PlaceLab

An MIT and TIAX Initiative

The **House_n research group of MIT** and **TIAX LLC** have developed PlaceLab--an apartment-scale shared research facility where new technologies and design concepts can be tested and evaluated in the context of everyday living. The research conducted at PlaceLab will help in developing new products and technologies that improve health and wellbeing in the home. Study areas will include proactive health, user interface, indoor air quality, energy conservation, diet, disease management, and accident prevention.

PlaceLab is an apartment in a residential condominium in Cambridge, Mass. and is occupied by volunteers who agree to have their activities monitored while they live in the facility. The 1000-square-foot space has literally miles of wire located within the walls and cabinetry that link hundreds of sensors, allowing researchers to study nearly every aspect of life in the home, from human activity to environmental conditions.

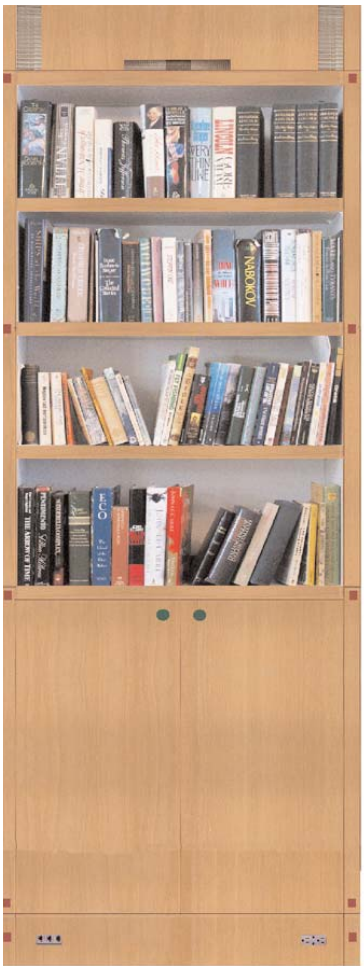
Overview

The home is rapidly becoming a center for health and wellbeing, learning, communication, energy conservation, entertainment, work, and care of our nation's elderly. Industry leaders, policymakers, and academic researchers recognize this situation as offering exciting opportunities for new products, technologies, and ways of designing the home. But there are daunting challenges as well. Consumers are reaching a limit to the number of stand-alone technologies they will accept into their lives. The products and services developed and tested in laboratories often fail in the real world because designers make erroneous assumptions about their effectiveness in complex natural settings such as the home. Focus groups, surveys, and other marketing inquiry methods frequently fall short of anticipating exactly how people will interact with new devices in the home.

Since behavior in real-world settings is both difficult to predict and difficult to simulate in a laboratory, PlaceLab has been designed to combine the capabilities of a highly instrumented research lab with the natural environment of a home. We believe that PlaceLab creates research opportunities that are not available in any other facility in the world.

Shared Research Facility

PlaceLab represents a new model of collaboration between academia and industry. The facility can accommodate multiple and simultaneous experiments by academic, industrial, and government researchers. Research proposals are evaluated by a scientific peer review process reflecting academic, government, and industrial perspectives. Final approval decisions made by the TIAX and MIT co-directors are based on the potential impact that the study results may have on industrial innovation and large-scale societal change. The researchers are asked to fund or provide the necessary additional resources to conduct studies in PlaceLab. TIAX is available to assist in company-initiated research and in the transition to commercialization.



Typical sensing infrastructure as shown in one of 15 PlaceLab cabinets (computer rendering).

The upper section of this cabinet contains a microcontroller and light sensor, humidity sensor, CO_2 sensor, barometric pressure sensor, infrared camera, color camera, and speakers (2). The side faces of the cabinet contain IR illuminators (2), a microphone, and temperature sensors (2). The lower panel contains a power connection and subwoofer. The removable and upgradeable cabinet module has a single power and network connection to the base building.

PlaceLab during technology fit-out.

Research Agenda

PlaceLab has been designed to incrementally add research projects according to the interests of academic and corporate participants. Initial areas of study include the following:

- **Proactive health care and just-in-time information:** Techniques will be tested that support the effective human-computer interaction required for the proactive encouragement of healthy behaviors related to diet, exercise, and medication adherence.
- **Activities of daily living:** PlaceLab's rich sensing infrastructure will be used to develop techniques that recognize patterns of sleep, eating, socializing, and recreation. Changes in these activities, particularly among the elderly, are often early indicators of emerging health problems. The unique data sets that are generated will be used to develop activity pattern recognition tools.
- **Biometric monitoring:** PlaceLab can accommodate research into the viability and acceptance of wearable, physiological medical monitoring equipment and its related interfaces.
- **Indoor air quality:** The facility may be used to demonstrate and test novel air-quality monitoring and energy-efficient, health-promoting ventilation and space conditioning products that are enabled by advanced, cost-reduced sensors, wireless controls, and advanced air treatment technologies.
- **OSBA interior infill strategies:** PlaceLab will be used to investigate a path for more sophisticated sensing, lighting, and control systems to be installed in prefabricated interior components to minimize complex and problematic field labor and allow for non-disruptive upgrades and changes.
- **Privacy and trust:** PlaceLab will be used to study the privacy and trust issues raised by highly instrumented responsive environments, including opt-out strategies, data review techniques, and methods to address the perception of control.

