

Integration of Large Language Models into Control Systems for Shared Appliances

Frédéric Montet, Karl Löwenmark,
Marcus Liwicki, Fredrik Sandin, Jean Hennebert



HEIA-FR
HTA-FR

iCoSys
Institute of Complex Systems





http://localhost:8581

I'm John Smith 🤖

How may I assist you regarding our heating control system, John Smith?

Are you heating now ? 🤖

Yes, the heating system is currently operating at 18.26% of its maximum capacity. How may I further assist you with our heating control system?

I'm Robinson Crusoe 🤖

How can I assist you with our heating control system, Robinson Crusoe?

I would like to have 42 degrees in my room 🤖

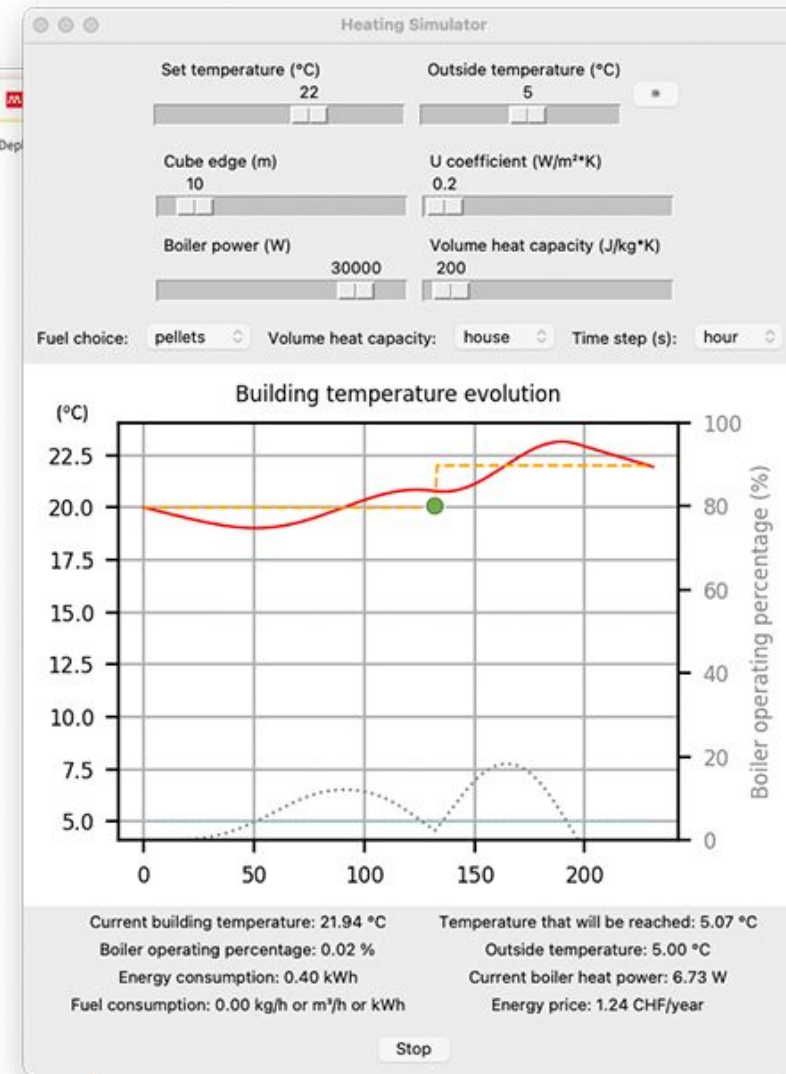
I apologize, but the set temperature must be between -10 and 40°C. Would you like to set it to a temperature within this range?

no, 42 degrees please 🤖

I'm sorry, but the temperature cannot be set to 42 degrees as the system supports temperatures only between -10°C and 40°C. It's essential to choose a temperature within this range to ensure the system operates safely and efficiently. Could you please select an alternative temperature within the supported range?

