Research Questions

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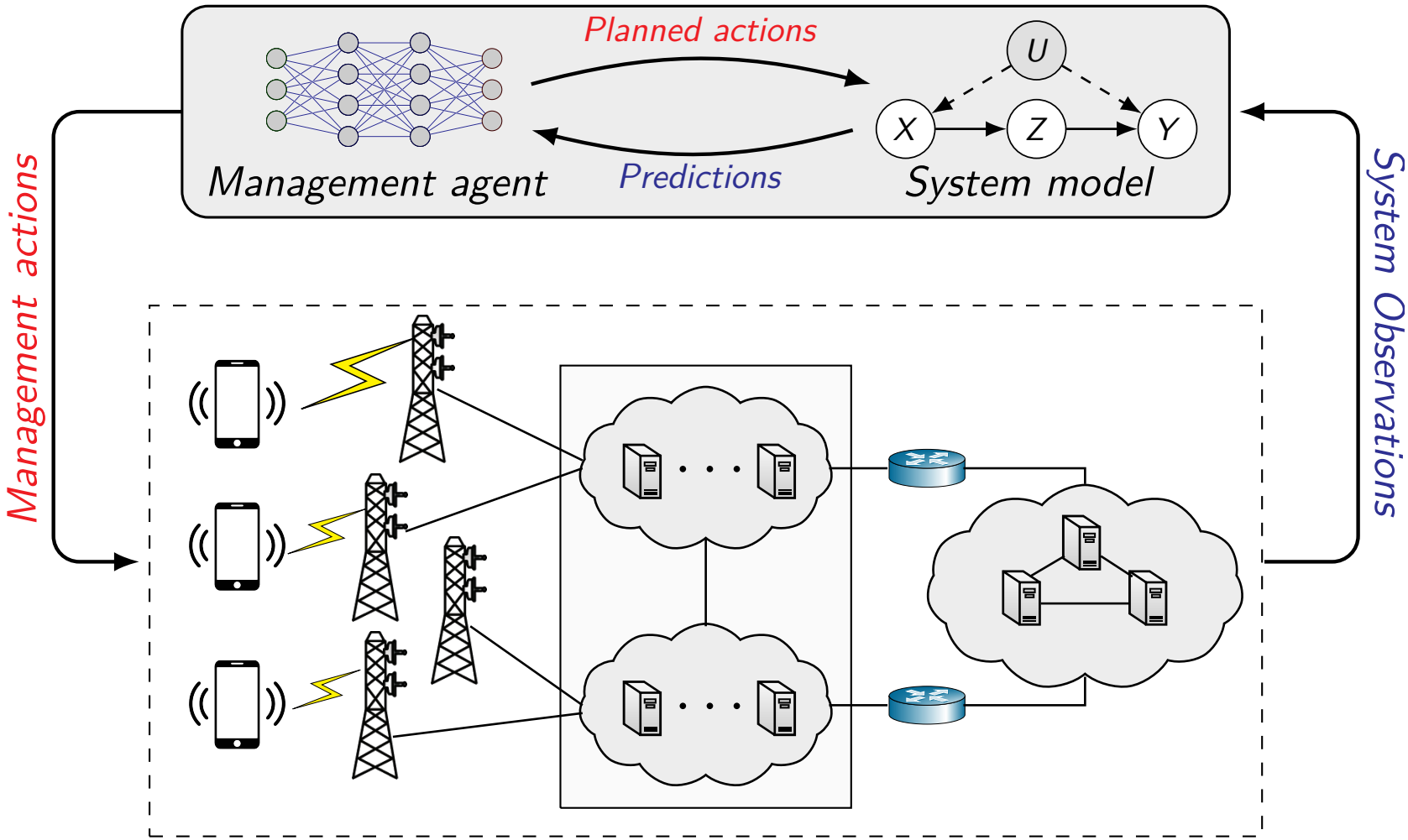
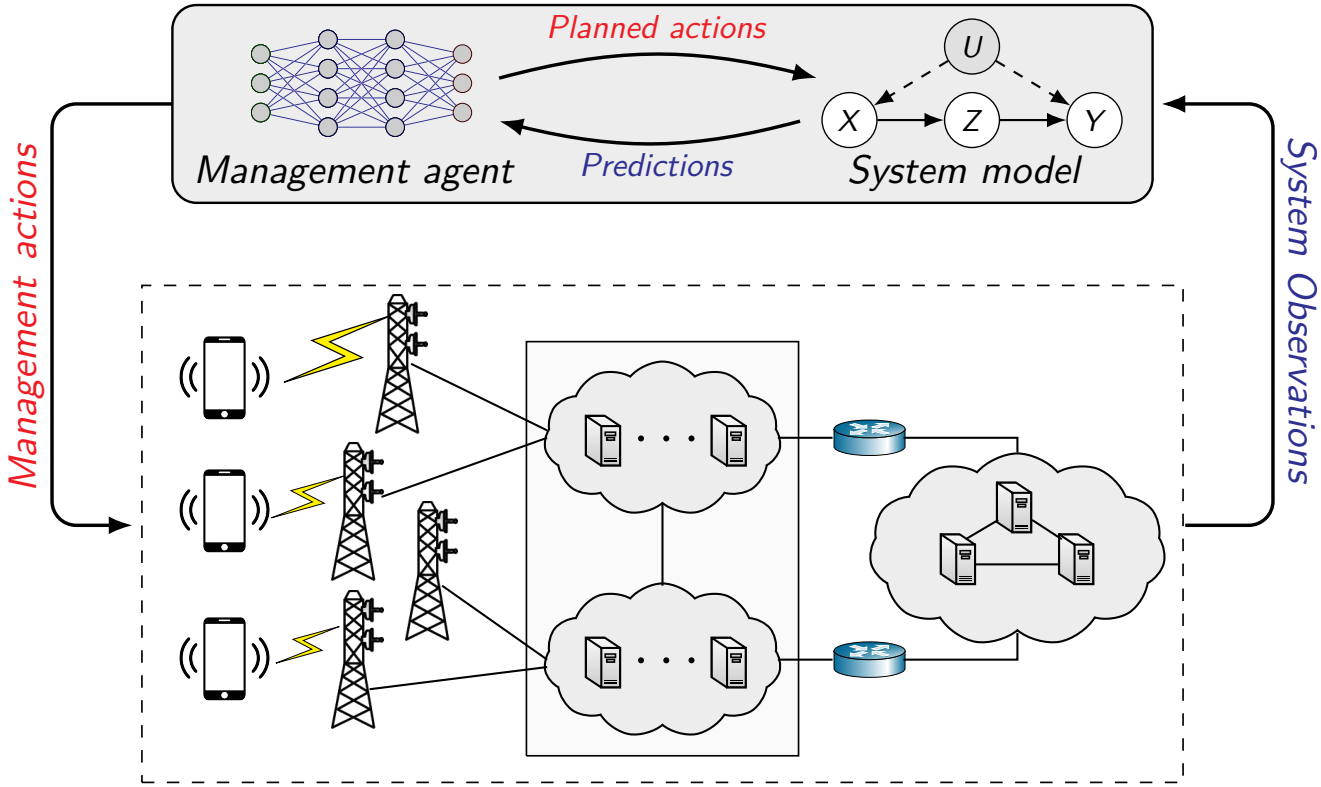
Causal System (World) Model



