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Developing a RESTful Communication Protocol and an Energy Optimization Algorithm for a Connected Sustainable Home

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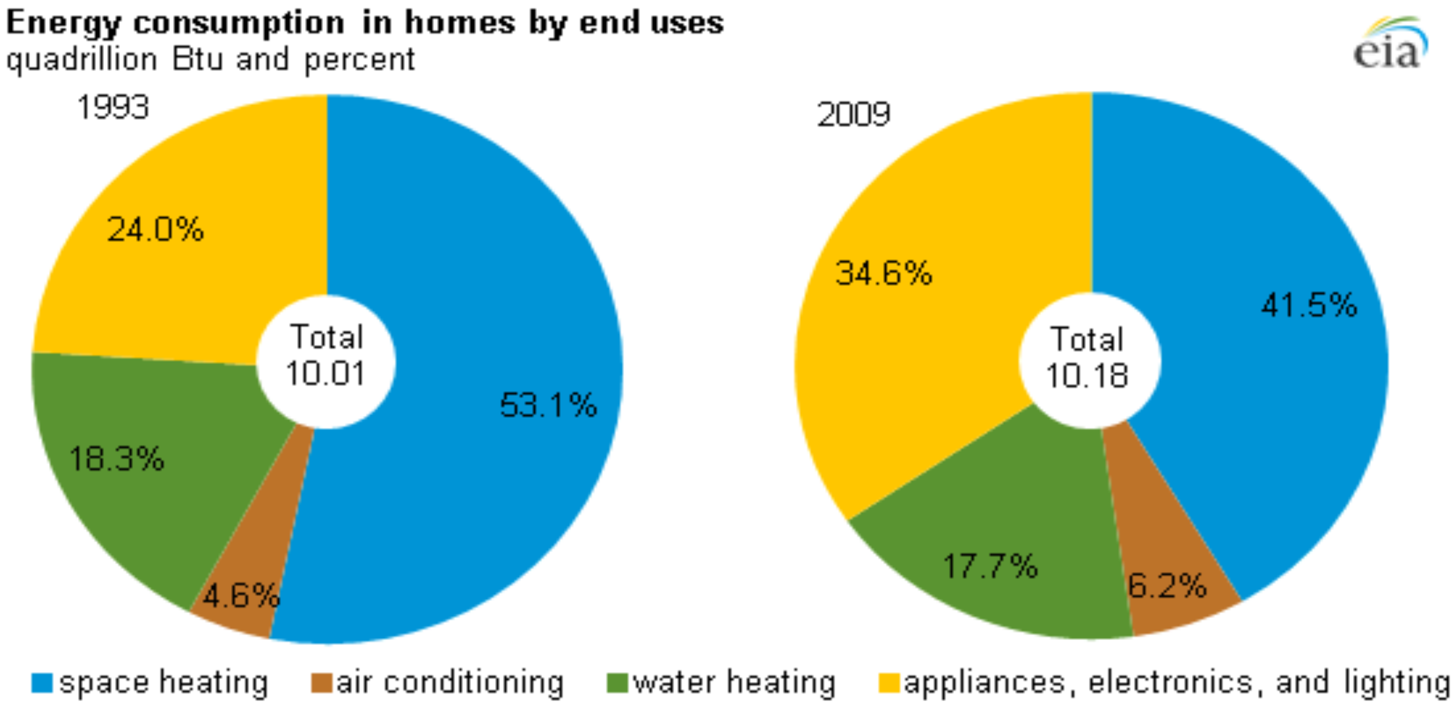
OUTLINE

1. Problem statement
2. Architectural solutions
3. Communication structure
4. RESTful protocol
5. Android Application
6. pSulu: Energy optimizer
7. Contributions and future work