Talk to the bot

Used 11006 tokens



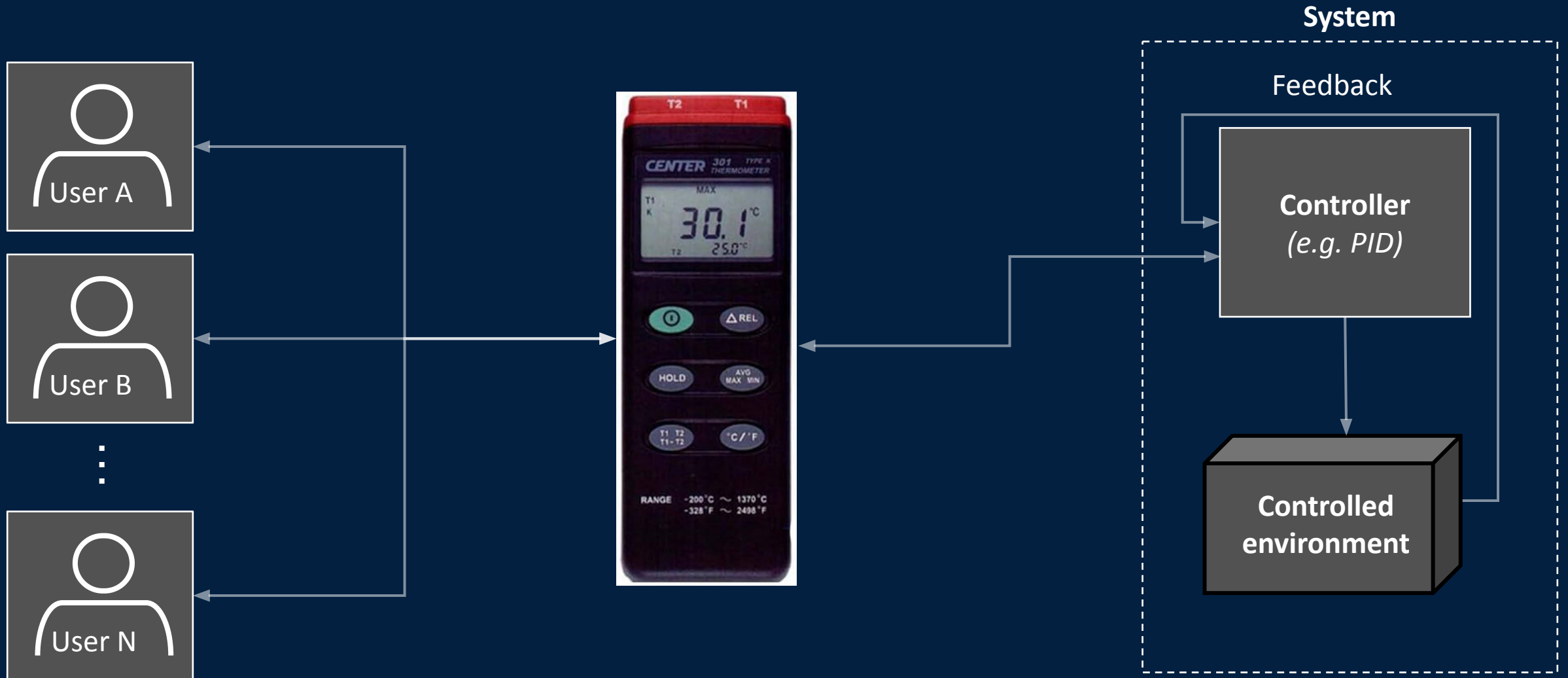
- New temperature set
- Building temperature
- - - Set temperature
- Boiler operating percentage

