An Ecological View of Smart Home Technologies

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An Ecological View of Smart Home Technologies

Outline

- Smart Objects: A Rupture Technology for Domotics
- Home as Provider of Services
- The Inside-Out Smart Robot
- Categories of Smart Services
- Qualities for Smart Homes Technologies.

Smart Objects

Nabastag

Nest

Roomba

Smart Refrigertor

Jibo

Ordinary objects augmented with sensing, communication, action and interaction using digital technologies.

Smart Objects are an rupture technology for Domotics

Early Home Automation

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Classic Home Automation

- Centralized control of lighting, heating, ventilation, air-conditioning, shutters…
- Analog Timers and controllers
- Installation by certified technicians
- No user intervention required (or allowed).

Domotics as Home Automation

Modern (Digital) Home Automation

- Centralized control of lighting, heating, ventilation, air-conditioning, shutters…
- Digital timers and controllers
- Installation by certified technicians
- Bridge to digital hub
- HTML based User interface

Domotics has had very little market pentration. Why?

Why Did Domotics Fail?

Take home Lesson No.1:

Rupture technologies require new organization models

Productivity (Solow) Paradox

1. Productivity of factories with electricity (1890s)
2. Productivity of business with computing (1980s)

There are many other examples in the history of innovation

The Solow Productivity Paradox

Replacing a steam engine with an electric motor did not improve productivity for 19th Century factories.

The Solow Productivity Paradox

Mainframe computers did little to enhance productivity for office work in the 1970s and 1980s.

Take Home Messages

1. Rupture technologies require new organizational models.
2. Quality of life technologies are more valued than time saving technologies.
3. Smart means Embodied, Autonomous and Situated.
4. Privacy, Trust, Reliability and Controllability are not optional

A new organizational model for Smart Homes

Ecology:

The scientific study of the interactions between living things and their environment.

Scientific approach used in biology, anthropology, sociology, environmental studies, economics and others

Ecological interactions are formalized as an “exchange of service”

Ecology:
An organizational model for the home

Home: A place of residence; A physical structure that provides protection for persons and possession.

As technology advances, homes provide an increasing number of services to inhabitants

Home as Provider of Services

Paleolithic home:

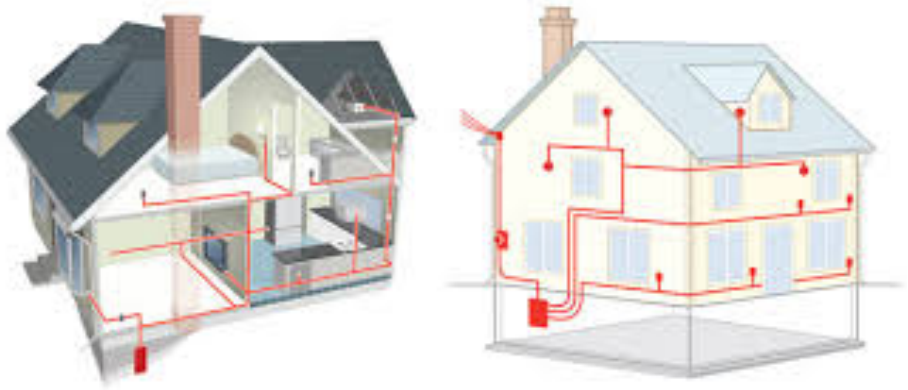
- Shelter from weather and predators for persons and possession.
- Place for Fire for protection, heat and meal preparation

Home as Provider of Services

Early Modern Homes (last 500 years):

- Shelter for persons and possessions
- Heat (wood, coal, peat, city gas)
- Light (Tallow, candles, oil lamps, kerosene, city gas),
- Food storage (Food cellar, harvested ice, artificial ice)