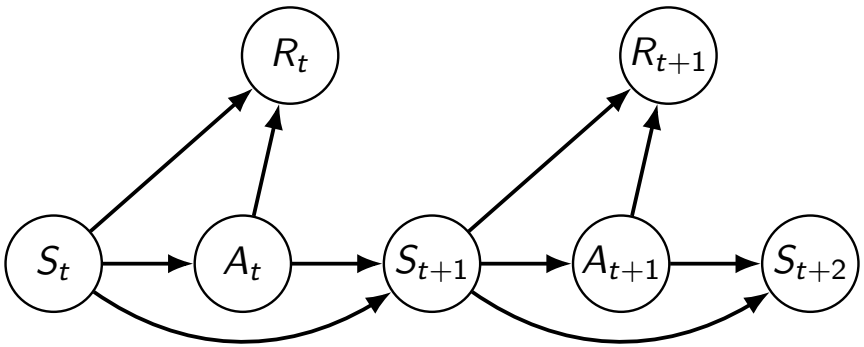
Causal System (World) Model



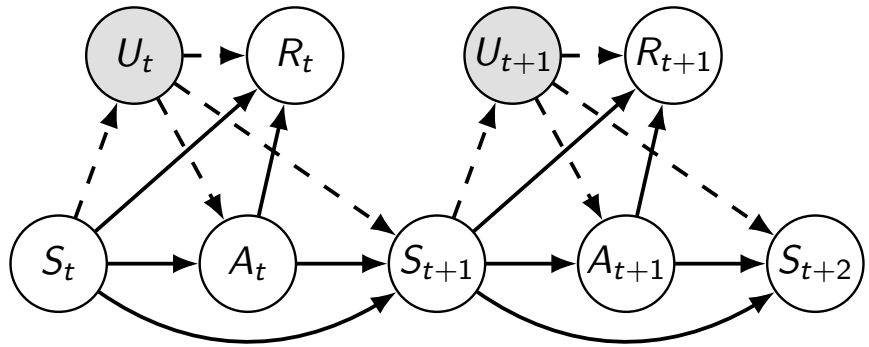
Research Question 1

How to use a causal system model for effective network management and control of a 5G network? Exploit causal structure to improve scalability and generalizability.

