

# SENSIBLE NODE: NETWORK-BASED GENERAL PURPOSE ARCHITECTURE MODULE THAT REFLECTS ENVIRONMENT

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## ABSTRACT

In this paper we propose a network-based architecture module that reflects the environment; which is called “Sensible Node”. The aim of this module is to offer the comfort and spiritual richness; not convenience that is stereotypically sought in space utilization with computing. Also, the module has considerable flexibility that enables designers to construct the space, the integrated space of real and information, with single or multiple modules linked up together. This brings you unconventional and free designs of context aware system based on multi network which differs from traditional one-on-one pair model or server client model. In this paper, lastly we will introduce two application examples as the basic module of Sensible Node and as the module group.

## 1. INTRODUCTION

At present, ubiquitous environment is steadily progressing but what exactly is the relationship like between architecture and computing? In terms of the scope of architects can be classified broadly, by the scale of the architecture, into categories of interior product, space, housing and city. In these categories, introduction of the computing is done especially in the space category.

Mainly, space is sectionalized 3 domains; public, work, housing space. And various context aware systems are planned and implemented. As an example of public space, navigation system for visitors in relatively large-scale space is known [Nakanishi et al (1)]. Besides the housing environment, there are cases where the real and information space is integrated in a museum [Boymans van Beuningen Museum (2)] or used as a user assisting navigation system in an art exhibit [Kusunoki et al (3)]. There are lots of cases with workplaces using the systems that improve the efficiency of work or accelerate

collaboration [Voids et al (4)] [Voids et al (5)] [Huang et al (6)]. Workplaces packaged as an information space is provided by a company [Smart PAO (7)]. On the other hand, there are some research institutes and companies that researches from multiple points of view on design, technology and software in housing as a context [TOYOTA PAPI (8)] [TRON Project (9)] [The Aware Home Research Initiative (10)] [Harper (11)] [Gullart and Cantarella (12)]. These context aware systems have in common that by embedding a sensor or a device in a space; it senses people, things and environment according to the context, and gives feedback. The purpose of these is to reconstitute the space and support people to act reasonably and seek conveniences in space design.

If we are to say that a reconstitution of space in convenience can be considered as an aspect of the integration of space and technology, the reconstitution of space in the spiritual richness and comfort can be considered as another aspect of it. This is the aspect of the architecture being the art. Since ancient times, decoration has been embedded on both the inside and outside of architecture as art. Not to mention the architectural vision of *universal man* [Burckhardt et al (13)] in the Renaissance, the architects were also talented as artists. When architects learned the technology of computing, the art of static and fixed architecture which was embedded came to a turning point. In other words, this was the beginning of an “active” expression. Active expression can be classified broadly into 2 categories. One which plays the programmed action according to the timeline [Aoki (14)], and another is which activates real-time according to the change in people, things and environment [Bloomberg ICE (15)] [CLASKA (16)]. In the latter, there is an approach to take the architecture, which structures the environment physically, as a hardware and take the architecture, which is the program that produces interaction in that environment [HAQUE (17)]. These interactive architectural expressions are missing the concept of network in common. Ambient display can be the reference as an embedded type which constructs and

integrates the real and information space. The device which change interactions by measuring the distance between people and the place [Prante et al (18)] [Vogel (19)], or the implement that reconstruct the space by sensing the environment and converting into sounds and movies [Skog (20)], are the examples of existing ambient displays. However, these devices don't have any conception of network and remain on a simple interaction. On the other hand, by enlarging the point of view from expression to product, there are some cases which correspond to network. Although server client model like Ambient Devices [Ambient Devices (21)] and the system which is designed for connecting the remote products based on one-on-one pair model [Chang et al (22)] are representative cases, these only work on one-on-one relationship.

Under these circumstances, we will take the positions as below.

- Proposition of architectural structure aimed to reconstruct the space for spiritual richness and comfort.
- Implementation of multi networked architectural structure; many-to-many network.

