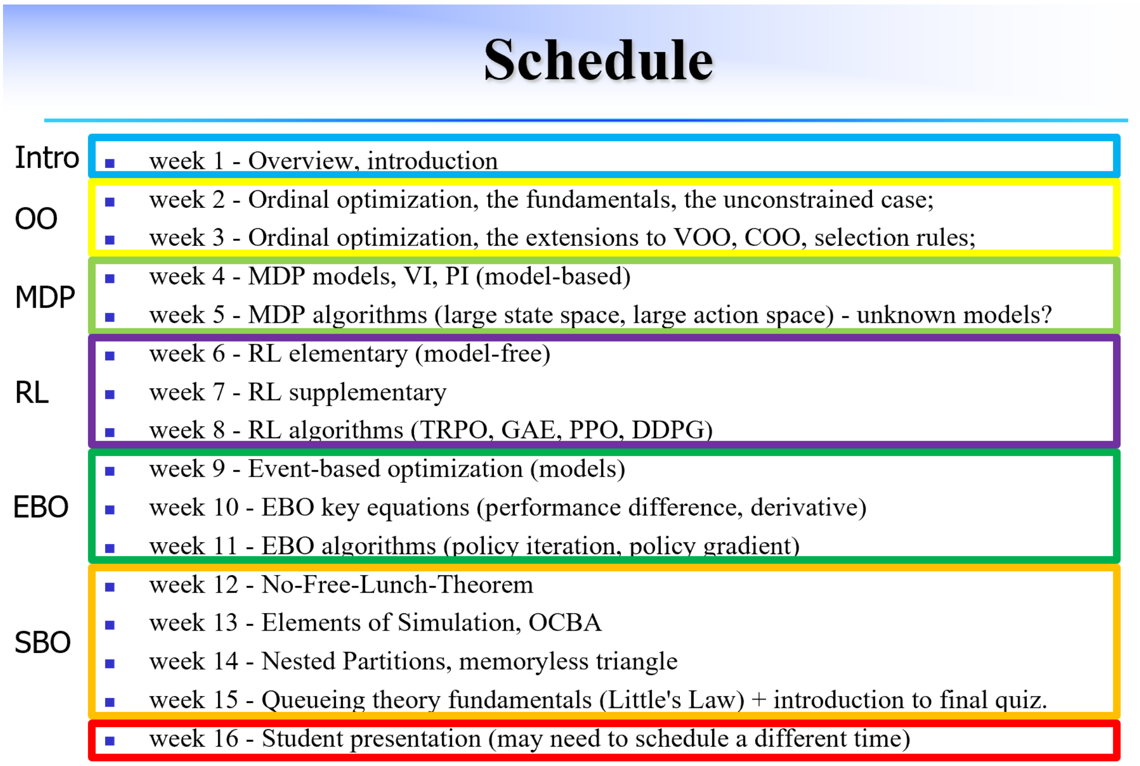
Intro to Complex Systems

Course Content



Intro to DECS

1. What is Complex System:
   - simulation-based
   - takes long time to simulate
2. Time cost of simulation
   - a computer network, an electronic grid ...
   - several days --> optimize
3. What can we do?
   - **Model** the DEDS
   - **Simulate** the DEDS
   - **Evaluate** the DEDS
   - **Optimize** the DEDS
4. What is DEDS:
   - Discrete event dynamic system
   - state s_i is concrete
   - state transition mechanism is **event-driven**

