

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

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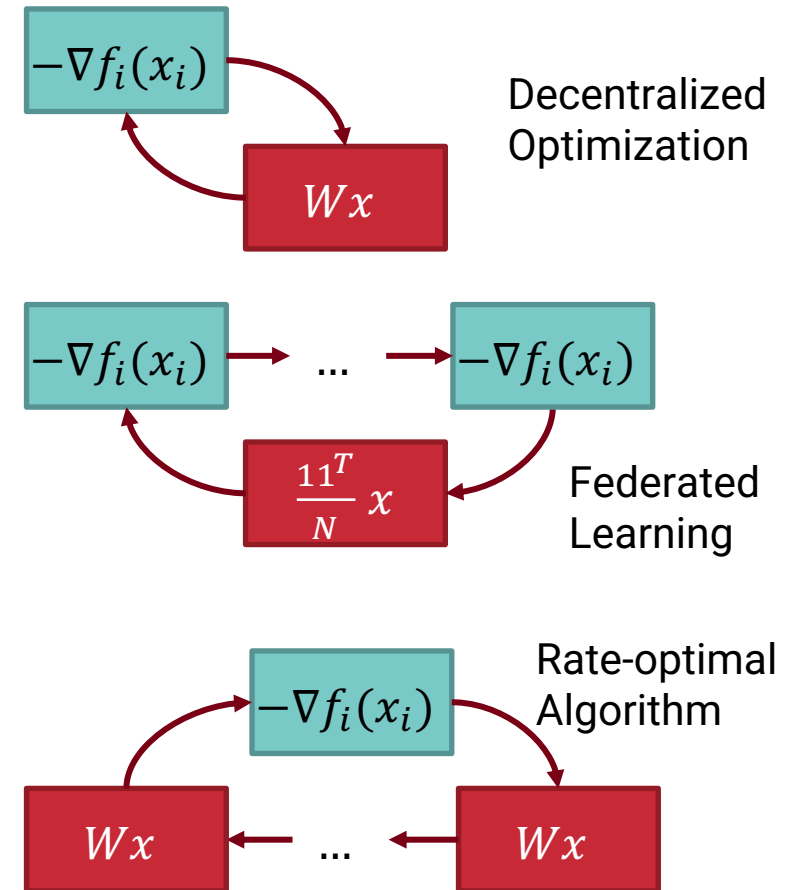


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Classification of Distributed Optimization Algorithms