In the first case, no examples exist that specializing in the integration of space and technology for these purposes at present situation. The latter, it is made possible for a new architecture expression and a new design of the real and the information space to appear by embedding the concept of a network inside the architecture and the structure, and enabling it to connect internally and externally through network with the fixed sensor or the actuator.

Under these concepts, we propose the architecture module, Sensible Node, which reflects the environment including the people by network under these circumstances. Sensible Node

is an intelligent wall built with a general wireless network infrastructure, wireless network camera, wireless speaker and a luminous device. Not only does it functions as a module by itself, as the sensing device and the actuator is on the network, but also enables the space design and the information space design for the real world by matching different kinds of modules together. We have assumption that designers can combine the modules for arbitrary network and various designs will be created.

In the next chapter, we will state the design concept of Sensible Node. Sensible node was designed under the designing method for the experience design we propose.

## 2. DESIGN CONCEPT

### 2.1 Experience Circuit

The word "experience design" first appeared in the web design field. Around year 2000, IDEO and Phillips urged the importance of experience design in the product design procedure. At the same time, experience based design started to be advocated and used in management and marketing in the economic field (Figure 1). There are some fine proceeding researches by research institutes on the domain of experience and how to design experience, but they have not reached the point to build a specific method. In fact, at present, in order to design experience, existing design methods are used. Undoubtedly, experience is the users' subjective emotion so it is difficult to design. But, it is possible to design the possibility of ones quality and richness of experience. Therefore we believe that it is possible to install a system with the possibilities of the users' actions.

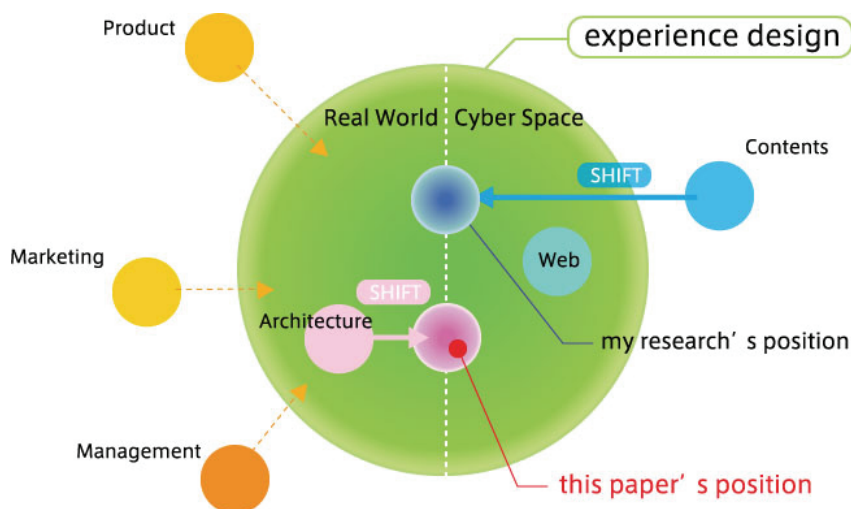


Figure 1 Experience Design

Based on this premise, we set a new domain for contents design in the experience design field and searched for a method based on experience. By this, we set up a hypothesis “Experience Circuit” as a method for contents design (Figure 2).

