A Distributed Agent-based Approach to Stabilization of Global Resource Utilization

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Intelligent Interactive Distributed Systems

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Motivation

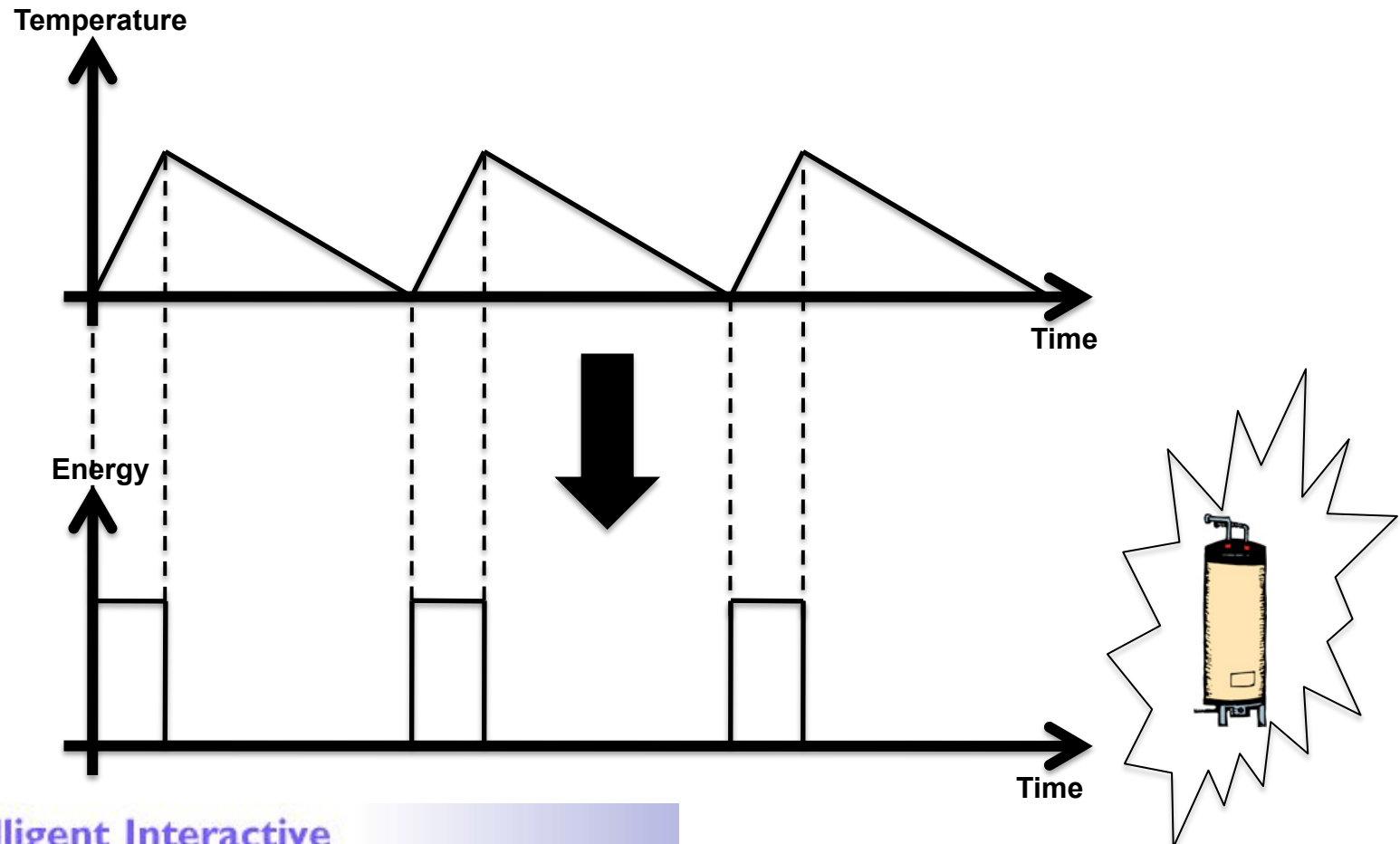From **local resource utilization** to **global resource stabilization**

Challenge..!

Motivation (cont.)