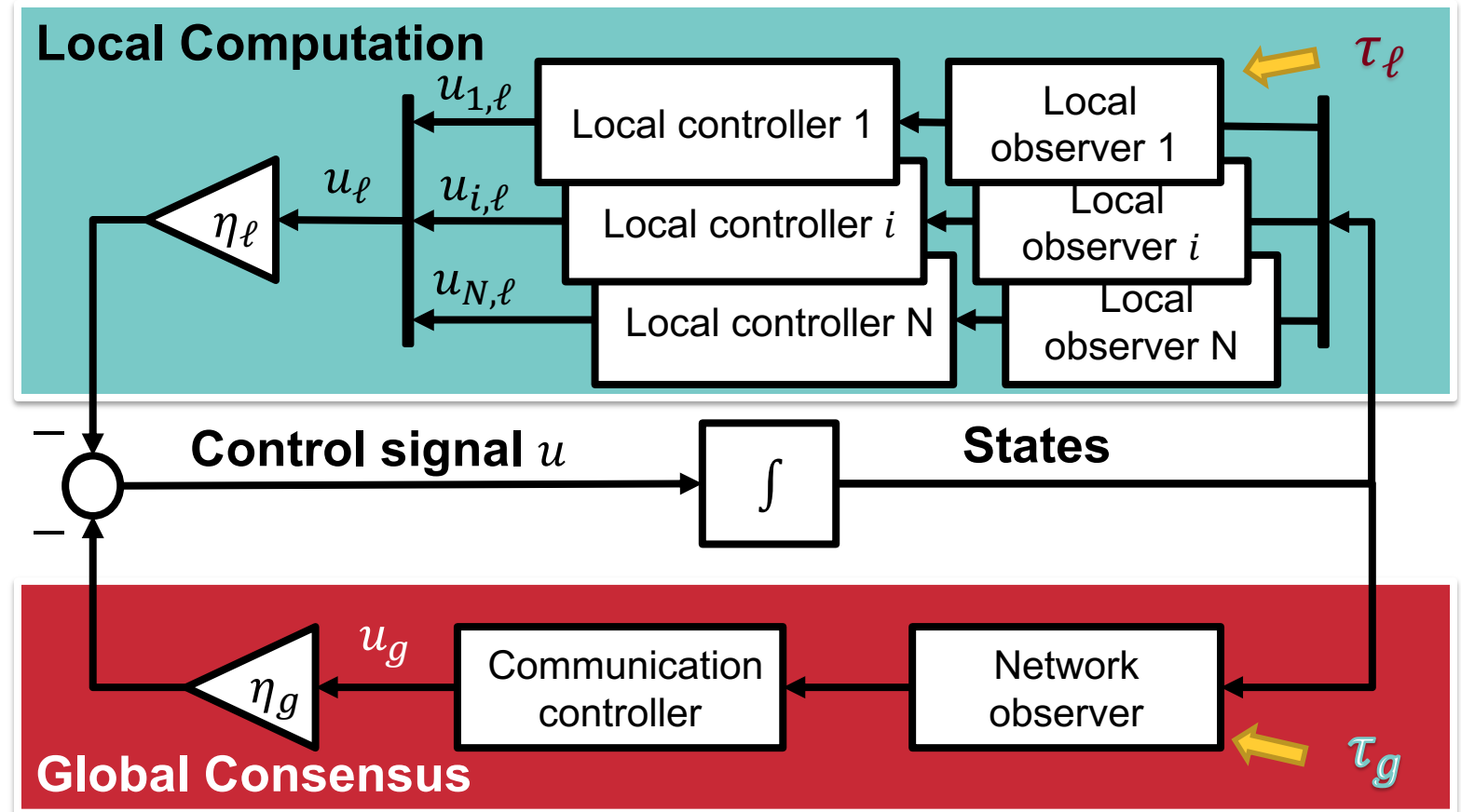
- Decentralized Optimization (DO)
 - Communication graph are usually not complete
 - One step local update & one step communication
- Federated Learning (FL)
 - Server + client, complete/star graph
 - Multi-step local update & one step communication
- Rate-optimal Algorithms (RO)
 - One step local update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