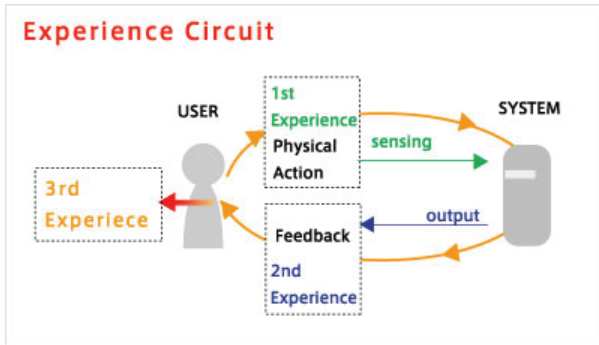


Figure 2 Experience Circuit

Experience Circuit (Figure 2) is built with 3 types of experiences. First, in contents where communication between people or with people and things is done, there is a need to interpret the information from people, things or the environment as an input. This active experience in the input procedure is the first experience. The input action in Experience Circuit involves physical action. This is because we presume that the physical action will strengthen the memory of experience [Bergson et al (23)]. Then, the system processes the input and gives feedback to the user or the environment. This active experience in the output procedure is the second experience. Finally, the actual feeling or the substance that the user obtains through this procedure is the third experience. The second and the third experience differ in its quality. The second experience is the perception of information, whereas the third experience is the experience linked to memory. The image that the users have on the contents is the defined image given by the third experience. We hypothesize that by bringing these 3 experiences in the center of design, it is possible to design a contents that remain in the users’ mind. This is the main concept of Experience Circuit.

## 2.2 Experience Circuit in Architecture

In the architecture field, bringing the experience in the center of design is done from ancient times. As represented by the *modulor* theory advocated by Le Corbusier [Corbusier et al (24)], architecture with the need to design the action of the user in space, it involves the experience design in the space.

The existing experience design in architecture was only that of physical space (real space). But as space integrates with technology, an experience based design that integrates the real space and the information space in architecture is needed. In this new area, we apply the experience based design method, Experience Circuit which we propose in the contents design field. In order to apply this, we expand the existing Experience Circuit. As the architecture modules do not premise the movement, modules are considered to be linked with each other by network. The network is realized in the 3 levels of Experience Circuit (Figure 3).

Unlike the existing Experience Circuit, as the 3 experiences are all linked by network, another factor needs to be considered. Those factors are *the linkage with experience* and *storage of experience* which was not considered in the existing Experience Circuit. For example, there is a linkage between two of the first experiences, by setting the input action data of the user on the network and another module making it possible to refer to. Also, a linkage between the third experiences can be considered, by storing the third experience on the network enabling another user to refer to this afterwards.

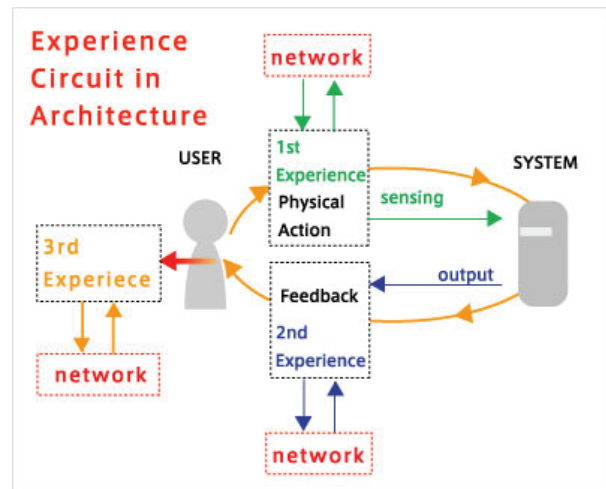


Figure 3 Experience Circuit in Architecture

## 2.3 Purpose

In this paper, we propose the architecture module, Sensible Node which pursues the spiritual comfort and richness, and not the architecture field that aims to pursue convenience by integrating space and technology. Sensible node takes in the concept of multi network which was not applied in existing architectural structure. Not only does it have the flexibility and versatility as a base module specification, but by implementing the network, it aims to restructure the real

space and information space in many ways. Also, at the same time, by applying Experience Circuit, the method for experience design, it aims to pursue not only the spiritual comfort and richness but also the factor to stay in the users' memory for the untamed territory of experience design of the real and information space in architecture.

### 3. Sensible Node as Module

In this chapter, the module specifications of the proposed Sensible Node are stated.

