Smart Bedroom: The Haven of the Future

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Executive Summary

In a world where new ways to communicate, learn, and simply accomplish a certain task seems to come to light every day, it might be a little surprising how little has changed in our own homes. Fridges, stoves, heating systems, beds and closets, have arguably gotten more efficient and better at what they do, and styles have certainly changed, but their core functionality has remained remarkably the same. They are all largely single purpose devices used in a very specific way, a far cry from the predictive, convenient and often automated devices first imagined by science fiction authors in the 20th century.

This is a problem, not because we all necessarily *need* lights that adjust themselves to be at the perfect brightness, or smart security that keeps track of every inch of our house, but because we have the technology to make our lives better and we have yet to figure out how to, on a large scale, take advantage of these advances. Companies have tried to make new smart home technology powerful, easy to use, and ubiquitous, but are still only in the earliest phases of making this technology truly a part of our daily lives. We believe that there is a way to make a smart home technology package that will appeal to a large group of people and that can enhance their day to day experience. Because this is a large space we will focus on the implementation of a smart bedroom to demonstrate our ideals, but we believe that our general approach to the problem can be applied to other areas of the house as well.

There are lots of smart home technologies and devices that exist today that can be utilized in the bedroom. There are beds that make themselves (Ohea smart bed), lights that change their color and composition based on the occasion (Philips hue), robots that will clean an area at set time intervals (iRobot Roomba) and many more. However, most of these devices are made by different manufacturers who often utilize different technologies that don't necessarily work well with other manufacturers. There exist products such as Smart Things which make it far easier to integrate different smart products under one central hub and that even provide basic sensors for various functionality, but this integration does not always work as expected, the interfaces provided can't anticipate properly this variety of various devices, and at the end of the day the onus is on the buyer himself to purchase all of the required technology, set it up, and make it work seamlessly. In short, in today's market, companies rely on the ingenuity of their consumers to make the company's products really shine in the home, and work with other devices. Smart home enthusiasts have been forced to have to spend a lot of time trying to make these various products work well for them. While this has been happening, the larger broader market, made up of less enthusiastic consumers who might have otherwise benefited from these innovative technologies, but are unwilling to spend this time, have because of these reasons, thus far ignored these advances.

We solve this problem by creating a smart technology bundle for the bedroom which includes all of the features we think, as a cohesive whole, lead to a really great *smart* bedroom experience, where the central hub technology that comes with the bundle is created from the ground up to support these features in a really intuitive way(details will be provided in the requirements section). Moreover, because we are providing a bundle of particular technologies, our system can be made extremely easy to setup because we can design installation procedures that can rely on the presence of other specific devices in the provided package. We also include novel features that have not yet been fully utilized such as smart closets that can do things such as open up and present clothes to you to put on when you wake up, and can be integrated with an app to allow you to see what the clothes you have available would look like on you without having to physically put them on. While our system will include a variety of components that are tightly integrated for the best synergistic effects, and will thus work really well out of the box, we will also allow the user to customize how the system works with technologies such as IFTTT and compatibility with other devices, although these additions may not work as seamlessly as what comes with the bundle because of the large amount of variety that cannot all be designed for in advance. Our system runs the risk of not appealing to the crowd of people who prefer the current a la carte approach to smart home integration provided by our competition and the industry as a whole. However, we are confident that the tight coupling and focused design we create with our bundle will create an experience that will *just work*, take care of needs people didn't realize they even had, and thus appeal to a larger audience in general.

Requirements

Before going into the specific use cases that our system will provide for our stakeholders, it is first important that we make clear the specific features and general functionality that our system will have.

Smart Bed and Integrated Wake Up Features

Our bedroom will include a smart bed which will be able to make itself and whose features such as firmness and whose status (i.e bed is currently unmade) can be adjusted and viewed from the central smart bed console (most commonly accessed through an iPad app). The smart bed will be fully integratable with the alarm functionality that comes with the system such that the bed can be set to automatically raise you up at your set alarm time and such that sensors in the bed detect your overall wakefulness and wake you up at a time (within a set time interval of your choosing) that is optimal with respect to minimizing grogginess. When it comes to waking up in general, the bed will only be a part of the process in the ways mentioned above. The lights system will also slowly raise the amount of light in the room as you get closer to your wakeup time to make the process less jarring and the system will give you the option to play music of your choosing when waking up through a sound device of your choice. In addition users will have the ability to integrate their online calendars with the smart bedroom system (such as google calendar) such that when waking up, a small projector located in the room projects their schedules and general things to do on their ceiling to remind them of their plans for that day.

