Occupancy Sensor - Final Concept Selection
Product Design Lab 520.427

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Patent Reviews

Patent Number: 7123139

Patent Title: Wireless Integrated Occupancy Sensor

Abstract: An occupancy sensor is provided for determining whether a room is occupied. The occupancy sensor integrates a battery-powered PIR motion detector and a battery-powered Hall Effect switch, each of which communicates wirelessly with a controller, in a single housing.

Claims Summary:

1. An occupancy sensor contained in a single housing for detecting the occupancy of a room with an access door.
2. A battery-powered passive infrared motion detector for producing a motion detected status message.
3. A battery-powered Hall Effect switch for producing a door open or door closed status message.
4. The unit wirelessly transmits a low battery status message when batteries below 20 percent capacity.
5. A housing with tamper switch and ability to send a tamper detected status message.
6. The motion detector and the Hall Effect switch communicate wirelessly with a controller and are both contained in a single housing.

Effects on Design:

The reviewed patent/system is similar to the Motion & Distance concept solution. The sensors for our project are not incorporated into the housing that contains the microcontroller and wireless transceiver, so that aspect does not pose a difficulty. However, the low battery status message and the use of a PIR motion detector to determine if a room is occupied are similar to our concept design. The Hall Effect switch for determining whether a door is open or closed would probably not conflict with our design choices.
Patent Number: 6587049

Patent Title: Occupant Status Monitor

Abstract: A system using passive infrared technology to determine whether a person is present in a space by analyzing the thermal situation. A detector mounted on the wall or ceiling collects the thermal data. A microprocessor in a desk top control module or a personal computer determines occupant status (normal or emergency) from the data and instructs a wall-mounted indicator to activate occupant status signals.

Claims Summary:

1. A detector disposed to sense a plurality of parameters of thermal energy in and relative to a given space and transmit this data to a processor.

2. A processor to receive data transmitted by the detector, compare that data with a predetermined data set representative of attributes of one of a person and of the space, and to transmit a plurality of instructions.

3. An occupant status monitor wherein the detector is at least one passive infrared receptor.

4. An occupant status monitor wherein the processor is a microcomputer housed in a stand-alone control module.

5. An occupant status monitor wherein the processor is a personal computer.

Effects on Design:

This system is similar in some aspects to the Thermal concept solution. The fact that this product uses a thermal sensor to detect the presence of an individual and then uses a microprocessor to analyze the sensor data and transmit status signals is significantly similar to our design concept. However, the fact that this design is used to determine the actual status of the individual and not just if they are in the room helps to make it different from our design.
Patent Number: 7245991

Patent Title: Distributed Architecture Irrigation Controller

Abstract: The system consists of a primary processor connected to multiple station modules. Each station module controls a valve and has its own microcontroller. The processor executes a stored watering program to control/instruct the station modules. Messages are generated and bi-directionally sent and received between the main processor and modules. Each message contains an identification field with an instruction that describes a meaning of the message. The processor and the micro-controllers each interpret the messages received and determine a course of action.

Claims Summary:

1. Each module contains a microcontroller that can process multiple sensor inputs.

2. The main processor and the microcontrollers in the modules communicate over a bus network using bi-directional messages. All units involved are capable of generating messages and performing pre-determined actions based on the messages they receive.

3. The messages used to communicate over the network consist of an identification field and an instruction field that can be interpreted by the processors.

Effects on Design:

This product is similar to our overall design of a distributed system of modules that process sensor inputs and communicate with a central controller. The bi-directional communications aspect is similar to our design, but we plan to create our own network protocol to differentiate the product from other systems that communicate in similar manners. Overall, this design is similar only in its overall layout, as our design will use wireless communications and the modules will be different from this system.
Abstract: This system is comprised of a room occupancy sensor, a home automation system and a method for automatic control of devices throughout a home. The occupancy sensor system consists of entry/exit sensors for detecting movement through doorways that separate rooms in the home, room motion sensors for detecting room occupancy, spot sensors to detect occupancy of specific locations within the rooms, and house status sensors to detect the status of certain parameters of the home. A central controller communicates with the sensors and controlled objects over a communications network. Sensors and controlled objects can be added to the system in a ‘plug and play’ manner, and are monitored by using a system of states for each room.

Claims Summary:

1. The spot occupancy sensors are adjusted based on the feedback from the room occupancy detector.

2. Each occupancy sensor is redundantly checked by other occupancy sensors, all of which use a base algorithm to determine if a set of sensor readings matches a pre-determined profile of motion and room occupancy.

3. The method of using entry/exit sensors to detect motion between rooms, room motion sensors to detect occupancy within a room, and spot sensors to pinpoint locations within an area.

4. The interface of using the home automation system to gather information from the occupancy sensor network and automatically control devices in the home.

5. The method used to analyze sensor input and make automatic control decisions based on a pre-determined set of options.