Sensible Node is an architecture module that positions as the experience design which connects the real space and the information space. As implied by the word "node", it functions as the node of network. The Sensible Node is installed with a general platform and camera that senses the environment including people through network. Also, a luminous device and speakers are set as an actuator to restructure the environment. Moreover, the Sensible Node is a module so it functions as a structuring factor. As the modules are linked by network in the level of sensor or actuator, designs of the real space or the information space are possible by matching multiple modules variously.

The basic specification of Sensible Node is stated in the following.

#### 3.1 Basic Specifications

In the design stage of Sensible Node, we referred heuristic evaluation of Ambient Displays by Jennifer Mankoff [Mankoff et al (25)] in the view point of the integration of the real and information space. Based on Nielsen and other researchers' heuristics [Nielsen (26)], Jennifer Mankoff and his colleague quoted 12 items including 6 Ambient Displays' specialities.

The specific items are as follows.

- sufficient information design
- consistent and intuitive mapping
- visibility of state
- aesthetic and pleasing design
- easy transition to more in depth information
- "peripherality" of display

All these items considered, Sensible Node is designed to have flexibility with the basic function itself to make designers who use the modules customize arbitrarily and construct the

architecture as various software. Not only direct sensing and actuation on the spot but also modules as network component units are linked together in the sensor/actuator level, and this brings you variety of design.

Sensible Node is structured with a general platform, camera, speaker and luminous device.

The ADR2010 from ontrak is used for the general platform. ADR2010 has 8 digital I/O, 12-bit analog inputs and two PWM outputs. This general platform is connected to the device server by Lantronix by RC232 cables on x-port and it is made wireless by connecting the Ethernet cable to the Ethernet converter. The port information of the general platform can be obtained by accessing the IP address given by the x-port and sending a fixed command.

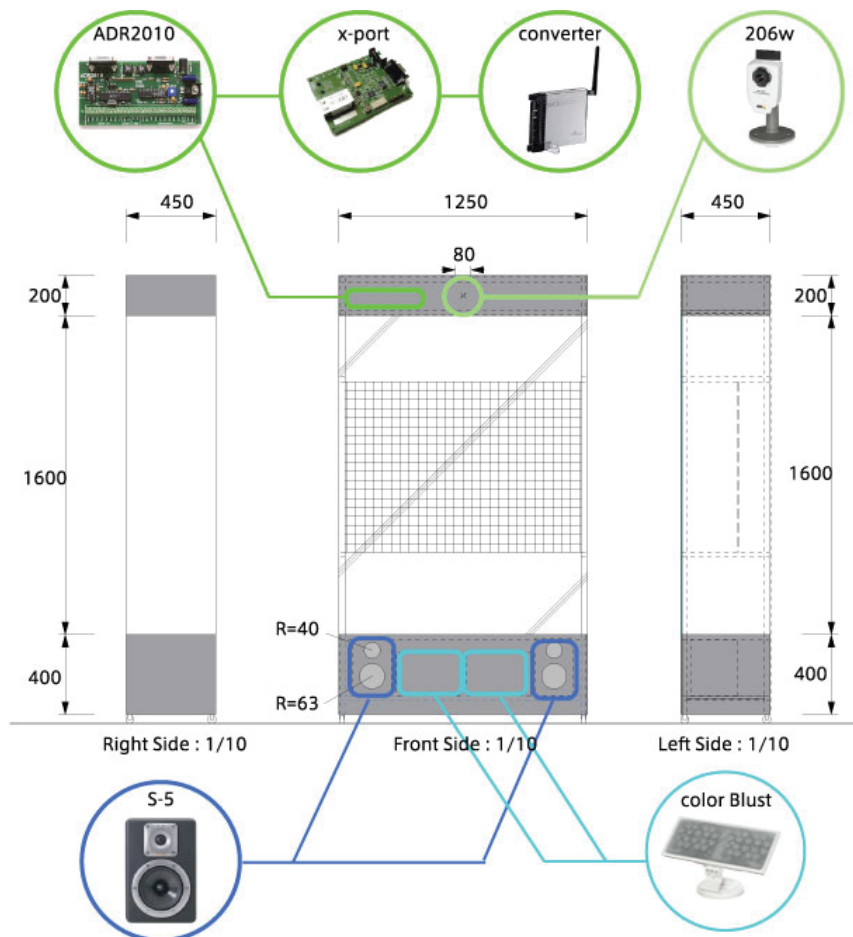
The Axis206w by Axis is used for the wireless network camera. This enables streaming of jpeg images or motion-jpeg movies from the internal server by accessing the IP address given to the wireless network camera.