ADDRESSING THE GLOBAL ENERGY CHALLENGE: IMPROVING ENERGY EFFICIENCY IN RESIDENTIAL BUILDINGS

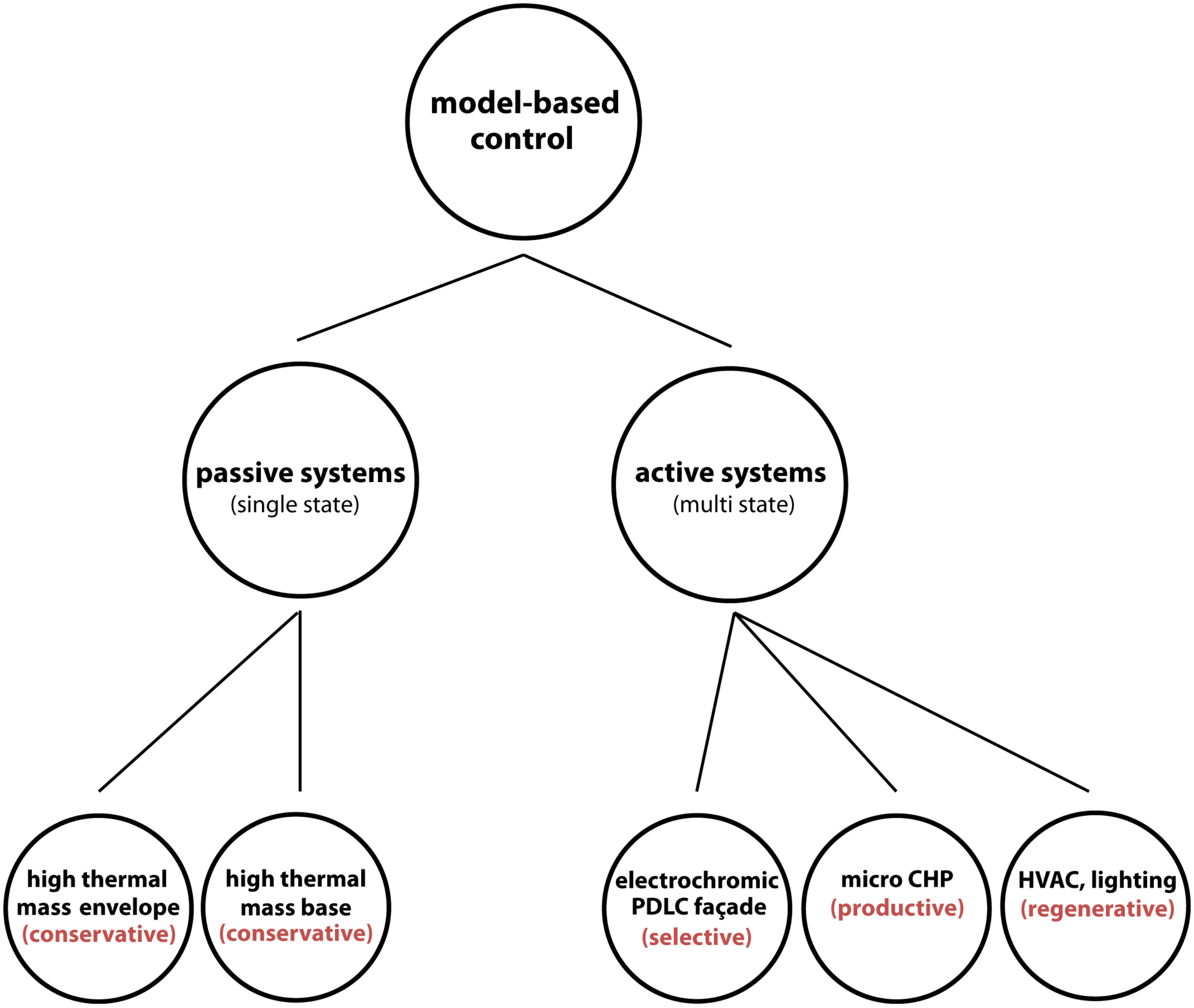
In 2012, residential buildings consumed nearly 40% of total energy usage in the U.S. Heating and cooling accounted for 48% of the residential energy consumption.



Deployment of:

1. *Passive* and *active* building technologies
2. *Modular, prefabricated, transportable* structure
3. *Actuated components* and *switchable* materials in windows
4. *Cogeneration plant* (solar + heat) electricity
5. ***pSulu: Real-time energy optimizer***
6. ***Full implementation of the Web of the Things paradigm* in home automation**