**How can LLM agents
be used as mediators and
controllers in cyber physical
control system?**

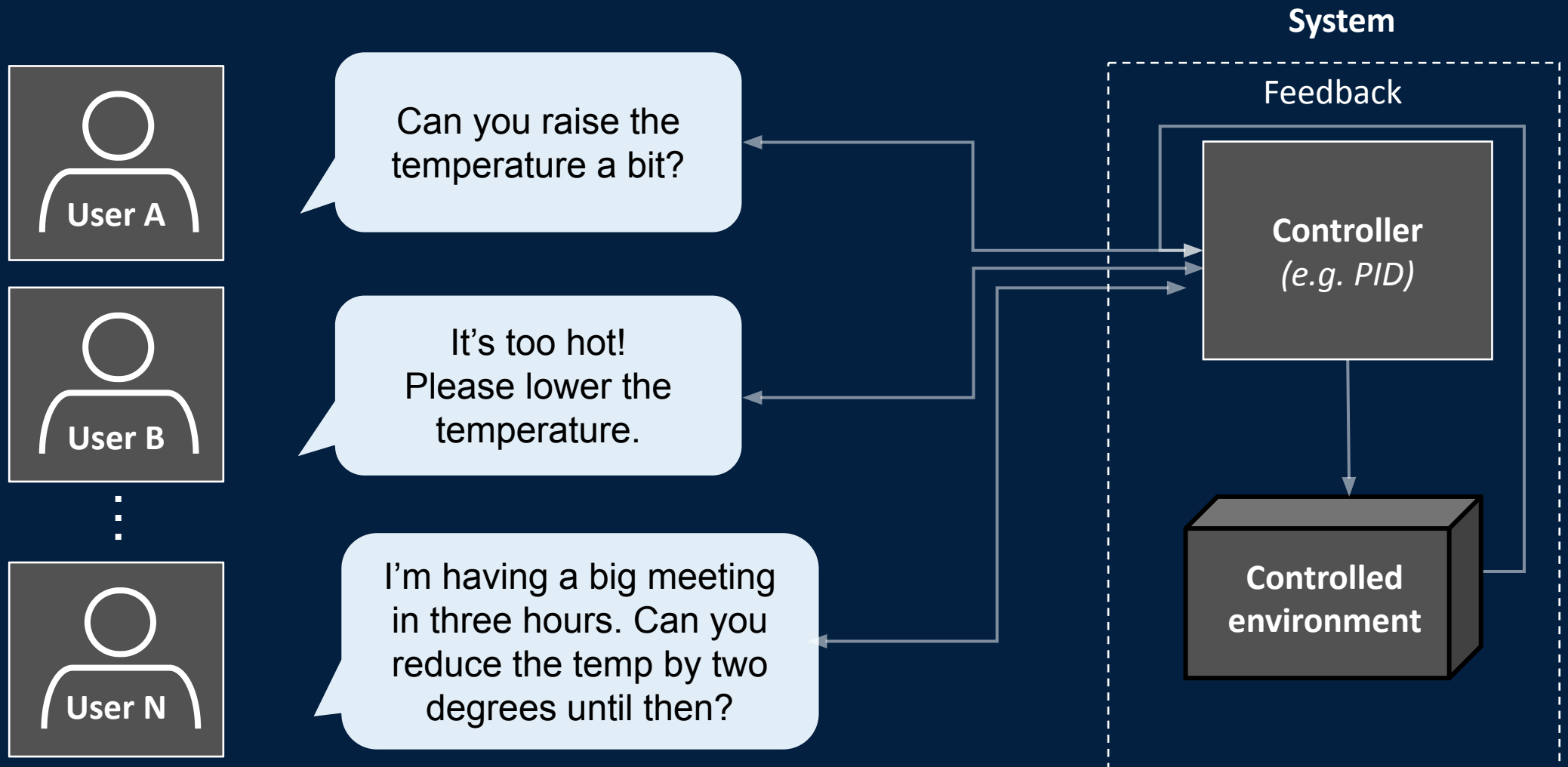
Research Questions

1. What **architectures** can be used to leverage LLMs for improving user interfaces within control systems?
2. How can LLMs incorporate **user preferences and circumstances** into a control system?
3. How can LLMs **mediate** between users with varying preferences or constraints?

