Session III: Interacting with Hardware

Bridge the gap

- Between Bloqade and hardware!

$$\frac{H}{\hbar} = \sum_i \frac{\Omega(t)}{2}\left(e^{i\phi(t)}|g_i\rangle\langle r_i| + e^{-i\phi(t)}|r_i\rangle\langle g_i|\right) - \sum_i \Delta_\mathrm{i}(t) n_i + \sum_{i<j} V_{ij} n_i n_j$$

`BloqadeSchema.submit_to_braket`

`emulate!(prob)`

Learning objectives

By the end of this class, you will be able to:

- **Describe** the Bloqade to Hardware pipeline
- **Differentiate** transformation and validation functions to work within Hardware Constraints
- **Design, Submit, and Retrieve** Hamiltonians for Hardware

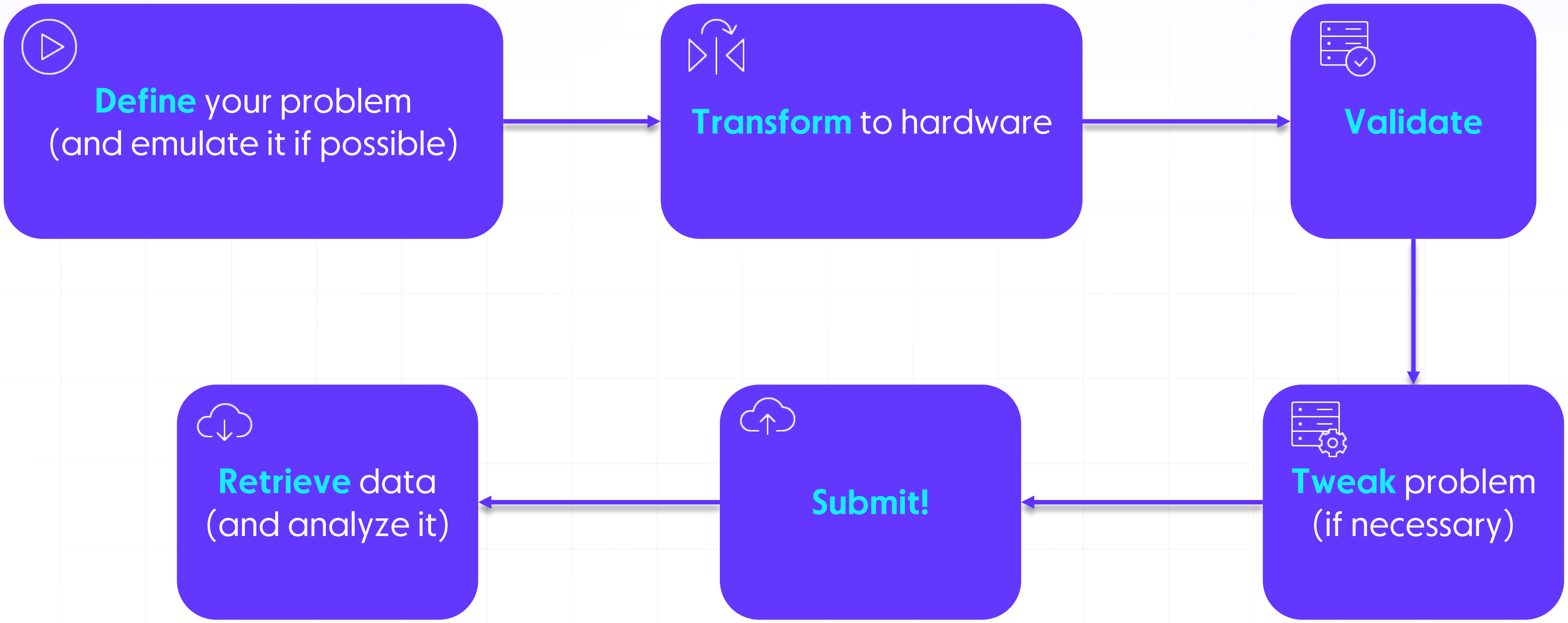
Start with a question:

- If you got here after going through sessions I and II, you already know how to operate Bloqade for doing emulations.

