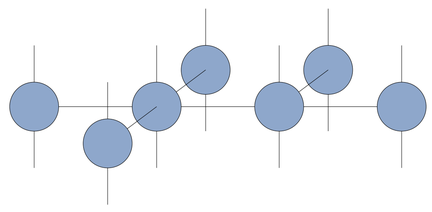
where Q is a set of small quantum systems or sites and the operator $A^{[s]}$ acts on site s.
If Q represents a 1D-chain, we can bring such an operator in matrix product operator form



using cellular automata, e.g.

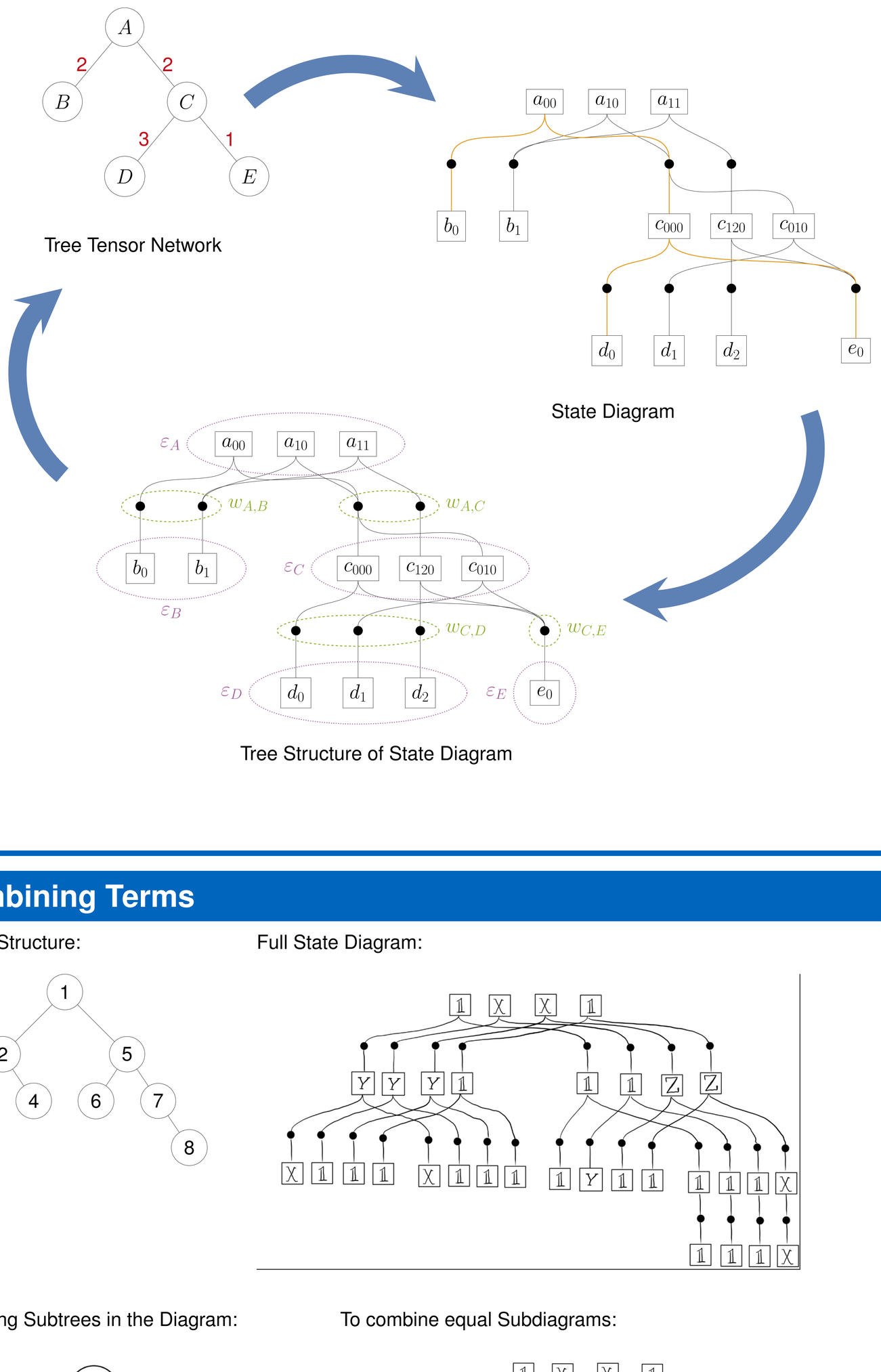


However, if Q or the operator have a tree structure it can be advantageous to use a tree tensor network operator

