

# A Stochastic Multi-Rate Control Framework for Modeling Distributed Optimization Algorithms

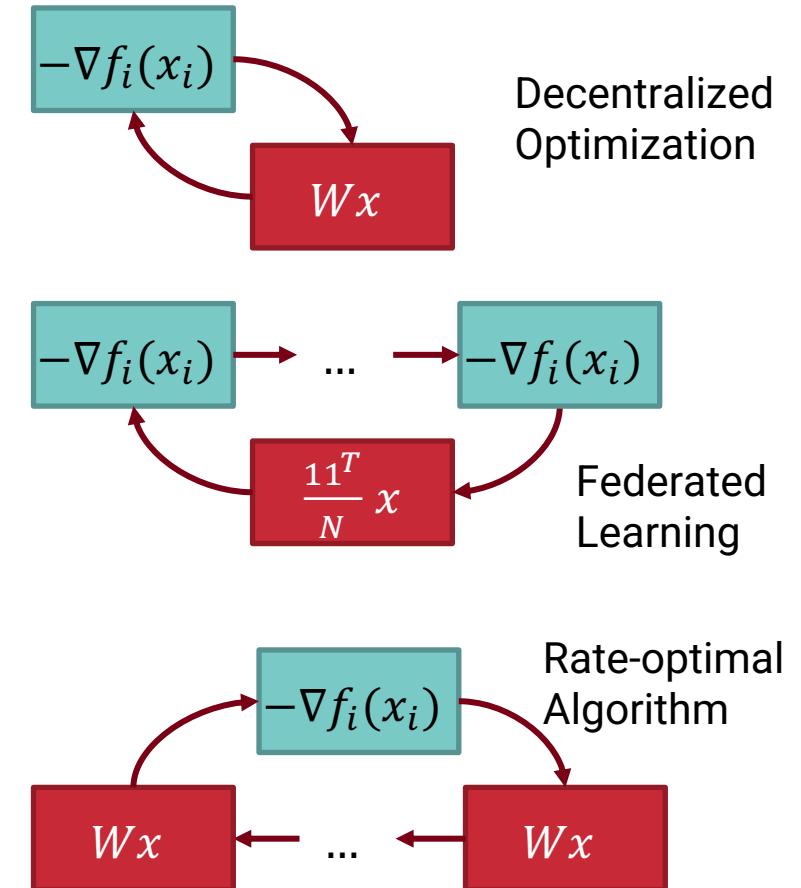
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June 27, 2022