  - Activity: Think-share

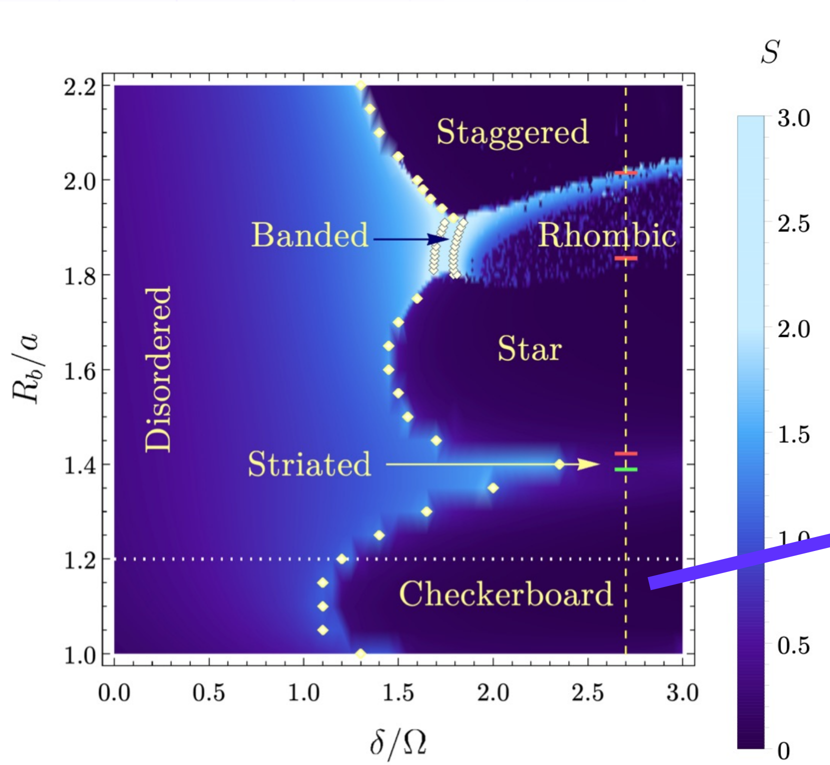
    - What steps would you claim need to happen in order to submit an algorithm you developed in Bloqade to run in a real quantum computer?

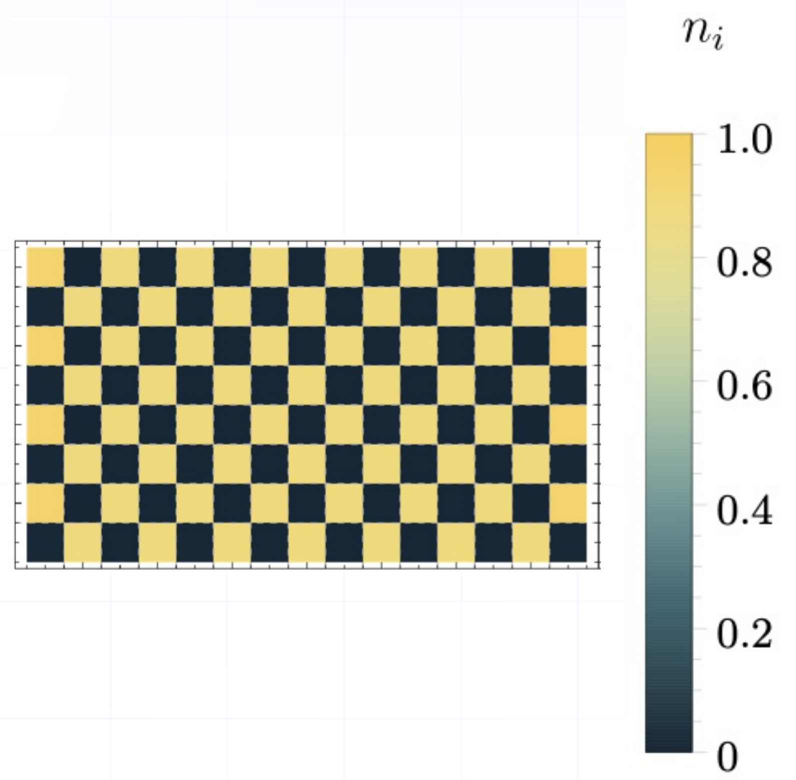
Big picture


Define your problem
(and emulate it if possible)
Transform to hardware
Validate
Tweak problem
(if necessary)
Submit!
Retrieve data
(and analyze it)

Start With a Problem

- *Attempt to recreate **2D Checkerboard Phase***





Let's revise on Bloqade!

R. Samajdar et al., Phys. Rev. Lett. 124, 103601 (2020)

|QuEra>

`transform` and `validate`: why?

Make sure your algorithm will run BEFORE submission to hardware

transform

- *Hardware has some important limitations to consider*

Activity: name some hardware constraints you learned of in previous sessions

- Atoms have a minimum distance they can be placed next to each other
- Have finite-valued Rabi, Detunings, and Phase
  - Final waveforms on hardware must be piecewise Linear/Constant (discretization necessary)
  - Your slope or “slew rate” cannot exceed certain maximums
- Minimum time resolution to consider (smallest increment of time you can define)

Find Hardware Constraints documented Here:
https://queracomputing.github.io/Bloqade.jl/dev/capabilities/