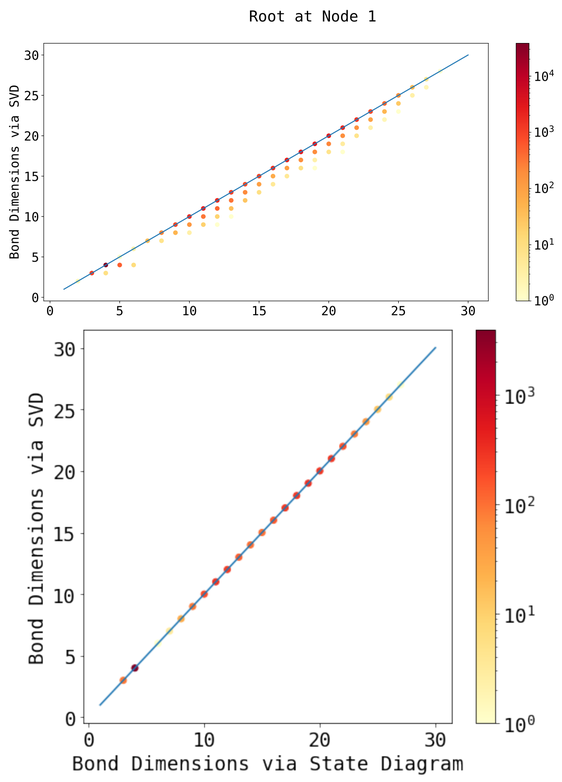


In this case the basic automaton method fails. Therefore we considered state diagrams and developed an algorithm to obtain a state diagram that corresponds to a given operator.

The State Diagram



Bond Dimensions

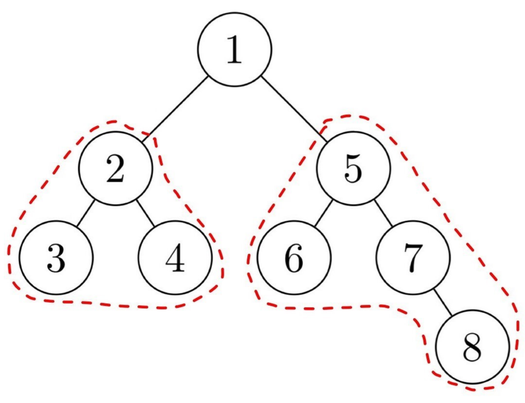


Combining Terms

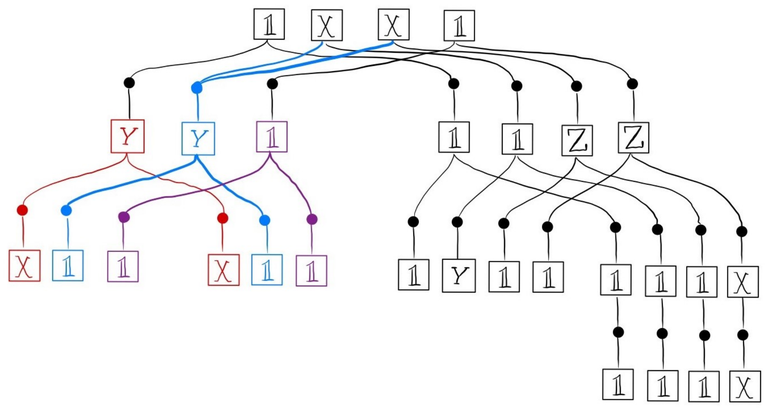
Tree Structure:

Full State Diagram:

Checking Subtrees in the Diagram:



To combine equal Subdiagrams:



Reference

Richard M. Milbradt, Qunsheng Huang, Christian B. Mendl; *State Diagrams to determine Tree Tensor Network Operators*; arxiv: 2311.13433

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The research is part of the Munich Quantum Valley, which is supported by the Bavarian state government with funds from the Hightech Agenda Bayern Plus. The research is also supported by the Bavarian Ministry of Economic Affairs, Regional Development and Energy via the project BayQS with funds from the Hightech Agenda Bayern.