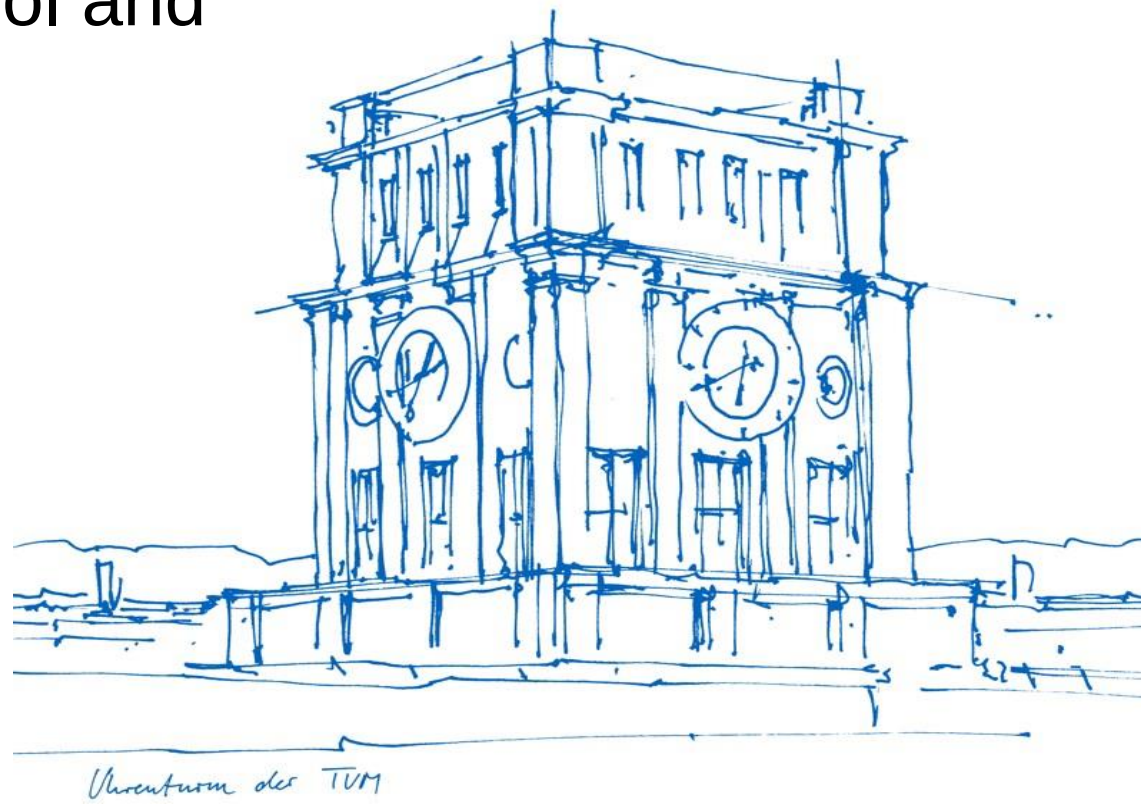
Chair of Communication Networks
Department of Electrical and Computer Engineering
Technical University of Munich

Machine Learning for Network Control and Digital Network Twinning



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Deep Neural Networks become ever larger – up to 540 billion parameters.

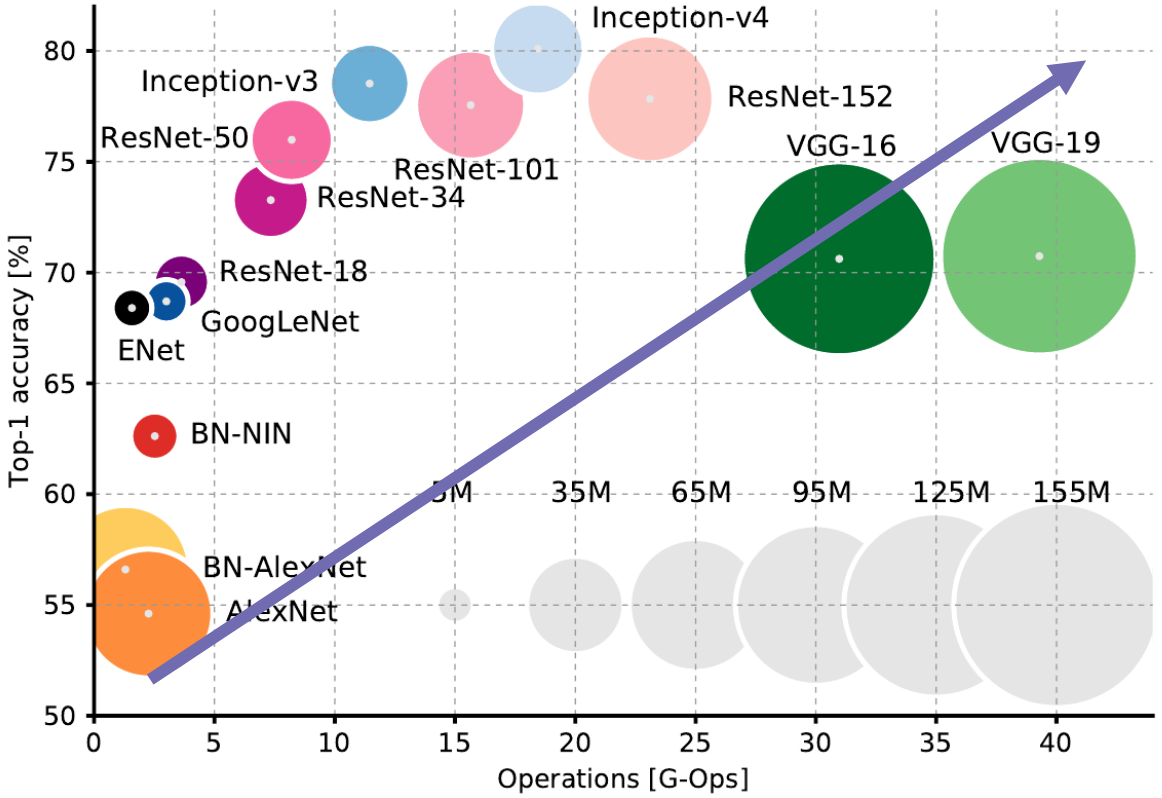
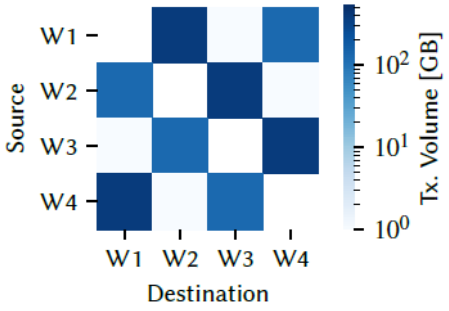


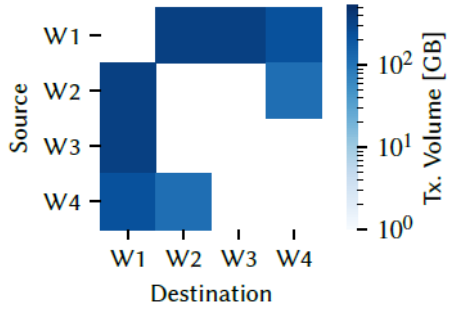
Figure taken from [1].