2. ARQUITECTURAL SOLUTIONS

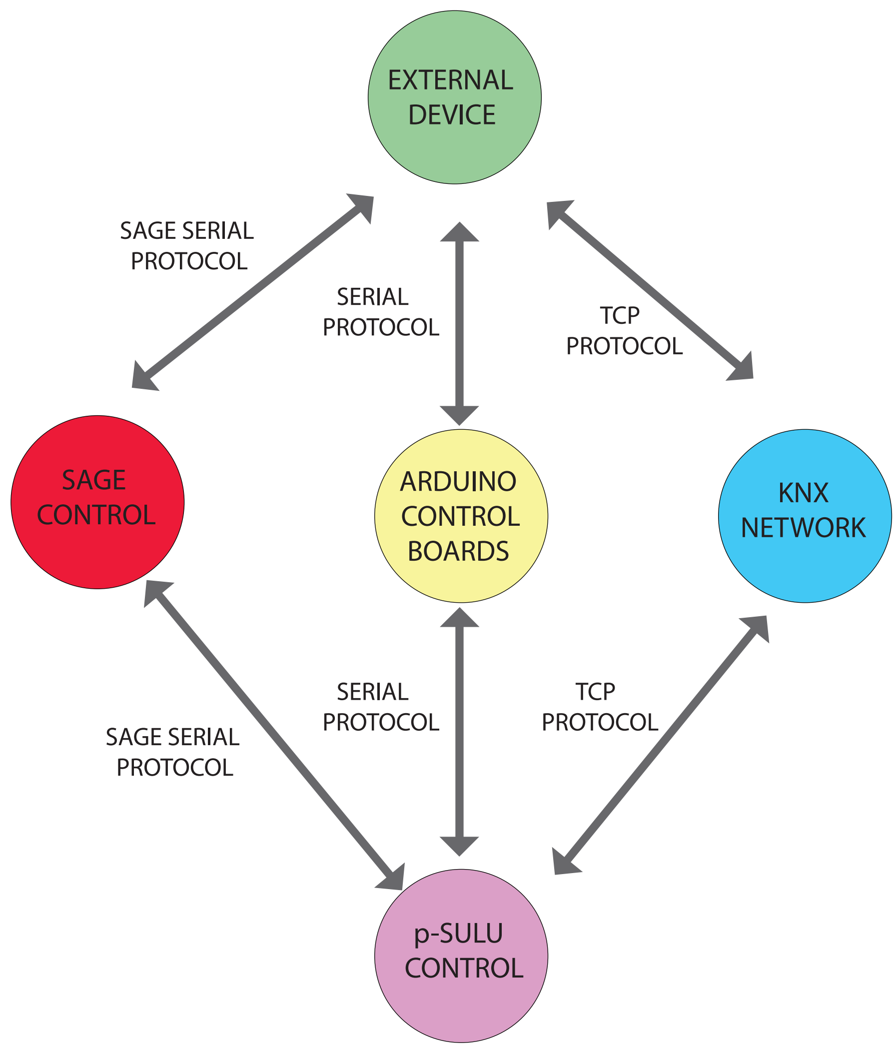


2. ARQUITECTURAL SOLUTIONS

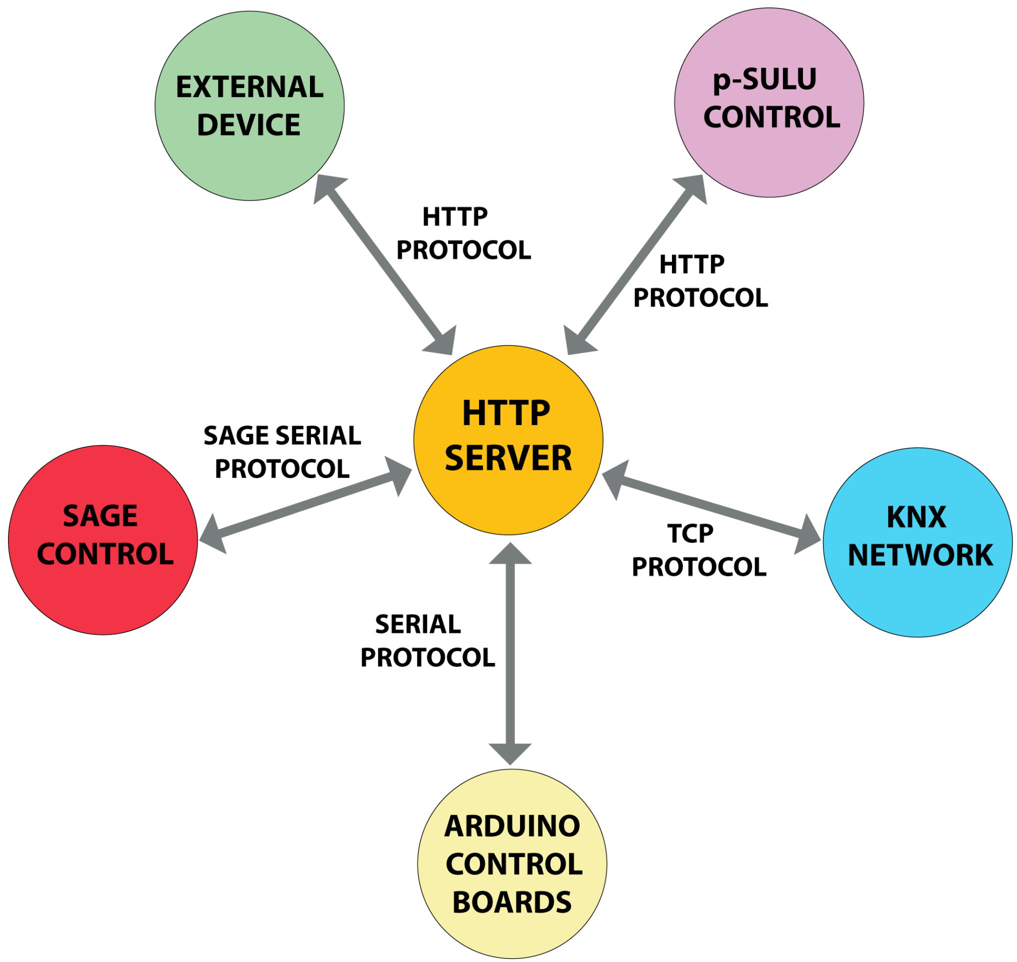
Communication constrains

1. Non-dependency on device-specific protocols
2. Scalability for large number of devices
3. Compatibility with existing technology
4. Security