The S-5 active speaker by Tapco is used for the speaker. This active speaker can be made wireless by using a wireless speaker system consisting of a 2.4GHz transmitter and a receiver.

The Color Blast by Color Kinetics is used for the luminous device. The Color Blast, which can light 160,000 colors in 255 levels in each RGB is connected to a special controller and activates approximately 200 different programs through the serial. The special controller can be made wireless by an x-port and an Ethernet converter.

The drawing and the position of installed hardware are shown in Figure 4. The chassis has a net hanging inside and non-contact environmental sensors such as temperature sensors, humidity sensors and light sensors can be installed. A detachable translucent acrylic board is set on the front of the chassis. The light is projected from the device set on the bottom of the chassis and projects to the back wall of the chassis. Then the light reflects and spreads to the acrylic board on the front and presents to the real space. The reason why we use translucent acrylic boards is that we assume the use of projector as well as luminous device. In this case, the image is projected from both inside and outside of the chassis.

In addition to this, based on the modulator theory, the height of Sensible Node is 2200mm; the height that the man who stands 1750mm tall reaches out his hand.

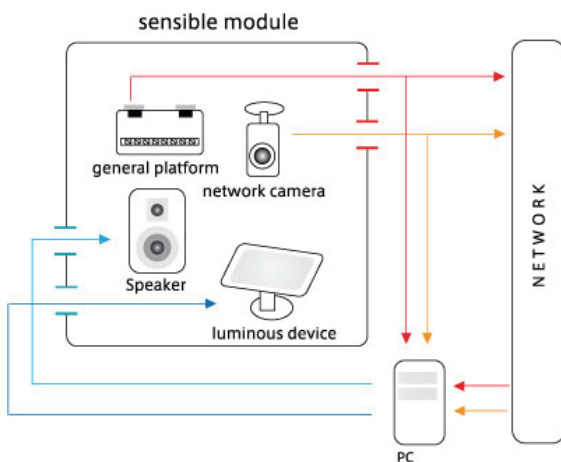


**Figure 4 Drawing of Sensible Node**

### 3.2 Network

Sensible Node is linked to the network as a single module (Figure 5).

The input devices for this module are the general platform and the wireless network camera. The information can be obtained by accessing to these devices through a remote computer.

