

## S&T Campaign: Computational Sciences Advanced Computing Architectures

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### Research Objective

- ❖ To develop a framework for implementing quantum networks, from the top level classical control layer down to the quantum control of hardware, and to explore the applications of quantum networks.

### Challenges

- ❖ Simulating quantum networks. This task is challenging due to the dynamics of the network links and the large Hilbert spaces that result.
- ❖ Designing networks to perform specific functions, such as optimal entanglement distribution or sensing

### Approaches

#### Programmable Quantum Networking

- ❖ Identify and modify OpenFlow attributes to support quantum metadata network communications
- ❖ Develop programmable multi-node quantum network topology simulations

#### Simulation of network hardware

- ❖ Use an automated approach to obtaining dynamical equations from network structure (e.g. QHDL)
- ❖ Use MPS methods for handling imperfections such as time-delays in network links

#### Control methods for network elements

- ❖ Simulate network nodes with input wave-forms and use optimal control techniques to realize elementary network functions such as routing and frequency conversion

### ARL Facilities and Capabilities Available to Support Collaborative Research

- ❖ Theory team with expertise in quantum measurement, quantum control, software-defined networking, parallel programming
- ❖ Large array of supercomputers and support staff
- ❖ ARL is building an optical entanglement Lab to support this Research effort.

### Expertise/Facilities/Capabilities Sought in Collaboration

- ❖ Complementary expertise in open systems, simulation algorithms and methods, and approximation methods.
- ❖ Quantum Entanglement Lab facilities at APG

### References

- ❖ Breuer and Petruccione, The Theory of Open Quantum Systems (OUP, Oxford, 2007).
- ❖ Dasari, VR and Sadlier RJ, et al (2016) "Programmable Multi-Node Quantum Network Design and Simulation" arXiv:1604.01276
- ❖ Dasari, VR and Humble, TS (2016) "OpenFlow Arbitrated Programmable Network Channels for Managing Quantum Metadata" arXiv:1512.08545
- ❖ Eisert, Browne, Scheel, Plenio, Annals of Physics 311, 431 (2004)

### Figure Captions

- Programmable 3-node quantum network Simulation
- Programmable quantum quantum node model
- Schematic diagram of a quantum network with a single atom at each node (Rempe group, Nature (2012)).

