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THE CONTEXT-AWARE LIVING PROCESS SMART HOME ARCHITECTURE

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ABSTRACT

In the proposed living process smart home design, we consider not only the control aspects, but also the contextualized interactions of the family members' living processes that will affect the services needed to meet the living goals of the people in a living process smart home. The sensor signals are from the physical sensors and the info-sensors, processed from internet based-on the specified data-of-interest. The info-sensor will provide warning before the occurrence of an event and alert on imminent occurrence of an event so that family members can decide how to proceed. The physical sensors, however, when on, imply disruptive events have occurred and some predefined actions must be activated and the home owners can also activate the control array to take certain countermeasure to resolve the problems.

KEYWORDS: Smart home, context-aware smart home, living process smart home, info-sensor, living process.

1. Introduction

Traditionally, the smart home implies the implementation of sensors and controls to address the problem of comfort, safety and lower cost of operating a house [1]. The dimension of living interaction in a smart home just started getting some attention from researchers [2-4] but not addressed by previous research or commercial implementations. In this paper we will address the context of a smart home with inhabitants who are family members including elders such as grandfather and grandmother, father and mother, sons

and daughters. Each person in the household has his or her own personal living processes such as process after waking up, process preparing breakfast, process ready to work, process related to sons and daughters going school, process driving to work, process afternoon lunch, process afternoon working, process going to pick up kids, process extracurricular activities after school, process preparing dinner, process family time after dinner, process ready to sleep as depicted in Figure 1 showing three interacting living processes of husband, wife and son.

But there are key living processes that are similar such as wake up, morning routine (taking a shower, brushing teeth, dress up, breakfast), lunch, dinner, family time, sleeping. Even all the key processes are similar, there a myriad of details and interruption possible to change the sequence of these processes.

In this paper, we propose and develop the concept of the Context-aware Living Process Architecture for Smart Home. This architecture provides a unique innovative way to support the process interaction of family members whether they are at home or at work, on vacation or on assignment, they are all can manage any events affecting a family members or home. It is almost impossible to handle all the cases of interaction between living processes.

In section 2, previous work on living process smart home will be reviewed. Section 3 will define the living process and Section 4 is about context and living process processing. The architecture of Context-aware Living Process Smart Home will be described in Section 5 and the processing algorithm will be outlined.

2. Previous Work

Most of the published work on Smart Home concentrates on designing the control and sensors operations to optimize the environment and comfort of people living in a smart home [1-4]. The incorporation of context is another logical step toward the design of a more precise smart home control system since it is more likely to be able to provide a better service profile for the home members since some of the typical situations can be accounted for.

However, there are a few papers start investigating the living processes of people living in a smart home as related to the issue designing a control algorithm that can provide the right services to every context configuration. Humayun et al. [3] addressed the human living processes of family members such as sitting, walking reading, eating, and also whereabout of them in the house. Each member has a preference environment setting. The goal is to

optimize living comfort of the members. k nearest neighbor matching technique for inferencing the predefined services against the service profile wanted by the family members.

Humayun et al. [3] recognized that smart home environments are complex and dynamic. With a very large context space and hence it is impossible to account for all the situations, hence, making the automatic control response to maximize the family member comforts in all situation is almost impossible. Machine learning is proposed to learn the context configuration with the preferred matching service. Marjan et al. [4] proposed the E-care@home, a smart home design that attempted to address the living process of in a mart home by processing a number of predefined context aware data collected through IoT sensor network and to perform context recognition based on the activities and the events occurring in the home. However, this approach still needs to process a large context aware data set with different associated desired outcomes since they are all generated by the living processes of individual members of the household.

3. Living Processes

Let us define the Living Process as the human behavior comprising four main key processes. Morning process, Afternoon Process, Evening Process, and Night Process.

These Main Key Processes can be decomposed into activities and tasks. Activities of a person can interact with the activities of another person. In general, the complexities of interactions between n persons is

$$\sum_{i=2}^{n}\binom{n}{r} = \binom{n}{2} + \binom{n}{3} + \binom{n}{4} + \cdots + \binom{n}{n} \quad (1)$$

Which is of order 2^n. Hence, it is almost impossible to model interacting living processes for a large family with more than 10 family members. In implementing the interacting living process of a smart home, a centralize system will be used to handle all the interacting matters as illustrated in Figure 1.