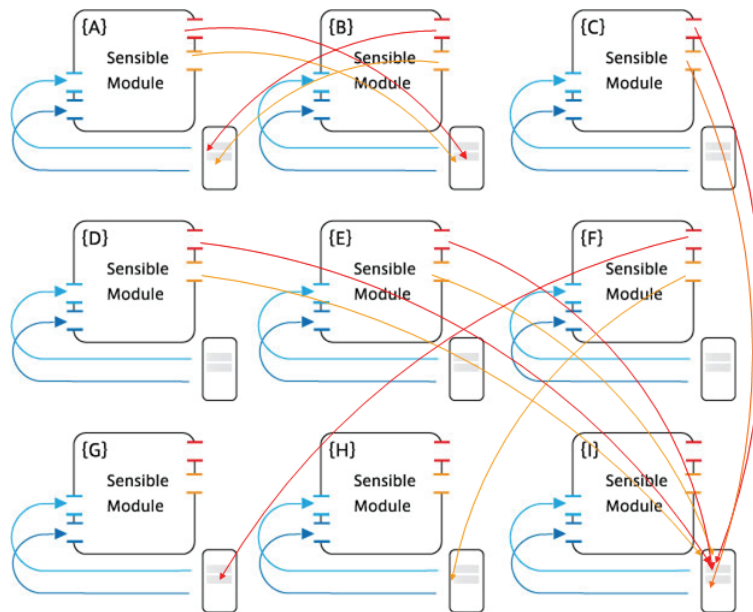


**Figure 5 network as a module**

Also, by using a local computer with this Sensible Node, it enables to link the figures of the sensing devices with an output device such as the luminous device and the active speaker in the module. A connection is made possible by connecting the luminous controller and the local computer with a RC232 cable. Alternatively, it can be controlled by accessing directly to the IP address using the x-port and the Ethernet converter. The active speaker plays the sound information outputted by the local computer through the wireless transmitting system.

As stated above, Sensible Node has enough functions to be a constituent factor in space as a single module by linking the input and output devices with the network for each module. In the case of single use, it is considerable that Sensing Node restructures the space using light and sound by sensing the environment of the place.

Moreover, by linking a number of modules, not only is it a constituent factor of physical space but it also has a possibility of becoming a constituent factor with many designs in the information space (Figure 6). For example, module {B} outputs the results by sensing environment of



**Figure 6 Network as a module group**

the place where the module {A} settled and vice versa. Add to this, the information of each environment of module {C}, {D} and {E} can be stored in module {I} and module {I} outputs that.

In the next chapter, we will introduce two of the applications using Sensible Node and state a new experience design in real and information space.

## 4. SENSIBLE NODE AS APPLICATION

### 4.1 Smart wall - Case study1 as Module

**4.1.1 Design.** We designed Smart wall as an application example of a singular module. The Smart wall is set in the gallery in the campus. It senses the amount of the person's movements when entering the gallery and observes the situation of his activity and gives a feedback based on the state of action by sound and light. The gallery, which is originally a silent space, restructures itself by setting the Smart wall and making the space ambient.

Smart Wall has 4 interaction levels.

- 1: No one is inside of the gallery (= default)
- 2: Someone is inside of the gallery and active.  
(relative moving distance: 75-100)
- 3: Someone is inside of the gallery and moderate.  
(relative moving distance: 25-75)
- 4: Someone is inside of the gallery and non-active.  
(relative moving distance: 0-25)

Through this interaction, we try to realize the provision of ambience synchronizing to users' mental situation.

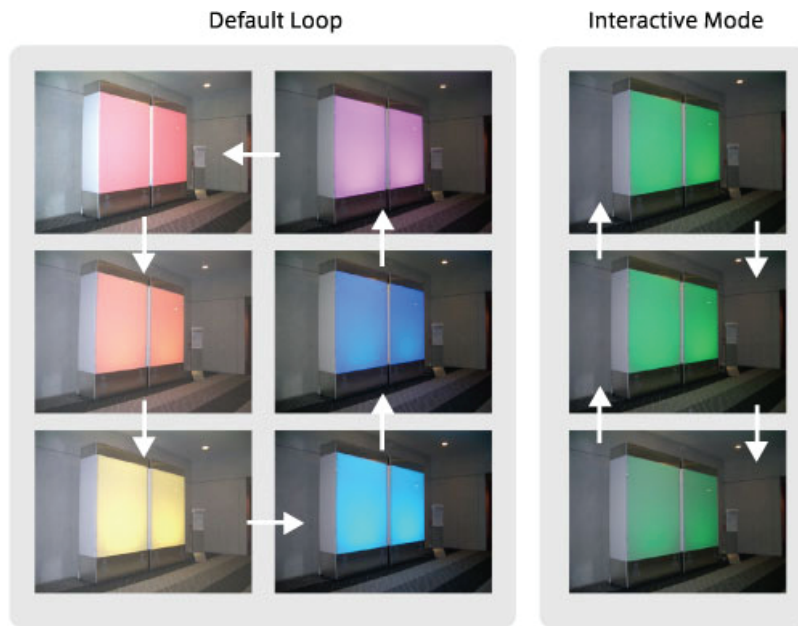
The first experience of the Experience Circuit in Smart Wall is the amount of movement in the set place. The second experience is the feedback with the sound and light. Then the third experience is the mental synchronization "moderate-active".