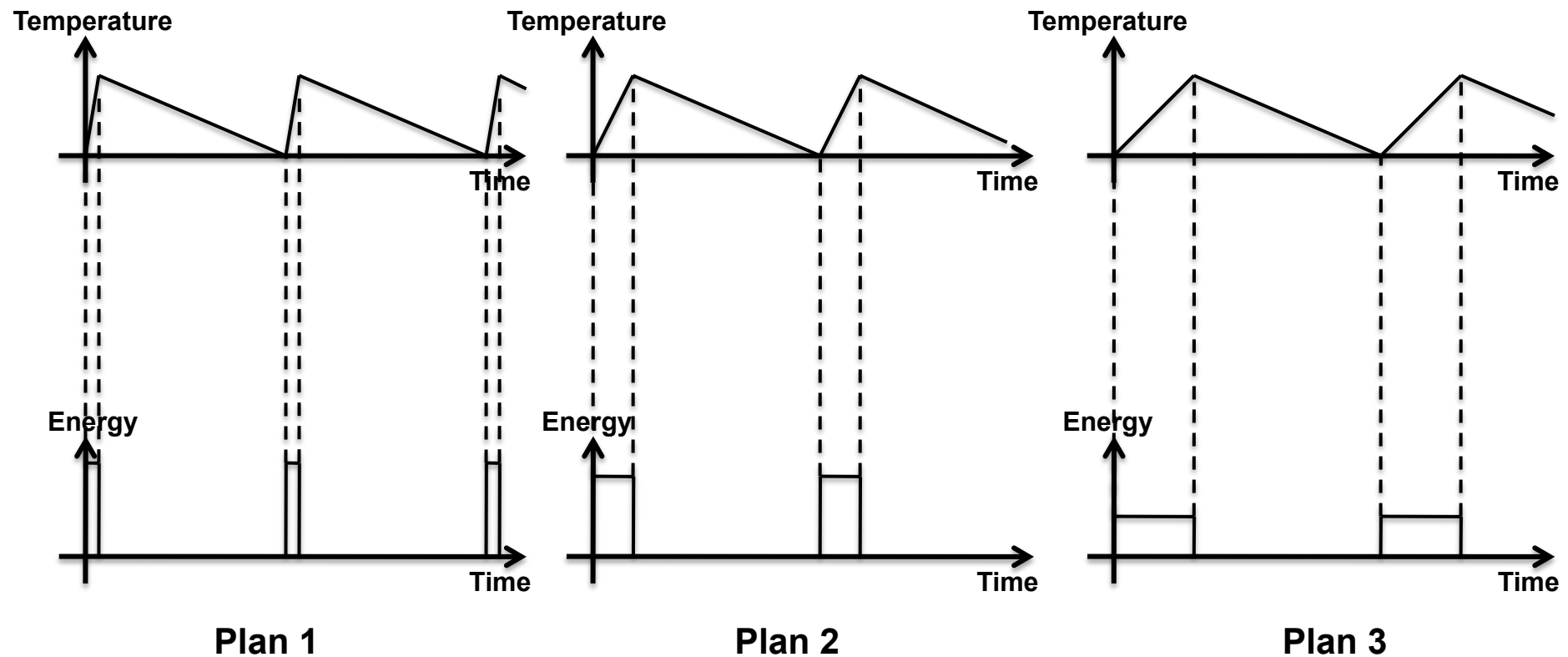Yet, another **resource allocation problem**?

Resource Allocation Problem

Energy plans generated and executed by **thermostatic devices**

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Resource **Allocation** Problem

The **selection process** from a set of locally generated **possible plans**

Plan 1   Plan 2   Plan 3

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Resource Allocation Problem

Achieve **global stabilization** in energy utilization (**minimum oscillations**)

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Problem Overview

Yet, another resource allocation problem?

Actually, a distributed - flow resource - coordination problem!

Research Question

How can the **local plan selections** result in a **global stabilized plan**?

Central Coordination

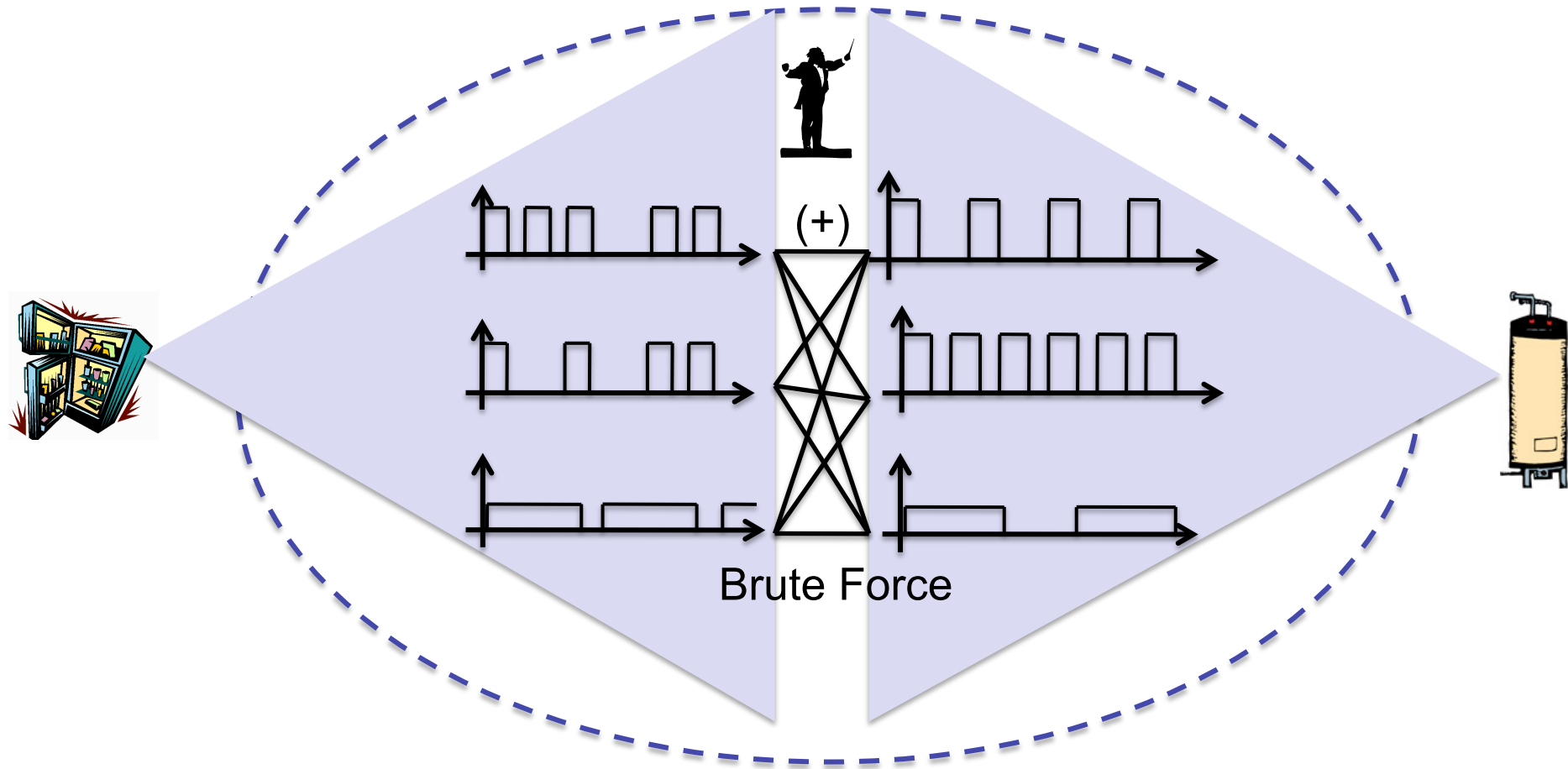➢ Gustavo Dudamel: A very young and talented conductor