20th Century - The Electric Home

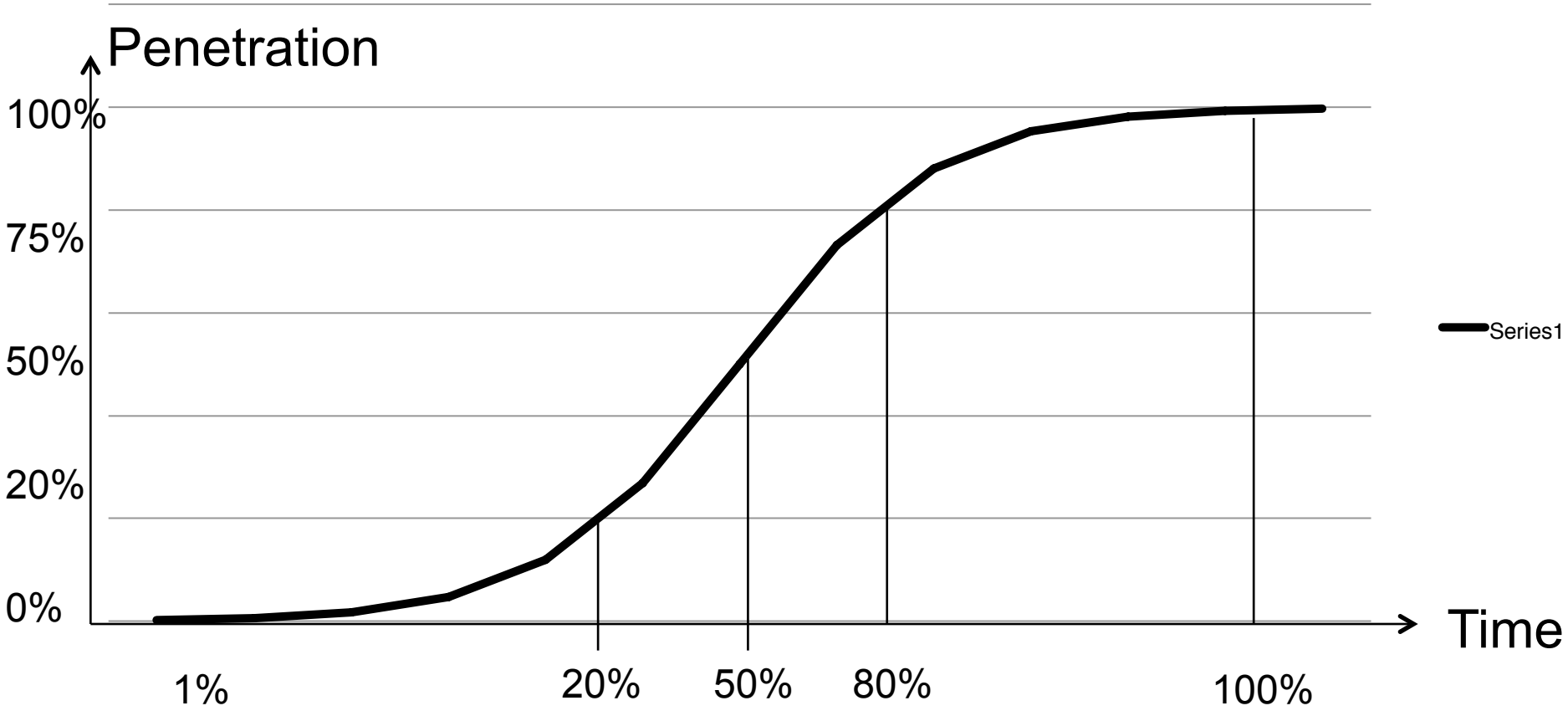


Electricity in the home enabled an explosion of new services.

Electricity was a rupture technology for the home.

The electric home offers important lessons for smart homes.

Ecological Penetration – The Logistics S curve



Electric Appliances and their Penetration Rates

1% penetration: Appliance (years to 50% penetration)*

Time Saving Appliances

1890: Telephone (56 years)
1909: The Electric Iron (24 years)
1915: Vacuum Cleaners (40 years)
1916: Clothes Washers (20 years)
1934: Electric Kettle (33 years)
1948: Blender (22 years)
1950: Clothes Dryer (22 years)
1973: Microwave Oven (13 years)

Quality of Life Appliances

1913: Refrigerator (13 years)
1911: Air Conditioner (22 years)
1920: Radio (6 years)
1948: B&W Television (5 years)
1961: Color Television (6 years)
1969: VCR (9 years)

Quality of Life appliances achieve faster market penetration!

*S. Bowden and A. Offer, 1994.

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What do we mean by “Smart” ?

To be considered as "intelligent" a system should be:
embodied, autonomous, and situated. *

Embodied:	Possessing a body; Able to act on the world
Autonomous:	Self-governing; Having independent existence
Situated:	Exhibit Appropriate Behavior for the Environment

* L. Steels, and R. Brooks, The artificial life route to artificial intelligence: Building Situated Embodied Agents. New Haven: Lawrence Erlbaum Ass., 1994.