# Classification of Distributed Optimization Algorithms

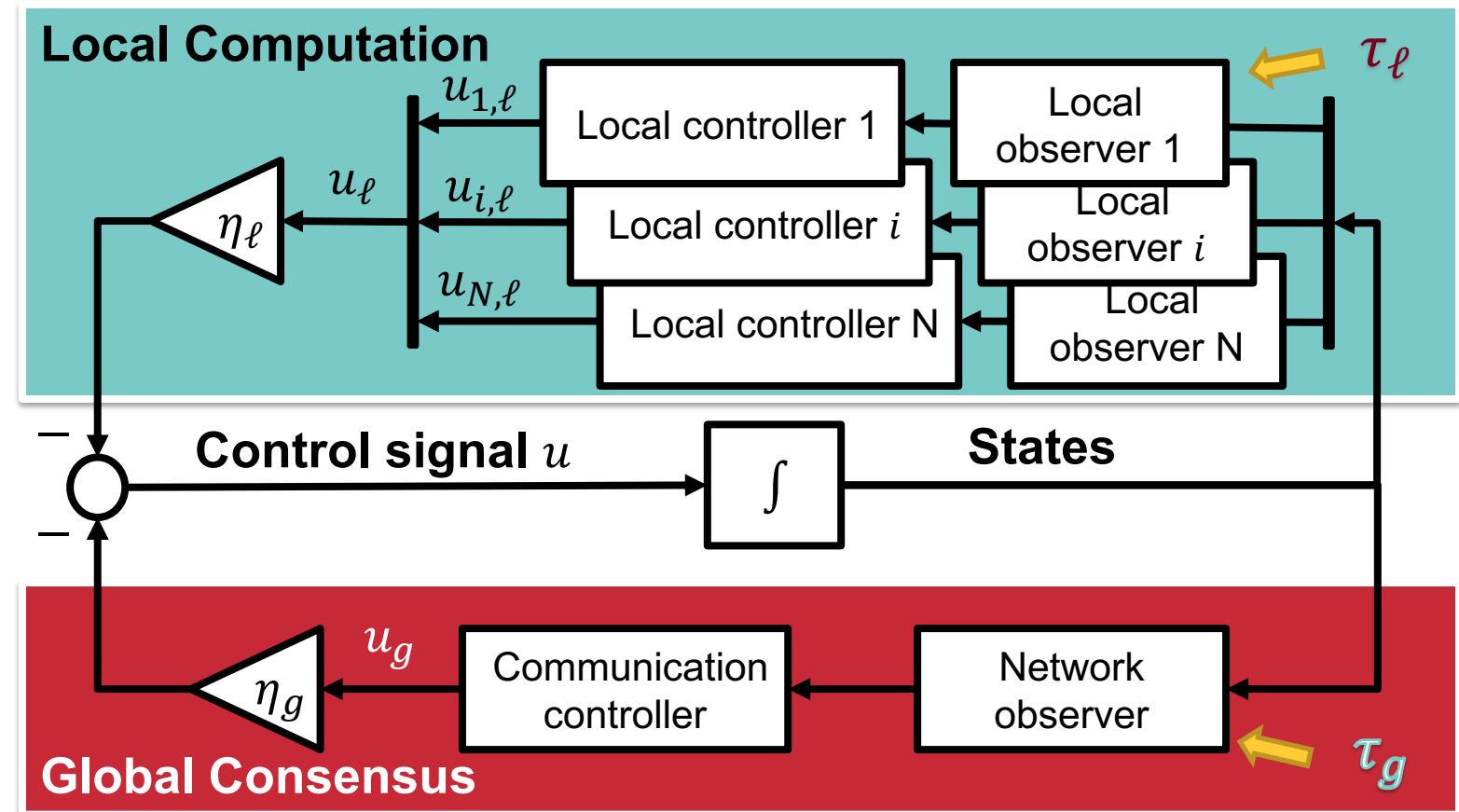
- Decentralized Optimization (DO)
  - Communication graph are usually not complete
  - One step local update & one step communication
- Federated Learning (FL)
  - Server + client, complete/star graph
  - Multi-step local update & one step communication