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Central Coordination (cont.)

➢ Although so young and talented he can end **overloaded**!

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Central Coordination (cont.)

(+)

Brute Force

Complexity = # of possible plans[# of devices]

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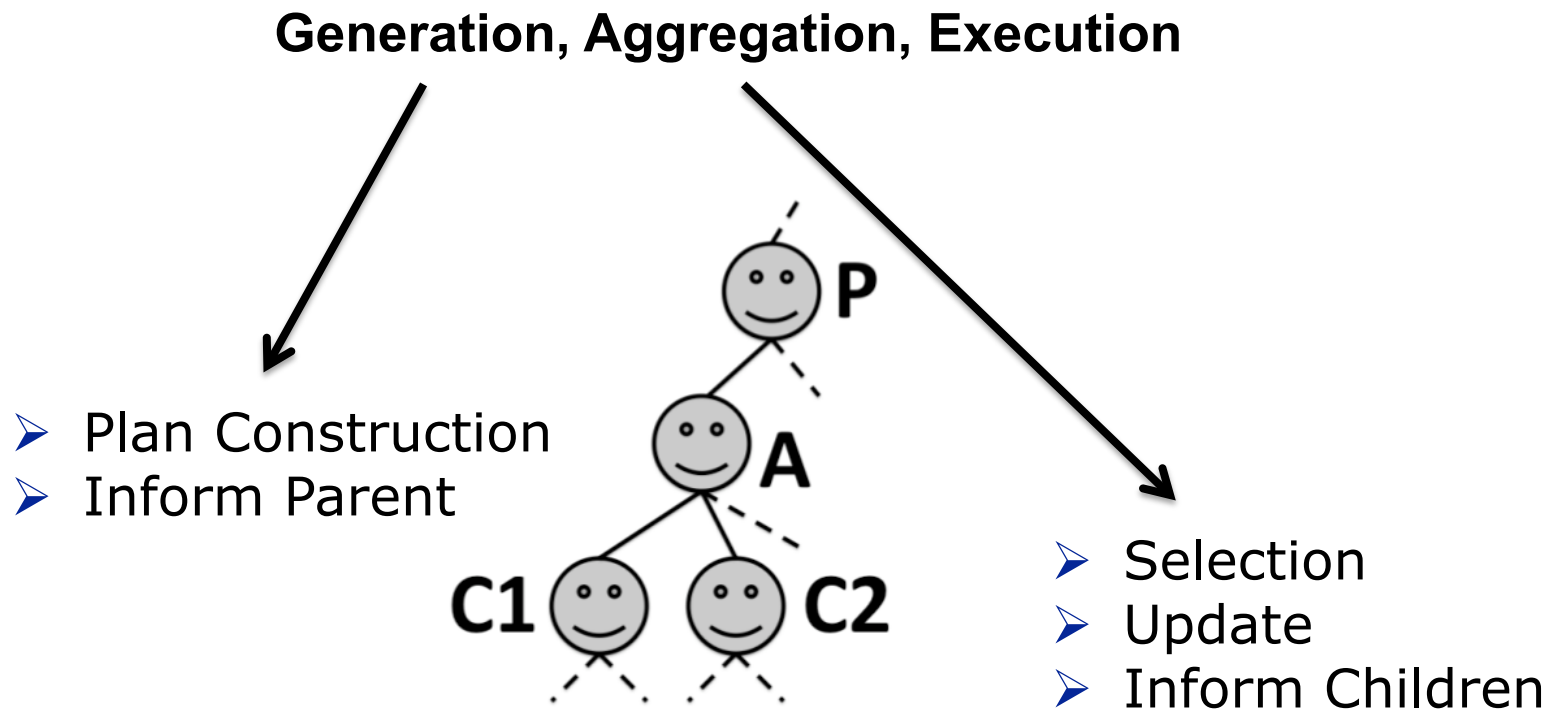
Central Coordination (cont.)

