Adaptive Learning Controls

for demand-responsive electricity management

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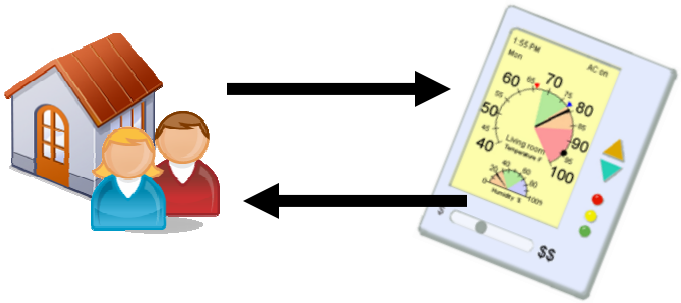
Adaptive Learning Controls

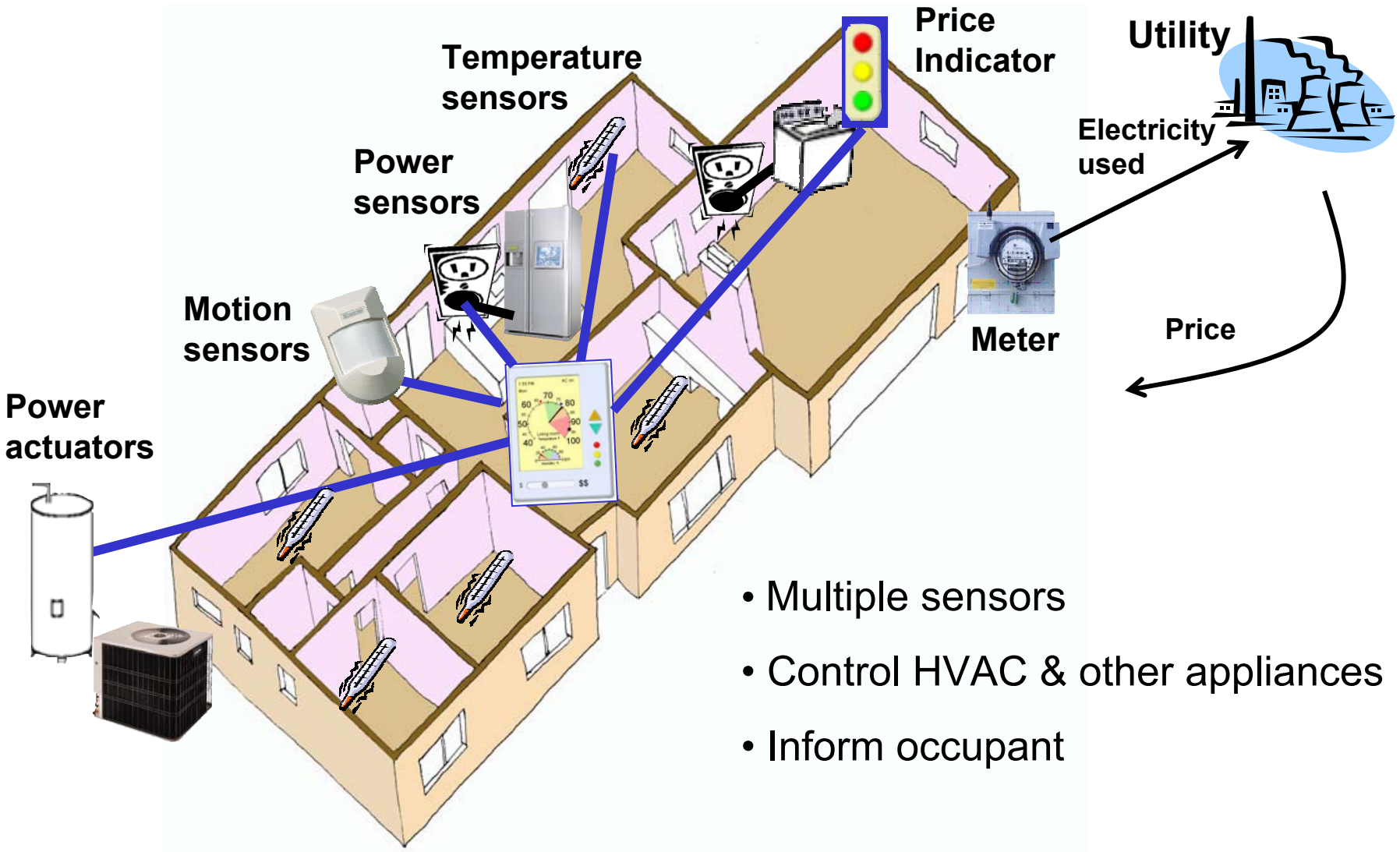
Optimization

Out-of-box Initial Defaults

Two-way Learning



DREAM:
Demand Response
Electrical Appliance Manager



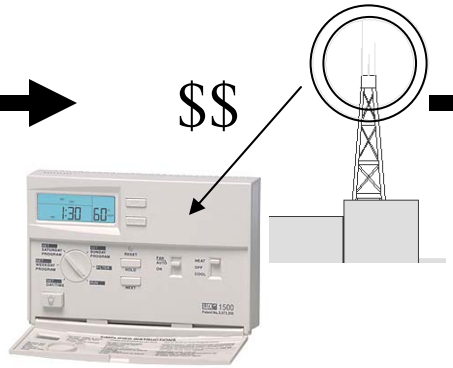
- Multiple sensors
- Control HVAC & other appliances
- Inform occupant

Leverage Technologies

- **Integrated sensors**
