PlaceLab

A House_n + TIAX Initiative

The MIT House_n Consortium and TIAX, LLC have developed the PlaceLab - an apartment-scale shared research facility where new technologies and design concepts can be tested and evaluated in the context of everyday living. PlaceLab is being constructed by TIAX and will be operated cooperatively by TIAX and MIT. To be completed in early 2004, this 1000-square-foot facility is located on the ground floor of a new full-service condominium building between Harvard and MIT.

Overview

The home is rapidly becoming a center for proactive health care, distributed energy, learning, communication, commerce, entertainment, and work. This creates exciting opportunities and daunting challenges for companies developing related products and services. Consumers are reaching a limit to the number of stand-alone technologies that they will accept into their lives, and products and services developed and tested in laboratories often fail because designers often make erroneous assumptions about the effectiveness and use patterns in complex natural settings such as homes. The interaction of people with other people and with devices leads to unexpected behavior that is difficult to anticipate with focus groups, surveys, and other standard product development and marketing inquiry methods.

Since behavior in these real-world settings is enormously difficult to simulate in a laboratory setting, the PlaceLab has been designed to combine the capabilities of a highly instrumented research lab with the natural environment of a home. We believe that the PlaceLab —where volunteers inhabit a highly instrumented research environment in a residential building in a residential neighborhood —creates research opportunities not available in any other facility in the world. Not a prototype, and not a demonstration environment, the PlaceLab is a new type of scientific "instrument" that allows researchers, for the first time, to systematically test and evaluate strategies and technologies for the home in a natural setting.

Research Agenda

The PlaceLab has been designed to incrementally add research projects according to the interests of academic and corporate participants. Initially, House_n and TIAX, LLC researchers will use the facility for the following areas of research:

o **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, medication adherence, etc.

o **Activities of daily living.** The rich sensing infrastructure of the PlaceLab will be used to develop techniques to recognize patterns of sleep, eating, socializing, recreation, etc. Particularly for the elderly, changes in baseline activities of daily living are believed to be important early indicators of emerging health problems – often preceding indications from biometric monitoring. The unique data sets generated by the PlaceLab will aid in the development of activity pattern recognition tools.

o **Biometric monitoring.** The PlaceLab is designed to accommodate research into the viability and acceptance of wearable, physiological medical monitoring equipment and their related interfaces in the context of daily living. Discussions are underway with funding agencies and medical researchers to use PlaceLab to study the use of home-based and wearable monitoring systems including EKG, pulse oximetry, blood pressure, respiratory auscultation, weight, blood sugar levels, etc.

o **Indoor air quality.** Proposals have been developed that, if funded, will use the facility 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.

o **OSBA interior infill strategies.** The PlaceLab will be used to investigate a path for more sophisticated sensing, lighting and control systems to be installed in prefabricated interior components - minimizing complex and problematic field labor, and allowing for non-disruptive upgrade and changes. This will test one aspect of the House_n Open Source Building Alliance chassis/infill strategy for creating high performance, low cost, agile, and responsive environments.

o **Privacy and trust.** The PlaceLab will be made available to researchers interested in studying 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.

Shared Research Facility

The PlaceLab will be capable of accommodating multiple and simultaneous experiments proposed by academic researchers, industrial researchers, or collaborative groups. Selected families will occupy the apartment as consenting subjects in scientific experiments that range in time from several hours to several months. The apartment infrastructure will allow researchers to study each family's activities at any point in the day throughout the duration of their stay. An advisory board, consisting of leaders from both academia and industry, will make recommendations for the criteria used to select research projects conducted in the facility. Two committees will evaluate research proposals: a scientific review committee and an industrial review committee. The committees will rate the expected outcomes of each proposal on the potential influence those results may have on industrial innovation and large-scale societal change. The MIT and TIAX project directors will make a final selection of projects and determine their scheduling. Corporate and trade organization members of the House_n consortia will have the right to submit research proposals for consideration. Any academic researcher may submit research proposals for consideration. Companies and academic researchers must fund or provide the necessary additional resources to conduct the research in the facility. TIAX will be available under a separate business arrangement to assist in company-initiated research, and with the transition to commercialization.

One of 15 PlaceLab cabinets showing typical sensing infrastructure.

The upper section contains a microcontroller and light sensor, motion sensor, humidity sensor, smoke detector, IR illuminator, IR motion sensor, CO2 sensor, barometric pressure sensor, and speakers (2). The face of the cabinet contains IR transmitters (4) and microphones (2). The lower panel contains a 1-wire network connection, Ethernet connection, and power. The removable and upgradeable cabinet module has a single power and network connection to the base building.