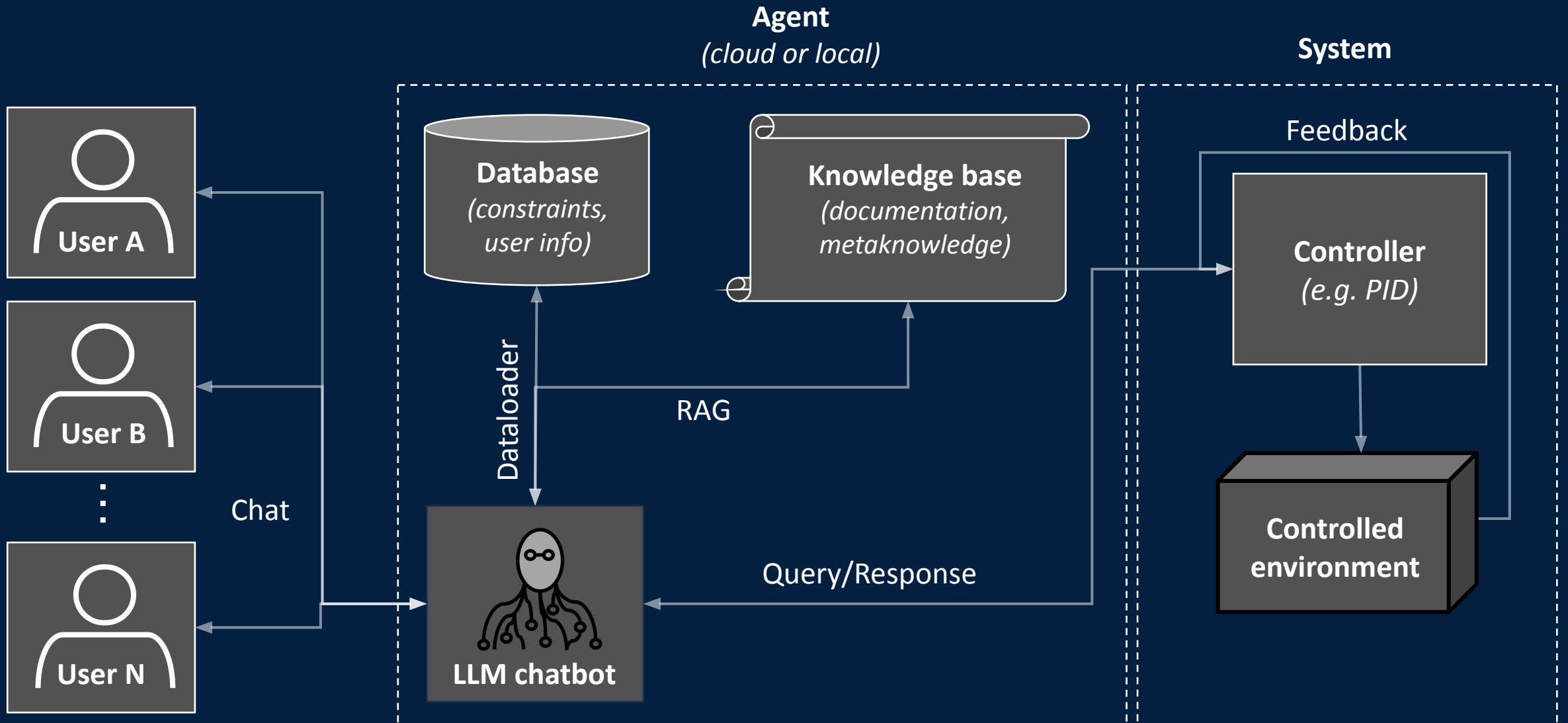
Heating a Building



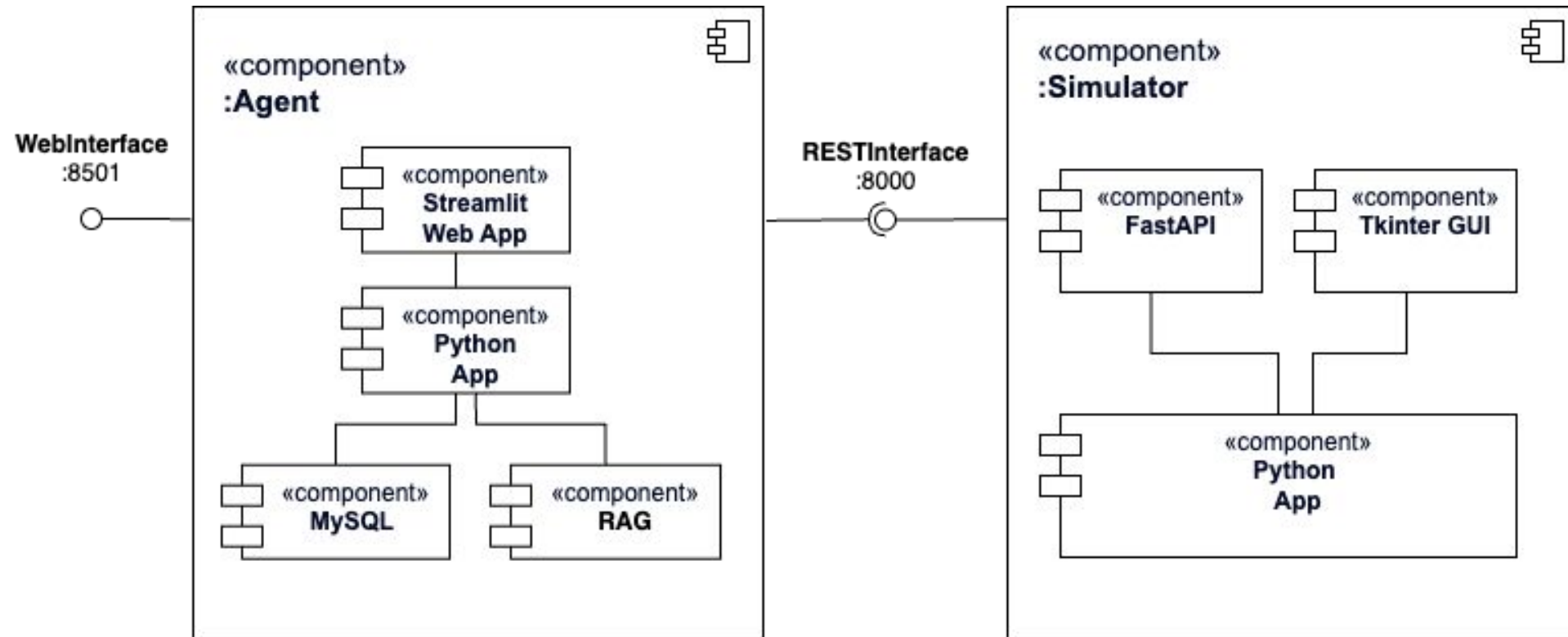
Can we chat instead?