Causal Decision Theory



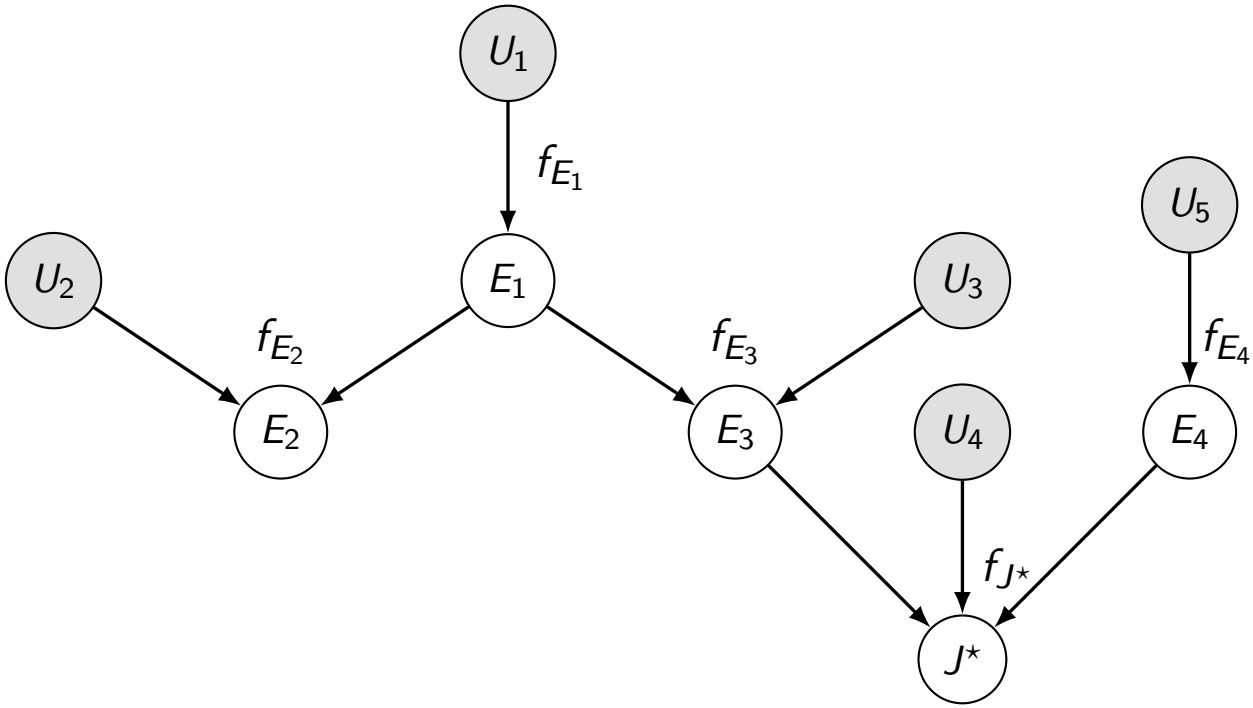
(a) Standard MDP



(b) Confounded MDP

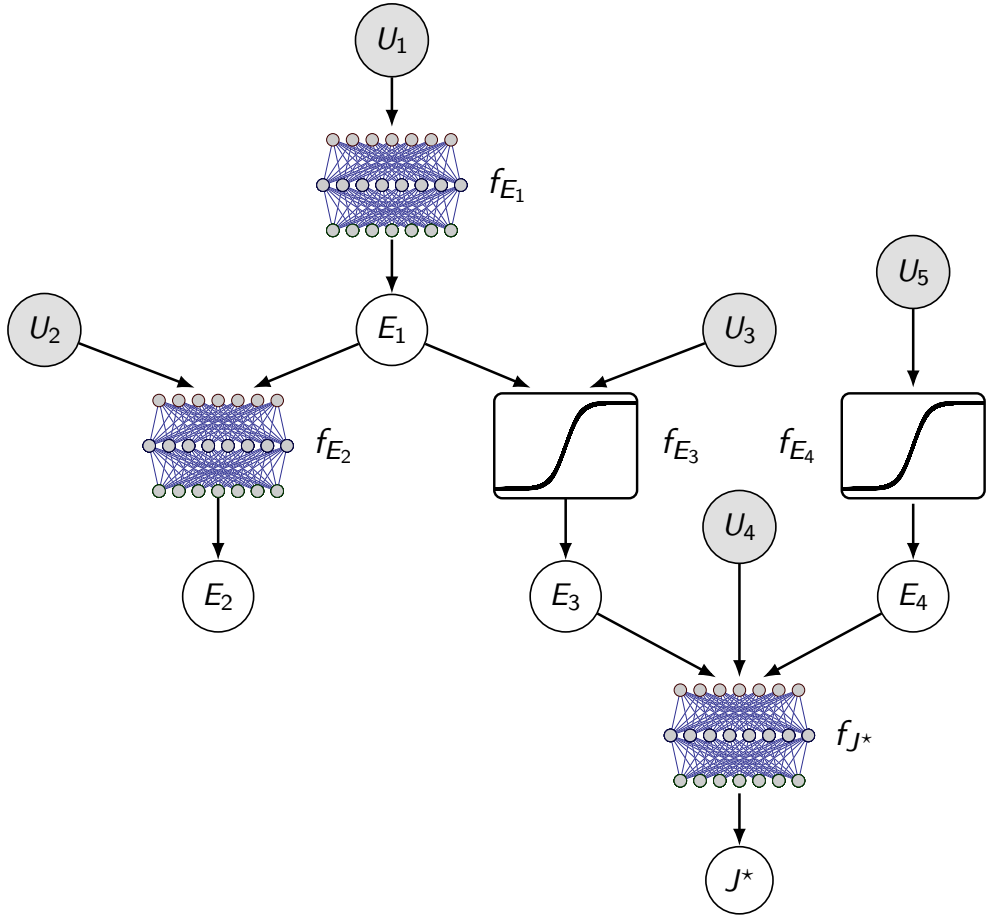
- Classical decision-theoretic models (e.g., MDPs) make strong implicit assumptions about the causal structure.
  - These assumptions may not hold in practice, leading to poor peformance once the control strategy is deployed.
- With a causal system model that expresses more realistic structures, we can compute more robust control strategies.
- We can exploit the invariances captured by the causal system model to reduce computational complexity.

Structural Causal Model



- Exogenous variables: $\mathbf{U} = \{U_1, \ldots, U_4\} \sim P(\mathbf{U})$.
- Endogenous variables: $\mathbf{E} = \{E_1, \ldots, E_4, J^\star\}$.
- Causal functions: $\mathbf{F} = \{f_{E_1}, \ldots, f_{E_4}, f_{J^\star}\}$.