PlaceLab Features

The innovative PlaceLab design includes a backbone—or "chassis"—system that distributes data and power to modular "infill" cabinets customized to accommodate sensors. These sensors combine with advanced activity-recognition software to allow efficient observation. Researchers also have access to sophisticated audio, video, and still image recording capabilities. Major PlaceLab features include (illustrated on Page 4):

"Tini" micro-controller and some of the sensors embedded in cabinetry.

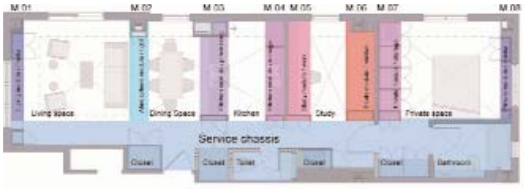
- **Interior components:** The PlaceLab interior is formed by 15 prefabricated cabinetry interior components that can be rapidly reconfigured or replaced to allow for the rapid and non-disruptive upgrading of the facility.
- **Sensor network:** Each interior component contains a micro controller and network of 25 to 30 sensors. New sensors can be rapidly added to this network.
- **Environmental sensing:** Each interior component has environmental sensors, such as floor and ceiling air temperature and humidity. Additional environmental sensing, such as CO and CO_2, may be added as required.
- **State sensors:** Small, wired and wireless sensors are located on every object that people touch and use, including cabinet doors and drawers, controls, furniture, passage doors, windows, and kitchen containers. These sensors detect on-off, open-closed, and object movement events.
- **Audio sensing:** Barely visible microphones are installed in each interior component to capture audio.
- **Still image and video capture:** A sophisticated video capture system processes images captured by discreetly placed visible light and infrared cameras installed behind panels in each interior component.
- **Context-aware experience sampling:** Context-specific feedback from people can be captured with standard PocketPC devices, using sensors to trigger and acquire information. For instance, the computer can monitor heart rate and trigger questions based upon heart rate variation over time.
- **Activity recognition algorithms:** MIT algorithms can be used to study activity-related data and to automatically detect certain activities, such as walking, housecleaning, moderate physical movement, and body posture, in real-time to trigger an action or intervention.
- **Image-based experience sampling:** Computer vision algorithms, used with portable cameras, can collect video and audio data from the environment.
- **Wearable biometric and motion sensors:** These small, comfortable, and low-cost biometic and accelerometer devices can be worn for days or weeks to collect data. In combination with a mobile computing device, such as a PDA, the sensors can detect specific activities in real-time and provide or collect context-specific information.
- **Audio communication:** Stereo speakers installed in each interior component allow audio to be directed to specific PlaceLab locations as required.
- **Addressable lighting:** The intensity and color temperature of light in each major PlaceLab space can be dynamically controlled, allowing light to be used as communication tool and for aesthetic purposes.
- **Environmental control:** The PlaceLab HVAC system contains multiple zones, a heat exchanger, and sophisticated air filtration allowing dynamic control of environmental qualities.

Collaborators

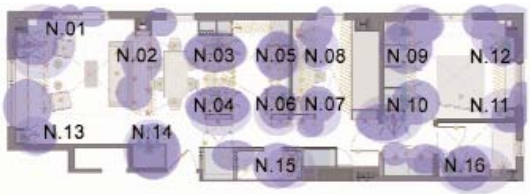
House_n is a Department of Architecture research consortium at the Massachusetts Institute of Technology that explores how new technologies, materials, and strategies for design can make possible dynamic, evolving places that respond to the complexities of life. Kent Larson is the director of the House_n research group.

TIAX is a leading collaborative innovation, product, and technology development firm that shares a long history with MIT with expertise in commercial and residential appliances, energy and indoor environmental technologies for buildings, wearable systems, and medical devices and instruments. Kenan Sahin is the president and founder of TIAX LLC.

Layouts Showing PlaceLab Sensor Locations



Cabinetry Modules



Location of Microcontrollers and Local Networks

Visible Light and Infrared Cameras

Environmental Sensors: Temp., Humid., etc.

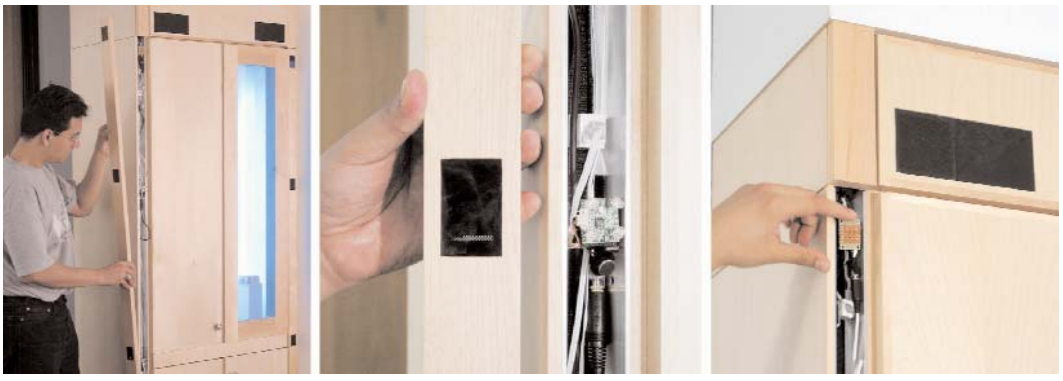
Addressable 24-bit LED Lighting

Microphones and Stereo Audio

Wireless Sensors on Furniture and Everyday Objects

Switch Sensors in Doors, Appliances, Etc.

Prototype Interior Infill Cabinetry Component with Integrated Technologies



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