- Rate-optimal Algorithms (RO)
  - One step local update & Multi-step communication



# Modeling Distributed Algorithm with a Double-loop Feedback Control System

Different sampling rates correspond to DO, FL and RO:

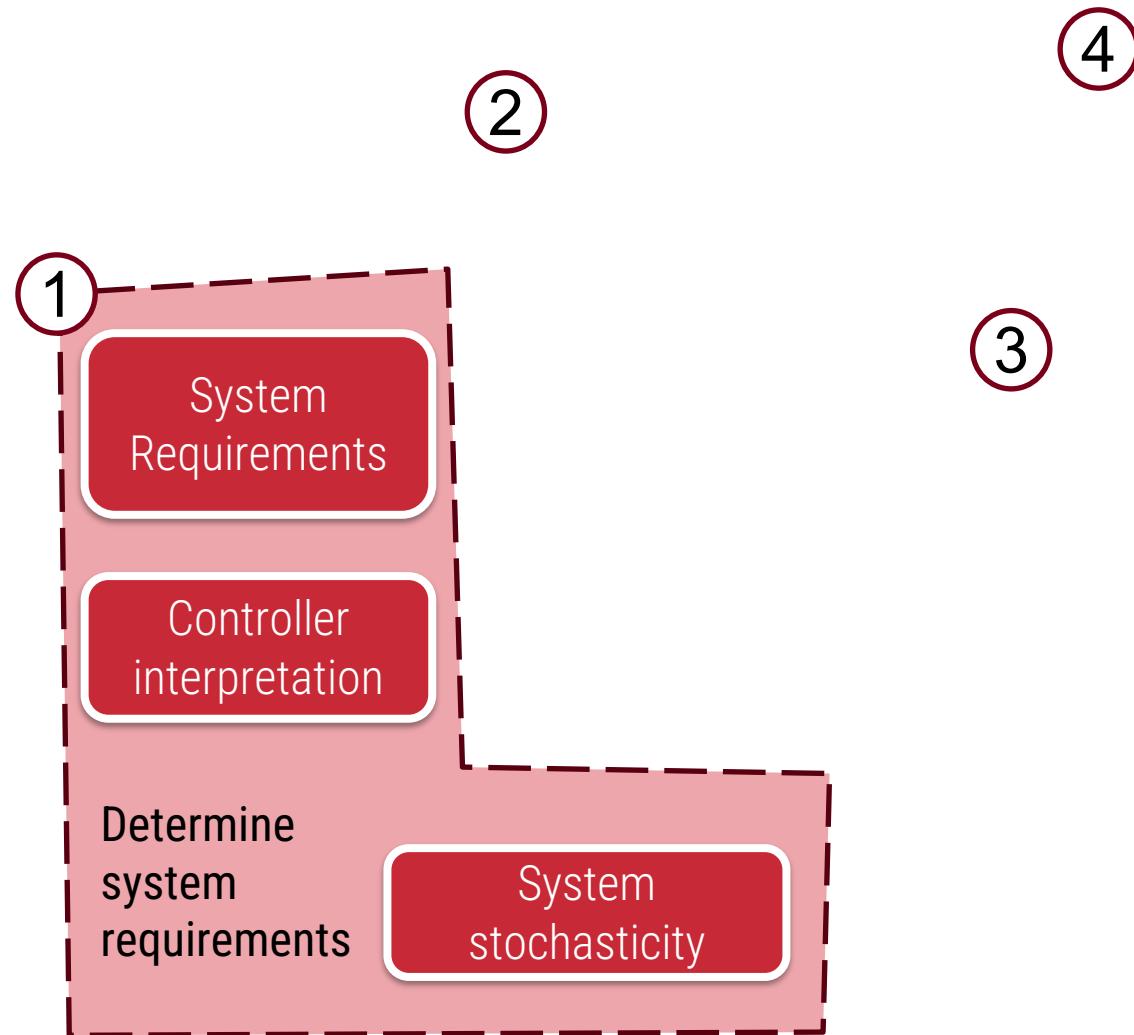
- DO:  $\tau_\ell = \tau_g$
- FL:  $\tau_\ell < \tau_g$
- RO:  $\tau_\ell > \tau_g$