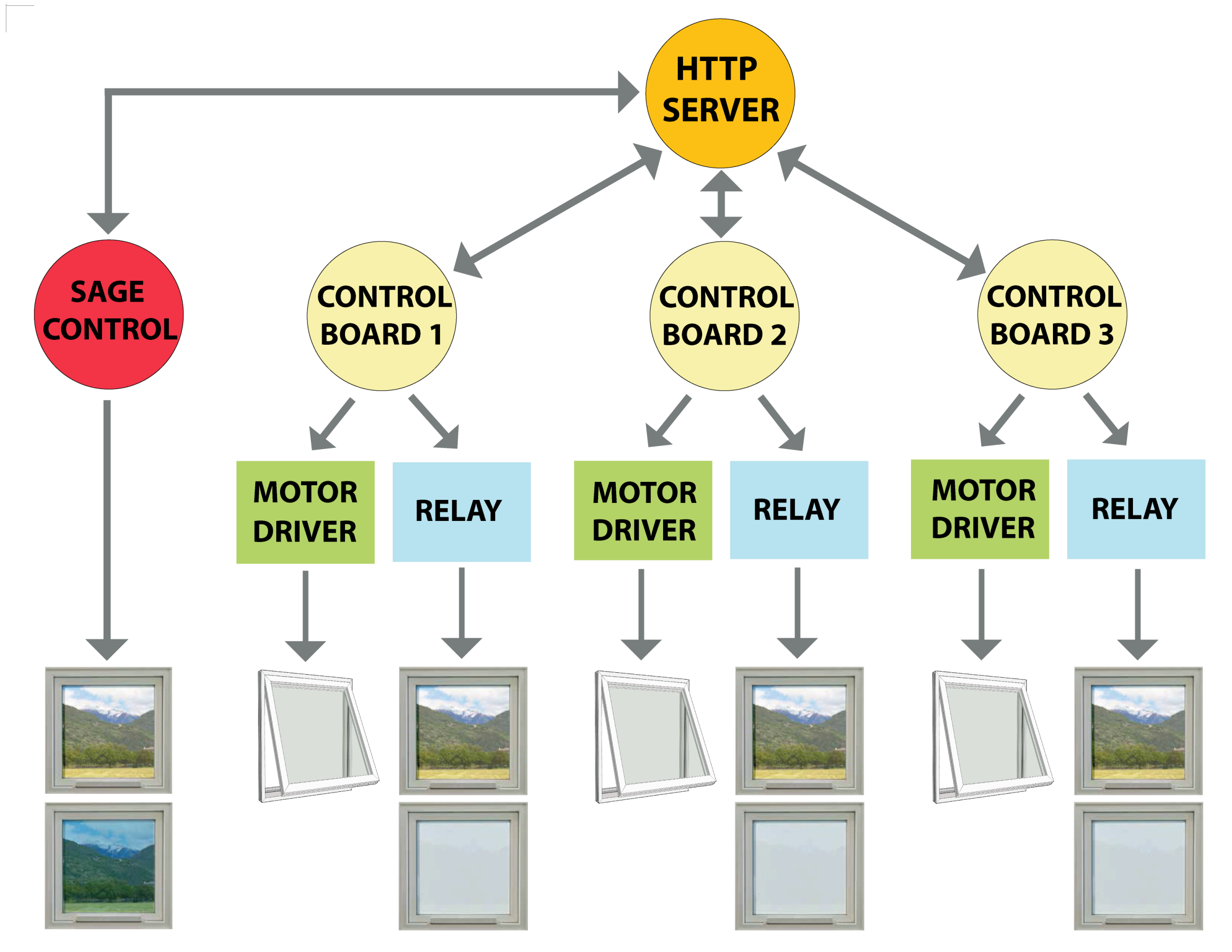
Naïve approach



Web of the Things paradigm



Façade communication structure



Representational State Transfer (REST) Architecture

1. Scalability of the component interactions
2. Generality of interfaces
3. Independence in the deployment of components
4. Existence of intermediaries that make the system safest

4. RESTFUL PROTOCOL

- Path Structure

- Uniform Resource Identifier (URI)
- Directory-based URI structure
- Path example: /home/window/c00