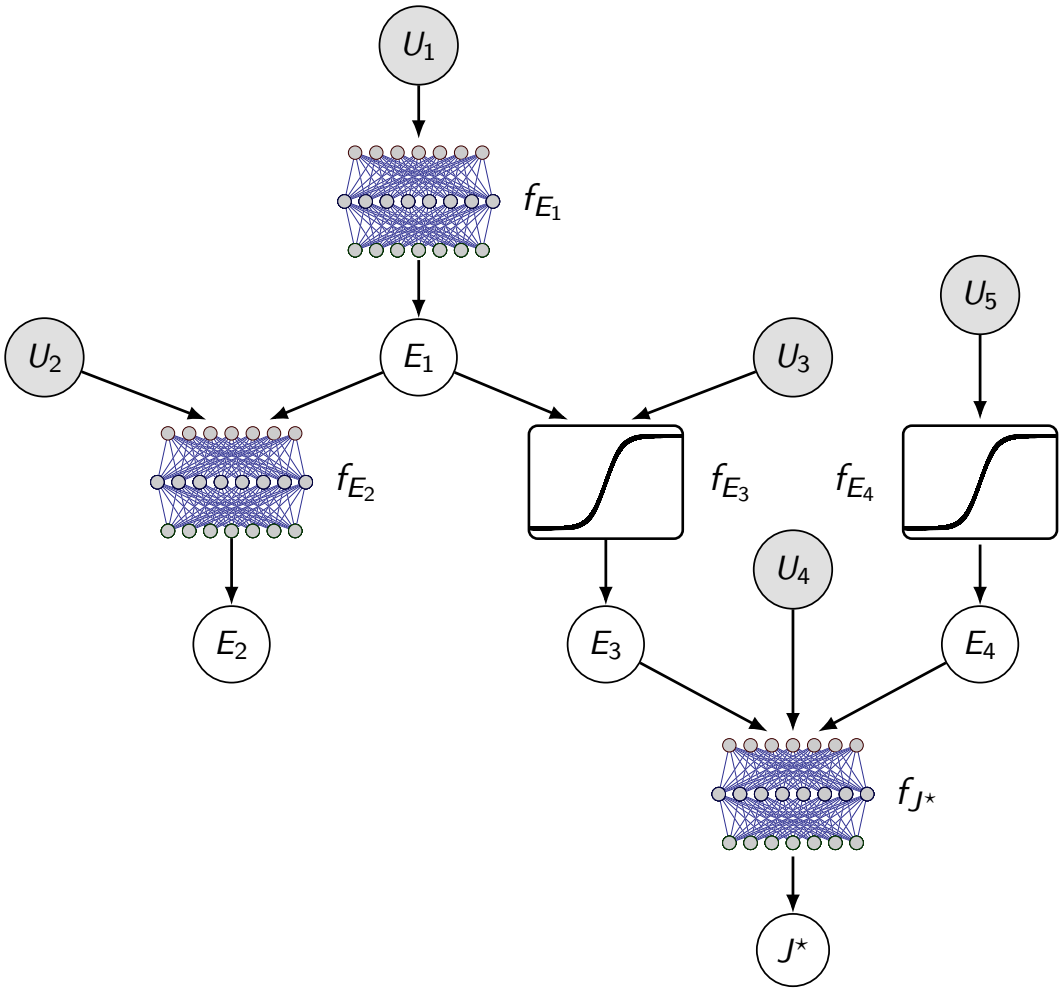
Causal Function Representation



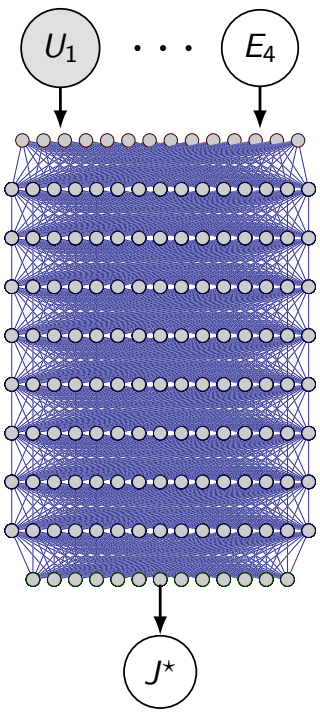
Research Question 2

How to represent the causal functions of a 5G network? A mix of analytical and neural functions. Foundation models?