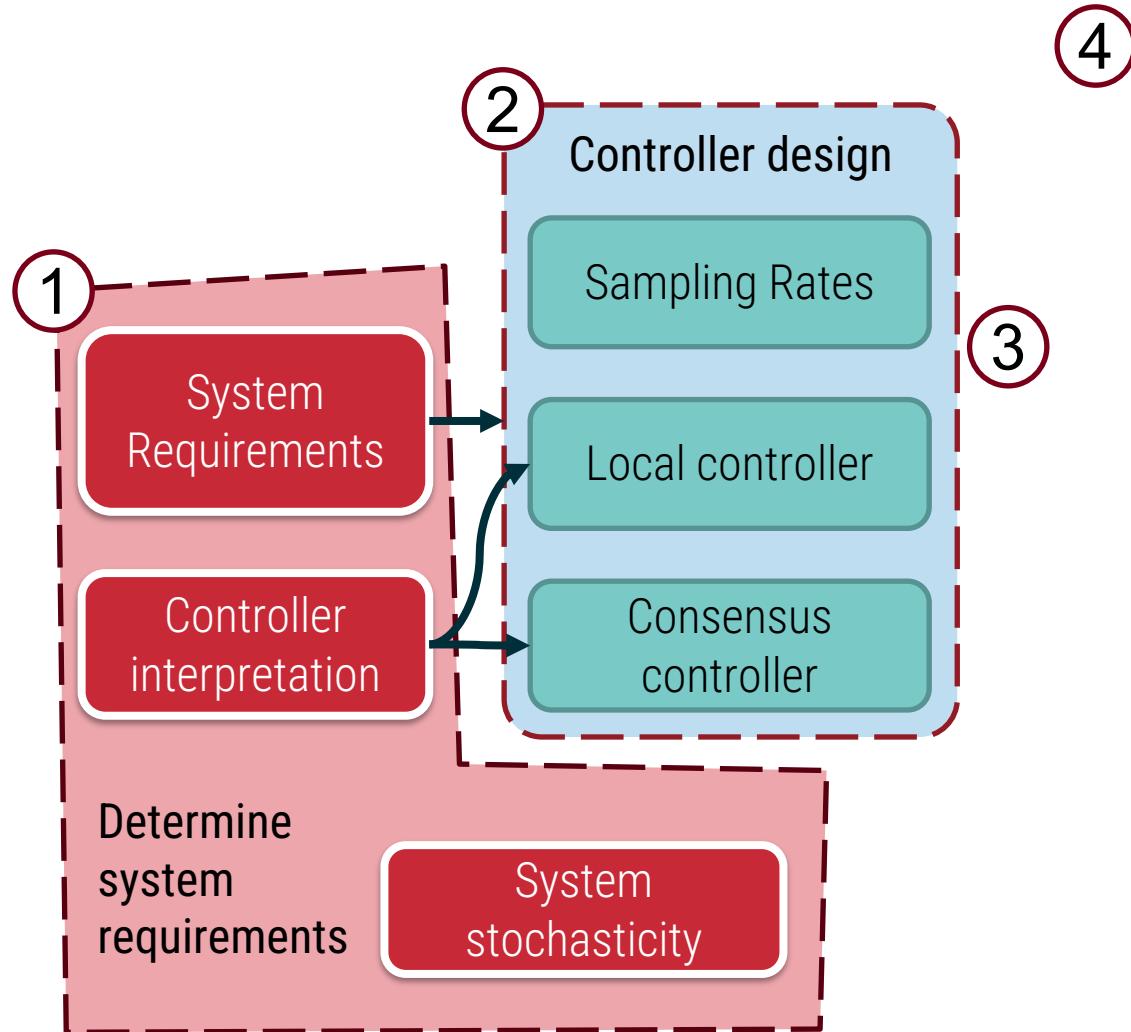
# Adding Stochasticity to the Controllers with Convergence Guarantee