Guarantees the optimum stabilization **but unscalable!**

Distributed Coordination

Tree overlay for aggregation
and decision-making

Intelligent Agents

Water heater   **Fridge**   **Freezer**   **Air-conditioner**

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Local Agent Tasks

Generation, Aggregation, Execution

➤ Plan Construction
➤ Inform Parent

➤ Selection
➤ Update
➤ Inform Children

Local Agent Knowledge

- ➤ Possible Plans ($p_1, p_2,...$)
- ➤ Aggregate New Plan (a_n)
- ➤ Aggregate Old Plan (a_h)
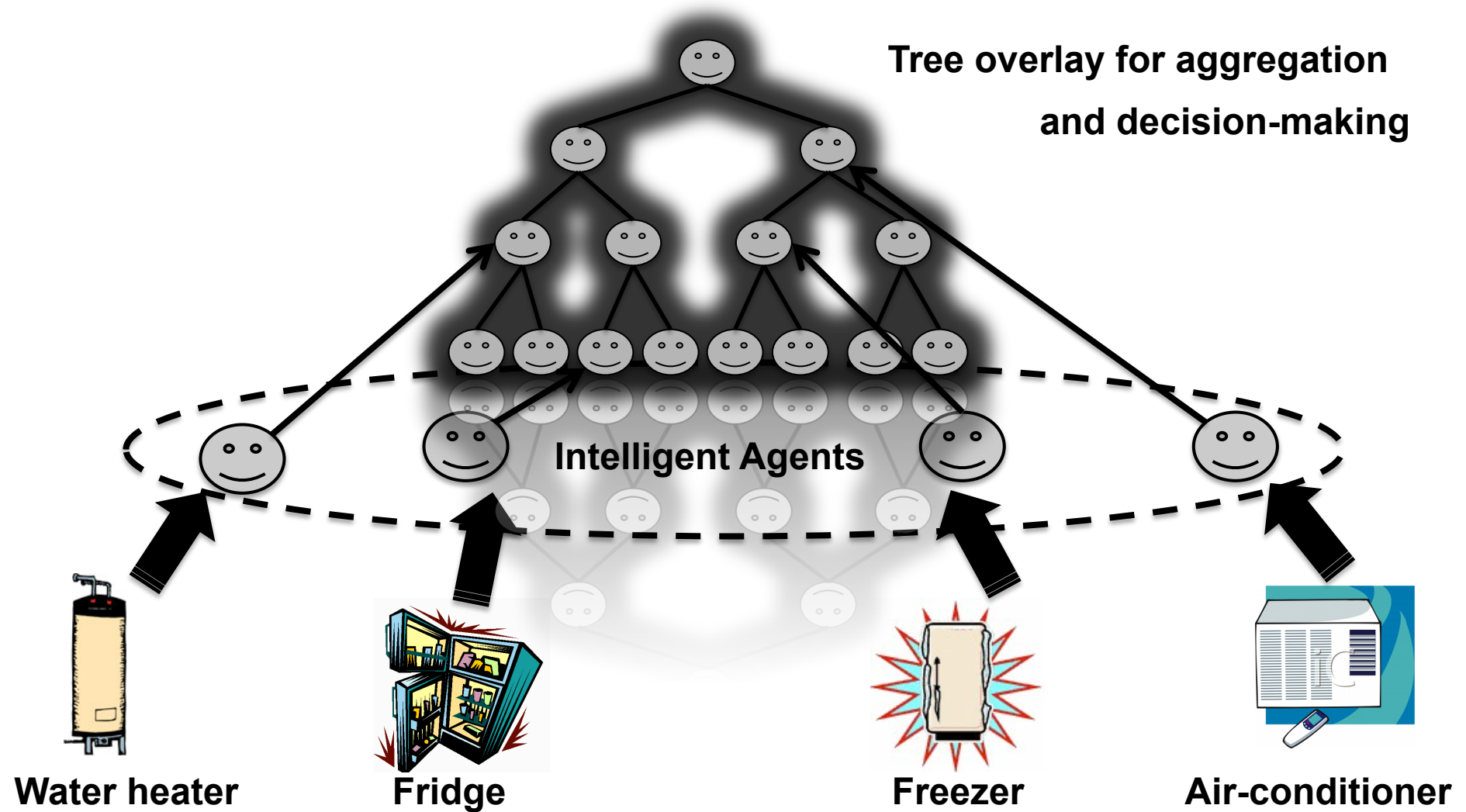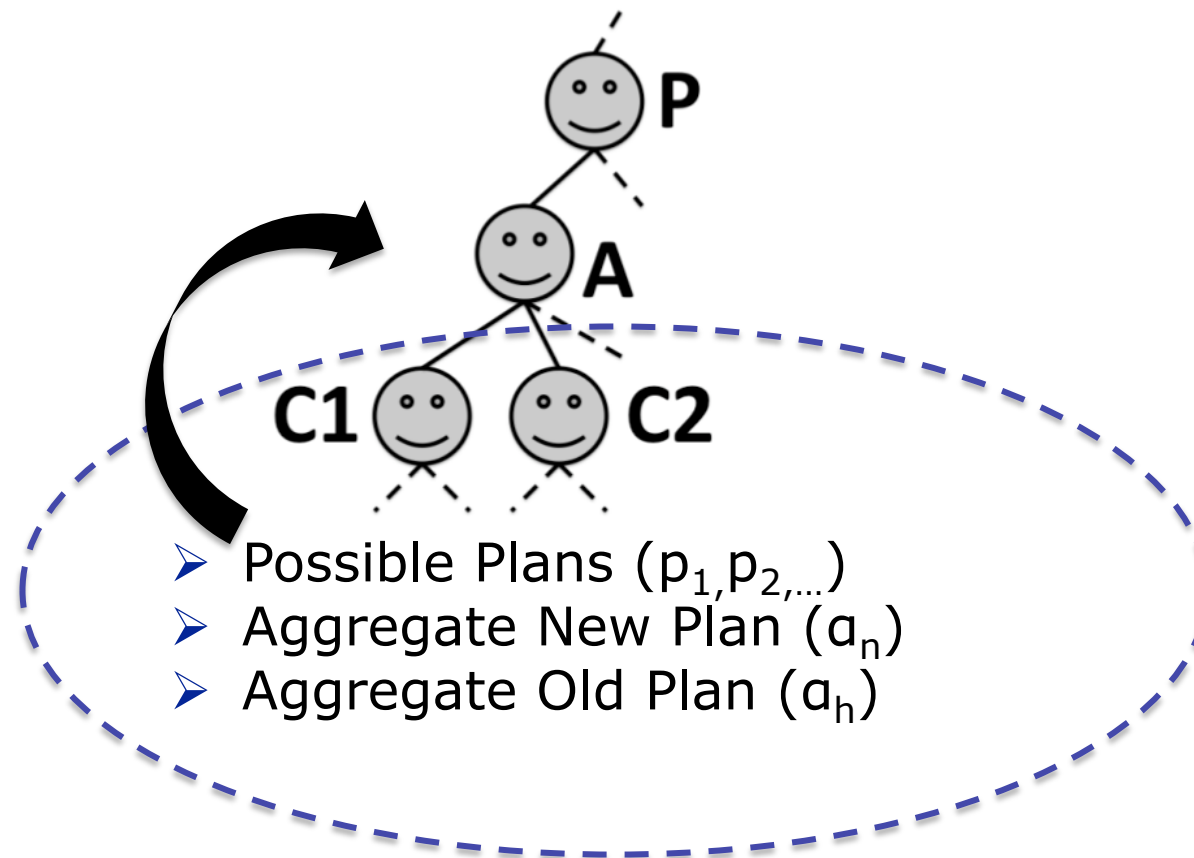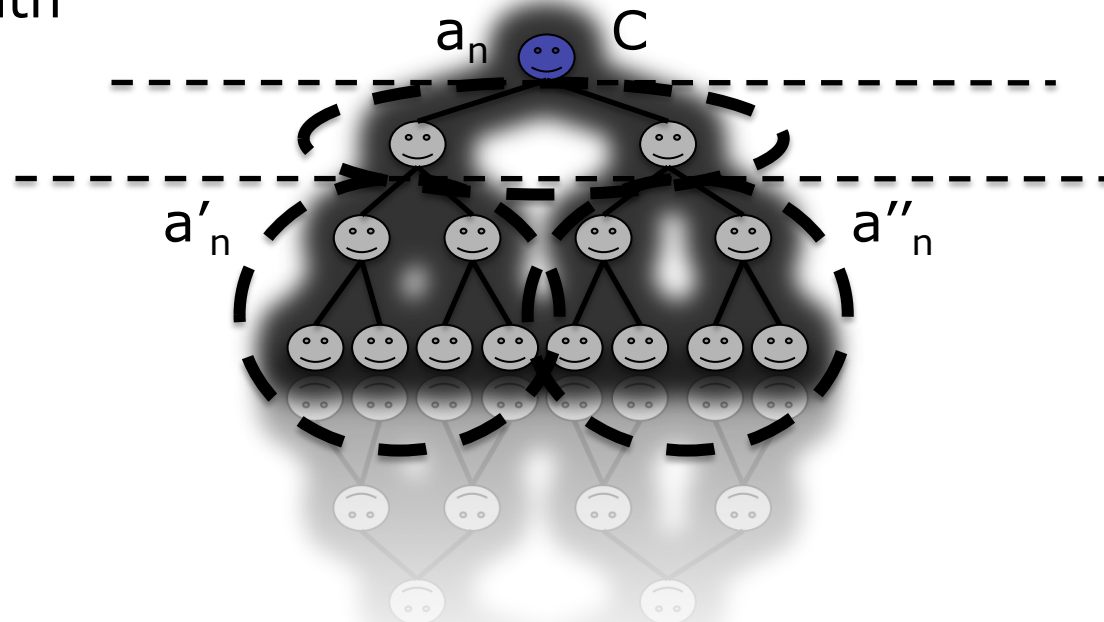
Local Plan Selection