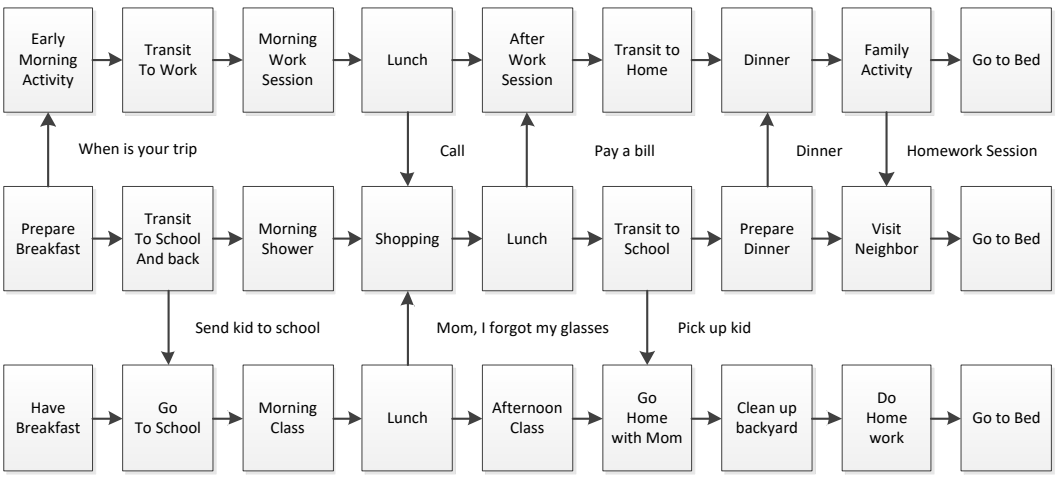

Figure 1 Interacting living processes

In order to effectively make possible the processing of interaction result in a meaningful way; a centralized channel will be used as shown in in Figure 2. This channel if implemented as a workflow channel, it will be too complex to develop into a meaningful system. A Context-aware Engagement Room is developed as reported in [1]. This innovation making the family members of the smart home always in contact to resolve any home and living-related problems.

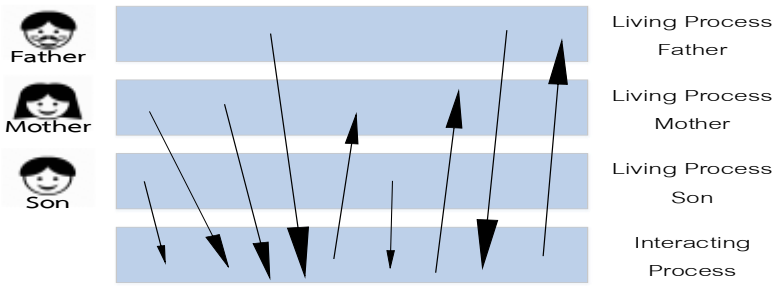

Figure 2 Using a centralized channel to manage the interactions of living processes

4. Context Processing of Living Processes

The context information can be divided into location data, temporal data, health sensor data, environment sensor data, human status data such as social status, physical activity data. In addition, in processing the context data of a smart home, we will define the information sensor data.

This class of context data is set and filtered to get a warning or alert vector that is relevant to the family or a family member. The processing of context information affecting the normal living process as shown in Figure 3. The output of the processing can be an alert or an activation of control devices or simply information to the member of the household for human processing.

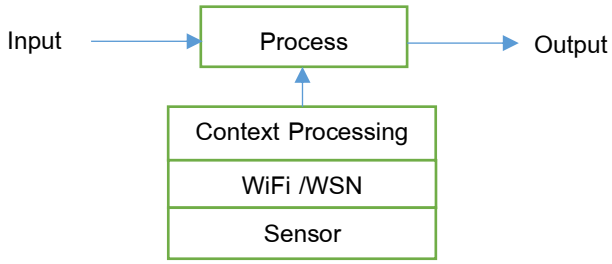

Figure 3 Context Processing Architecture

While the normal living processes progress in a normal repetitive cycle of 24 hours, under the context of time. There will be interaction of home environment and outside-home environment that will interrupt the normal living process progression. Here, the list of Abnormal events and problems.

Abnormal Events Related to:

1. Property
    1) Break-in and stealing.
    2) Quarrel and damage some valuable household articles.
2. Safety
    1) Fire.
    2) Flooding.
    3) Gas leak.
    4) Electricity short circuit.
3. Health
    1) Falling down.
    2) Heart attack.
    3) Poisonous food

4. Family Members
    1) Member not coming back at the set time.
    2) Sick leave.
    3) Accident.

Problems:

1. Personal Problems
    1) Cannot find car key, purse, eye glasses, passport, credit card.
    2) Not having sufficient time in preparing for the trip oversea.
    3) Wake up at 3-5 am and feel sick.
2. Crime Problem
    1) Forget to lock doors and windows.
    2) Forget to lock bedroom door.
    3) A stranger hiding in the house.
    4) Stranger monitoring outside the fence.
    5) Drone hovering to monitor.
    6) Break-in.
3. Energy Saving
    1) Air conditioning.
    2) Light switch control.
4. Natural Disasters
    1) Flood spreading from certain direction.
    2) Fire in vicinity.
    3) Riot at nearby area.
    4) Chain criminal.
    5) Spreading of contagious decease
5. Tracking of Family Members
    1) Loss of all internet-based connection (Line, Face Book, email, SMS).
    2) No mobile network communication.
6. Ambient/ Mood
    1) Family time.