**4.1.2 System.** The colors of the lights are fixed to a certain color at default. 6 colors – red (R255, G20, B0), orange (R255, G130, B0), yellow (R255, R240, B0), light blue (R0, G255, B0), blue (R10, G80, B255) and purple (R190, G0, B255) - switch from one to another in every 60000m sec linearly (Figure7). It switches its colors at default state to restructure the environment at all times. Also, it switches the color to make people notice the existence more easily. As for the sound, up tempo music at 120BPM, relatively slow music at around BPM80, moderate music BPM60, and silent music BPM30 are made for it.

The wireless network camera inside the chassis is used as a sensing device for Smart wall. It calculates the existence of a user and the amount of movement relatively by accessing the server in the camera from the application, downloading the image in every 1000m sec and detecting the subtraction by image analysis (minimum0 to maximum100).If the system detects a user, it gives feedback in 2 ways, light and sound.

The luminous device switched 6 colors in 60000m sec at default, but when it senses a user, it switches to a green (R0, G220, B50) color. The reason for making the interaction color green is because green has a calmness effect in hue





**Figure 7 Interaction of Smart Wall**

psychology [Aibers (27)]. At the same time as it turns to green, luminosity change occurs. Gradation sequence of luminosity change is divided into 3 levels and the each change span differs according to the interaction levels. In the case of interaction 2, the brightness change span shorten (3000m sec) and it makes interaction that corresponds to the active movement of people. Interaction 3, the change span is little longer (15000m sec) and represent moderate space with acting in concert with people staying calm. Further more, interaction 4 takes longer span (30000m sec) and restructure the space mildly as if it corresponds to the silent and relaxed state of people.

As for the sound, music BPM80 is played at default but when it senses a movement by a user, the song changes. If interaction 2 comes out, the song BPM120 is played and interacts as if it is reflecting the user's active movement. Also, if there is interaction 3, the song BPM60 shifts and create a calm space just as if it is reflecting the calm state of the user. Additionally, in interaction 4, song BPM30 comes out and corresponds to user's moderate and silent situation with mild rendition.

Moreover, the BPM of the sound and the speed of brightness change in the luminous device are synchronized. By synchronizing them, it gives the user and the place a sense of harmony with the space.

## 4.2 Com-wall - Case study 2 as Module Group

### 4.2.1 Design. We devised an application example of module

group, Com-wall. Com-wall is designed under the concept of linking experiences as in Experience Circuit in Architecture. Com-wall uses 2 pairs of Sensible Nodes, one pair on a remote and the other on a local place. One of the Sensible Node in each pair presents the local information and the other presents the remote information. These pair of nodes in Com-wall restructures the space into an ambient space through the metaphor of light as the information of a remote place by sensing it.

The sensing target is the environment of the place where the Com-wall settled and it has 4 interaction levels.

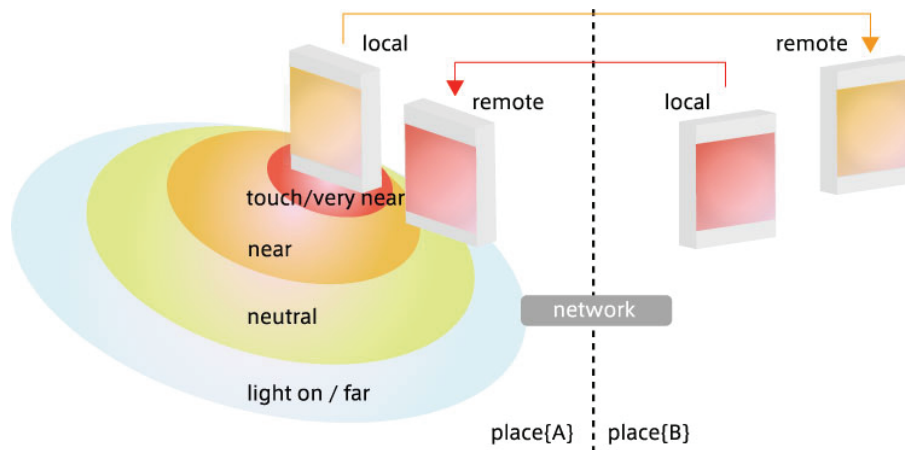
The 4 levels are as below.