[1] A. Canziani, A. Paszke, and E. Culurciello, “An Analysis of Deep Neural Network Models for Practical Applications,” arXiv:1605.07678 [cs], Apr. 2017, Accessed: Oct. 26, 2021. [Online]. Available: http://arxiv.org/abs/1605.07678

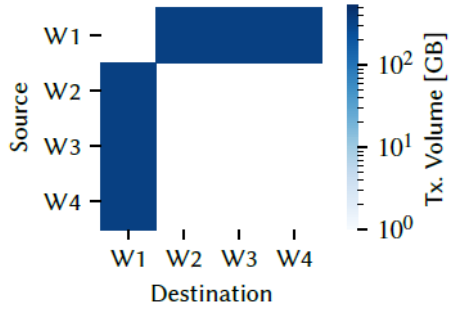
Frameworks have different communication patterns.



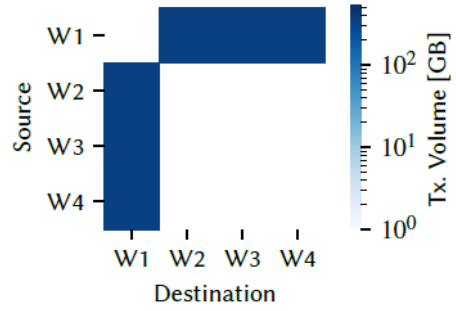
(a) Ring (Horovod).



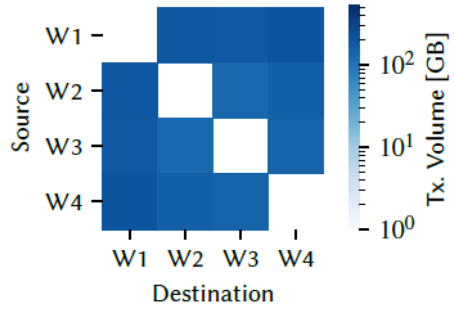
(b) BTS (KungFu S-SGD).



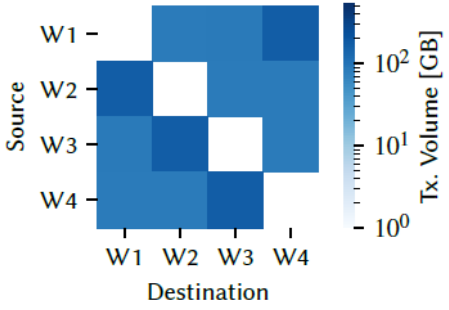
(c) Tree (KungFu S-SGD).



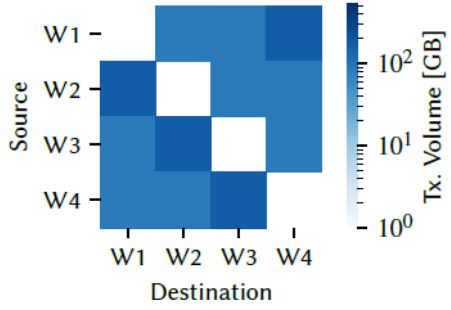
(d) Star (KungFu S-SGD).



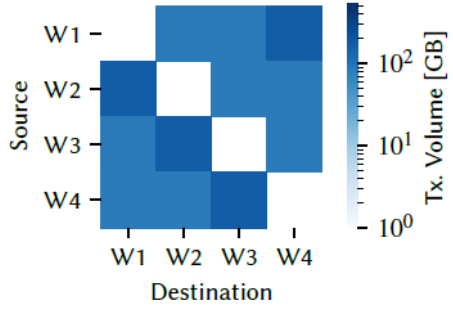
(e) Clique (KungFu S-SGD).



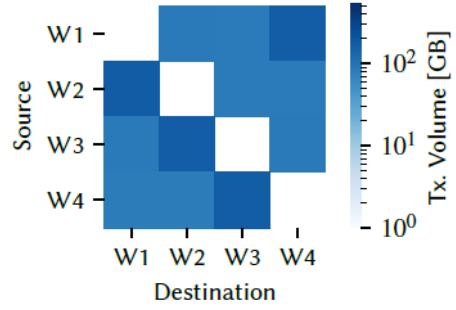
(f) BTS (KungFu PairAvg).



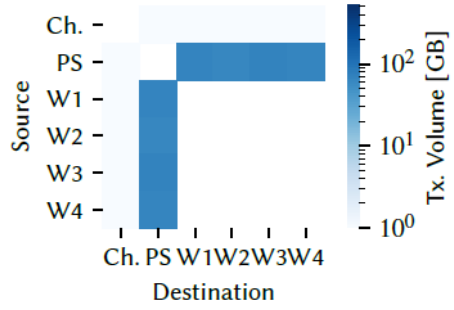
(g) Tree (KungFu PairAvg).



(h) Star (KungFu PairAvg).



(i) Clique (KungFu PairAvg).