Pre-processing

- **Generate combinations** (C) of the possible plans of the children
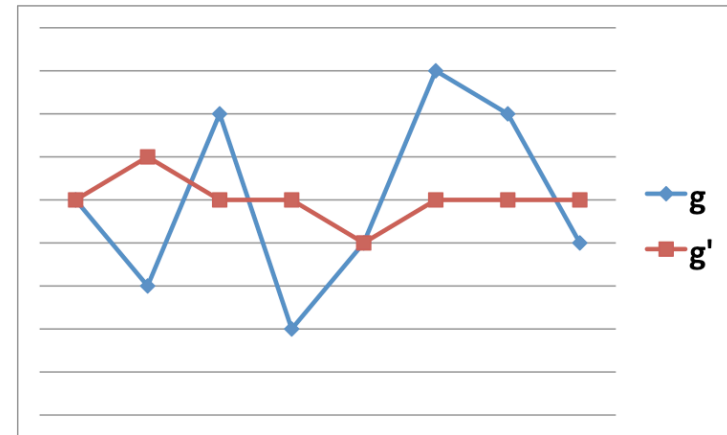- **Merge Aggregate Plans** ($a_n = a'_n + a''_n$) from the branches underneath

a_n C

a'_n a''_n

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Local Plan Selection (cont.)

2 fitness functions

Minimum Deviations

Keeping the oscillations to the minimum continuously

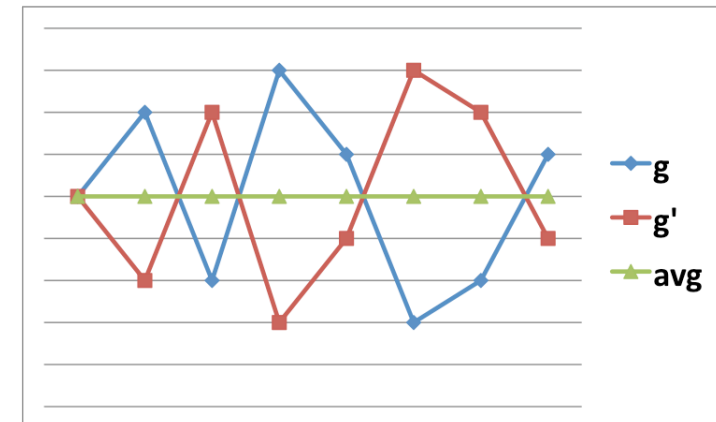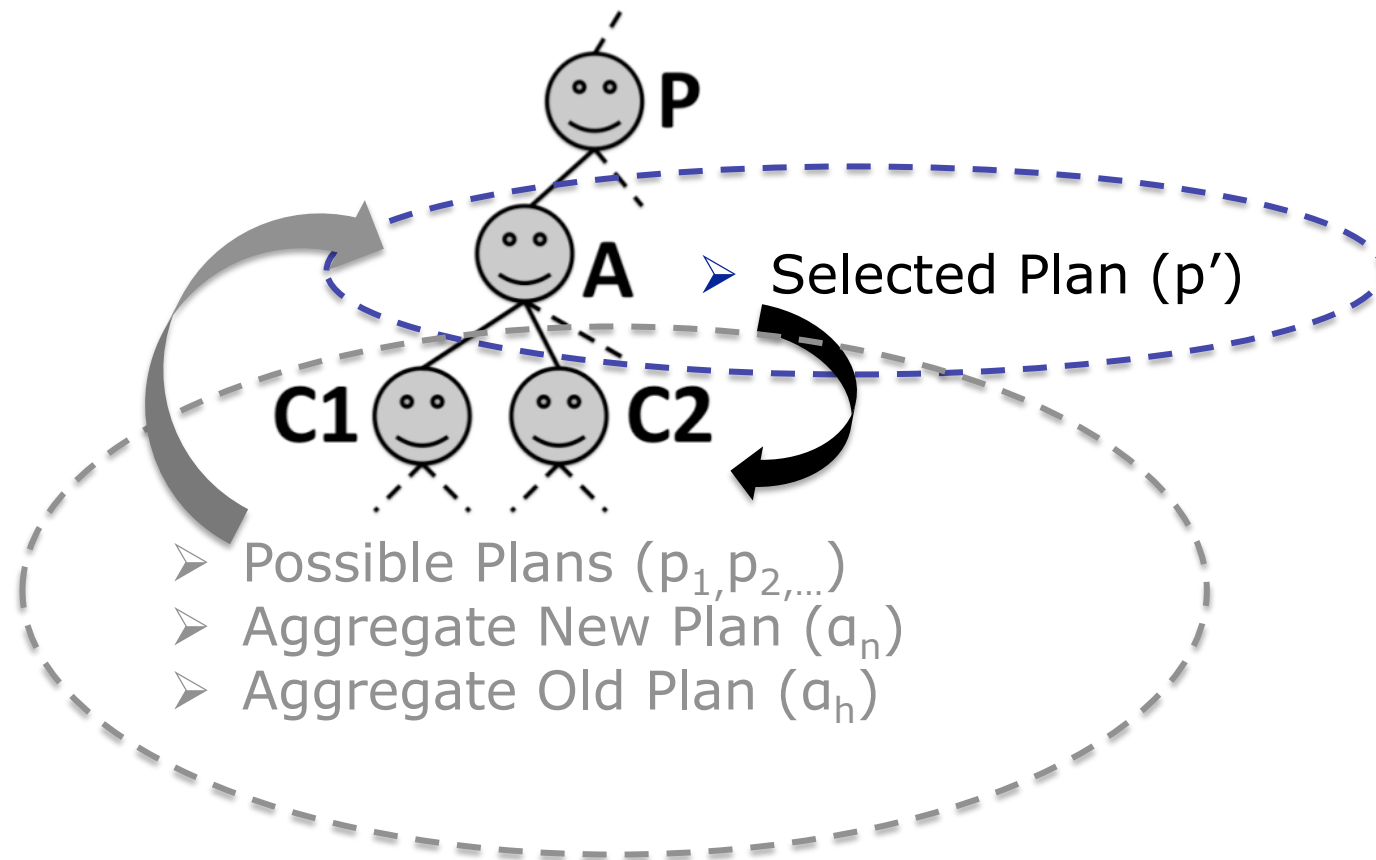$$f_{MD} = \min_{i=1,2,\ldots,|C|} \sigma(\boldsymbol{a}_n + \boldsymbol{C}_i)$$