- Decide the controller to add noise
  - Local controller: stochastic gradient, zeroth-order optimization, etc.
  - Consensus controller: dynamic communication graph, compression, differential privacy mechanism, etc.
- Decide the property of the noise
  - Additive / Multiplicative noise
  - Noise statistics: Mean, variance, correlation, etc.
- Under certain assumptions, we can characterize the convergence of the stochastic system based on a convergent noise-free system.

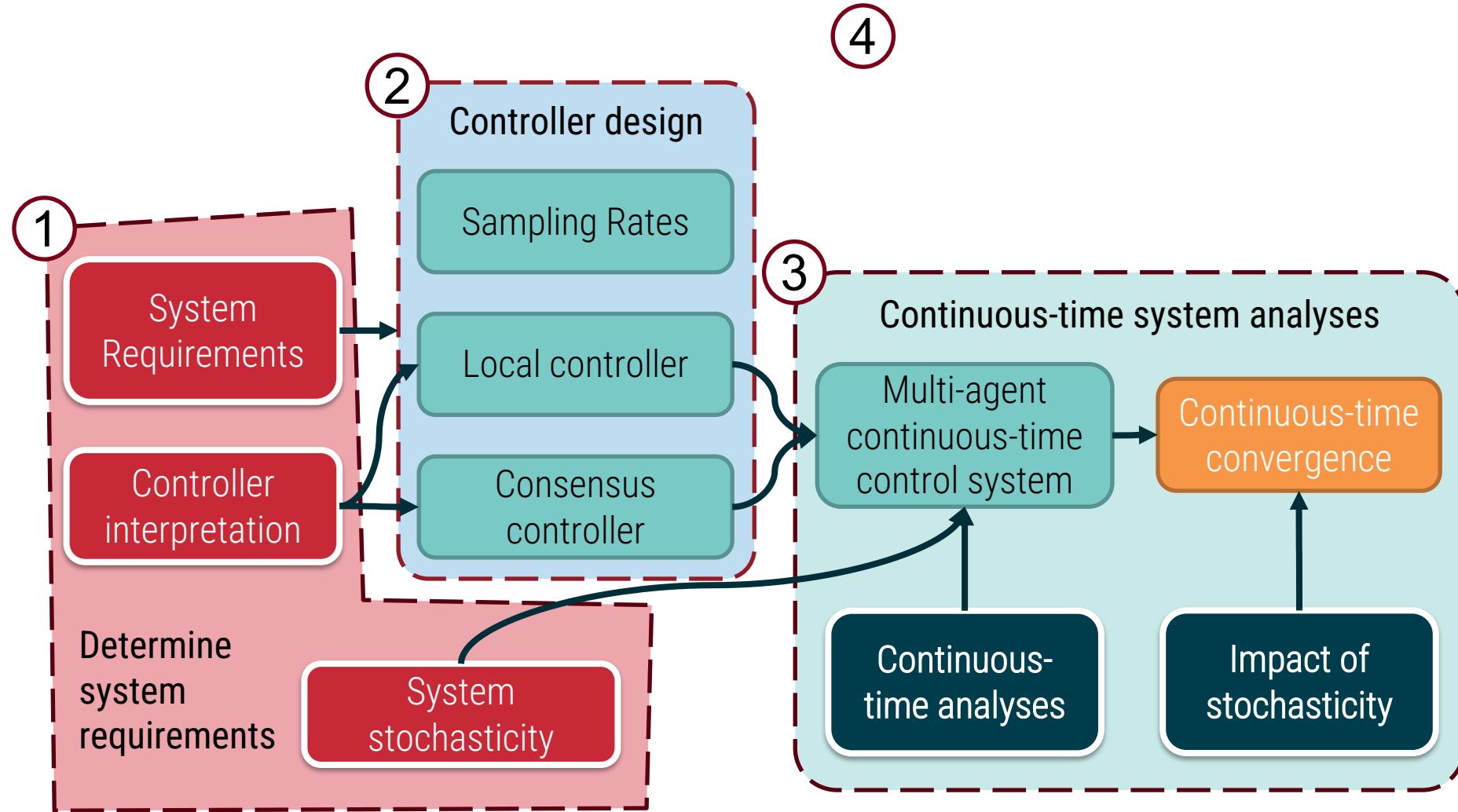
# Application: Algorithm Design



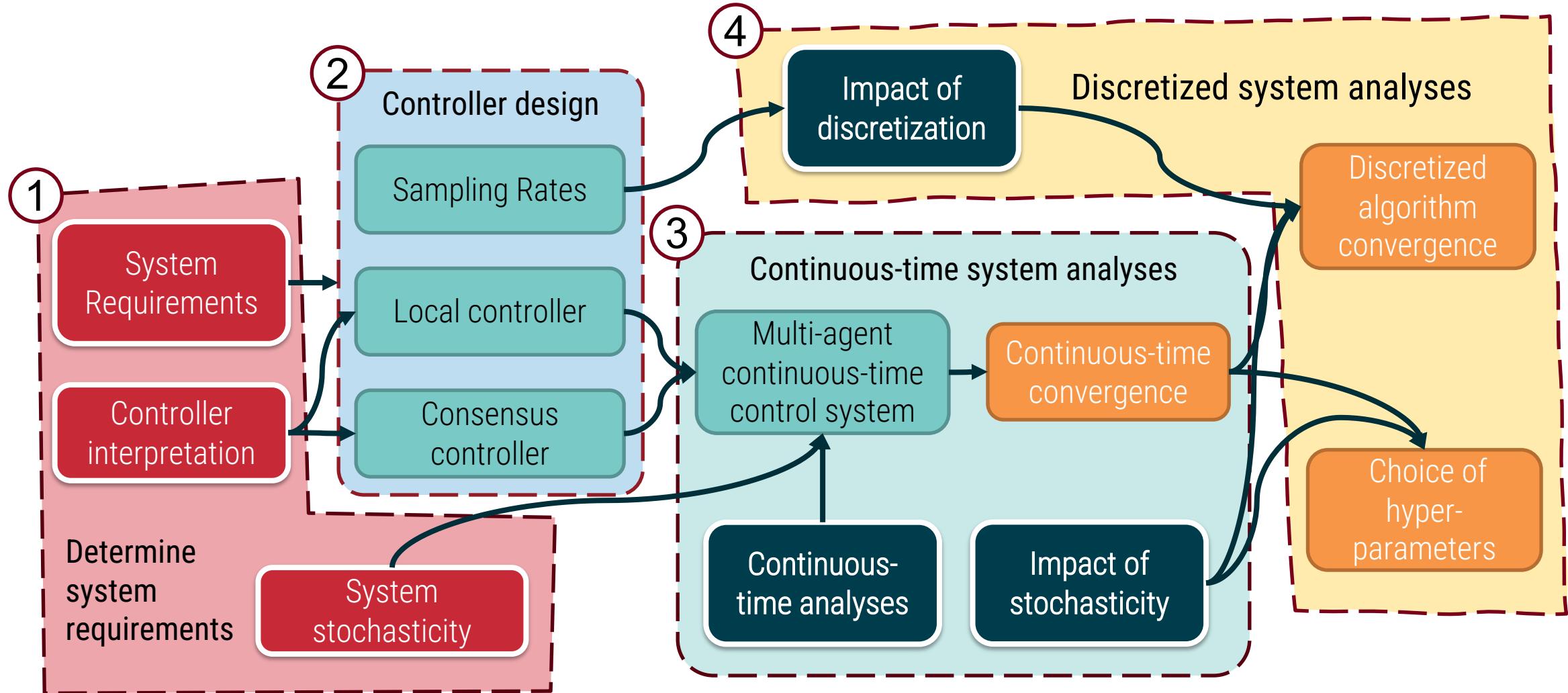
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Thanks!