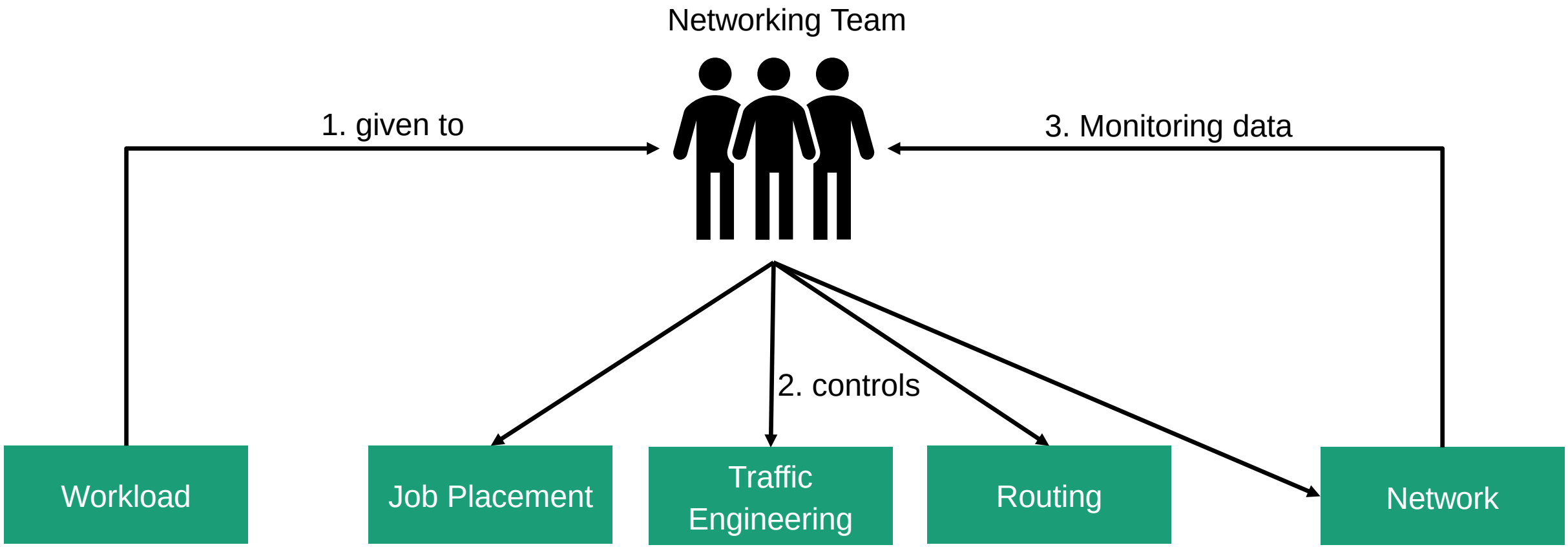


(j) PS (TensorFlow).

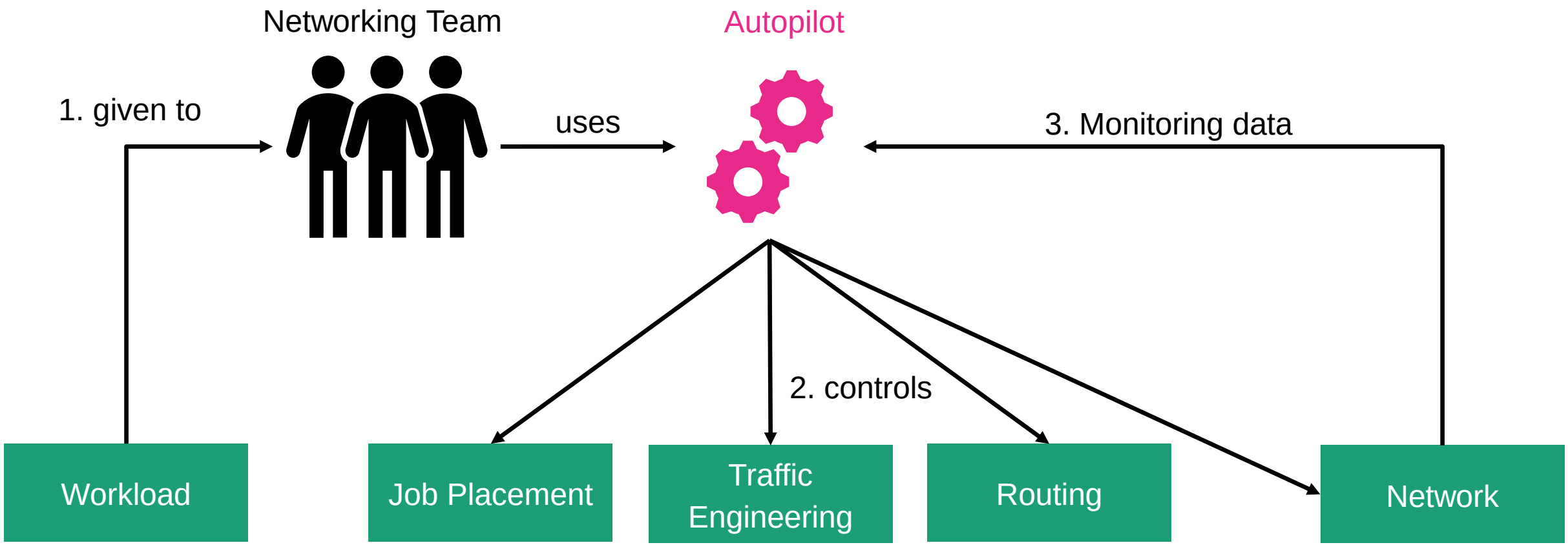
What is a good communication network topology, routing, and traffic engineering scheme to accelerate training?

J. Zerwas, K. Aykurt, S. Schmid, and A. Blenk. “Network Traffic Characteristics of Machine Learning Frameworks Under the Microscope”. In: Proc. CNSM. Izmir, Turkey: IEEE, October 2021, pp. 1 –9.

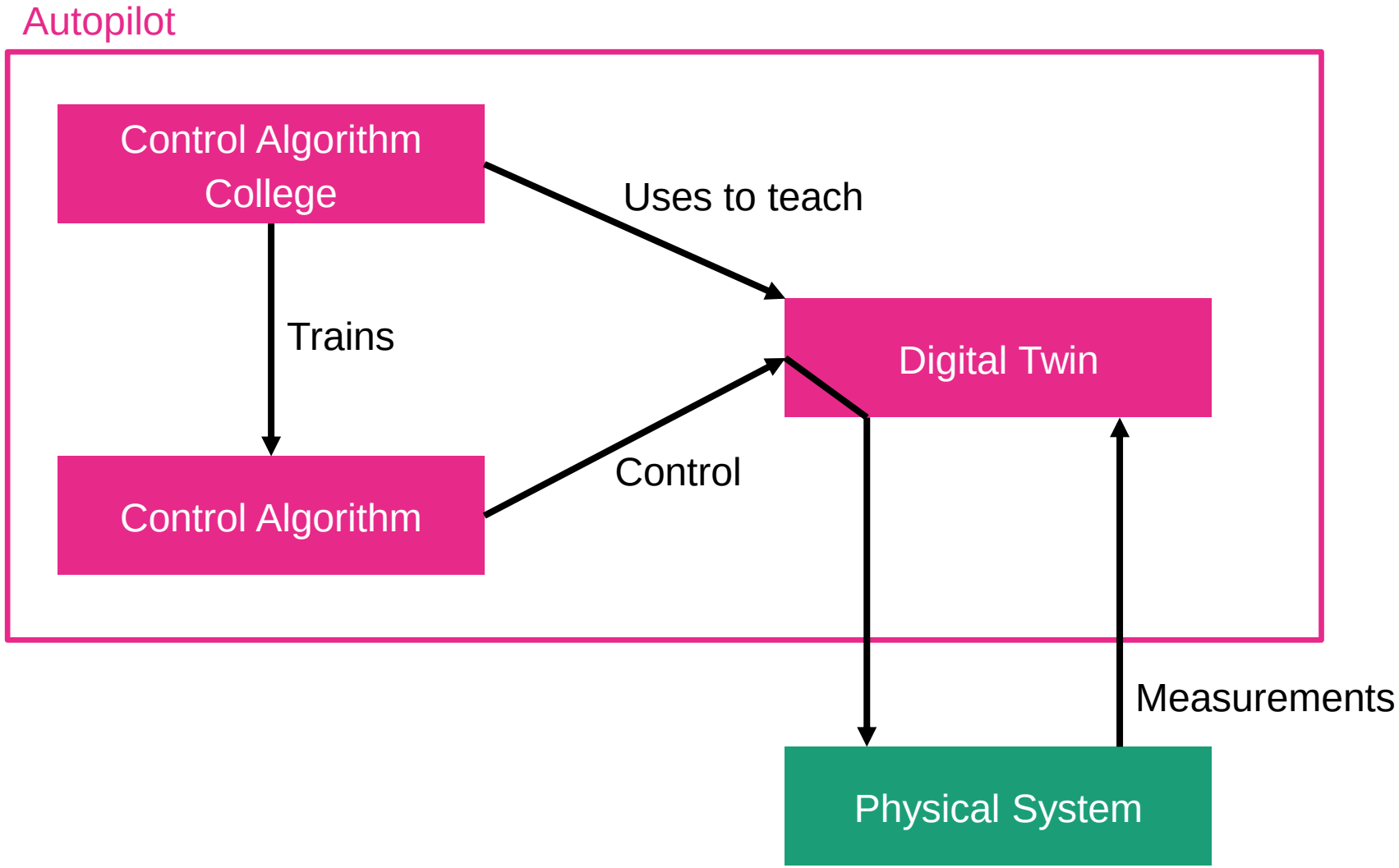
Deriving topology, routing, or traffic engineering is challenging and requires diverse skills.