Comparison with Non-Causal System Models

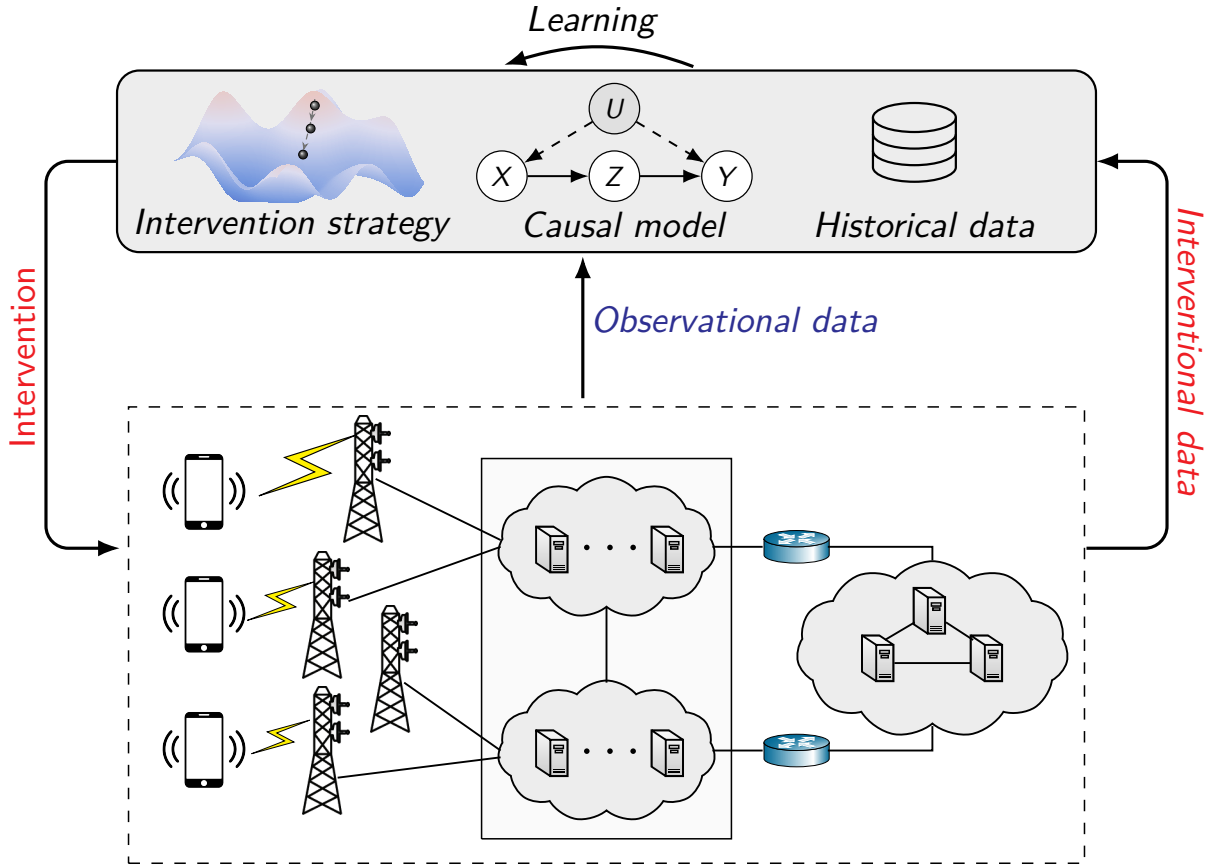


a) Causal System Model



b) Non-Causal System Model

Causal Online Inference and Learning



Research Question 3

How to learn a causal system model from observational and interventional data in a 5G network? Requires reasoning about interventions, identifiability, and do-calculus.

Summary

1. How to **use** the causal system model for effective control?
2. How to **represent** the model for a networked system?
3. How to **learn** the model from operational data?