This calendar and projection service can also be utilized outside of just being projected when the user wakes up and the user can customize this calendar as they see fit in the main smart bedroom console.

Sensors Sensors Sensors

Since this is a smart bedroom there will be a large variety of small unobtrusive sensors that will be placed throughout the room that will provide information such as temperature and amount of light to all devices in the room and will enable these devices to then react to these specific indicators in the way the user sees fit and sets in the central console. As an example of this feature, all sockets in the room will be *smart sockets* such that even if one plugs in a non-smart device into the socket other smart devices in the room will be able to detect that that device was plugged in or turned on and react to that event accordingly.

Smart Lighting

Our bedroom will include a smart lighting system which can be set to automatically adjust the brightness and overall intensity of the light provided in accordance with outside light sources and the user's preferences. The light system will enable the user to change the color arrangement and general style of lighting in a wide variety of ways and will include the ability to easily program the light style to react to certain events in the room such as time of day, and the tv in the room turning on. In addition, the light system will be connected to a system that opens and closes the blinds in the room to let in or obstruct natural light in accordance with the homeowners overall light preferences. For events that aren't explicitly covered in the room, the lights will support the IFTTT protocol which will allow the user to program additional triggers for lighting such as creating a dark spooky looking lighting setup when his or her friends text him with the message #halloween.

Smart Dresser/Closet

Our bedroom will include a smart dresser. The smart dresser will allow the user to be able to see specific information about his or her clothes, how many socks they have left, the number of shirts that are in the closet and various other clothing related tidbits of information that will be gathered by sensors in the dresser. The dresser will be integrated with other smart features in the bedroom such as the alarm system in which the user will be able to specify that his or her clothes be presented to him or her when they wake up for selection (you can see a mockup of how this can be done later in our report). In addition the dresser will include swivel technology(http://www.facecake.com/swivel/), which will allow users to scan in their clothes and then later stand in front of a kinect driven camera in a certain subsection of their dresser and see how clothes in the dresser look on them without putting them on.

Smart Heating/Cooling

Our bedroom will include smart heating and cooling systems which will be highly configurable. For example users will be able to specify from their home console that the heating/cooling be toned down if after a certain period of time after leaving a room they don't come back for maximum energy savings. These systems will also be IFTTT compatible so users can for

example set fun novelty options such as having the room rapidly heat up when they get a text saying flameon!

Smart Cleaning Robot
Our smart bedroom will come with a cleaning robot which will clean the floors of the room at set times. This robot will also be accessible from the main smart bedroom console and can be activated even outside the bedroom by use of that functionality. The robot will also be highly configurable, for example users will have the option to have the robot go back to it's charging dock as soon as anyone enters the bedroom if it was cleaning at the time, and users will be able to set the robot to clean every day at specific times.

Major Stakeholders
Other than the home occupant another large stakeholder in this system are any guests that interact with the bedroom in any way such as watching a movie with the home occupant.

User Stories

As a <role>	**I want <goal>**	**So that <reason>**
Home Occupant	to be woken up effectively by any set alarms	I can ensure that I wake up in time to get my planned tasks done.
Home Occupant	to be woken up in an optimal environment	I can reduce my overall grogginess level
Home Occupant	my bedroom to be extremely clean all the time	I can really enjoy the space i'm sleeping and spending a lot of time in.
Guest	to not find myself confronted by a cleaning robot when entering the occupants bedroom	I can enter the room without any problems or disruptions
Guest/Occupant	to have a bedroom that is heated/cooled to my liking depending on the time of day	So I can be comfortable in the room i'm spending time in.
Home Occupant	to be able to see what certain outfits look like without having to physically put them on	I can more efficiently and effortlessly figure out what I want to wear.
Home Occupant	to have a lighting system that is highly customizable and varied	So that I can easily have lighting arrangements that fit a wide variety of occasions and situations.