Reversing Deviations

Balance a sudden unavoidable (predicted) peak in the system

$$f_{RD} = \min_{i=1,2,\ldots,|C|} \sigma(\overbrace{\boldsymbol{g} - \underbrace{\boldsymbol{a}_h}_{}}^{history} + \overbrace{\underbrace{\boldsymbol{a}_n + \boldsymbol{C}_i}_{replacement}}^{new})$$

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Local Agent Knowledge

- ➤ Selected Plan (p')
- ➤ Possible Plans ($p_1, p_2, ...$)
- ➤ Aggregate New Plan (a_n)
- ➤ Aggregate Old Plan (a_h)

Simulations

3280 agents

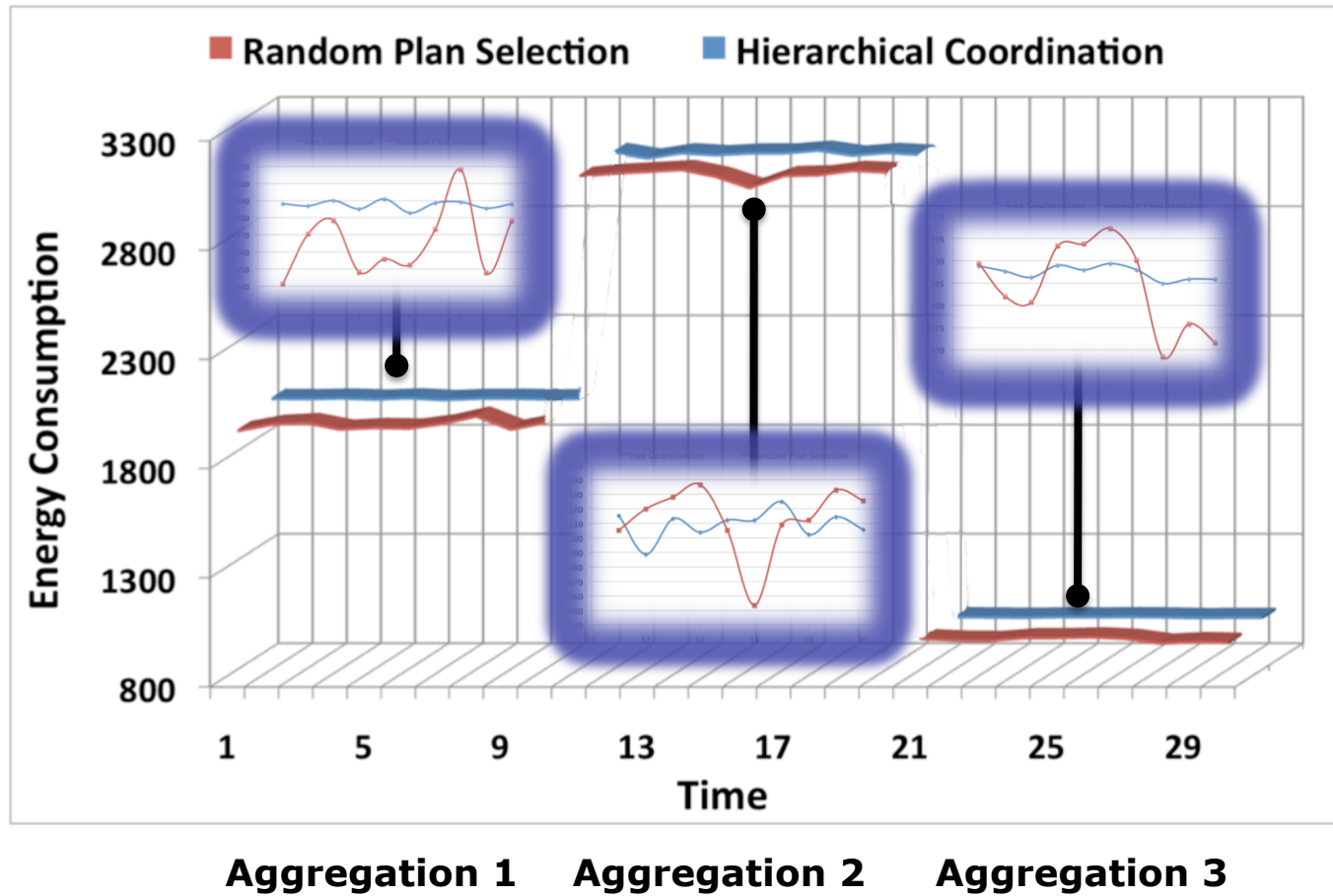**3 different types** of thermostatic devices