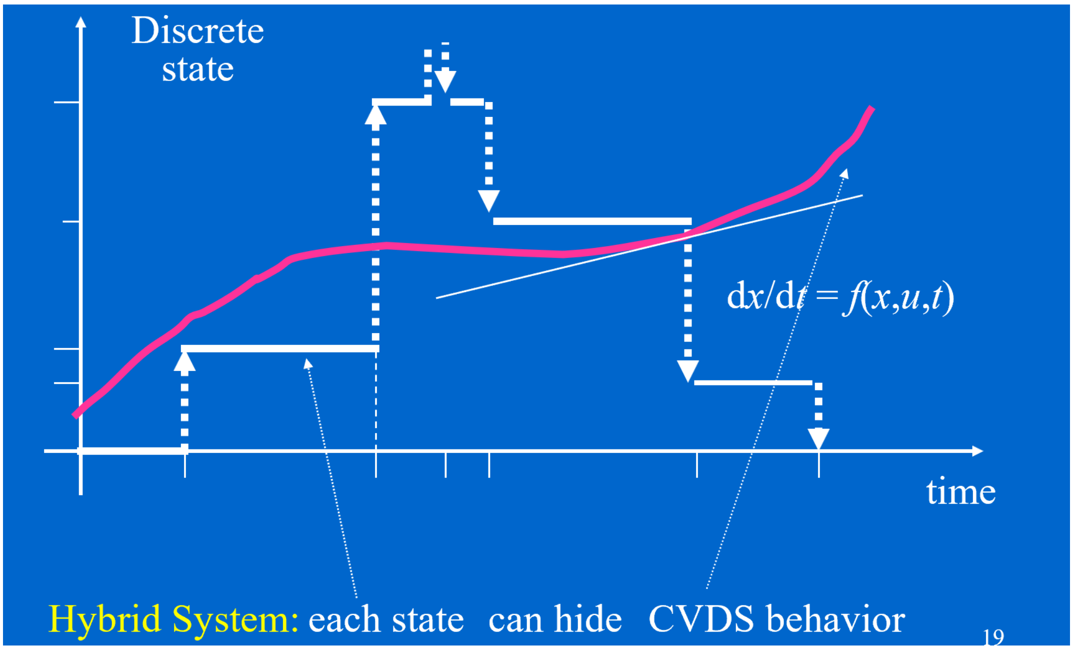
     e.g. Airport, The Internet
5. Nature of DEDS:
   - A set of tasks

- A set of resources
- Routing (among resources)
- Scheduling (among tasks)

> Just like an optimization problem......

6. Comparison with a CVDS Trajectory:
   - y axis --> event --> no value

     > Q: If we integrate the DEDS trajectory several times, we shall also get a smooth trajectory. What is wrong with this?
     >
     > A: Because there are no metric assigned on the state space of a DEDS. **Integration of the DEDS trajectory makes no sense**, because the units of verticals axes has no meaning only graphical.

   - 

7. Modeling Ingredients:
   - Discrete State:

     combinatorial explosion
   - Stochastic Effects
   - Hierarchical:

     depending on what level is needed to optimize the performance of interest
   - Computational

     computationally feasible algorithms
8. Mathematical Specification:
   - state approach
     - X: finite state space
     - A: event space, e.g. arrival
     - $\Gamma(x)$: enabled event space
     - f: state transition function
   - input / output approach:
     - string & language

- clock mechanism:
    - $c_n(\alpha)$: the n-th lifetime of event α
    - $\tau_n(\alpha)$: the time of the n-th occurrence of event α
- Different Models:

	FSM (Markov Chains)	Queuing Network	Min-Max Algebra	Petri Nets	Language & Processes	GSMP
STATE	yes	yes	yes	graphical	no	yes
EVENT	input	yes	yes	yes	yes	yes
FEASIBLE EVENT	**yes**	yes	yes	yes	not really	yes
TIME	no	yes	(yes)	yes	no	yes
TRANSITION	yes	yes	yes	yes	no	yes
RANDOM-NESS	no/yes	yes	no	yes	no	yes

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9. The workflow:
    - building models
    - validation and analysis
    - **evaluating the model**
    - **optimization and tuning**
10. Performance Evaluation:

- sensitivity analysis: $J(\theta + \Delta\theta)$
- performance surface: $J(\theta)$ at $\theta^{(i)}$
- find optimal parameter $\theta_{optimal}(t)$

11. Three Approaches to a Simple Control Problem:
    - open loop control
    - feedback control
    - stochastic control