Idea: Use data-driven algorithms to automatically adjust networking to the workload -> Self-driving network.



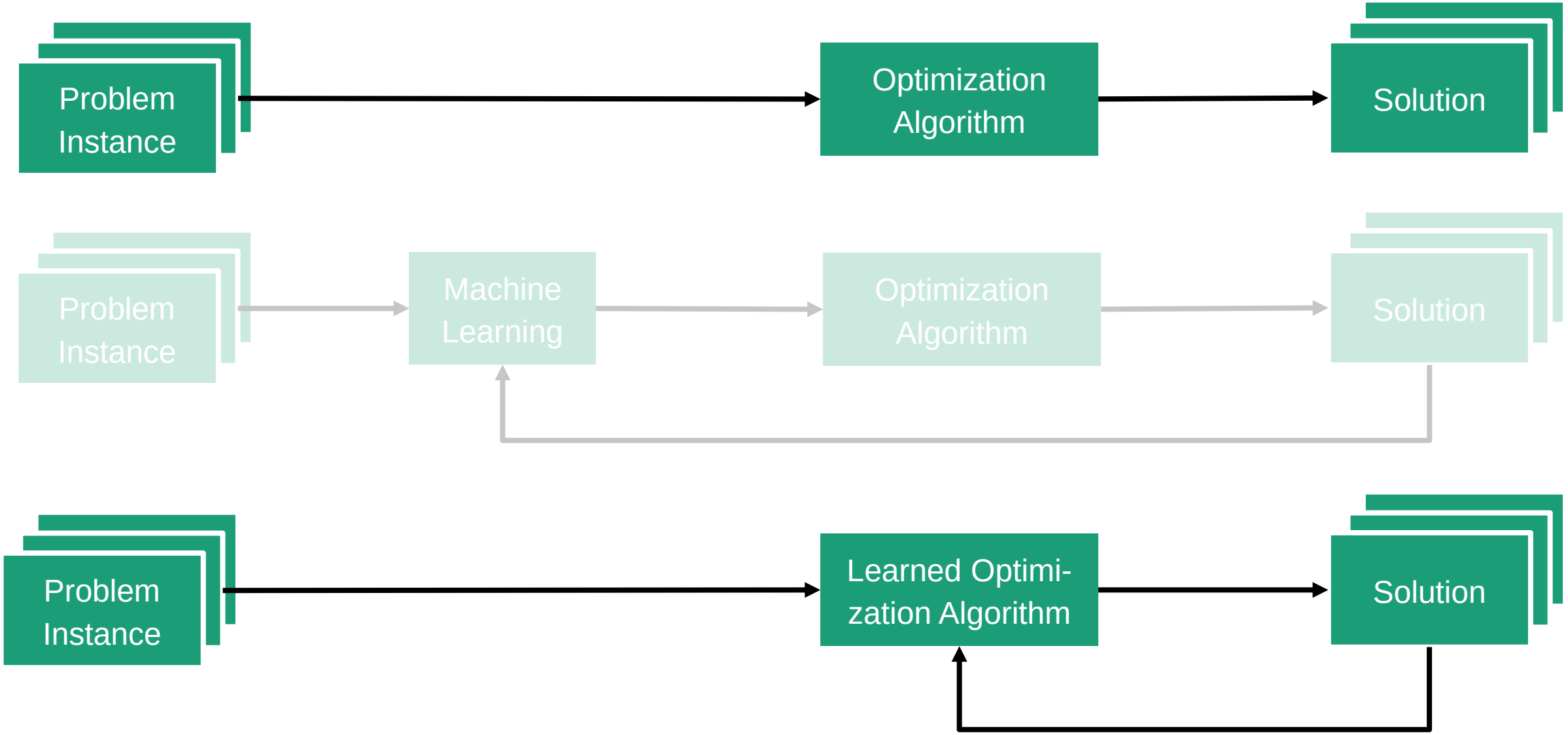
Our vision: A self-driving network that controls itself.



