

## Concept

- We are at beginning of 10+ years of turbulence in concept of “thermostat”
- Unlikely that we can today design what we will need / want in 2020
- Can establish a framework / path to start going there
- Key concept is (digital) networks
  - Standards-based
  - Distributed functionality
  - Layered construction
- Lets hope we are not still using term “thermostat” in 2020

## What components are in the distributed comfort network?

- Information displays / controls
  - Thermostats
  - Other displays / remote controls (local and distant)
- Sensors (many): temperature, occupancy, air quality, door/window status, ...
  - Coordinate with other building / non-bldg. systems
  - Price, weather, ...
- Thermal sources (central heat/cool), spot sources
- Distribution
  - Conventional fans; transfer ducts; valves
- Shell control: window shades, electrochromic windows, ...

## This all seems very complicated

- This problem has been tackled before — twice
  - IT networks
    - High degree of interoperability
    - Many core concepts with great uniformity
  - CE Networks
    - Much confusion in connectors, connectivity, models for how things should work
    - Significant diversity even within standards

Thermostat of future will be more electronics-like, with interchangeable, interoperable parts

## OSI = “Open Systems Interconnection Basic Reference Model”

Idea for how to design network systems that are flexible, economic, interoperable, scalable, etc.

Layers of standards / functions / implementation are narrow in scope and independent

Each layer interacts only with adjacent layers

Provides for diverse applications and implementations

Provides for easy evolution over time

A key principle underlying developing Internet and related technologies



## The Model

#	Name	Function
7	Application layer	“I want a web page”
6	Presentation layer	.
5	Session layer	.
4	Transport layer	.
3	Network layer	.
2	Data link layer	.
1	Physical layer	“Bits on a wire” (or non-wire)



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(8th layer — User Interface)

## Possible Layers for Thermostats

Name	Function
User Interface	Controls, indicators, terms, symbols, colors, metaphors, ...
Control Layer	Applications, algorithms, ...
Object Layer	<b>Physical:</b> Sensors, actuators, displays, fans, thermal sources, shades, ... <b>Concepts:</b> Prices, temperatures, schedules, occupancy / presence, building topology, ...
Data Exchange	Several layers of moving bits around

## Role of Standardization

Name	Function
User Interface	Controls, indicators, terms, symbols, colors, metaphors, ... CC-specific: Understandable to people
Control Layer	None: Manufacturer innovation
Object Layer	<b>Physical:</b> Sensors, actuators, displays, fans, thermal sources, ... Some CC-specific, some generic Provides for interoperability Concepts: Prices, temperatures, schedules, occupancy / presence, ...
Data Exchange	Several layers of moving bits around Existing standards; legacy CC-spec.

## Data Exchange Layer

- Leverage industry-standard data / network connection technologies as much as possible
- Need to support legacy interfaces
- Prefer neutrality to particular physical interfaces (but necessary to select a few preferred ones)

## Object Layer

- Standard definitions facilitate interoperability
- Some concepts may “float up” into UI
  - Schedules, terms, metaphors, objects
- Object examples: sensors, schedules, preferences, events, ...

## Control Layer

- Area for innovation, differentiation
- May need no standards

## Layered Network Model

### Advantages

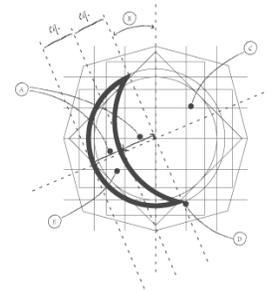
- Facilitates multiple physical layer technologies
- Facilitates evolution over time
- Open standards drive low prices, interoperability
- Technology, media can be shared

### Context: Other emerging building networks

- Lighting
- Security
- Digital CE networks

## User Interface: Precedent

- IEEE 1621 — Defines terms, symbols, indicators, colors, metaphors for power control of electronic products
  - “strongly recommended” by Energy Star”



## Summary / Next Steps

- Need to adopt a vision / approach that will be more — not less — satisfactory over time
- Layered concept with several core standards — object and UI layers (will take time to complete)
- First, create rough sketch of whole system
- Engage industry, standards organizations
- Develop detailed scheme
- Plan path from legacy equipment of today
- Change the world

Thank you!