Home Occupant	to be able to activate smart devices to do certain things through triggers such as web services like facebook and twitter	So that I can further customize my smart devices to work off all kinds of interesting and novel situations, some of which involve these services.
Home Occupant	to have sensors in my room that detect a wide variety of things such as the tv being turned on	so that I can have my smart devices react accordingly to a wide variety of events(movie mode for lights when tv turns on is an example).
Home Occupant	to have easy access to all aspects of my bedroom in one central place	so that I can easily configure my bedroom arrangements, control and monitor its various aspects and easily figure out cool ways to further the setup to my liking.
Home Occupant	to have an easy setup process	so that I can focus on enjoying the benefits of having a smart bedroom and further enhancing the experience
Guest	to be able to rely on the home occupants smart home systems to work well and as expected(i.e signal what they are doing)	so that I don't get any unexpected and strange surprises when spending time in the occupants room.
Home Occupant	to have a room that is always just as bright as I want it to be.	so I can have the most comfortable living arrangements.
Home Occupant	to wake up and view the events/meetings I have for the day	so I won't forget the events I have planned for the day
Home Occupant	to have an alarm automatically set before my first event/meeting for the day	so I wake up in time for my event/meeting and I'm not late
Home Occupant	to know how much sleep I am getting on a regular basis	so I can improve my sleeping habits
Home Occupant	my bed to make itself	so that I if I'm in a rush I don't have to worry about my bedroom being neat

Due Diligence

There are two types of competitors to our system and two companies that represent the best in their class of this type of competition. The first type of competition is an a la carte solution which gives users the most power, by design, to customize their smart bedroom by buying a variety of smart home products and using software to attempt to tie them together. SmartThings does this best. They provide an app that detects different smarthome solutions, including many of those used in bedrooms, and makes them available for control and customization. They also provide a wide variety of sensors and proprietary smart home items, many of which would be useful in a smart bedroom, that integrate well with their application and give more power to the user to make a smart bedroom that best suits them. Their application is supposedly easy to use and supports a wide variety of different smart home products.

The second type of competitor our system faces are full service providers, or companies that have developed an ecosystem of smart home products and sell those to builders and sometimes to homeowners interested in the smart home space through intermediaries. When selling to homeowners they sell through licensed “integrators” who work with customers to meet their smart home aspirations often customizing the particulars of a smart home solution to fit a particular person or families needs. Savant is one of the premier companies that do this. They make partnerships with smart home builders to provide their particular solutions and license those who deal in home improvement to use their products and utilize their services. These solutions tend to be more tightly coupled because they are all created to work in the centralized smart home ecosystem that Savant maintains. They do not however sell directly to consumers like many other smart home solutions which can be found on major retail sites like Amazon and rely on their licensed integrators to instead offer their services. Their solutions also utilize a smartphone/tablet to control the various facets of their smarthome system.

Design

The class diagram below represents the software that drives our smart bedroom. Most of the components of our system are run by the various sensors that feed in data to the ‘smart’ features in the bedroom, which the bedroom owner (user) customizes to suit his/her needs. For instance, in the case of the smart bed, the bed sensor would read in how awake a person is by monitoring the person’s body movements and sleep cycle. When the person chooses to set a ‘smart’ alarm for the morning, the bed sensor will choose to wake up the person at the optimal moment of ‘wakefulness’ by raising the bed to a certain level (set by the person) between the time range specified (also set by the person). In accordance, with the alarm, the lights in the room will also brighten slowly to a certain level/color specified by the user to assist in waking up the person gradually. The person can also adjust the temperature they would like to sleep and wake up with as well as whether they would like to wake up to a song and receive an outfit suggesting in the morning.

The example above is just one of several ways in which a person can customize the integrated smart bedroom system to their needs. Since our system is largely focused on the

user and his/her custom settings, the system will keep record of all the different custom settings the user makes for any smart bedroom feature. The system will use these past custom settings and propose them to users any time they try to create a new setting for a feature in the system or use a setting the user has commonly used before if the user forgot set a setting at his/her usual time. For instance, the system will keep track of the time ranges and settings the user has specified for the smart alarm in the past. So if the alarm feature is 'on' and the user forgot to set an alarm, depending of the day of the week and averages over a period of time, the system will set an alarm automatically for the user to wake up the next morning. Additionally, if a user has synced his/her calendar with Google and the user forgot to set an alarm for the morning, the system could automatically set an alarm 1 hour before the first event of the user's day, so that the user will not wake up late for that event. The sensors also play a role in harvesting data for analytics and making the system smarter. Specifically, the bed sensor will keep track of when you go to sleep vs. when you wake up and gather data for a mini dashboard on the console displaying the average number of hours the person is sleeping throughout the week and graphs representing their sleep cycles; this could in turn help the user manage his/her sleep schedule.