Effects on Design:

This design uses a plurality of sensors to determine occupancy. This could affect our design choices, as one of our designs uses a similar system of multiple sensors to determine occupancy and for redundancy. However, our system will not be used to automatically control a set of household devices.
Patent Number: 6970751

Patent Title: Method and apparatus for providing distributed scene programming of a home automation and control system

Abstract: A method and apparatus for providing a simple user interface for programming scenes and multi-way groups in a home automation and control system. Each device participating in the home automation and control system is equipped with control logic for providing the simple programming interface. Through the control logic, each device maintains its status in a system-wide programming mode and retains knowledge of its inclusion or exclusion in the current scene or multi-way group being programmed. Broadcast messages are used to maintain the integrity of the system programming mode. Each device knows when a scene or multi-way group being programmed and is automatically captured and incorporated once the new scene or multi-way group has been started.

Claims Summary:

1. Each device has a plurality of states that are entered as the result of messages sent from other members of the scene or multi-way group or as the result of actuation from a sensor input.

2. The method for placing a device into a said state based on input gained from other devices in the same scene or multi-way group as the device.

3. The ability for a device to automatically maintain the knowledge of what scene or multi-way group it is part of and the ability to notify other devices in the same collection of its membership.

Effects on Design:

The key claim of this system is the ability of the devices to automatically enter or exit groups based on programming messages sent throughout the system and sensor inputs. This concept is similar to our overall system scheme in that the final display aspect of our system will know about all of the active components and be able to display that information. Our system design does not rely on each device maintaining its state based on the states of all other related devices, which differentiates our solution from this one.
Interview Guide

*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?

2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?

3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?

4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.

2. Where would you prefer to have the object placed that would interfere least with your work?

3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?

4. Are there any other locations within your workspace that you believe would interfere with your work?

5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?

6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
Interview Responses
Interviewee: Ryan Johnstin

*Note: open with the fact that we have developed a solution to our occupancy question

5. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   Yes all the time.

6. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   Yes all the time, probably no more than half an hour.

7. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   An hour.

8. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   Yes because I would then be able to interpret those areas as being occupied. I would not have to waste my time looking for that table to discover that the user was just temporarily not at the table.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

7. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   No as long as it was small and out of the way.

8. Where would you prefer to have the object placed that would interfere least with your work?
   It would be best for me if it was anywhere greater than arms length away, preferably at the edge or center of the table.

9. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   It should be no larger than a 8x11 sheet of paper.

10. Are there any other locations within your workspace that you believe would interfere with your work?
    I don’t allow it to touch my legs.

11. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
    $100 or less. I would say $5000 sounds about right, but maybe a little on the higher end.

12. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
    It would depend on the overhead of the organization trying to buy the system. If the company believes it can benefit from the system by increasing efficiency in the workplace I would say there is a very high probability that they would buy the system. However, if no revenue it generated from the system there is little chance of buying it.
Interviewee: Sage Farrar

*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   
   Yes it can be very frustrating.

2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   
   Yes for the most an hour but I always have people watch my stuff.

3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   
   It depends on what it is. A textbook I would say 20 minutes, but I would never sit at a table with personal possessions on it.

4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   
   Sure, but if it wasn’t an option it wouldn’t be a problem.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   
   No I don’t think so.

2. Where would you prefer to have the object placed that would interfere least with your work?
   
   Place it dead in the center of the table or at the edge or at the edge.

3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   
   3” x 3”. Keep it less than one centimeter thick.

4. Are there any other locations within your workspace that you believe would interfere with your work?
   
   Make sure I can still cross my legs without hitting the device.

5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   
   $5000 for one floor is too much. I think something like $10,000 for the whole library would be a good system. $50 per unit would be a good price.

6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   
   I don’t see many places buying this product because they could just find areas the old fashioned way. They could just go check an area to see if it is occupied.
Interviewee: Zach Rosswog

*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   Yes I do. If there is stuff at a table I’m not sitting there.

2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   No I don’t.

3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   Ten minutes.

4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   Yes that’s a good system improvement.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   It could potentially bother me. I don’t want it to dictate where I have to put my stuff.

2. Where would you prefer to have the object placed that would interfere least with your work?
   Put it in the center of the table.

3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   4” x 12”. Keep it less than two inches thick.

4. Are there any other locations within your workspace that you believe would interfere with your work?
   Not that I can think of.

5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   $100 would be a reasonable price, but I wouldn’t pay more than $200 per unit. I don’t think it is worth it at that price.

6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   Well Hopkins can just raise our tuition again and make us pay for it. That would make it real easy for them to buy a new system.
Interviewee: Alex Hsaie

*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   Yes I see it quite often.
2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   Yes all the time. I usually have someone watch it.
3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   If no one is there and the book has been there for a while I would sit there. I would sit down right away.
4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   Yes it brings in a little of my own judgment into the system.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   I am totally fine with that, especially if you understand why the object is there.
2. Where would you prefer to have the object placed that would interfere least with your work?
   Put it in the center of the table out of my immediate work area.
3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   I would like it about the size of a cell phone.
4. Are there any other locations within your workspace that you believe would interfere with your work?
   Having it on the edge would bother me a little.
5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   Around $500 would be reasonable, but pushing the price limit.
6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   A company just needs to see a return on investment to buy the system. Any company that can really increase their productivity by buying the system should do so. A new model probably won’t sell very well, but once the system is developed it could become pretty popular.
Interviewee: Jennifer Hou

*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   If there are things at a table, I assume that someone is there so the space is available. However, if it looks like only one person is at the table, I will try to sit there.