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The Smart Home:
Embodied, Autonomous, Situated

Possible paradigm:
The Smart Home as an Inside-Out Autonomous Robot

Embodied: Act with motors, actuators and communications
Autonomous: Maintain integrity and homeostasis
Situated: Act to provide service to inhabitants

Smart Home as an Inside Out Autonomous Robot

Autonomy: Integrity and Homeostasis

Services

1. Comfort: Interior climate control.
2. Hygiene: Detection and elimination of contaminants and waste.
3. Logistics: Management of consumables
4. Security: Protection of persons and property

Examples of Smart Home Services

Control of the Interior Environment

Comfort: Interior climate control

Integrated Control of Comfort and Energy

- Control of Temperature and Humidity
- Illumination (intensity, location and color)
- Air Quality

Examples of Smart Home Services

Control of the Interior Environment

Hygiene: Detection and elimination of contaminants

Monitoring of surfaces for contamination and waste

- Monitor sinks and counters for contamination
- Monitor floors and tables for clutter and spills

Can be used to

- Maintain log of cleaning
- Request cleaning from robotic devices
- Locate misplaced objects

Examples of Smart Home Services

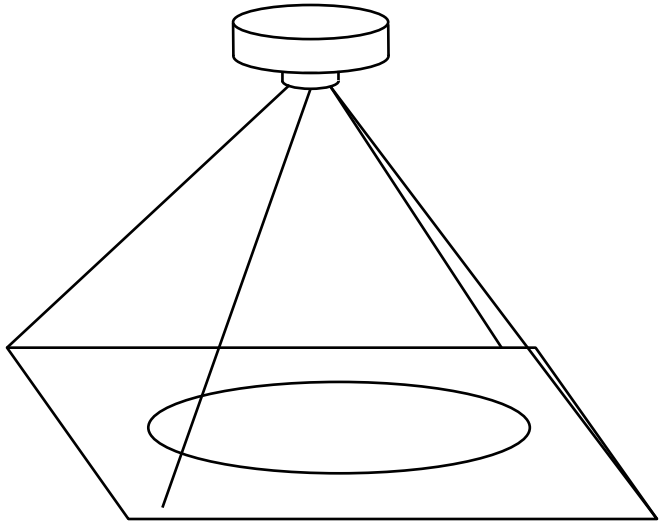
Hygiene: Detection and elimination of contaminants

Enabling Technology: Integrated Micro-cameras:

Integrated CMOS camera system with optics, retina, image processing and image analysis in a low-cost low power package. (Used for mobile devices)

Examples of Smart Home Services

Hygiene: Detection and elimination of contaminants



Low-Cost Visual Sensor:

Integrated wireless sensor package with micro-camera, low-power processor, image processing, computer vision, communications and power

Examples of Smart Home Services

Hygiene: Detection and elimination of contaminants

Use micro-cameras and computer vision to monitor cleanliness in washroom, kitchen and dining room.

- Provide real time measures of cleanliness
- Log history of surface cleaning (Episodic Memory).

Examples of Smart Home Services

Logistics: Management of consumables

1. Monitoring Contents of storage areas
2. Inventory control
3. Detection of expired consumables.

Refrigerator Time Machine

Bienvenue Emilie !

Accueil | Historique | Vos recettes | Vos listes de courses | Votre profil

Historique

Refrigerator Time Machine

The refrigerator time machine is an example of Episodic Memory.

Episode: Opening the refrigerator door

Memory: can be iconic (images), or symbolic (recognition of products, information from bar codes).

Refrigerator Time Machine

- Monitoring Contents of Refrigerator
- Recognize products
- Read Product labels
- Maintain list of Inventory