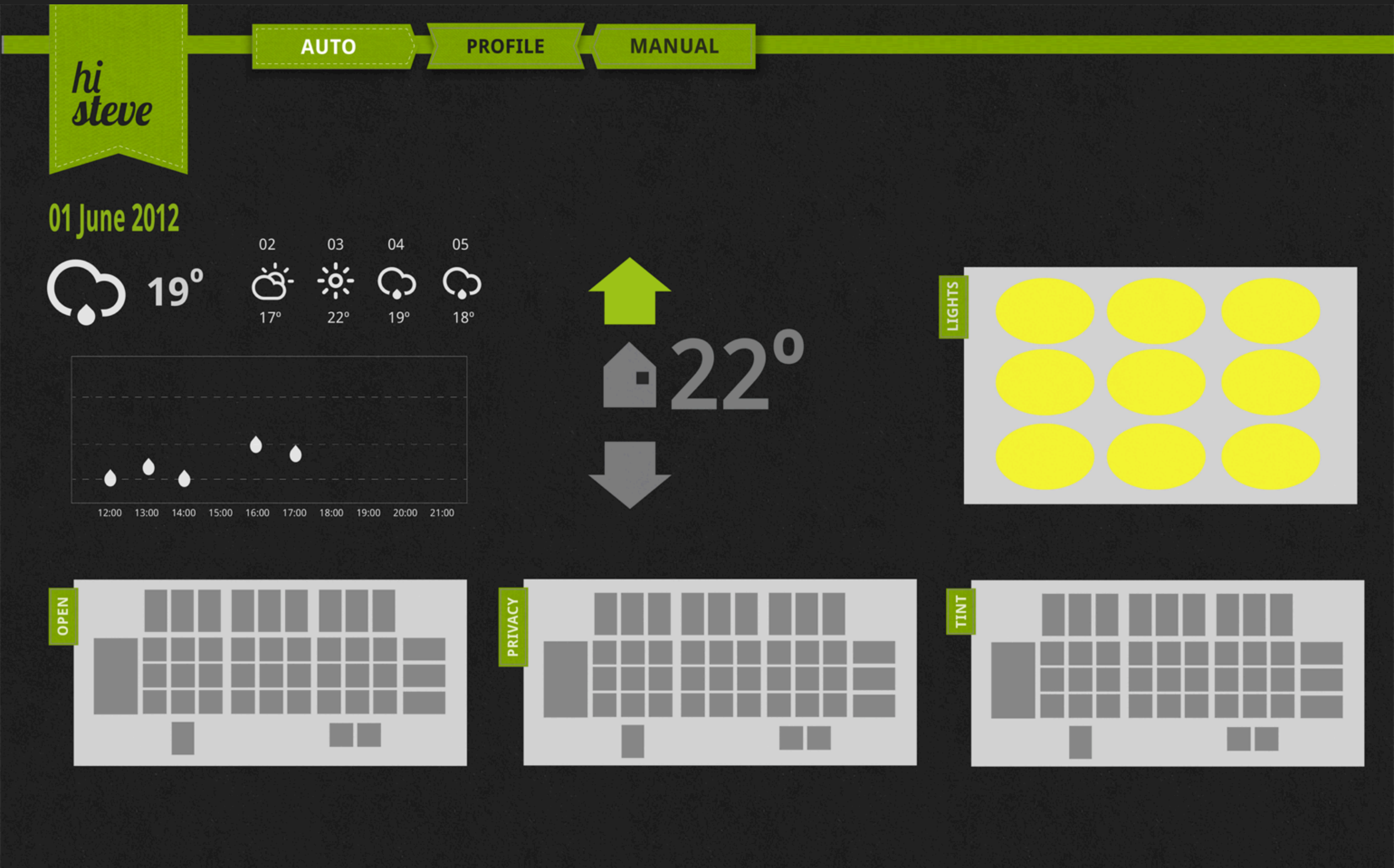
- Data Structure:

- JavaScript Object Notation
- Example: {“id”:”c00”,”tint”:2,”privacy”:true,”open”:8,”url”:”/home/window/c00”,"previous": "/home/window"}

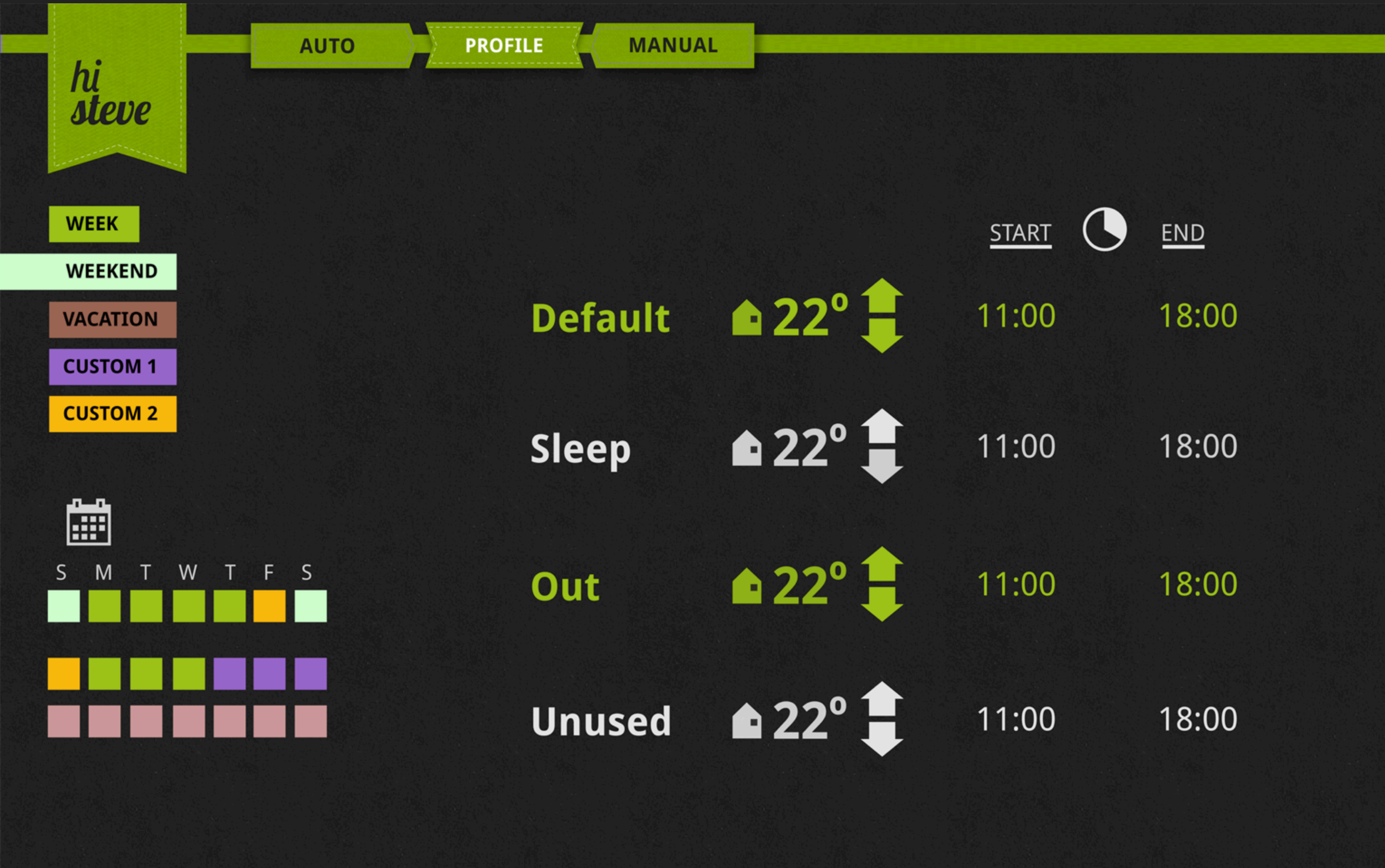
- Commands:

- GET: Retrieve the state of one resource
- PUT: Change the state of one resource

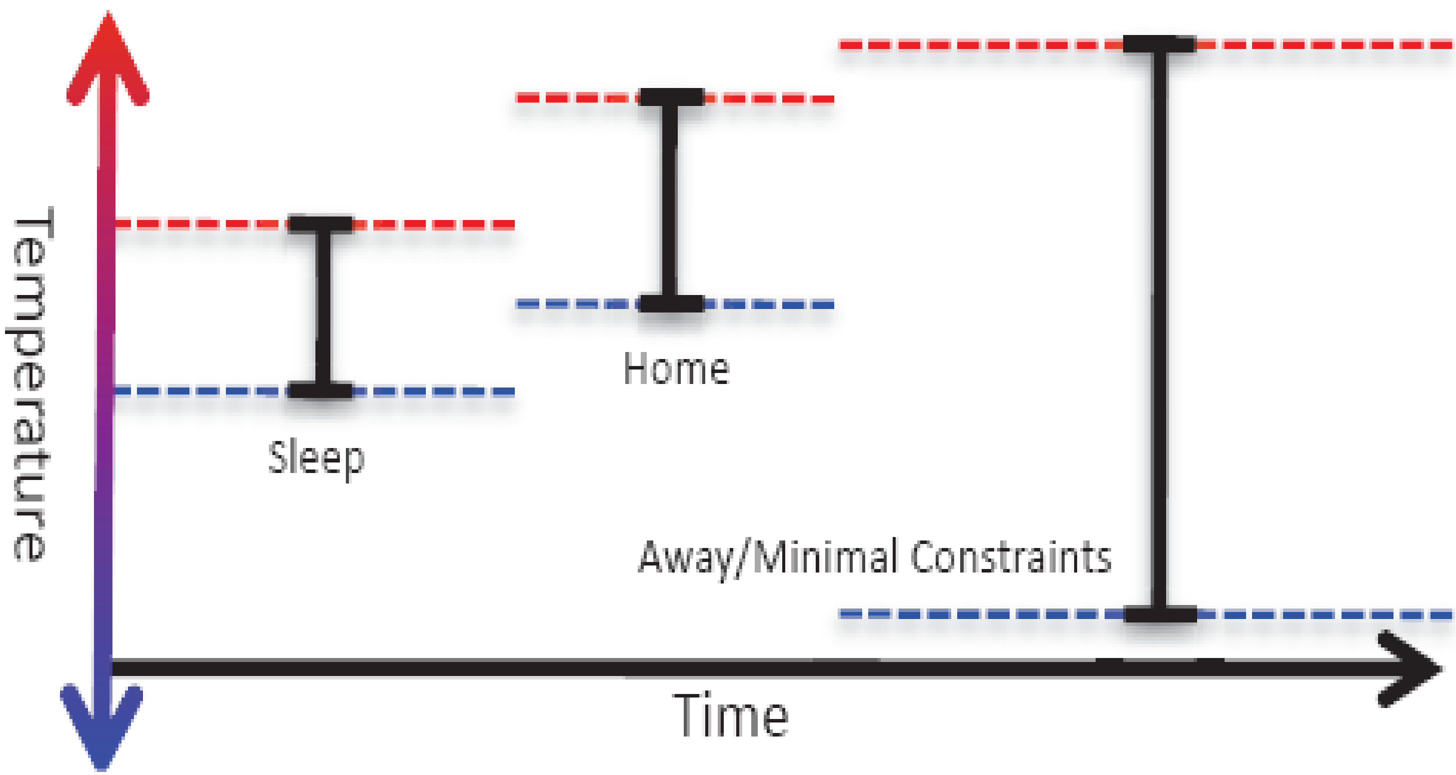
5. APPLICATION: ANDROID APP



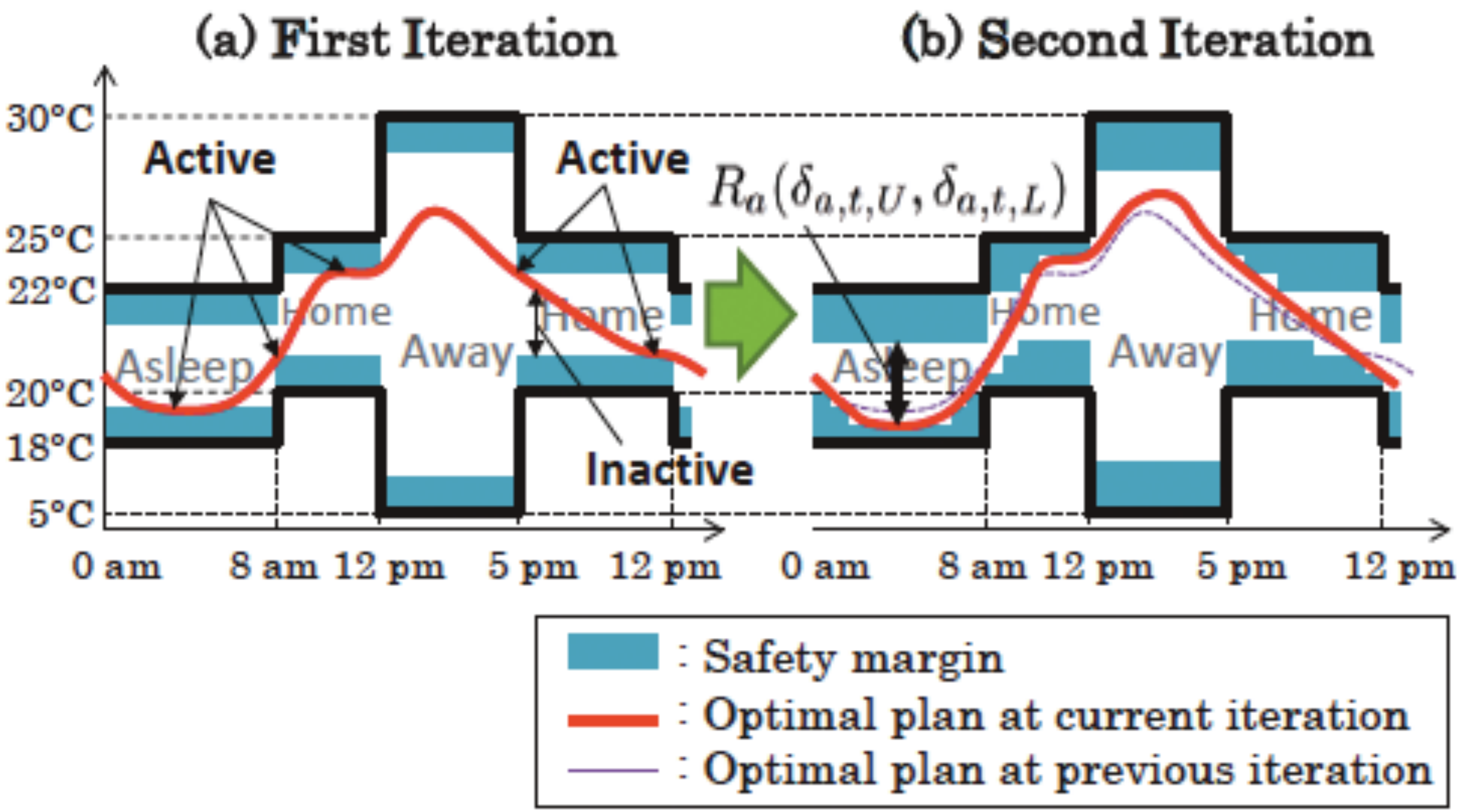
5. APPLICATION: ANDROID APP



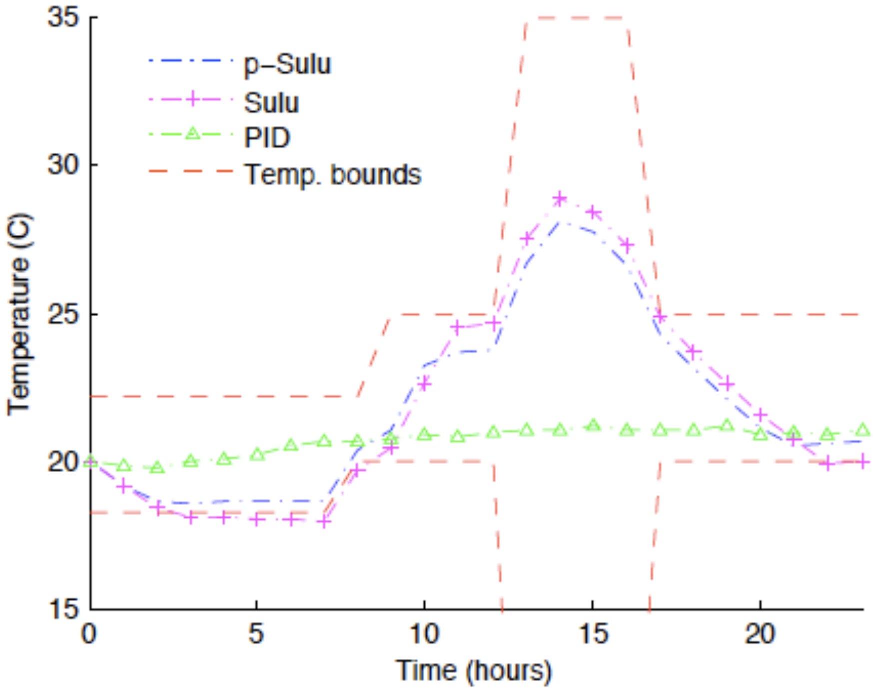
Chance-constrained qualitative state plan



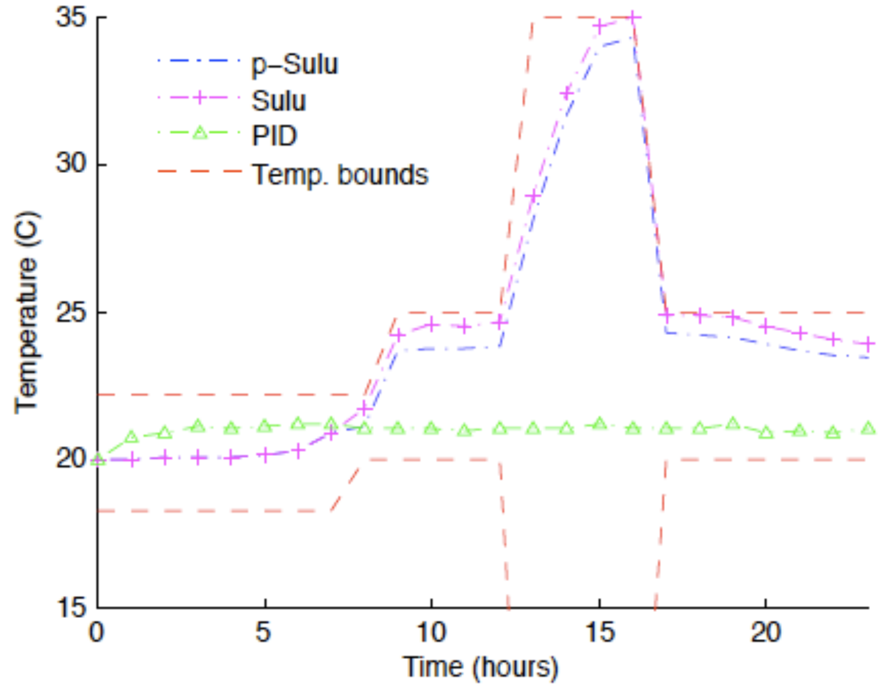
Intuitive explanation of the algorithm



Simulation of control system



(a) January 1



(b) July 1

Results of execution of the PID (proportional-integral-derivative), Sulu, and p-Sulu controllers on January 1 and July 1 .

6. pSulu: ENERGY OPTIMIZER

Comparison of energy use over a week-long schedule

	Winter		Summer	
	Energy	Violation Rate	Energy	Violation Rate
p-Sulu	1.9379×10^4	0.000	3.4729×10^4	0
Sulu	1.6506×10^4	0.297	–	–
PID	3.9783×10^4	0	4.1731×10^4	0

	Spring		Autumn	
	Energy	Violation Rate	Energy	Violation Rate
p-Sulu	3.3707×10^4	0	3.8181×10^4	0
Sulu	3.0954×10^4	0.308	3.6780×10^4	0.334
PID	3.9816×10^4	0	3.9955×10^4	0

<u>**19.8% of improving of pSulu over PID**</u>

CONTRIBUTIONS & FUTURE WORK

CONTRIBUTIONS OF THE CSH RESEARCH

- Deployment of *passive* and *active* building systems.
- Lightweight, modular, prefabricated, and transportable structure made out of natural materials.
- RESTful protocol compatible with common browsers
- Unified communication interface to communicate with all the home-devices
- Real-time energy optimizer.
- First known full application of the *WoT paradigm* in home automation

http://mobile.mit.edu/fbk/publications/
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