2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   Yes, to print something out, to find a book, or to go use a computer.

3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   I don’t really think about it. I usually just sit there right away.

4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   To be able to find out if things on a table are associated with people or just things left behind I believe would be very useful.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   No, this would not bother me at all.

2. Where would you prefer to have the object placed that would interfere least with your work?
   It would be best to put it in the center if possible, along the edges would be very difficult because people need to write.

3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   As long as it does not blink or make noise, I wouldn’t mind it at all.

4. Are there any other locations within your workspace that you believe would interfere with your work?
   The edge would be a bother.

5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   Just on the tables. $200 - $300 would be best because this is not really a new technology, just different.

6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   I would definitely suggest buying this system solution to any organization that needs additional structure to increase its efficiency. If the resources are available many companies may invest in this product.
*Note: open with the fact that we have developed a solution to our occupancy question

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   **Yes single books – left & forgot sometimes, but backpack equals occupied**
2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   **Yes, everything backpack, jacket, books, laptop. About 15 minutes.**
3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   **15 minutes.**
4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   **Yes, I consider the table occupied if there are objects on it. This would help me to find a table more quickly.**

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   **No not really.**
2. Where would you prefer to have the object placed that would interfere least with your work?
   **Center of table would be unacceptable; stuff might get put on top of it.**
   **End of table, possibly raised, would be ok.**
3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   **Size of a novel would be alright, size of laptop would be too large.**
4. Are there any other locations within your workspace that you believe would interfere with your work?
   **Don’t put it on table where it could get in the way of books, laptops, etc.**
5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   **Per table $150**
   **$5000 for M-level sounds reasonable**
6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   **I would say that companies would probably not buy the system. It seems like more of a luxury item to me rather than a business necessity. The system does not accomplish enough to justify a large investment.**
Interviewee: Lindsey Giel

*Note: open with the fact that we have developed a solution to our occupancy question*

1. Do you frequently encounter areas that you believe are occupied because there are objects left on the table?
   
   Yes pretty often.

2. Do you frequently leave your own possessions in an area that you are working in? If yes, for how long?
   
   No never.

3. How long do you believe an object that has been left on a table should be left undisturbed before you consider sitting at the table with the object?
   
   15 minutes.

4. Are you interested in a system solution that will inform you that there are objects on a table, but no one is currently sitting at the table?
   
   Yes. This would not limit your detection capabilities.

It is important to inform you that the solution to this problem requires the development of a physical object that must be placed in the vicinity of the area of interest in question.

1. Do you have any concerns about placing this physical object in front of you in an area that may possibly reduce your total workspace? This physical object would likely have small dimensions.
   
   It wouldn’t really bother me.

2. Where would you prefer to have the object placed that would interfere least with your work?
   
   Center of the table or above the table would be good.

3. What physical object size do you believe will negatively impact the efficiency of your work or be a cause of annoyance to you?
   
   Make it 4” x 8” maximum dimensions. No more than 2” thick.

4. Are there any other locations within your workspace that you believe would interfere with your work?
   
   I need to be able to comfortably cross my legs.

5. What do you believe is a reasonable cost per table to determine if the table is in use? What price is more reasonable: $100, $200, $500, $1000? As a reference do you believe $5000 is a reasonable price to install the system on M-level?
   
   I wouldn’t pay more than $200 per unit.

6. Based on our discussion how likely do you believe it is for a company or institution that has a need for this system to purchase our product within the next year?
   
   I wouldn’t personally buy the system because there is not need. A company that has the money may buy it though. This could help reduce interruptions in meetings and save the company money.
## Results

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N – This was a very difficult number to approximate. Our product can be marketed to thousands of companies and organizations, but we have limited costing analysis strictly to universities in the U.S. College students must manage their time extremely well in order to successfully complete their work. The occupancy sensor system was developed partially as a tool to help eliminate undue stress placed on college students.

A – Within the first year of production A is the approximate number of universities we expect to become aware of the occupancy sensor system.

P – The total number of those universities that are aware of the sensor system that will actually purchase the system within one year of operation.

Q – The total number of sensor systems we can expect to sell to universities across the U.S.

\[ N = \text{number of U.S. universities} = 4,140 \]
\[ A = 0.5 \% \]
\[ F_{\text{def}} = 10\% \]
\[ F_{\text{prob}} = 20\% \]
\[ P = 0.4(0.1) + 0.2(0.2) = 4.8\% \]

\[ Q = (4140)(0.05)(0.048) = 10 \]

• For every sensor system that we sell we can expect to produce between 100 and 1000 sensor nodes per system. These approximations are functions of the size of the university and the number of students attending the university.

## Costing

4X Sonar Sensors: $30-$60
4X IR Thermal: $15 - $40

2X Motes: $100 - $200

Total cost: $380 - $600

Note, we already have two motes. Just need to buy sensors.