Agent Schema



Result - UML Figure



Result - Tests and Metrics

Normality

- Normal case
- Insistent user input
- User information gathering

Disturbance

- Erratic user input
- Chaos

System limitations

- Exaggerated user input

Error

- Unreachable system

Explainability

Does every user understand how to use the new system?

Mediation

How to resolve conflicts?

Robustness

Works as predicted?

I'm Robinson Crusoe



I'm here to assist with queries specifically related to our advanced heating control system. How can I help you with the heating system today, Robinson?

I feel cold...



The current temperature inside the building is 19.02°C. If you're feeling cold, would you like to increase the set temperature to make it warmer inside?

yes please

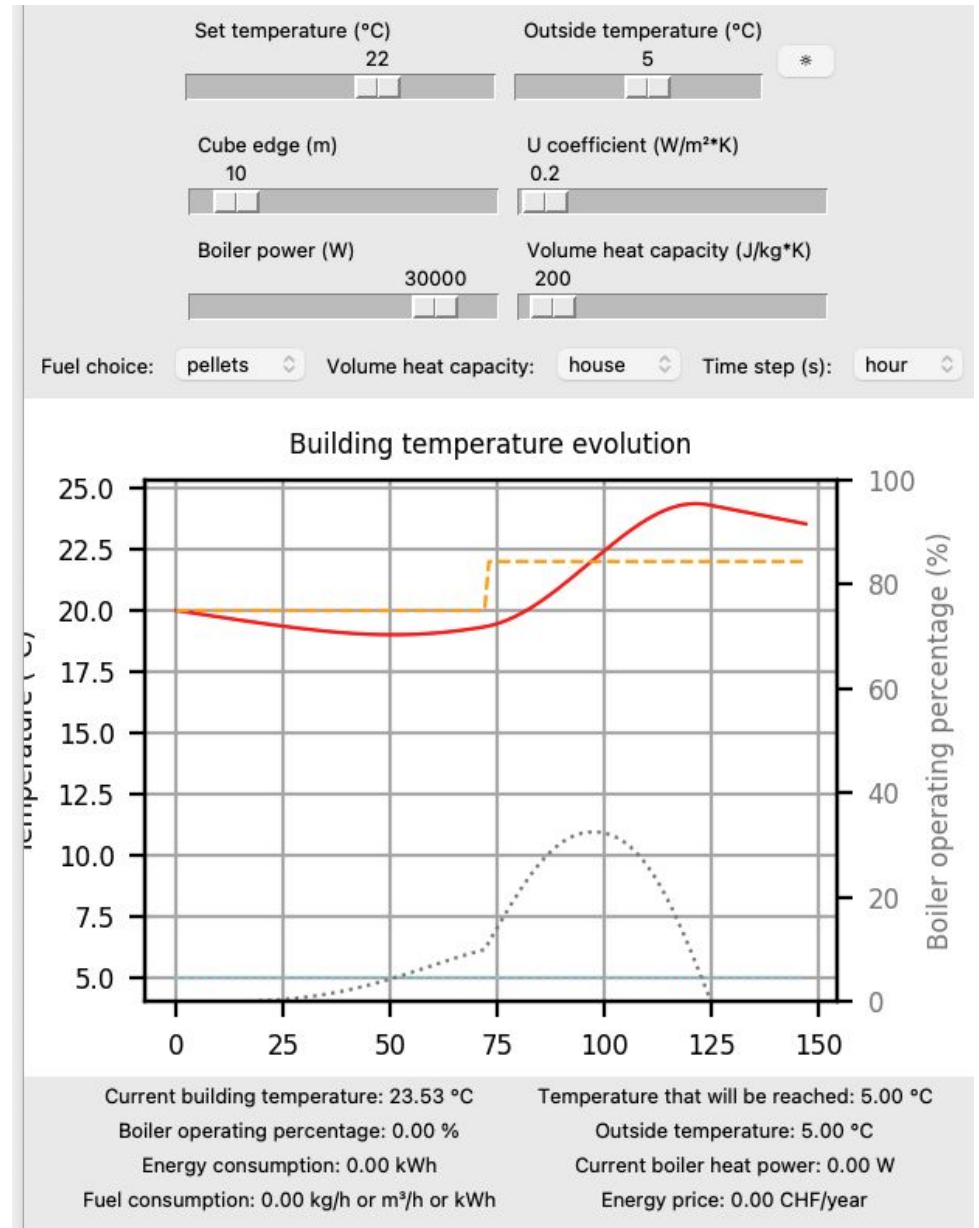


I have successfully increased the set temperature by 2 degrees. The new set temperature is now 22.0°C.

I would like to have 42 degrees in my room