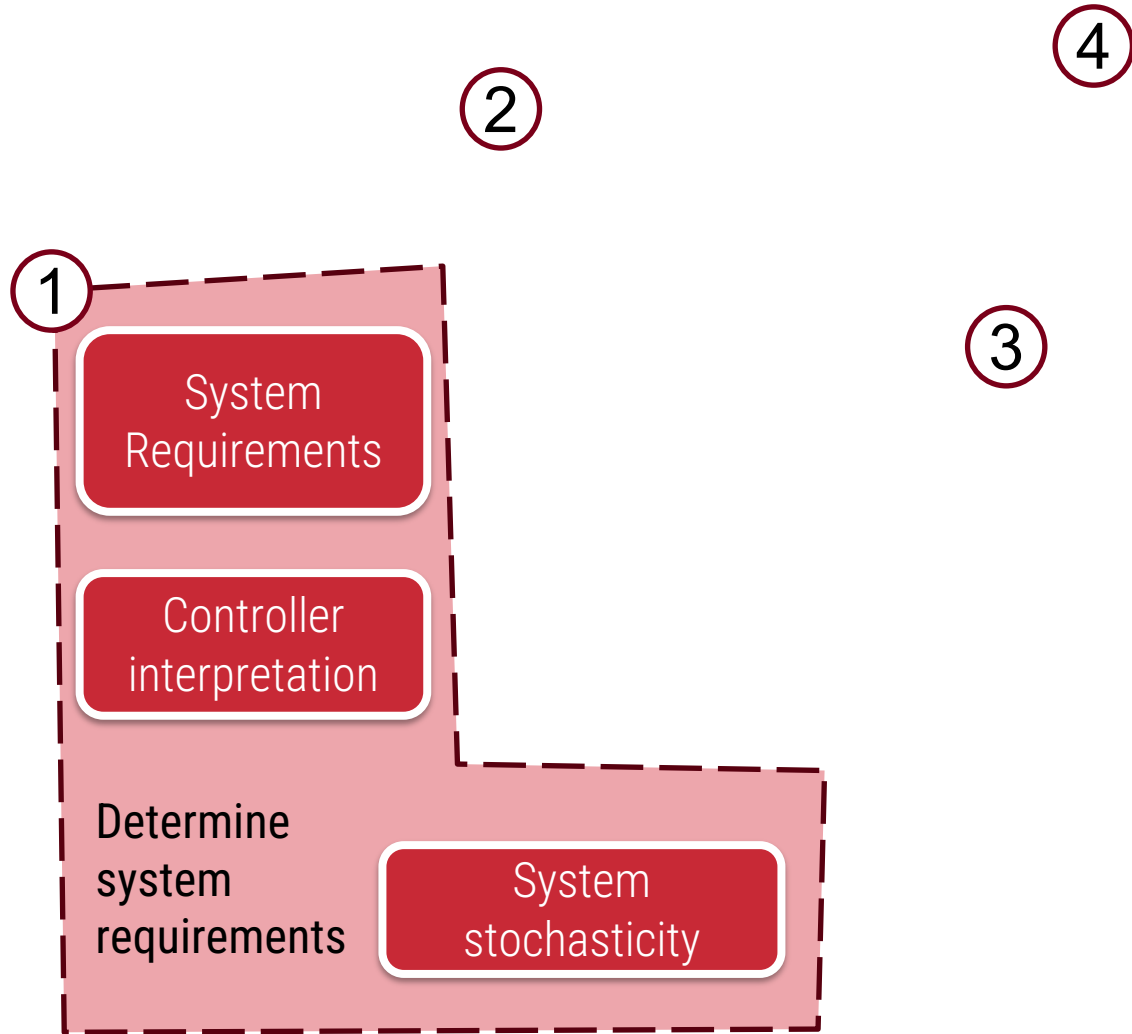


Adding Stochasticity to the Controllers with Convergence Guarantee

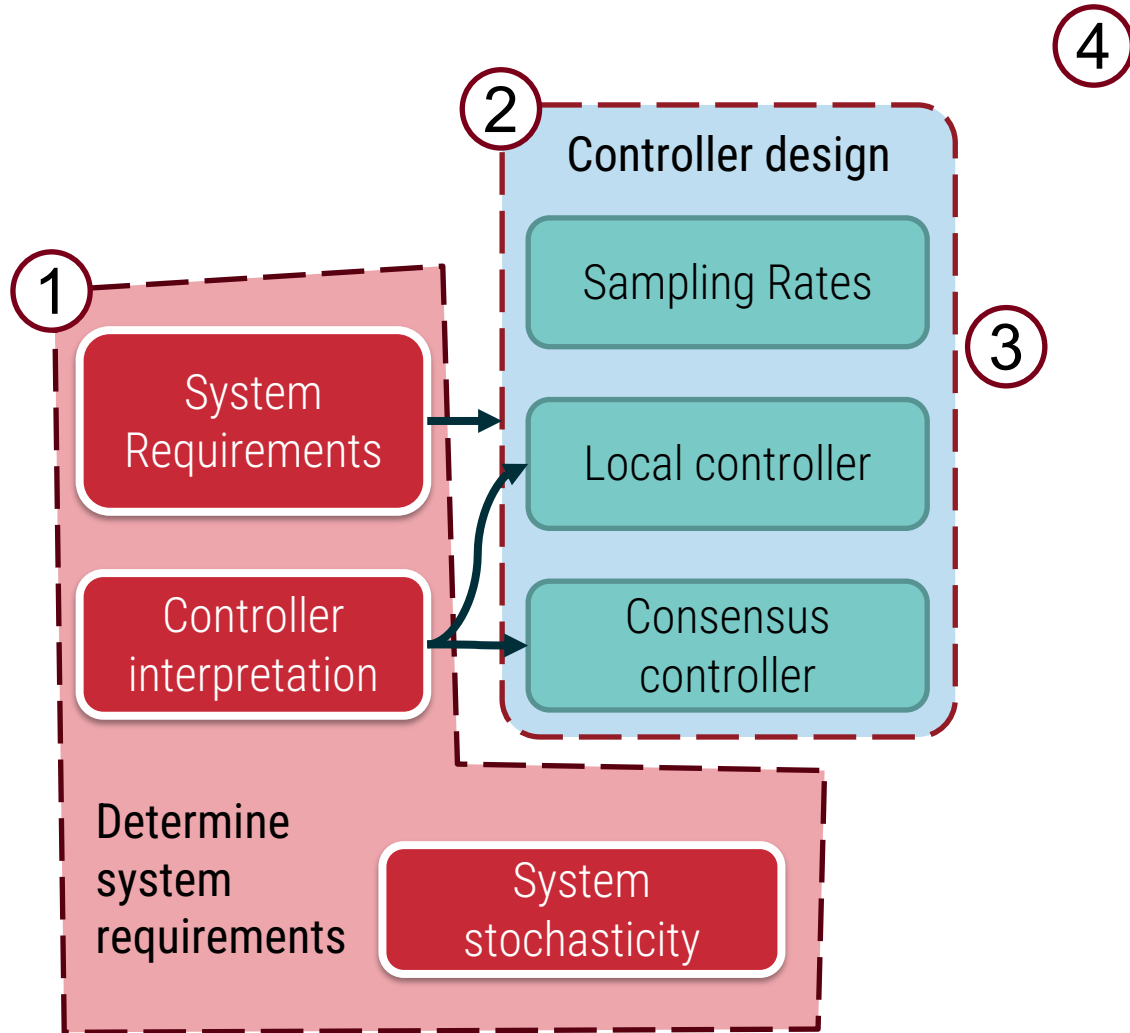
- Decide the controller to add noise
 - Local controller: stochastic gradient, zeroth-order optimization, etc.
 - Consensus controller: dynamic communication graph, compression, differential privacy mechanism, etc.
- Decide the property of the noise
 - Additive / Multiplicative noise
 - Noise statistics: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