  - Temperature, relative humidity, current, occupancy, solar radiation
- **Wireless network developments**
- **Smaller, faster microprocessors and radios**
- **Local and remote databases**
  - for adaptive learning and system testing

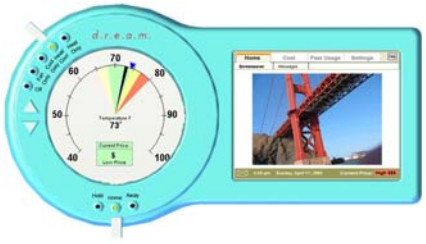
DREAM Goals: Increase Functionality

Programmable Thermostat



Programmable Communicating Thermostat

+ Adapting
+ Optimizing
= good defaults



+ Learning = Adapting "thermostat": Optimizing, Learning, Communicating DREAM

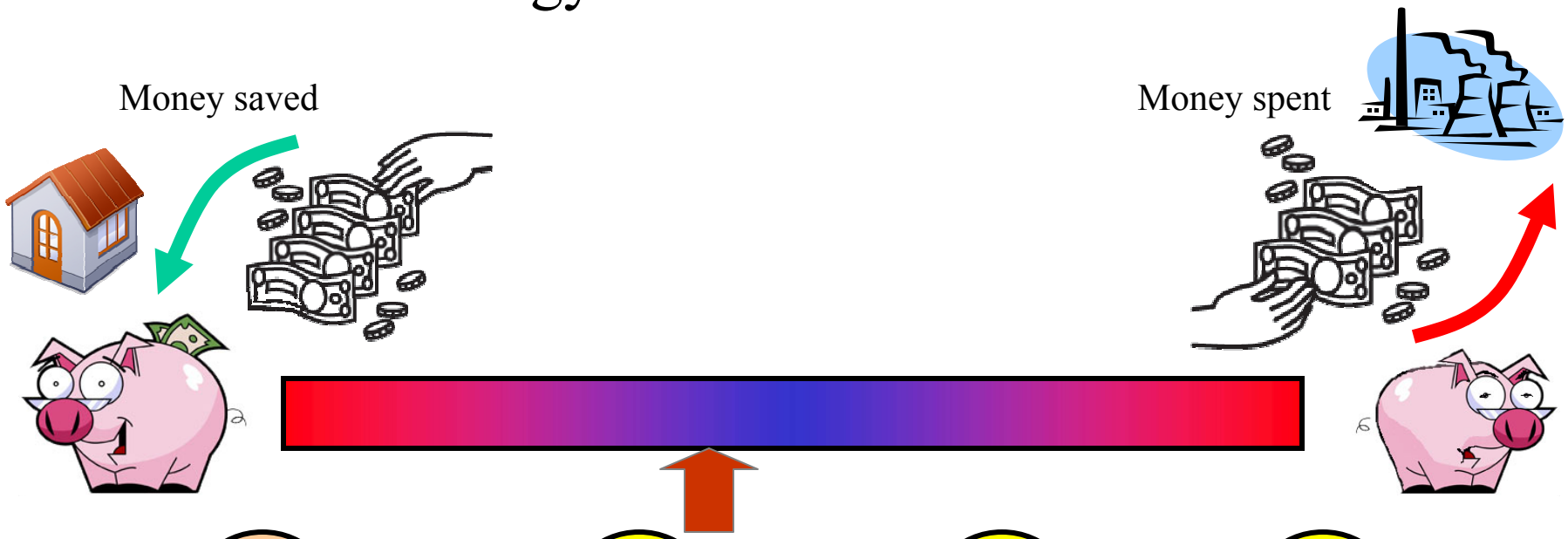
Hypotheses (1)