2) Music.

3) Temperature.

5. Architecture of the Context-aware Living Process Smart Home.

The proposed smart home architecture depicted in Figure 4 shows the components of the system supporting the living processes with various sensors and context information. The key component is the Living Process Social Room that provide a central facility for coordinating and disseminating the interaction information from all parties.

In this architecture, there are five layers of information processing

(1) Physical Sensor Interface Layer.

This layer is to manage the monitoring of

- physical sensors: water, gas, voltage, current, light,
- Physiological sensors: heart rate, blood pressure, sugar level.
- On/Off sensor: status of appliances including lighting and air-conditioning system
- Camera and Sound: CCTV, voice recording.

(2) Information Sensor Interface Layers.

The information sensor is basically monitored the living processes to derive the following types of information.

- Predefined Event (PDE) such as trip information next week to London,
- Disrupting Living Process Event (DLPE) such as a hazard vector is formed indicating the approaching flood will cross path with the house.
- Monitor Defined Events (MDE) that will be tracked such as crime location information and the distance from the sub-division in which the home is located.

(3) WIFI/ WSN Layer

This layer is to support the intercommunication between various sensors devices and the living processes. The main signals are WIFI, Lora, SigB,

The information from this layer will be sent to be processed with the direct input from the physical living processes with interaction in the Smart Home Social Room to coordinate, to determine resolution,

(4) Context Processing

This layer is to take in the input from physical sensors, info sensors, time context, and the current living process inputs at time t1 and the pending state from t2 to determine the best activation, alert, warning, coordination, communication to the member of family.

(5) Living Process Engagement Room

The Living Process Engagement Room is a system that take in input from living processes and input from physical sensors and info sensor and time context for the member of the smart home to determine the course of best action responding to any situation arisen.