The past and present

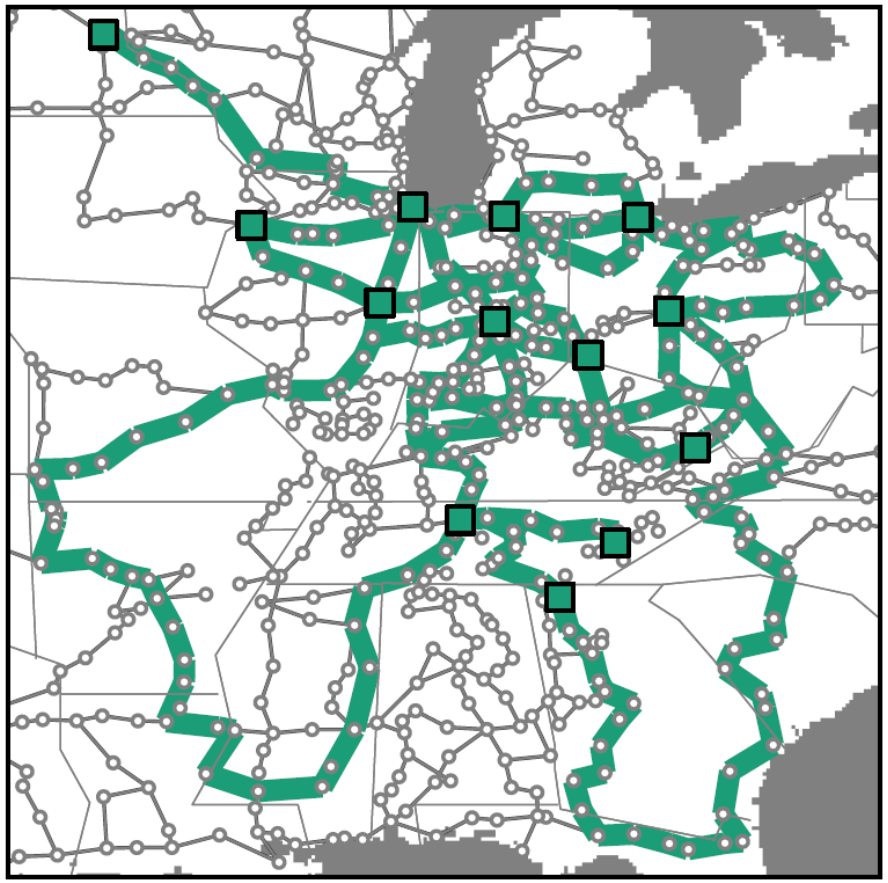
Data-driven network control algorithm design and adversarial network benchmarking.

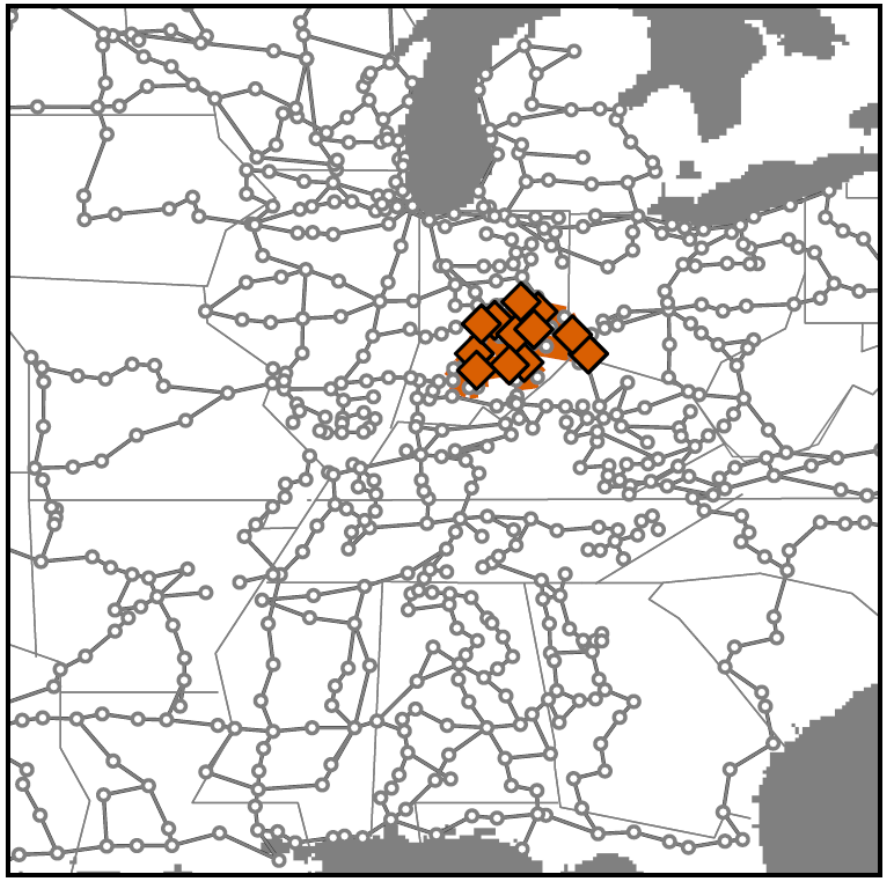
Machine Learning can augment or replace traditional optimization algorithms.



Use Case: Virtual Network Embedding

NeuroViNE improves VNE embedding algorithms through a smart solution space restriction.