3 children per agent

7 levels in a balanced tree

5 possible plans per agent

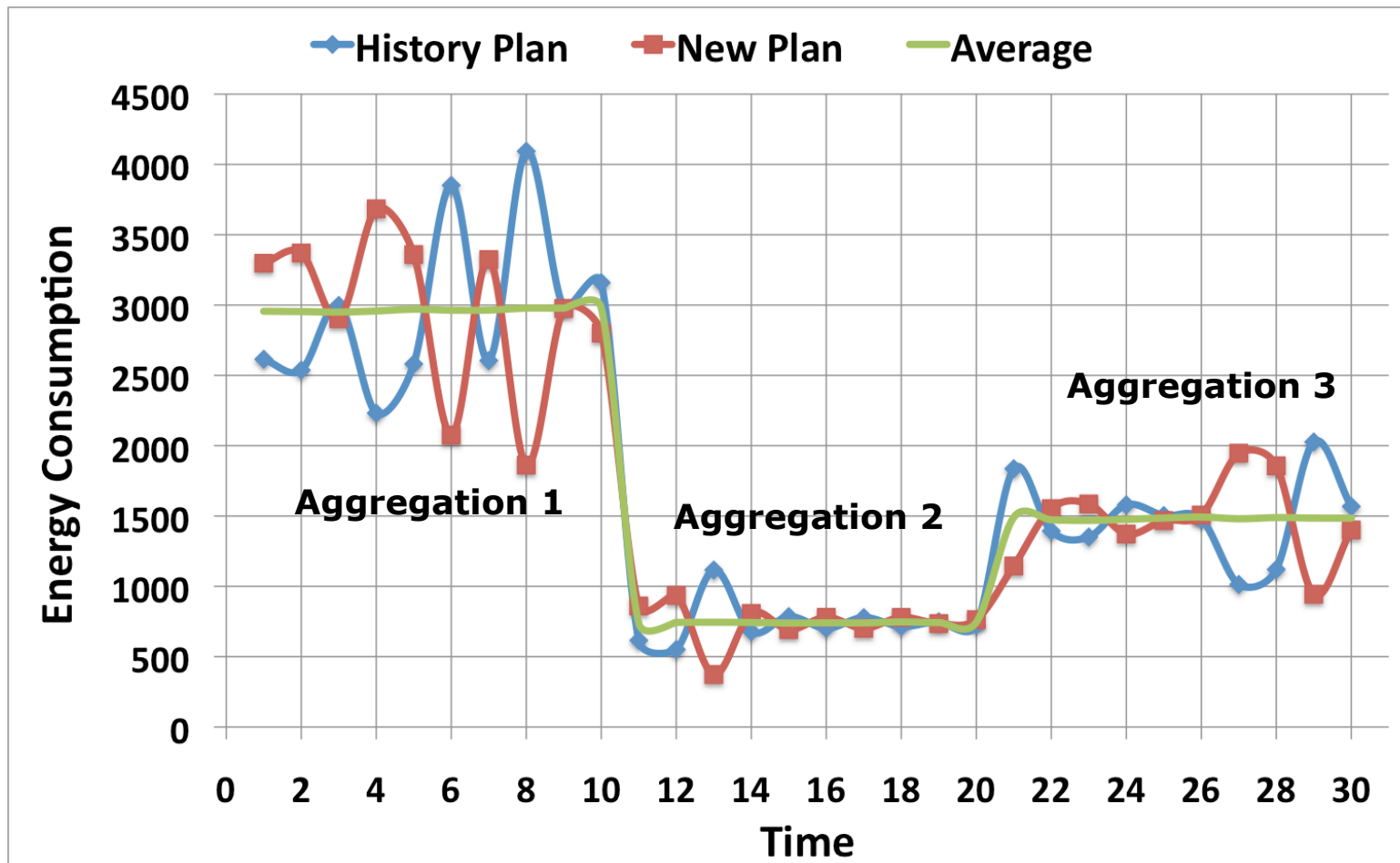Investigation of **minimizing deviations** and **reversing deviations**

Comparison with the **random plan selection** (greedy agents)

Minimizing Deviations

Aggregation 1   Aggregation 2   Aggregation 3

63% Avg. Decrease in Oscillations

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Reversing Deviations

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Conclusions & Future Work

➢ **Distributed hierarchical coordination**

➢ **Software agents** with **local knowledge** and **local tasks**

➢ **2 fitness functions** for **adaptive decision making: minimizing** and **reversing** oscillations

➢ *Improvement in keeping oscillations minimum and reversing oscillations*

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➢ How the tree organization influences the effectiveness of the aggregation

➢ Run experiments in an asynchronous communication environments

ありがとうございます。

Questions?

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