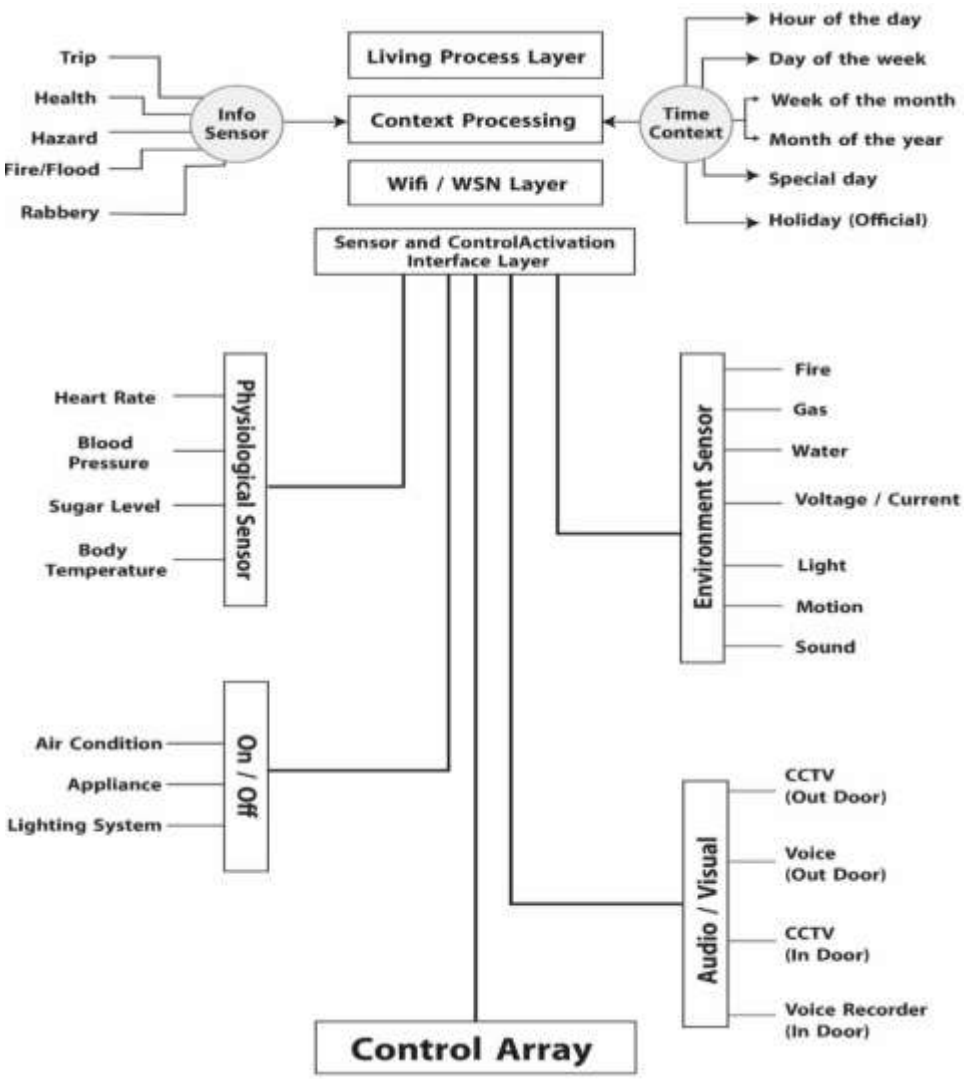

Figure 4 Architecture of Context-aware Living Process Smart Home.

The context processing feeding output to the Living Process Engagement Room (LPER) [6] is the key element of the Context Aware Living Process Smart Home. The Living Process itself is a cyclic trajectory of normal repetitive activities interrupting by the physical-sensor context and the info-sensor context, all under the time context. Figure 5 illustrates the processing of physical sensors information with predefined adaptive response activated by a sensor signal. The information then displays in LPER so that family member can have a consensus action to activate some control in response to the signal from sensors appropriately. As for the signal from info-sensor, the family member in the LPER can decide to continue the monitoring, or to modify the monitoring criteria to obtain additional. Hence, the algorithm coordinating the interactions of various context upon the living processes of home owners will be algorithmically described as follows.

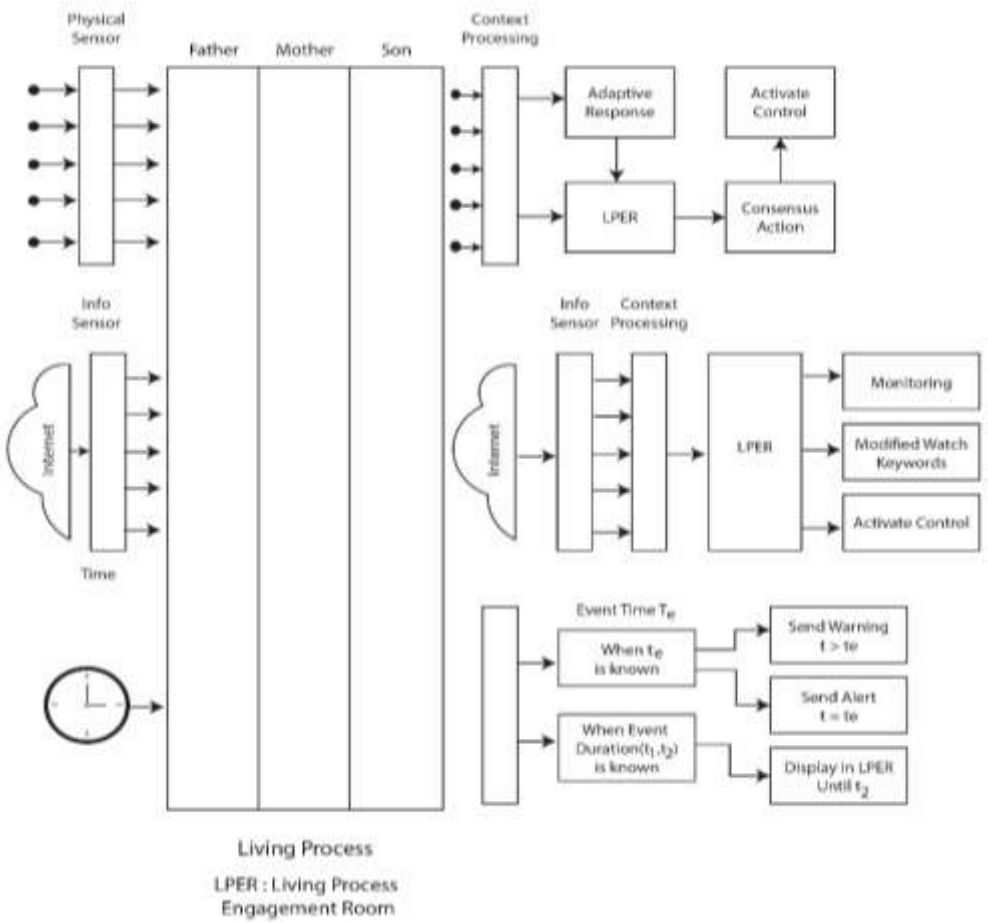

Figure 5 Overall Signal and Control Structure.