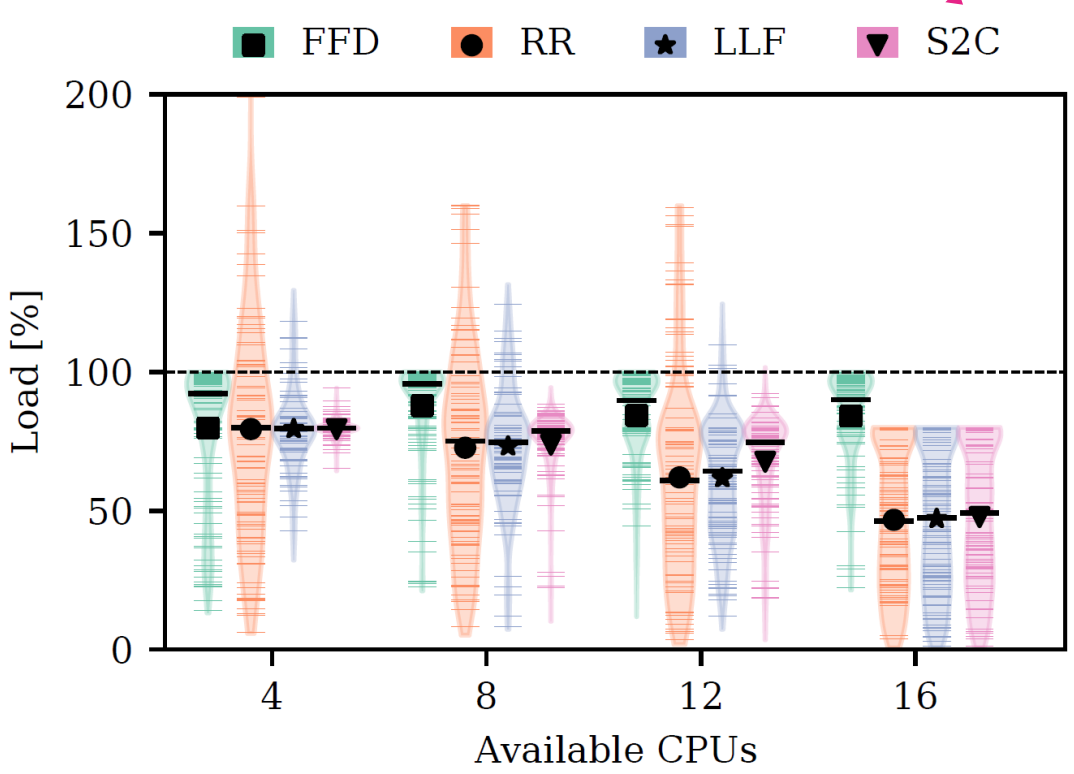


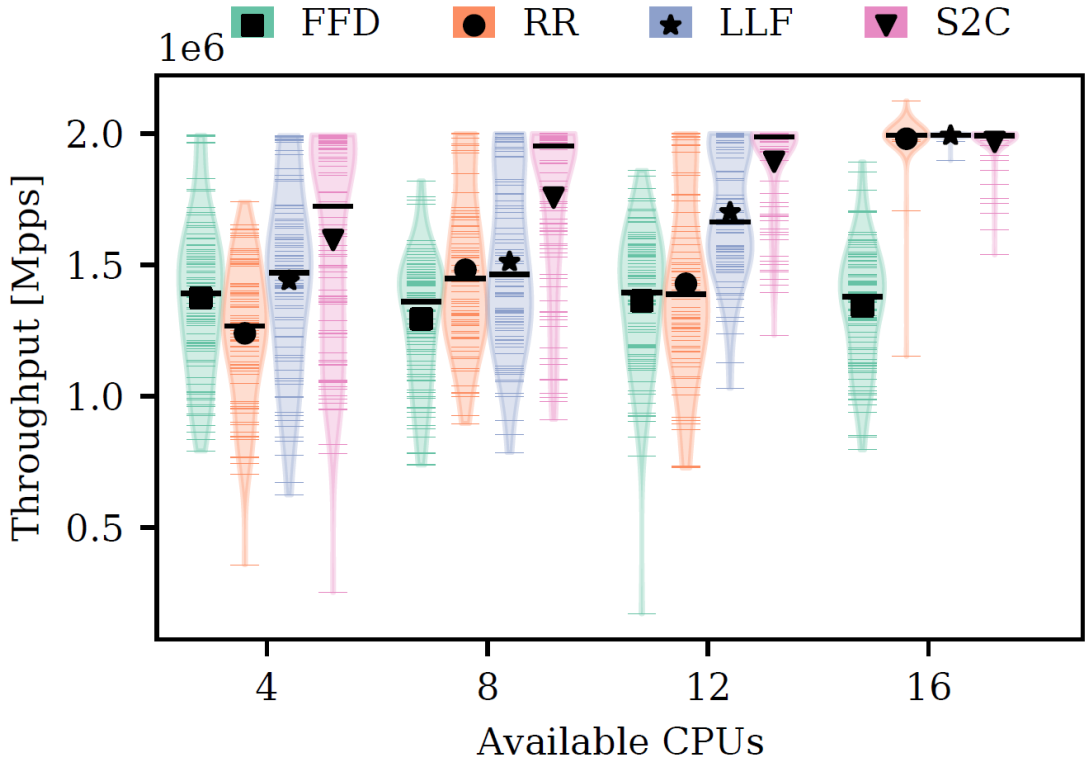
A. Blenk, P. Kalmbach, J. Zerwas, M. Jarschel, S. Schmid, and W. Kellerer, “NeuroViNE: A Neural Preprocessor for Your Virtual Network Embedding Algorithm,” in INFOCOM, Apr. 2018.

Use Case: Improving VNF co-location

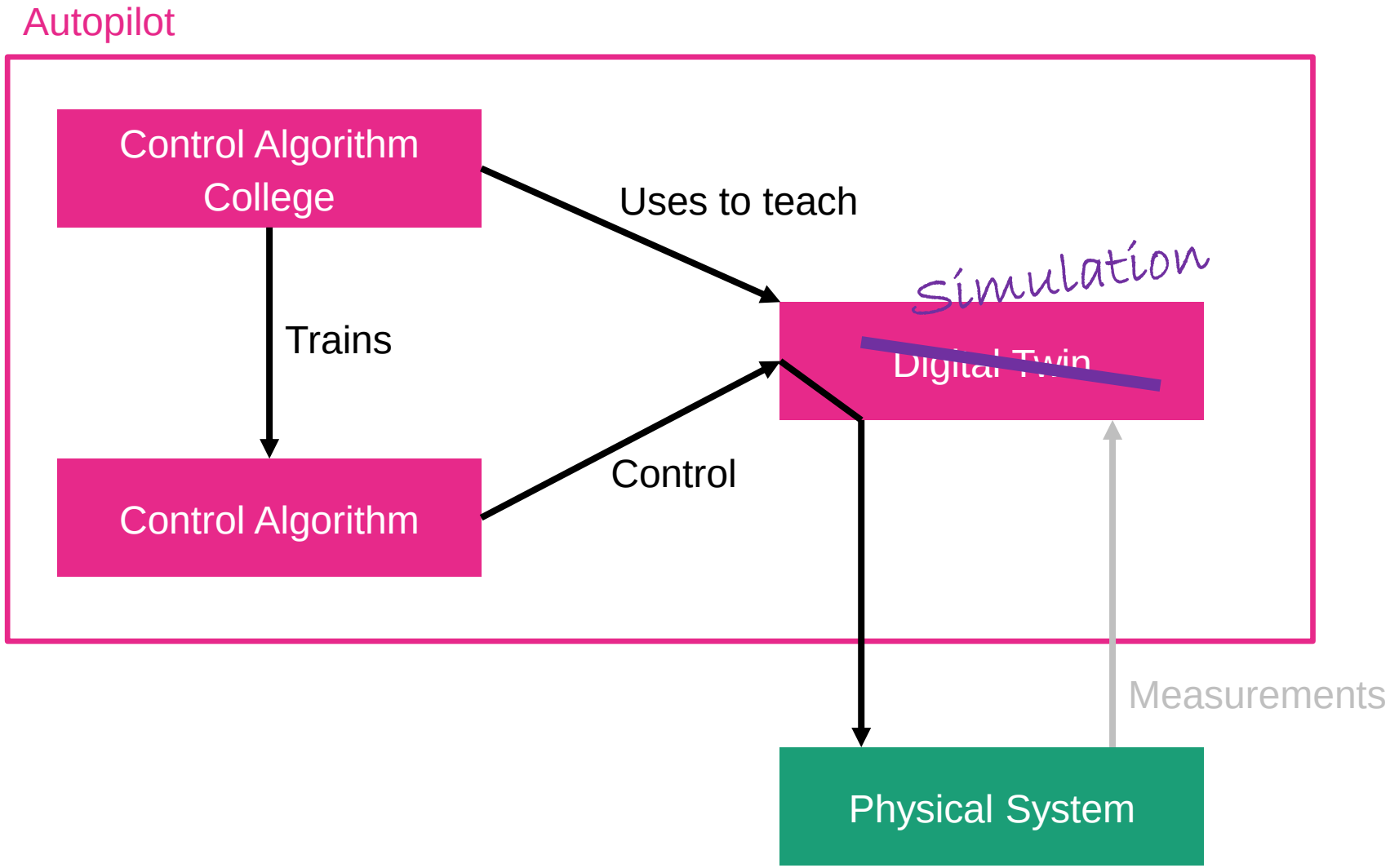
Learned optimization algorithms outperform heuristics in a load balancing problem.