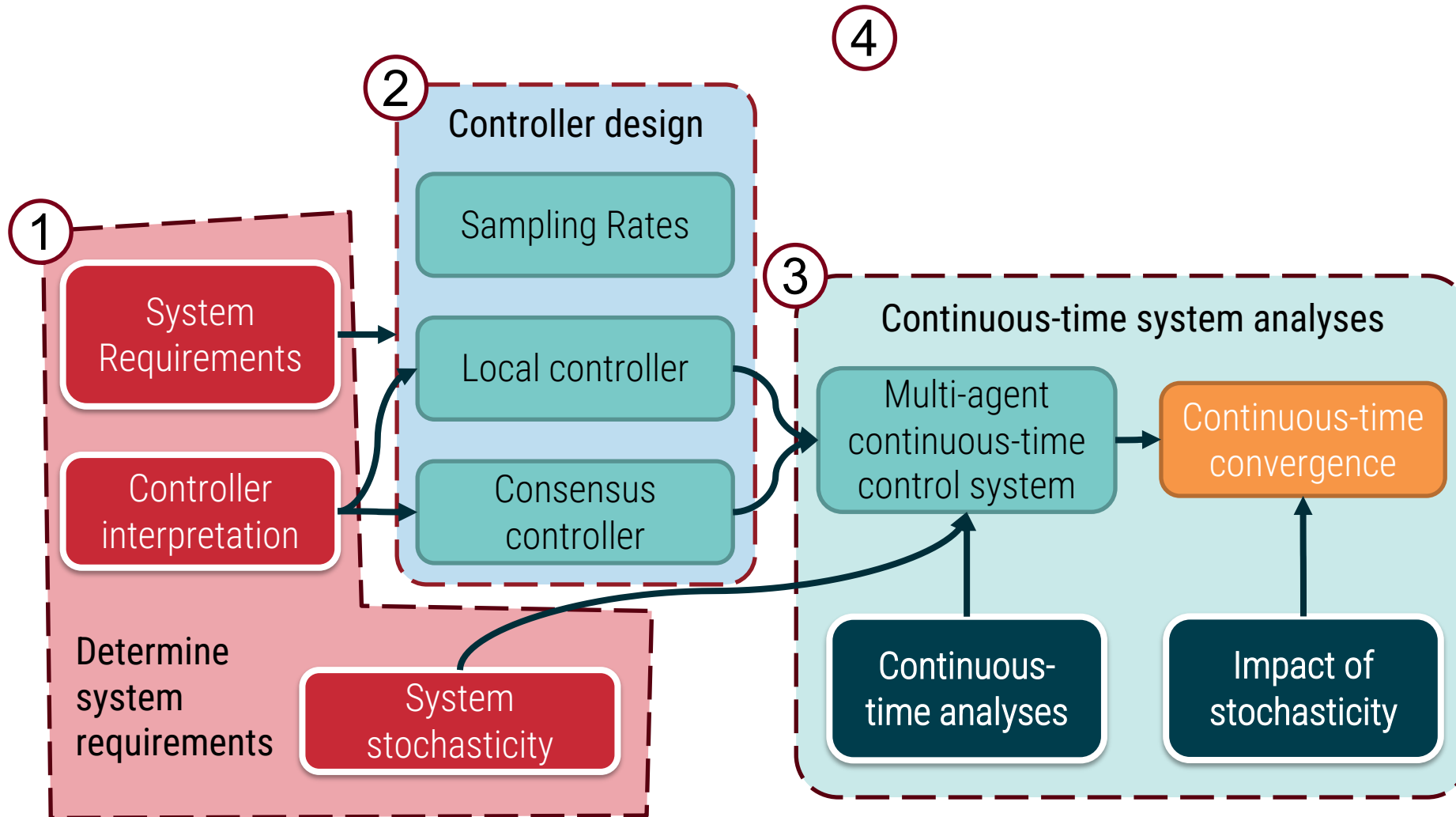
Application: Algorithm Design



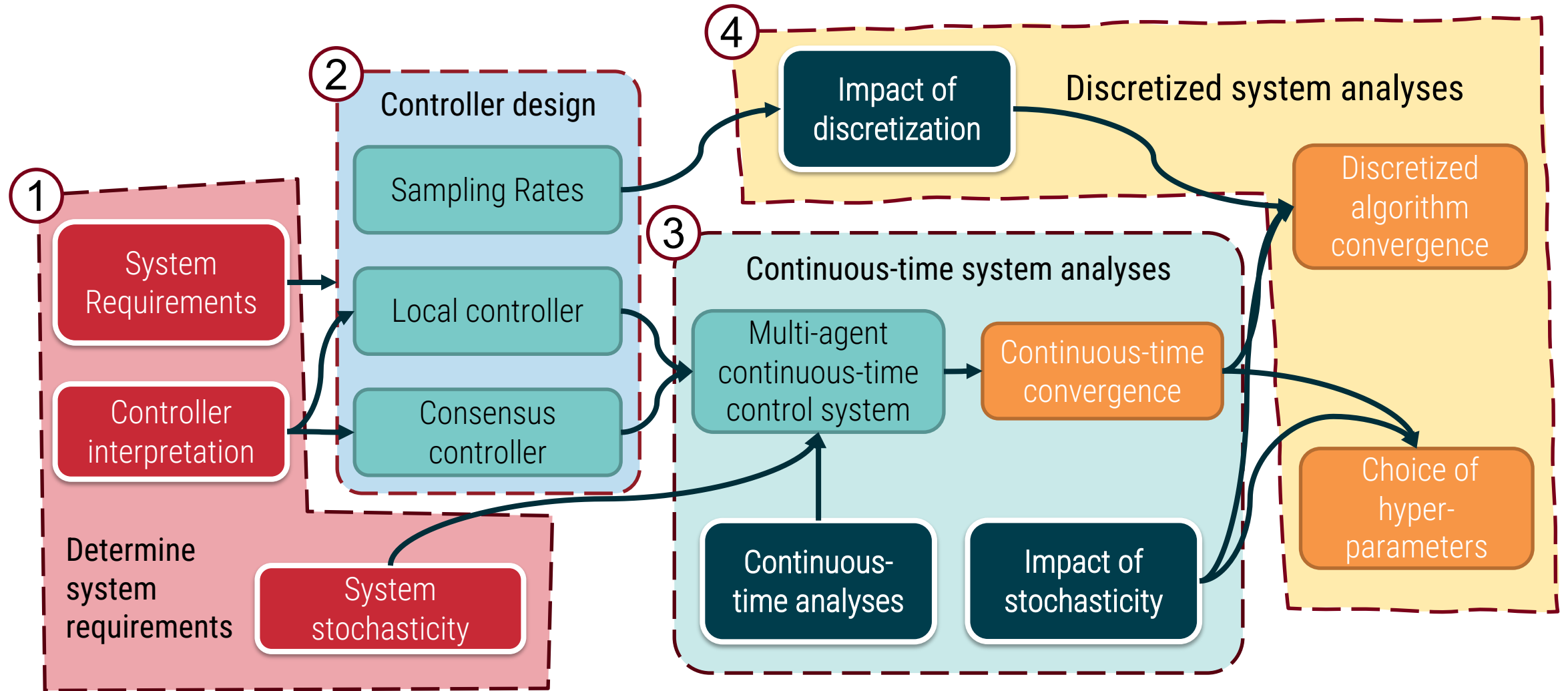
Application: Algorithm Design



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Thanks!