6. Context-aware Processing Algorithm

Setup data for time context processing

- 24-hour Cycle

  morning cycle (5.00-9.00)

  morning biz cycle (9.00-12.00)

  afternoon lunch (12.00-13.00)

  afternoon biz cycle (13.00-17.00)

  afternoon kid pickup (15.00-17.00)

  early evening cycle (18.00-20.00)

  late evening cycle (20.00-22.00)

  early night cycle (22.00-24.00)

  late night cycle (24.00-4.00)

- 7-day Cycle

  Day (Workday (mon, tue, wed, thur, fri), Weekend (sat, sun))

- 12-month Cycle

  Summer (April, May, June, July),

  Rainy (August, September, October, November),

  Winter (December, January, February, March)

- Official Holidays

  3-day long weekend (occasion, date1, date2, date3)

  4-day long weekend (occasion, date1, date2, date3, date4)

  5-day long weekend (occasion, date1, date2, date3, date4, date5)

  Occasion (religion (Buddhism, Islam, Christen),

  new-year (Thai, Chinese, International),

  royal-family (historic, king, queen),

  official (type)

- Personal Day and Time

  Anniversary-Day (name, date)

  Birth-Day (name, date)

  Thai semester recess day (begin-date1, end-date)

  School Time (name, t1, t2)

Father Work Time (t1, t2)

- Time Context Processing

If day d_e be the day of the event and the time context span from d_1 to d_2, let d_b n days before d_1, and d_a m days after d_2

if event e then $d_b < t < d_1$, softAlert ; $d_1 < t < d_e - 1$, hardAlert;

if $d_1 < t < d_2$ and under the physicalsensorcontext and infocontext then send alert, warning, info

if $d_b <= t <= d_e$ then send relevantInformation; and if $d_e <= t <= d_2$ then track location, incoming messages and send relevantInformation and messages from family members;

- Physical Sensors Processing

If video detect = FindingThing

Or FindingThing status is on and thing is specified

Then if ThingPresence is inside

Then DetermineWhichRoom = room (n)

Or LastSeen (video) is known

Inform home owner

If sensor detection case of sensor type

then under context A do activate J, Send info to LPER.

Physical Sensor type: Heat sensor: Gas sensor: Water sensor: Lock sensor: Break-in sensor: Motion sensor: Video sensor: Temperature sensor: Light sensor: Smoke sensor

- Info-sensor Processing

Track info-sensor (PDE, DLPE, MDE)

If event e is of type PDE, perform (alert, LPER)

If event e is of type DLPE, perform (warning, LPER)

If event e is of type MDE, perform (monitor, LPER)

Info-Sensor type: Reminder: Hazard vector

7. Conclusions

In this paper, we have proposed a new smart home design based on the context aware processing of living processes. For the sensor design, we define a new class of sensor signals derived from the monitoring of information on the internet as specified by the home owner. The info-sensors will provide alertable-signal and warning for certain activities and events so that the family members can make decision on how to handle the event. A detailed classification of time context is also use to provide multiple level of context interpretations of a time slot. All information will be routed to LPER so that the family members can make the final decision to take the right actions.

References

[1] Andres B, Alejandra F, Miguel J, Augusto S, Pedro W. Towards the evolution of smart home environments: A survey. International journal of automation and smart technology 2016; 6(3):105-36

[2] Robles RJ, Kim TH. Review: Context aware tools for smart home development. International journal of smart home 2010;4(1):1-12.

[3] Kabir MH, Hoque MR, Yang SH. Development of a smart home context-aware application: a machine learning based approach. International Journal of Smart Home 2015;9(1):217-26.

[4] Alirezaie M, Renoux J, Köckemann U, Kristoffersson A, Karlsson L, Blomqvist E, et al. An ontology based context-aware system for smart homes: E-care@home. Sensors 2017;17:1586.

[5] Prathumtevapibal S, Techakittiroj K. Digital home for Thailand. Technical report. EGATE; 2012.

[6] Kulthavarakorn C. Context-aware living process smart home architecture and living process engagement room [dissertation]. Pathum Thani, Thailand: Shinawatra University; 2019.

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