Ours

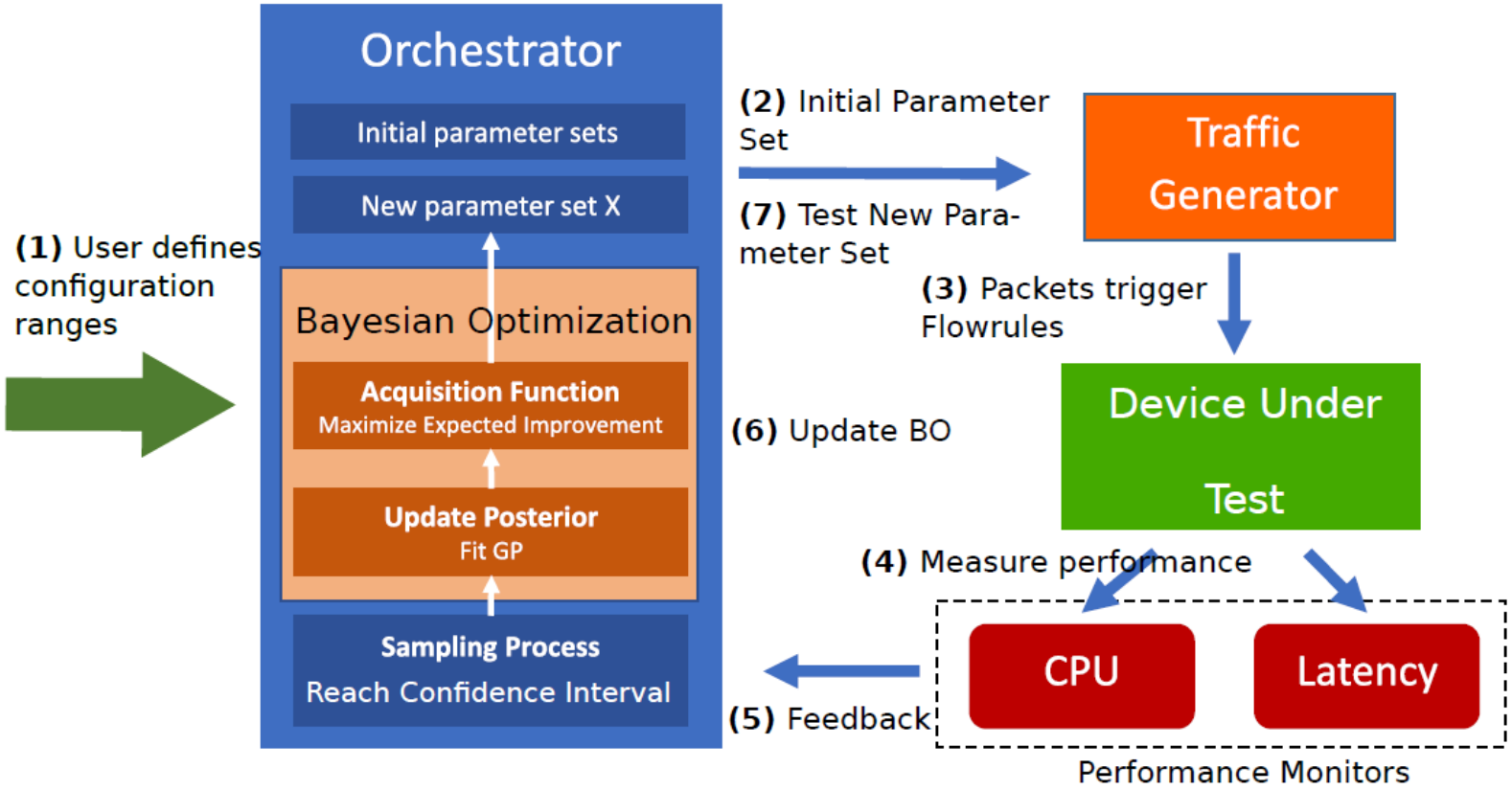




We do not have feedback from the physical system and simulations/mathematical models instead of a DT.



Machine Learning can suggest experiments to gather new data.