The set temperature must be between -10 and 40°C. Setting the temperature to 42°C exceeds the system's maximum limit. Please choose a temperature within this range.



Qualitative Results

Explainability

The agent clearly explained its process when queried.

Mediation

The agent caved in to pressure and always pleased the last user.

Robustness

The agent performed as expected within the limits of the system.



Discussion and Future Work

Agent can integrate different modalities of data

- Control system
- Component documentation and specifications
- User information

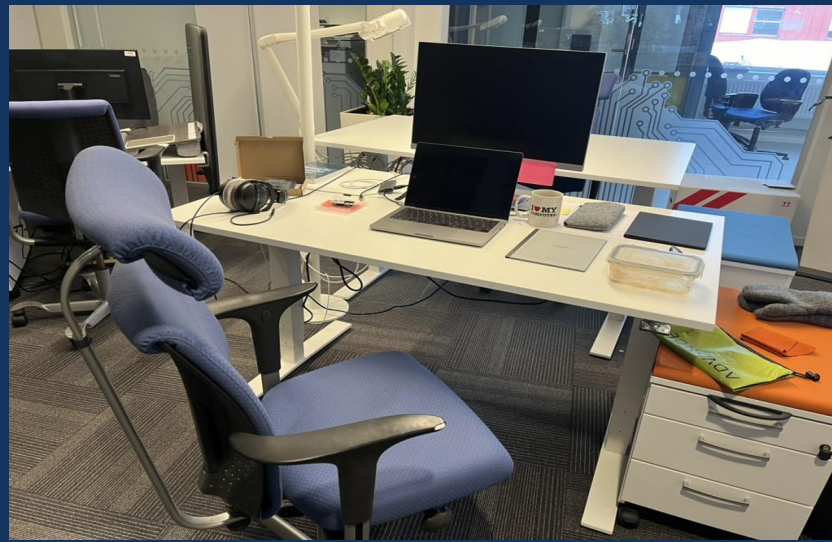
Can it be grounded in extraphysical constraints?

- Energy costs & Environmental impacts
- Health impacts
- Expected usage and predictive control

Mediation and ethical concerns

- Privacy vs customisability
- Conflict resolution - how to encode human ethics?

Solution - multiple LLMs?



Idag 17 jan. ☀️ 09:14 / 14:10

kl. 08 Klart

 **-30°C**

Känns som -38°C
N ↓ 2 (3) m/s
0 mm



Contact

frederic.montet@hefr.ch

karl.lowenmark@ltu.se

LULEÅ
UNIVERSITY
OF TECHNOLOGY

