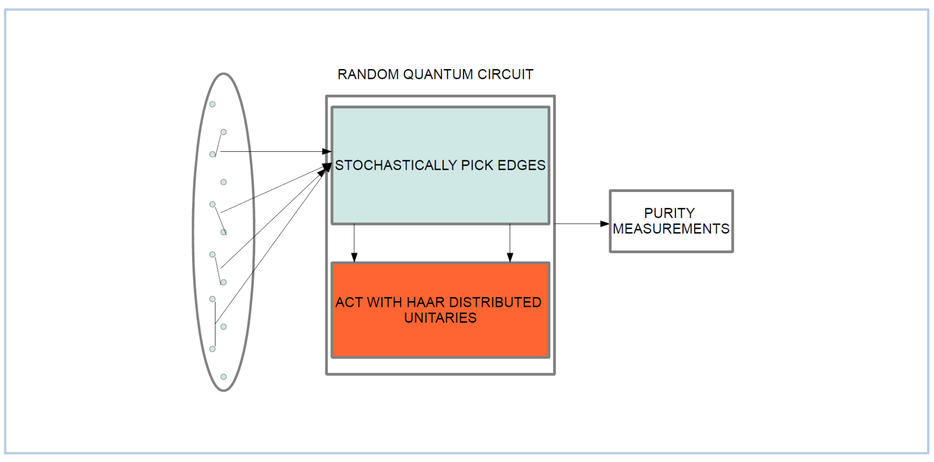
Developing Quantum Algorithms in High Performance Computing (HPC) Environment

S&T Campaign: Computational Sciences
Computing Sciences

Dr. Radhakrishnan Balu, (301) 394-4302
radhakrishnan.balu.civ@mail.mil

Research Objective

- **Model Entanglement dynamics of open and closed systems under physically motivated random processes**
- **Local random quantum circuits (L-RQC) formalism; quantum walks**
- **Tools to develop scalable models for quantum optics feedback networks: Quantum hardware description language (QHDL)**



Schematic showing the action of a LRQC defined on a 1-D chain of qubits with nearest neighbor connectivity.

Challenges

- **Efficient control; Faithful models of relevant interactions**
- **Bipartite systems coupled to a bath that is represented by continuous tensor product Fock space (beyond semi-classical description)**
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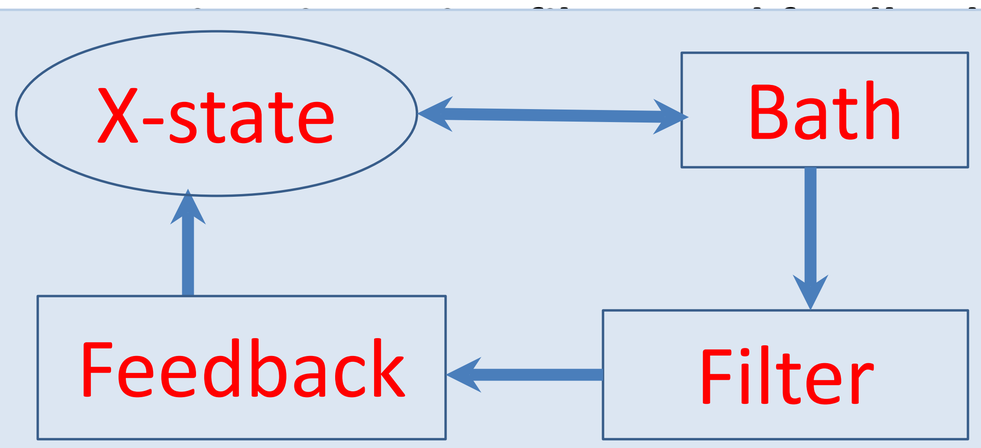

Environment (bath) is represented by a Fock space that has continuous tensor product structure

$$F = F_{s]} \otimes F_{[s,t]} \otimes F_{[t}, \forall 0 < s < t < T$$

Quantum stochastic calculus based analysis

ARL Facilities and Capabilities Available to Support Collaborative Research

- **ARL- DoD supercomputing research center infrastructure to build highly scalable modeling and simulations tools**
- **ARL Quantum sciences lab: Availability of multiple quantum hardware: ion traps (laser cooled), neutral atoms traps, fabrication facility, and coherent channels**
- **Multi-disciplinary team with background in quantum, computational sciences, and mathematics to formulate and experimentally validate models and novel algorithms**

Complementary Expertise/ Facilities/ Capabilities Sought in Collaboration

- **Specialized laboratory facilities for testing and validating models**
- **Expertise in quantum feedback control**
- **Suggestions for innovative new research approaches to address stated research objectives**

References:
Mou-Hsiung Chang, Quantum stochastics (Cambridge series in Statistical and Probabilistic Mathematics), Dec (2014).

A. Hamma, S. Santra, and P. Zanardi, Phys. Rev. Lett. 109, 040502 (2012).