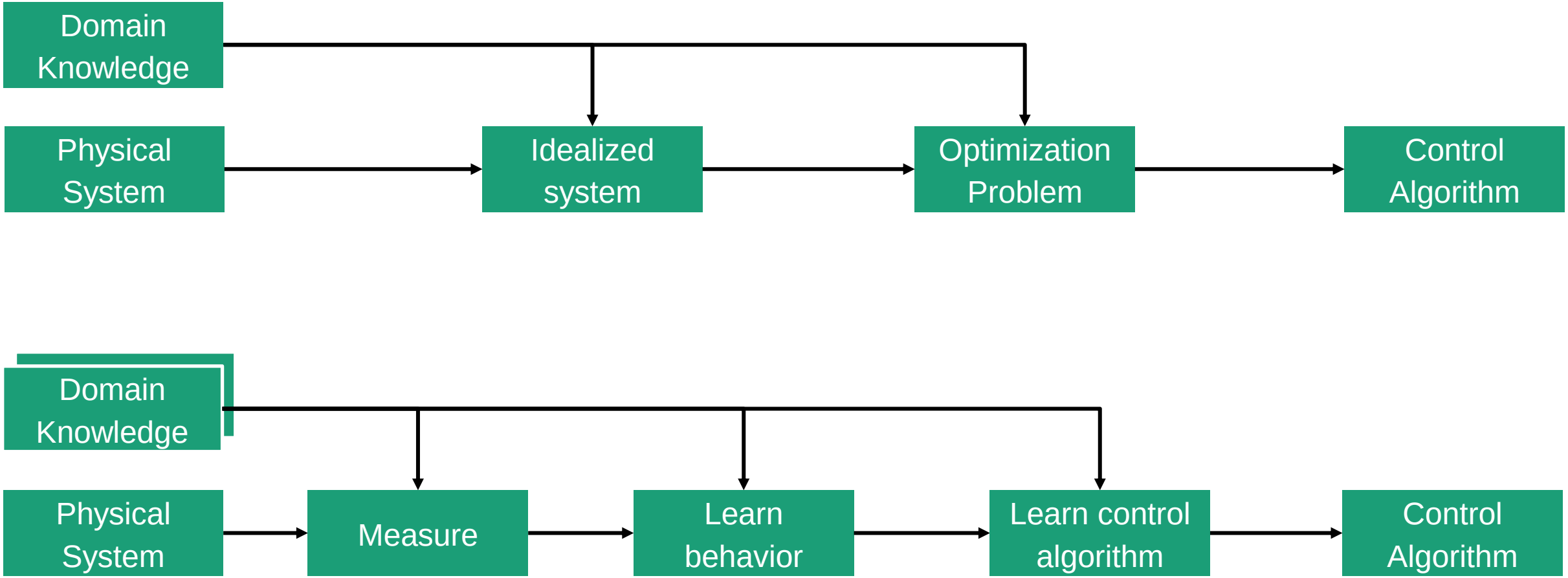


J. Zerwas, P. Kalmbach, L. Henkel, G. Rétvári, W. Kellerer, A. Blenk, and S. Schmid. “NetBOA: Self-Driving Network Benchmarking”. In: NetAI’19. Beijing, China: ACM, August 2019, pp. 1–7.

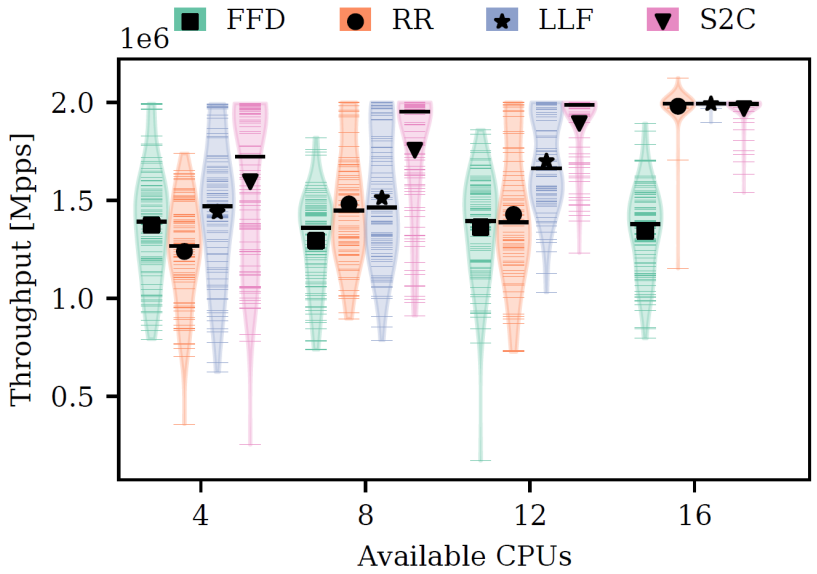
Ongoing work

Twinning the behavior of physical systems from measurements.

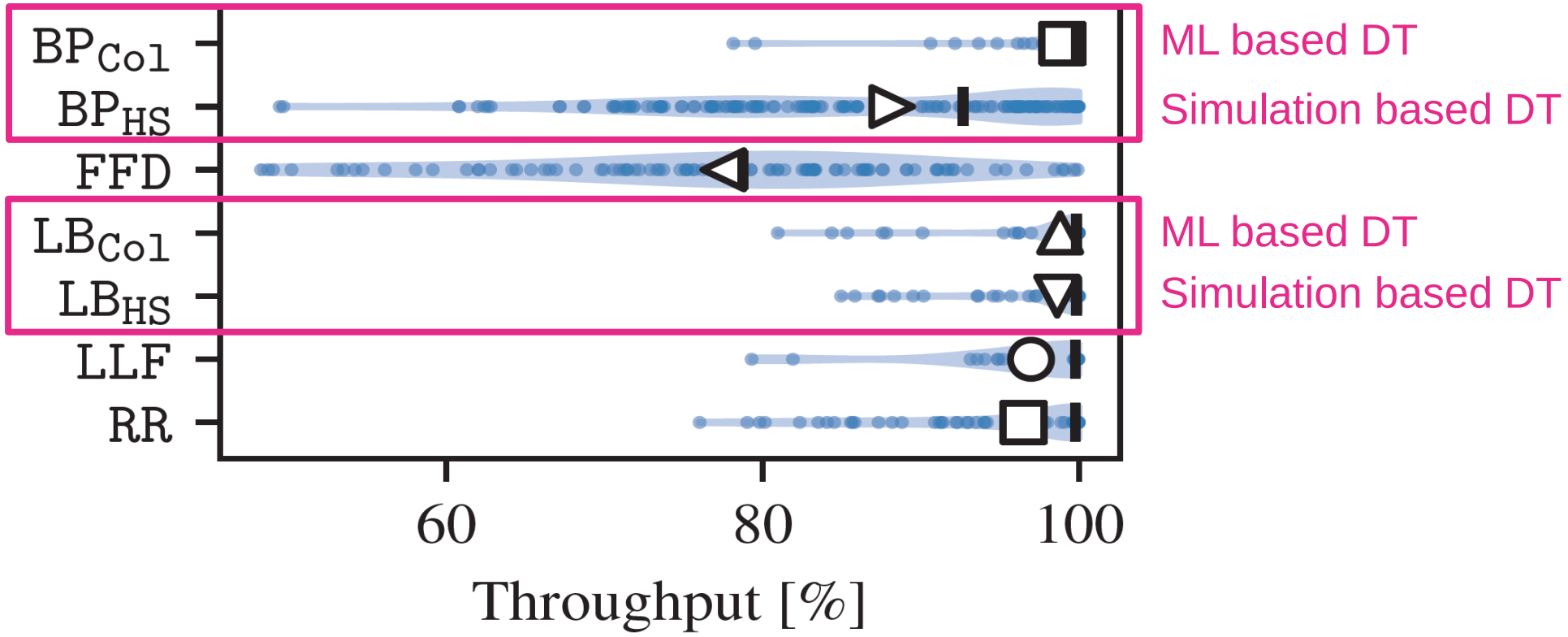
Use ML to model the behavior of physical systems.



Use Case: Improving VNF co-location



First results show that ML can improve the what-if-analysis of a DT resulting in better performance.



P. Krämer, P. Diederich, C. Krämer, R. Prieß, W. Kellerer, A. Blenk. "D_2A: Operating a Service Function Chain Platform with Data-Driven Scheduling Policies". In: IEEE Trans. on Netw. and Serv. Manage. (TNSM), under submission.

Let networks control and optimize themselves.

Enrich simulations and system models with learned behavior.

Use a data-driven approach to obtain network control algorithms.

ML might not be suitable to apply in a black box manner → Domain knowledge even more important!