Our smart bedroom system essentially harvests data for analytics by gathering information from the various sensors and by keeping track of the user's various custom settings to analyze patterns and suggest those settings the next time or automatically set them if the user forgot to set them occasionally.

iPad App

https://www.flinto.com/p/350cf44f

Cost-Benefit Analysis

Our system provides a compelling value by offering the best of both worlds of our two main competitors who adhere to a la carte model to smart bedroom furnishing and an all inclusive curated model respectively. Because our system comes bundled with a lot of essential smart bedroom smart home devices and these devices are decided on ahead of time, we can give our customers a smart bedroom experience which is thoughtfully designed for in advance, where the provided components work well together in intuitive ways and the customer can be guaranteed an easy setup process and smart console interfaces that take advantage of the tight coupling of our system. This is in sharp contrast with the a la carte model of a company like SmartThings which recommends certain devices for curious homeowners and allows them to integrate various devices together. However, that can't provide such a seamless design for an advanced experience to those unfamiliar with the space and unable to put in the time, experimentation, and dollars to make a perfect bedroom system for themselves.

Our other competitor Savant, can provide an easy setup process for customers and perhaps even provide a similar seamless smart bedroom experience because of the thought of in advance solutions they provide. However, this company is likely to be far more expensive since they employ a large amount of middlemen(integrators) who will demand a cut of the profits

and they need to actually pay for experienced technicians to engage in a back and forth with consumers and then actually implement their smart home solutions. This is essentially full scale contract work which regularly costs many thousands to purchase and complete, this is why Savant does not have standard prices or packages, because like other high valued services, their solutions and pricing tend to be very custom and expensive.

Not only is our solution likely to be as seamless and easy to work with as the Savant systems and cheaper then that system, but it also offers some features that work well with each other that neither SmartThings or Savant seem to offer (with Savant this is harder to judge because they don't explicitly list what they do but the demos they have demonstrate a lot of features and none of these are the features that we will list shortly). We actually utilize a smart bed, the Ohea smart bed, that does novel things like make your bed for you and that can be integrated with wakeup functionality in our system. We utilize swivel dressing software that has only very recently found it's way into department stores and only now started to be offered to the public and can really make it easy for homeowners to figure out what they want to wear for the day without frantically putting on lots of different clothing. Lastly, Our wakeup and calendar features really take advantage of the wide variety of smart devices that come bundled with our system in a way that Savant and SmartThings do not seem to offer.

Certain parts of our system have unpredictable costs. In particular, there aren't publicly listed costs for the Swivel system and the Ohea smart bed, although they are both in use. Similar smart beds cost roughly $7000 and the Swivel systems' components are a Microsoft Kinect ($300), and screen ($200) and the software itself which because it is being offered to consumers, will probably not cost more than $300. A philips hue light system cost roughly $200, a Nest thermostat $200, and various temperature, and motion sensors cost about 50$ each, we'd probably have around four of them at least. Smart AC units can be had for about three hundred dollars and a smart dresser as we imagined it does not seem to be on the market yet but we feel that such a device can be manufactured and our system still holds well without one. A good roomba cleaning robot costs $330. We can then add about $600 dollars in unexpected costs as we feel it is better to overestimate than underestimate costs, for things such as mechanical blinds, projectors for the calendar, and specific sensors for our lights system. In total we expect our system to cost roughly $9330 dollars which is a hefty amount.

This amount is still likely to be far less than the cost of the Savant system because they will most likely use similarly priced components and will factor in costs for labor and installation, while our bundle will be designed to be easy installable by our consumers. Obviously, the cost is far less than buying one or two devices and connecting them to the SmartThings ecosystem, but this kind of ad hoc connection of various smart devices will not be able to match the ease of use and designed for synergistic effects that our ecosystem provides. A SmartThings curated ecosystem is far more likely to result in a bedroom with some nifty additions as opposed to the smart bedroom experience that we provide. Ultimately, we believe that our system provides the best bang for your buck when it comes to actually providing a *real* smart bedroom system at a reasonable cost (reasonable to at least for some segment of the population) that still manages to be easy to setup and maintain, anticipates our users' needs, provides comfort and useful functionality to occupants, and enables them to fully enjoy and take advantage of smart home technology.