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Action Masking for Safer Model-Free Building Energy Management

Sharath Ram Kumar^{1,2}, Remy Rigo-Mariani¹, Benoit Delinchant¹, Arvind Easwaran²

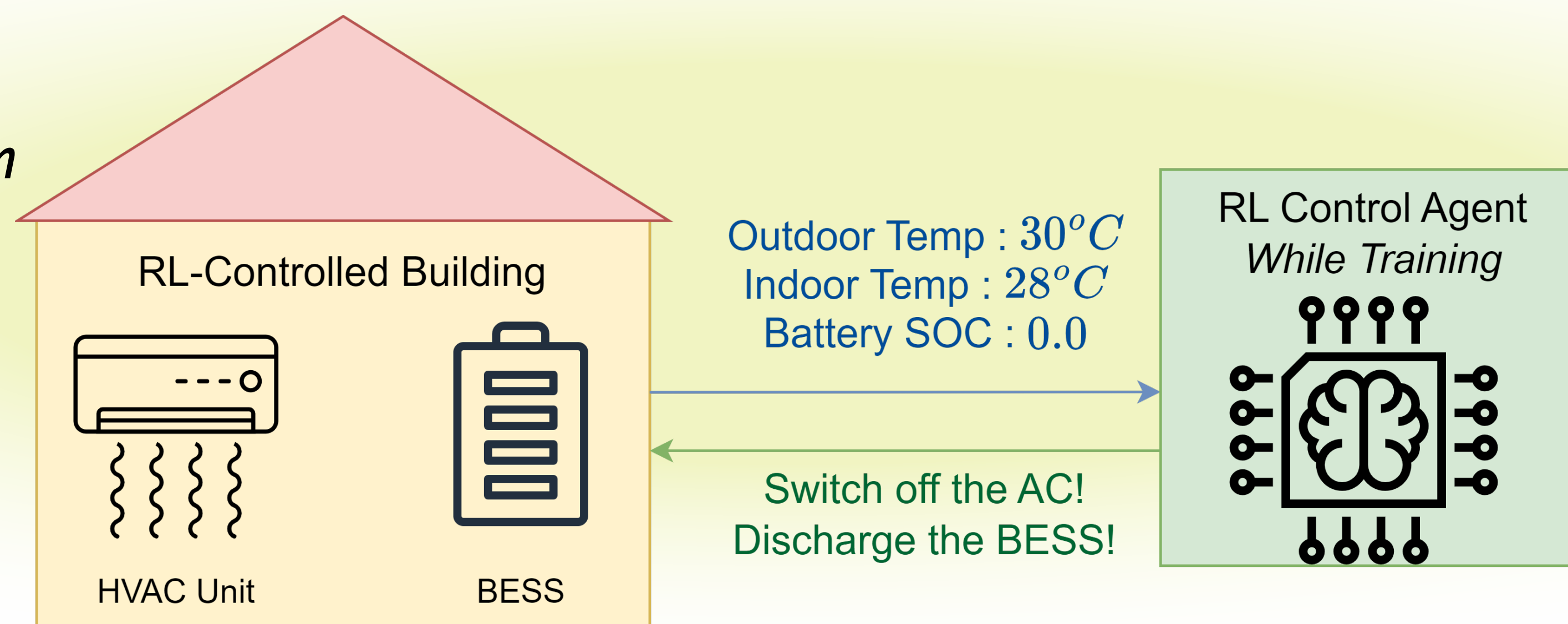
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REINFORCEMENT LEARNING METHODS ARE NOT PRACTICAL FOR CRITICAL APPLICATIONS

Most RL Algorithms require agents to explore the environment through a trial-and-error approach

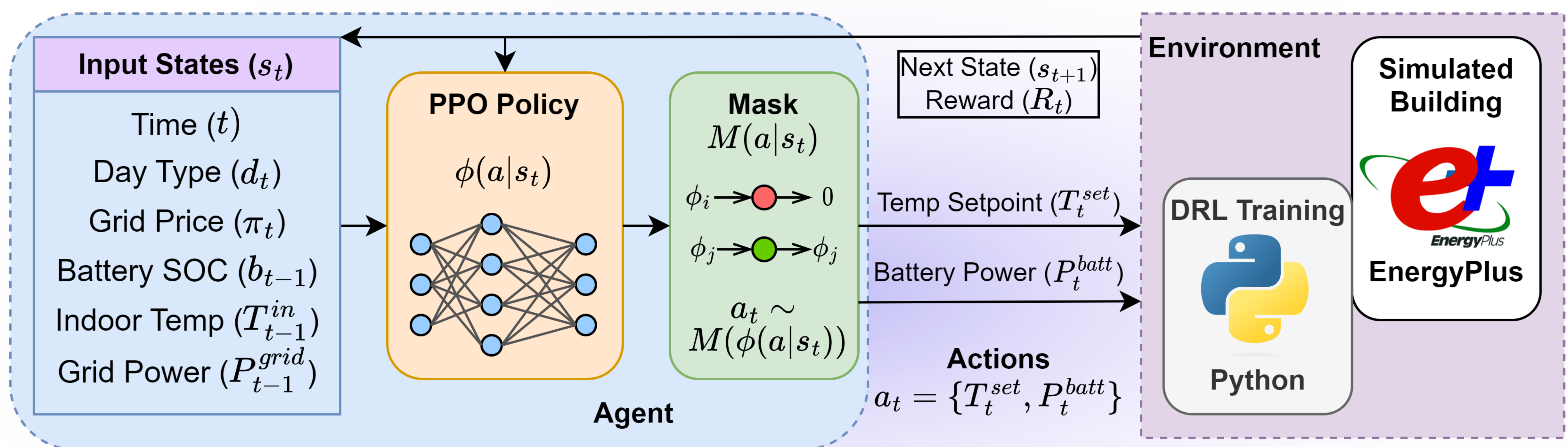
This is not feasible in many real-world control tasks, as unsafe actions may be taken in the learning phase



Problem Statement

To control the cooling HVAC and battery storage systems of a grid-connected building in Singapore, with a trade-off between the electricity bill and the thermal comfort.