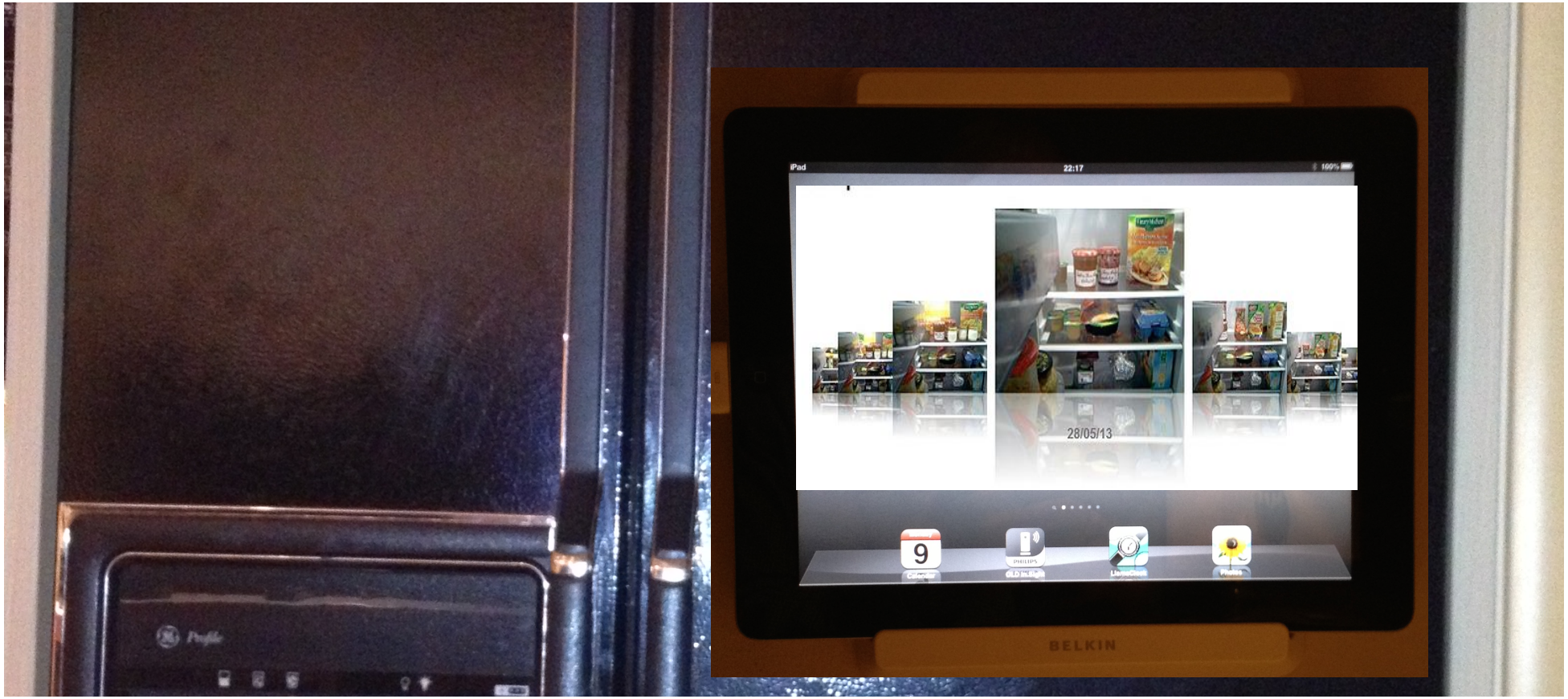
Refrigerator Time Machine

Use computer Vision

- To detect individual objects
- Recognize objects
- Read bar code

Maintain a record of
when each object was stored
and who placed or removed
each object

Display images for browsing



Categories of Service

Categories of Smart Services for the Smart Home

- Tools: achieve a goal; Invariant reliable behavior
- Housekeepers: perform routine chores as needed.
- Advisors: observe inhabitants and suggest possible courses of actions.
- Media: extensions to perception and experience,