Global Rydberg Values

Capability	Field	Value
Rydberg Interaction Constant	`c6_coefficient`	5.42×10^6 rad/µs × µm^6
Minimum Rabi Frequency	`rabi_frequency_min`	0.00 rad/µs
Maximum Rabi Frequency	`rabi_frequency_max`	15.8 rad/µs
Rabi Frequency Resolution	`rabi_frequency_resolution`	0.0004 rad/µs
Maximum Rabi Frequency Slew Rate	`rabi_frequency_slew_rate_max`	250.0 rad/µs^2
Minimum Detuning	`detuning_min`	-125.0 rad/µs
Maximum Detuning	`detuning_max`	125.0 rad/µs
Detuning Resolution	`detuning_resolution`	2.0×10^{-7} rad/µs
Maximum Detuning Slew Rate	`detuning_slew_rate_max`	2500.0 rad/µs^2
Minimum Phase	`phase_min`	-99.0 rad

Objective of `transform`

MAXIMIZE *your flexibility to design algorithms*

MINIMIZE *constraint bookkeeping by hand*

validate

- Occasionally, there are certain things that can’t be automatically transformed
  - Most commonly with atom position constraints
- Require some form of user intervention, this is where validation is necessary!
- Treatable as a catch-all for any incompatible Hamiltonians

Submitting

- *If the Hamiltonian passes Validation, you'll need your AWS Credentials to submit*
- *Upon submission, may need to wait a bit as tasks go on a queue that the machine will consume from when it's open*

Tuesdays	16:00:00	to	20:00:00	UTC
Wednesdays	16:00:00	to	20:00:00	UTC
Thursdays	16:00:00	to	18:00:00	UTC

*Outside of hours, tasks can be submitted to the Amazon Braket queue

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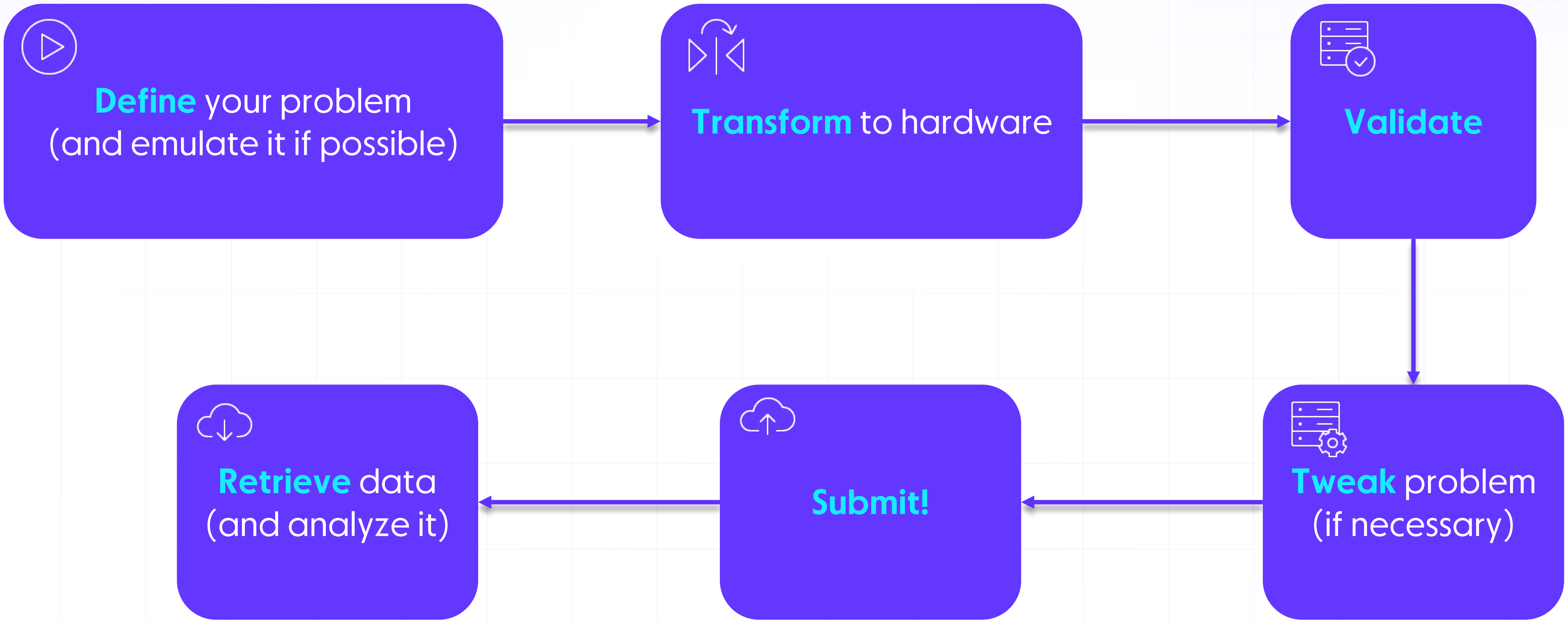
Retrieval

- Heavy lifting done by Braket.jl
- Results can be saved in HDF5-Compatible format or JSON for usage inside Python
    - JSON is the friendlier format!

Summary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