ACTION MASKING TO ENFORCE RULES ON THE AGENT



- * Cannot charge (discharge) a full (empty) battery
- * Cooling system switched off from 10 PM to 5 AM
- * Cooling system must stay ON if $T_{indoor} > 26.5^{\circ}\text{C}$

The agent is trained using PPO, a popular DRL algorithm

The action mask constrains the exploration space by dynamically limiting the actions the agent can take.

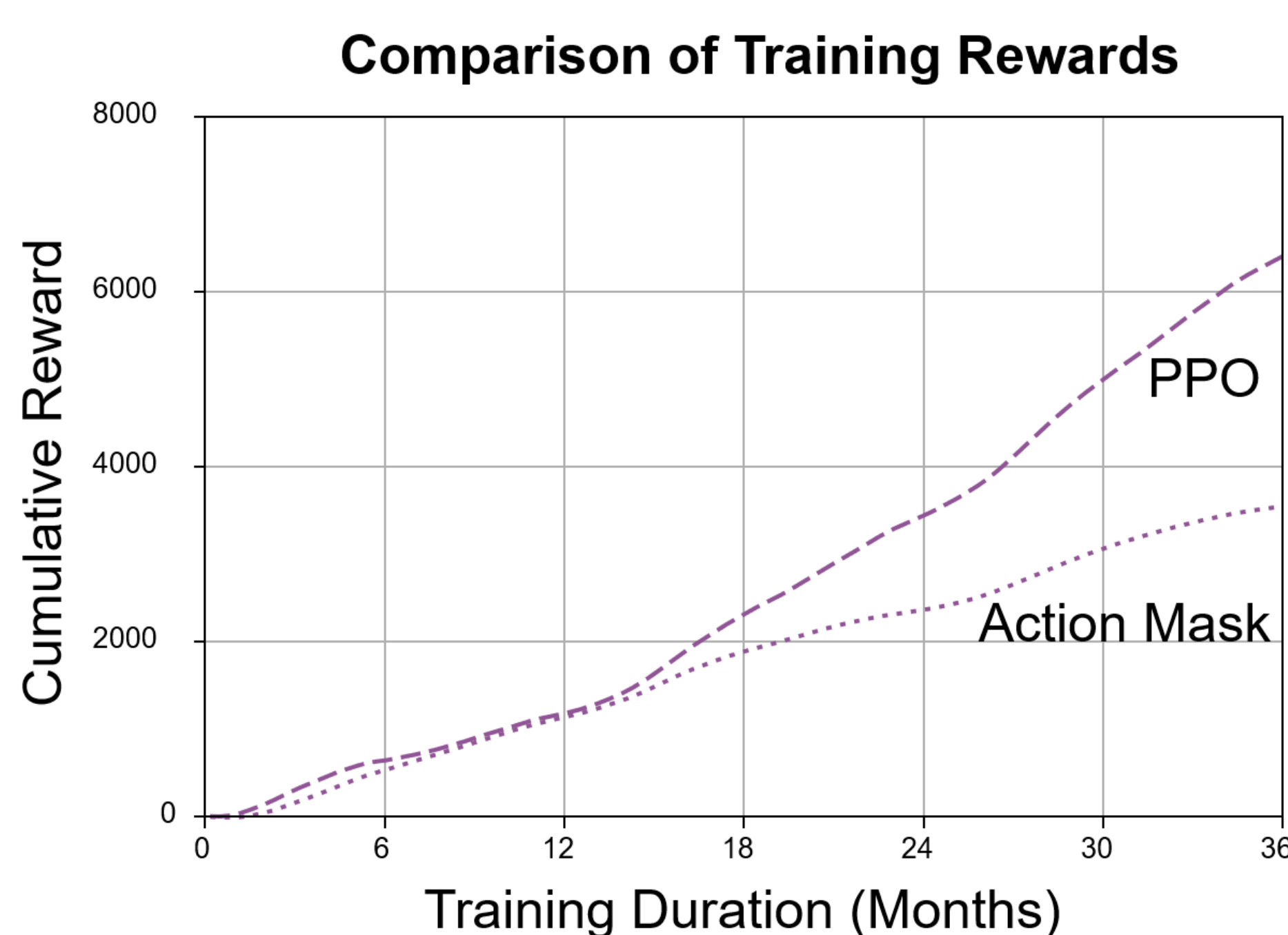
MASKED AGENTS CAN OUTPERFORM DIRECT RL AGENTS

Table 1: Summary of Results

| Agent | Cost (\$) | Comfort Score |
|-----------|-----------|---------------|
| RBC | 468.43 | 0.43 |
| Direct RL | 428.89 | 0.09 |
| Masked RL | 439.27 | 0.39 |

Key Results

1. Both DRL controllers achieved a lower cost compared to the baseline RBC.
2. The direct RL controller led to a significantly worse comfort score.
3. Action masking achieved a similar comfort score to the baseline while reducing costs.



Conclusions

1. The Direct RL controller prioritized a lower energy bill over thermal comfort (local optima) due to the lack of constraints.
2. The use of Action Masking resulted in a policy that reduced the energy bill while respecting thermal comfort rules, without any modifications to the reward function or hyperparameters.

References and Acknowledgements

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