Optimization: Cost & Comfort

Simple user-influenced optimization of cost and comfort will create control system more acceptable to users than automatic scheduled approach and will assure adoption of demand-response enabling technology

Optimization

- **Economic Index:**
  - cost of energy vs. thermal comfort



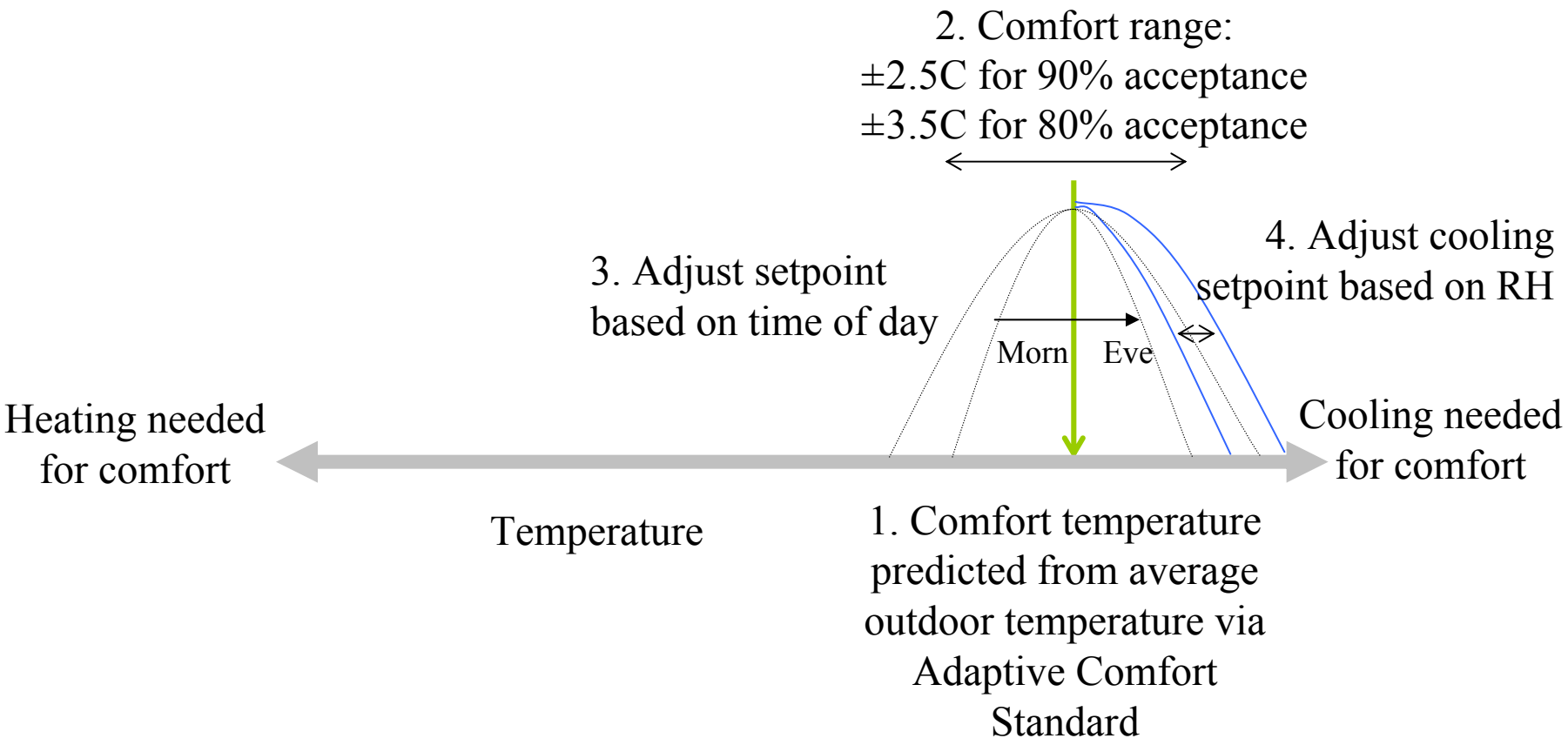
Hypotheses (2)