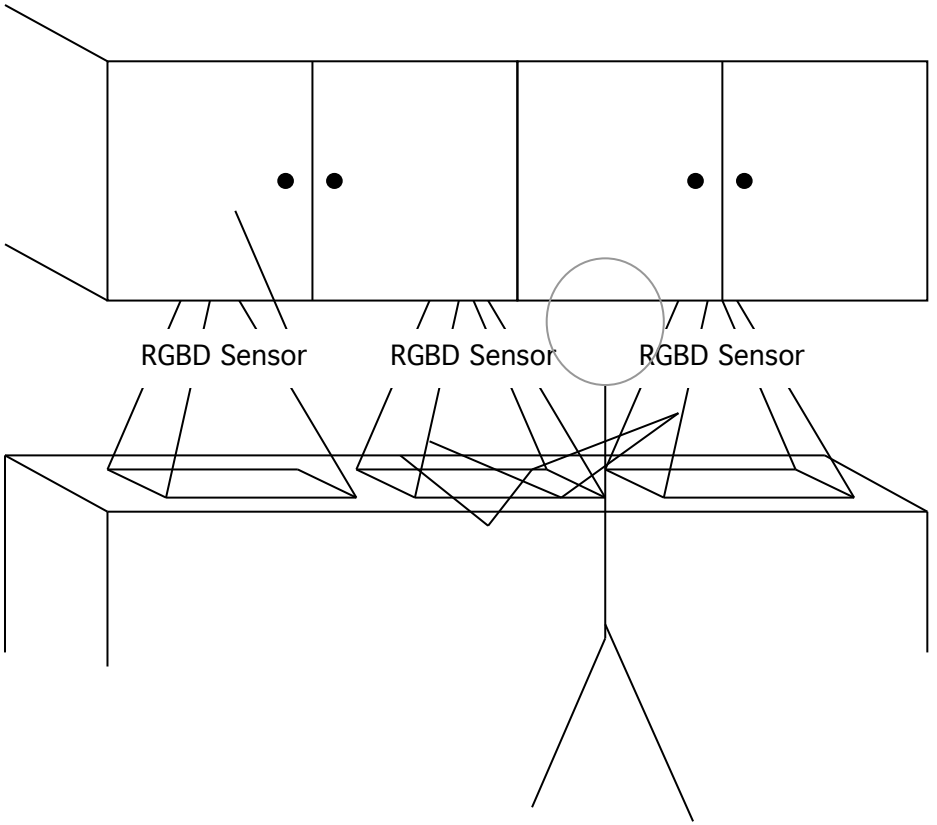
Categories of Service

Tools, Housekeepers, Advisors, Media

Categories of Service are Based on Interaction and not on the information.

Episodic Memory for Kitchen Workspaces

- Observe cooking gestures
- Detect and record events
- Organize events as episodes
- Display recent (short term) memory for inspection.
- Store episodes for advice



Examples of Services made possible by episodic memory:

Tool: Keep an accurate record of actions for quality control

Housekeeper: Note use of consumable products for re-order.

Advisor: Offer advise about cooking, cleaning, medication.

Media: Enable visual browsing of activities and events

Example: Smart Thermostats

Nest

ThermoCoach

Tool: (Nest) Maintain comfort while minimizing energy

Advisor: (Thermocoach) Maintain comfort; Send emails with suggestions on how to save energy

Qualities for Smart Home Services

Qualities:

- Defines the behavior of a system or service;
- Determines acceptability and rate of adoption

Qualities for Smart Home Services

- Controllability
- Reliability and Maintainability
- Usability
- Durability
- Security, and Privacy
- Trustworthiness

Controllability

The ability to regulate, dominate or command.

Control of ones' personal habitat is an important component of general well being and quality of life.

Reliability

The ability of a system to consistently perform its intended or required function without degradation or failure.

Home services are critical services.

Failures must be graceful with built-in safeguards and backups

Maintainability

The ease with which system can be modified to correct faults, improve performance or adapt to a changed environment.

Smart home systems should be easily repaired and easily upgraded.

Usability

Definition:

- Ease of use and learnability of a system;
- Compatibility of a system with the cognitive, perceptual, and motor abilities of a user

Smart home systems must be usable by ordinary individuals

Durability

The ability to withstand repeated use over a long period without significant deterioration in performance.

Smart Home should have technological life cycles that are on the same temporal scale as the home.

Programmed obsolescence is not an option.

Security and Privacy

The ability to resist unauthorized attempts at access or control.

Smart technologies are extremely invasive.

Such technologies can record the most intimate detail of daily life.

Smart home systems must not betray the privacy of the individual

Trustworthiness

The ability to assure the user that a system is secure, available, and reliable.

Not only must a system be security and private. The user must believe and trust in this security.

Security, Privacy and Trustworthiness

The potential for abuse of smart home services by companies and governments constitutes the biggest danger for their development

Personal information has value. Without legal restraints, it is very tempting for companies to base a business plan on the hidden value of customer information.

Legal restraints on corporate and governmental collection and use of personal data are important to the future of the smart home

Take Home Messages

1. Rupture technologies require new organizational models.
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3. Quality of life technologies have more valued than time saving technologies.
4. Privacy, Trust, Reliability, Usability and Controllability are essential to quality of life

Quality of Life

Definitions:

1. The General Well being of an individual;
2. The degree to which a person can achieve Being, Belonging and Becoming;
3. The degree to which a person can fulfill needs and achieve desires.

Contributing to Quality of life is the fundamental quality for smart home technologies.

Two Possible futures for Smart Homes

Smart Home Apps Store Approach.

(Closed, Proprietary, Automatic)

Consumer as passive prisoners of closed proprietary systems

Large companies sell closed ecosystem:

- Sell Proprietary hardware and communications.
- User Routines and activities uploaded to the cloud
- Big data and machine learning used to build smart home apps.

Challenge: Construct objects and apps that are so compelling that users will give up their personal data and control of personal space.

Danger: Users are locked in to a proprietary ecosystem

Users loose control of personal data

Two Possible futures for Smart Homes

Crowd Sourced End-User Development:
Open, crowd sourced, user engaged

Multiple providers agree on open ecosystem

- Open, extensible hardware and communications.
- Data on activities and routines remains in the home.
- Groups of end-users construct culture specific services that are offered to the community
- End user remains master of home and personal data

Challenges: Construct development tools that are easily mastered by users

Construct services that are usable, useful, reliable and trustworthy.

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