PlaceLab Features

With a rich sensing infrastructure, researchers have the ability to respond to the occupants' location and activities with a range of communication and control tools. Researchers also can take advantage of a sophisticated audio, video, and still image recording capabilities. Major PlaceLab features include:


"Tini" micro-controller and sensors embedded in cabinetry

- o **Interior components.** The interior of the PlaceLab 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.
- o **Sensor network.** Each of the interior components contains a micro controller and network of 25 to 30 sensors. New sensors can be rapidly added to this network as required.
- o **Environmental sensing.** Each interior component has an array of environmental sensors, including CO, CO_2, temperature, and humidity. Additional environmental sensing may be rapidly added as required.
- o **State sensors**. Small, wired and wireless sensors are located on the objects that people touch and use, including cabinet doors and drawers, controls, furniture, passage doors, windows, kitchen containers, etc. They detect on-off, open-closed, and object movement events.
- o **Location beacons**. Radio frequency devices permit the identity and approximate position detection of people within the PlaceLab.
- o **Audio sensing.** Nearly invisible microphones are installed in each interior component to capture audio.
- o **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.
- o **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.
- o **Activity recognition algorithms.** MIT algorithms can be used to both study activity-related data, and to automatically detect certain activities in real-time to trigger an action or intervention.
- o **Image-based experience sampling**. Computer vision algorithms can be used with portable cameras to collect video and audio data from an environment using MIT software, laptop computers and a tape-on sensor kit.
- o **Wearable biometric and motion sensors**. These small, comfortable, and low-cost biometic and accelerometer devices can be easily worn for days or weeks and used to collect data on what people are doing. MIT algorithms have been developed to automatically detect specific activities, such as walking, cleaning activities, moderate physical activity, and body posture. In combination with a mobile computing device (e.g. PDA or phone), the sensors can be used to detect specific activities of a person in real-time and provide or collect context-specific information. The devices are being validated by the medical community for use in monitoring activities of daily living.
- o **Audio communication.** Stereo speakers are installed in each interior component, allowing audio to be directed as required.
- o **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.
- o **Environmental control.** The PlaceLab HVAC system contains multiple zones, a heat exchanger, and sophisticated air filtration allowing dynamic control of environmental qualities.
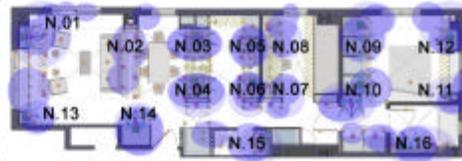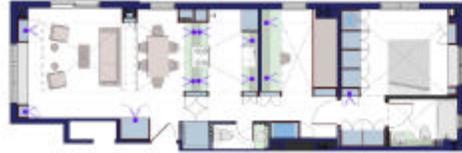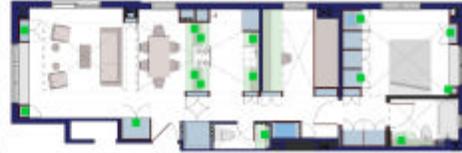

PlaceLab under construction
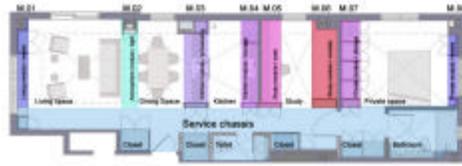
Cabinetry Modules

Location of Microcontrollers and Local Networks

Visible Light and Infrared Cameras

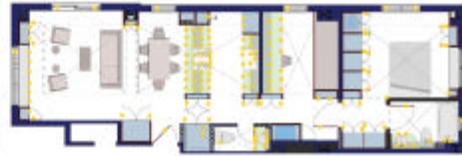Environmental Sensors: CO, Co2, Temp., Humid., etc.

Addressable 24-bit LED Lighting

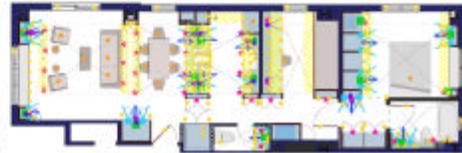Microphones and Stereo Audio

IR Transmitters for Location and Identity

Switch sensors in cabinetry doors, appliances, etc.

Wireless Sensors for Use of Movable Furniture

Composite Plan Showing All Sensors

Interior Infill Cabinetry Component with Integrated Technologies

About TIAX

With the MIT House_n consortium, TIAX is co-sponsor of the PlaceLab. TIAX is a leading collaborative innovation, product, and technology development firm that shares a long history with MIT. TIAX was formed from the Technology & Innovation business of Arthur D. Little, Inc., a company founded in 1886 by MIT engineering student, Arthur Dehon Little. Upon Mr. Little's death in 1935, he bequeathed the company to MIT, which operated it for several years before spinning it off. TIAX President and founder, Kenan E. Sahin, is committed to continuing Mr. Little's vision. He is an MIT graduate and former faculty member, who is very active at the university. The PlaceLab is an important step in the continued collaboration between industry and academia. Through its expertise in commercial and residential appliances, energy and indoor environmental technologies for buildings, wearable systems, and medical devices and instruments, TIAX is well positioned to assist in making the PlaceLab results industry-ready.   For more information about TIAX, please see http://www.tiax.biz

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