Out-of-box performance and default settings

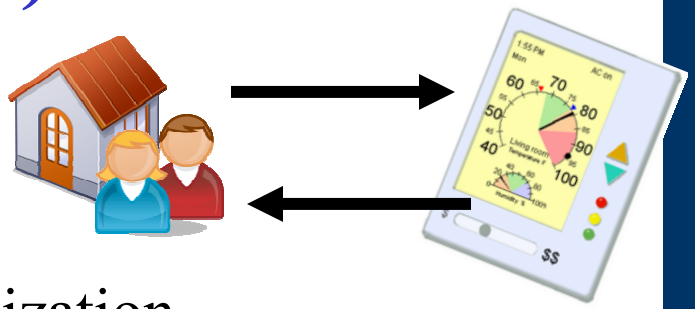
- Respond to price signals
- Respond based on whether house is occupied
- Optimized by pre-set economic index for comfort and cost
- Adapt to local climate
- Internal model predicts behavior of house

will reduce peak energy and provide better comfort than would a programmable thermostat

Good Defaults:
Dynamic Temperature Setpoints



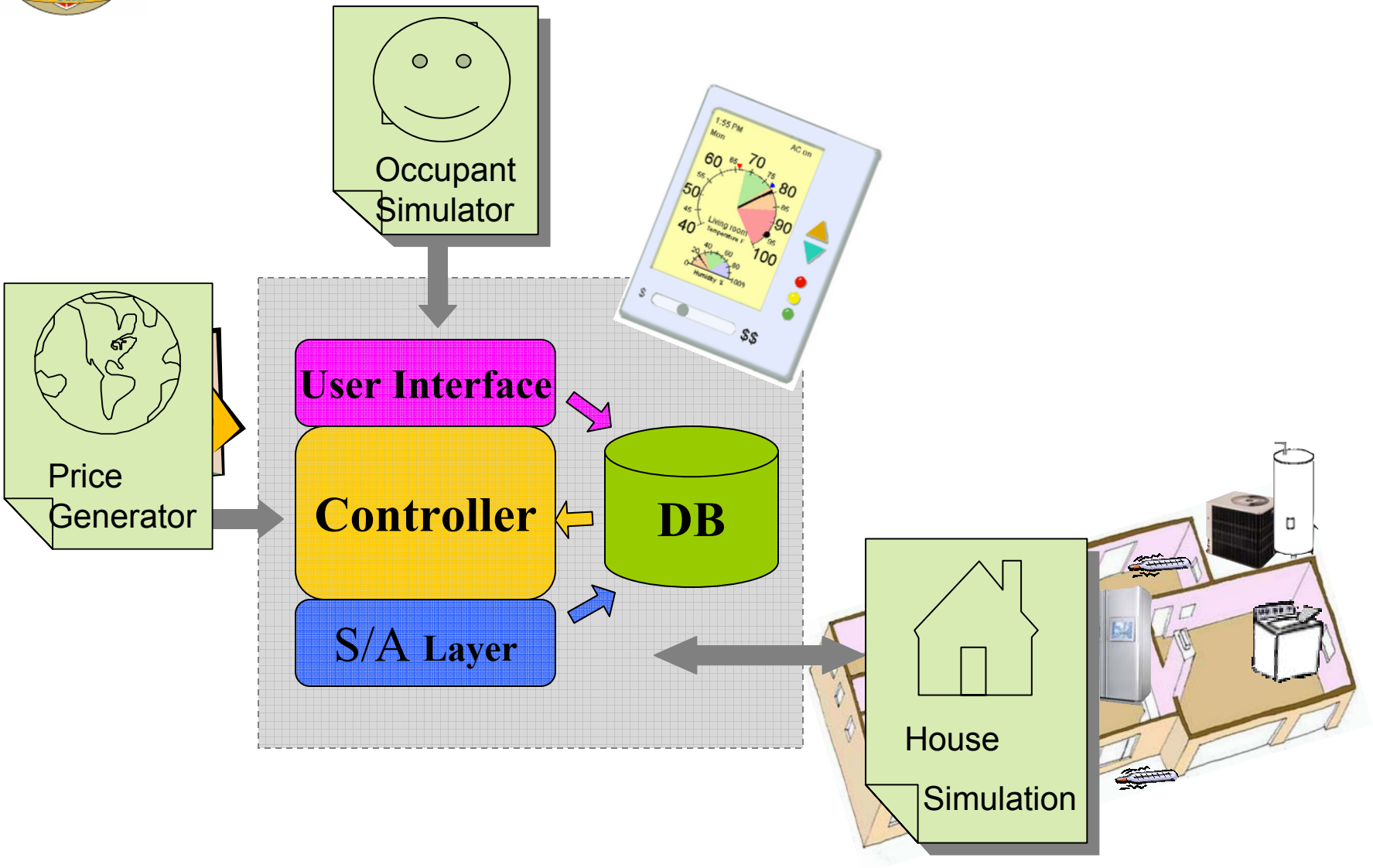
Hypotheses (3)