- 1: User switches on the light or stands remote position from the wall.
- 2: User stands little far from the wall.
- 3: User stands close to the wall.
- 4: User touches the wall or stands very closely.

Through these interactions, it is aimed to be conscious the connection of other people in remote place and to feel close by sensing his /her atmosphere or condition naturally.

The first experience of the Experience Circuit for Com-wall is the distance perspective between user and wall in the set place. The second experience is the feedback which is the light. And the third experience is the existence or the relationship felt to the remote partner in the change of light.

**4.2.3 System.** Com-wall senses the space using the information from the light, infrared, supersonic and touch sensors connected to the wireless platform in the chassis.



**Figure 8 Interaction of Com-wall**

Interaction 1 is implemented with the light and infrared sensors. If the light turns on, the light sensor reacts to it and gets back the value 1. Also, if a person enters the set place, the infrared sensor which detects the specific infrared rays of people turns back the value 1 as well. In the case that either one of two brings the value 1 to the system, the luminous device present blue (R0, G120, B190). At the same time, it changes brightness of 5 levels in 60000ms. The span of changing the brightness of blue color represents ambience as if you can perceive the slight existence of remote people.

Interaction 2 is implemented with the supersonic sensor (3cm ~ 3m measurement). If the sensor gets the value 150cm above, the system calls into account as 1. In this situation, the luminous device lights faint green (R0, G255, B80) and changes the brightness in 30000ms like interaction 1. The changing span and the brightness offer neutral and calm ambience.

Interaction 3 is implemented as well as Interaction 2 with the supersonic sensor (3cm ~ 3m measurement). When the sensor gets the value 20~150cm, the value 1 is sent to the system. Also, the luminous device turns to washy orange color (R250, G140, and B0) and changes the brightness in 15000ms. The changing span and the brightness make relaxed and warm ambience.

The supersonic and touch sensor are used in Interaction 4. The value 20cm below reacts and it is recognized as the value 1. Addition to this, if the touch sensor inside of the acrylic panel of the wall detects the changes in voltage when the user touches the board, the system gets value 1. In the case that either one of two turns the value, the luminous device lights red (R250, G30, and B0) and changes the brightness in 5000ms. The changing span and the brightness represent

the ambience that you can feel the body warmth of people near the wall.

As the figure 8 indicates, the information on each sensor of the set place A will be transferred to the computer in set place B through TCP/IP. As a result, the luminous device embedded in the wall on the remote side (set place B) will project a light according to the information of A. As in the same way, the information on each sensor of the set place B will be transferred to the computer in set place A through TCP/IP. As a result, the luminous device embedded in the wall on the remote side (set place A) will change depending on the information of A.

## 5. CONCLUSION

In this paper, we proposed Sensible Node, a network-based architecture module that reflects the environment. Sensible Node is designed under the concept of restructuring space with the comfort and spiritual richness by using the proposed Experience Circuit as a designing method. Then some examples were shown as the applications for basic modules and for module groups. In the application example in this paper, we proposed the link between experiences. We would like to propose an application with the storage of experience in the future.

Furthermore, PC is used for controlling the local actuators at present specification, but in the future work, the micro computer is going to be used to improve for controlling all the system.



## ACKNOWLEDGEMENT

This study is carried out as a part of "Research Institute for Digital Media and Content" promoted by Special Coordination Fund for Promoting Science and Technology.

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