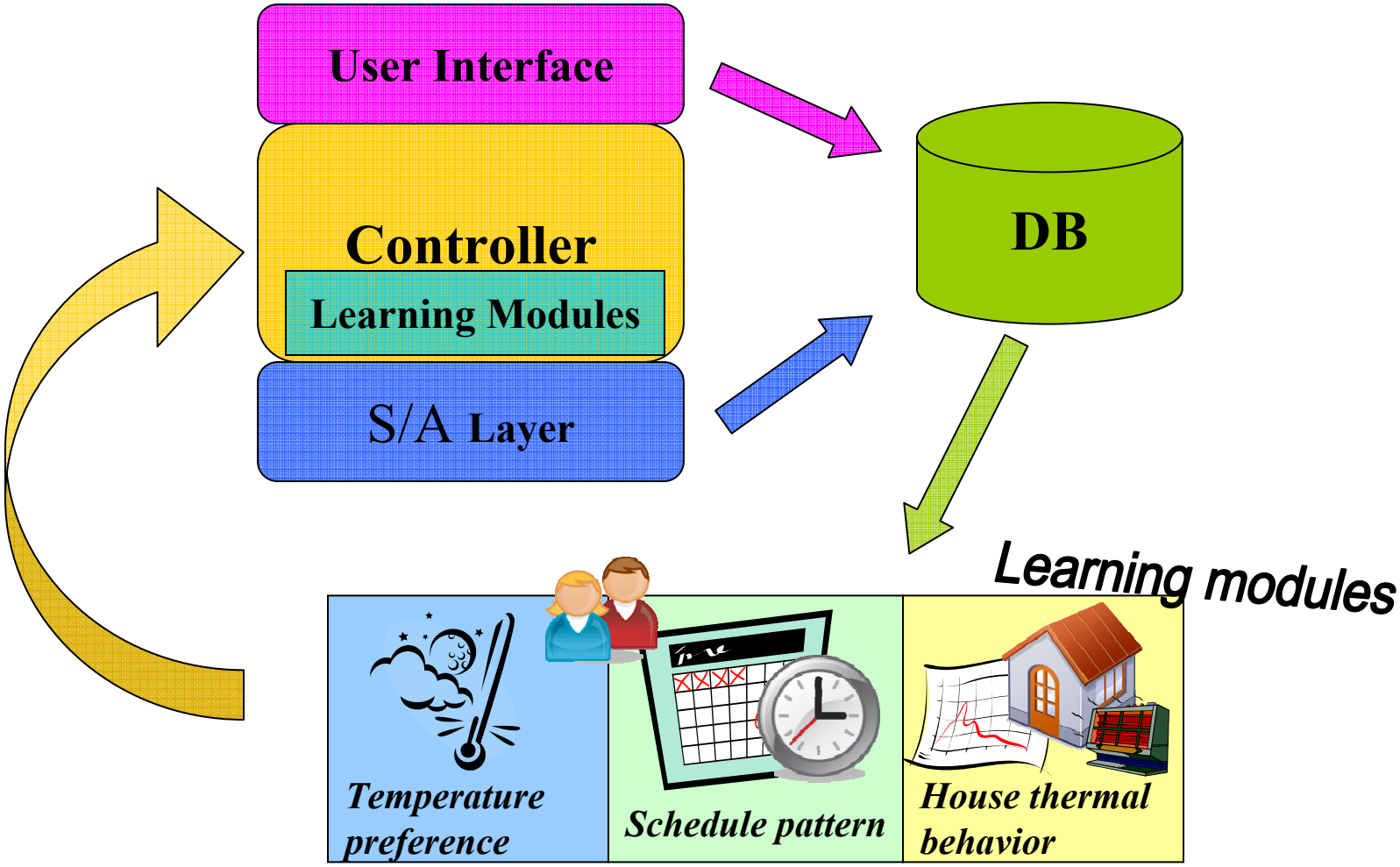
Two-Way Learning:

- Machine Learning will improve optimization
  - Occupant schedule pattern
  - House physical properties:
    - Learn power and energy required for comfort for better cost estimate for optimization
    - Learn house dynamics for effective use of HVAC equipment (i.e., precooling)
  - Occupant thermal preferences
- Educating Occupant: Informing and advising occupant of price and energy consumption will increase residential involvement in demand response

Learning System Structure



Functions of Learning



Recommendations

- Sensor development (temperature, RH, motion, radiation, CO2, pressure etc) vital to information-rich system
- Sensor design integration: Position and orientation of sensor critical to accurate measurement
- Resolution of sensor important for optimal control
- Communication design needed for low-power drain
- Field testing of technology necessary

Adaptive Learning Controls

Optimization

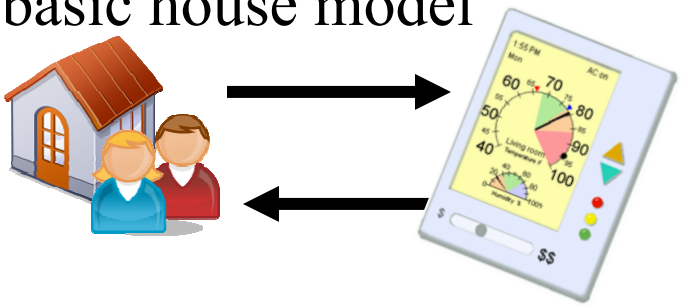
Comfort and cost

Out-of-Box Defaults

Automatically responds to price, occupancy, occupant economic index, local climate, basic house model

Two-way Learning

Machine AND people learn!



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