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A Process Oriented Integration Model for Smart Health Services

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Abstract: Cities are facing challenges of high rise in population number and consequently need to be equipped with latest smart services to provide luxuries of life to its residents. Smart integrated solutions are also a need to deal with the social and environmental challenges, caused by increasing urbanization. Currently, the development of smart services' integrated network, within a city, is facing the barriers including; less efficient collection and sharing of data, along with inadequate collaboration of software and hardware. Aiming to resolve these issues, this paper recommended a solution for a synchronous functionality in the smart services' integration process through modeling technique. Using this integration modeling solution, at first, the service participants, processes and tasks of smart services are identified and then standard illustrations are developed for the better understanding of the integrated service group environment. Business process modeling and notation (BPMN) language based models are developed and discussed for a devised case study, to test and experiment i.e., for remote healthcare from a smart home. The research is concluded with the integration process model application for the required data sharing among different service groups. The outcomes of the modeling are better understanding and attaining maximum automation that can be referenced and replicated.

Keywords: Process modeling; business process; business process integration; business process modeling and notation

1 Introduction

Smart service systems are present in homes as well as healthcare [1], and transportation sectors [2], among many others. The researchers defined smart services by selecting five characteristics: up gradation of efficient economy and value creation [3]; relationship of digital and physical world; services and product's extension with digitalization; transformation in business models from product centered to buyer centered; product transformation as a part of service [4]. The idea of smart service system is proved to be very beneficial in the development and utilization of technologies including Artificial intelligence (AI) [5] and Internet of things (IoT) [6] as it represents the technology application and integration for value creation to people in different sectors of life [7].

In recent years, use of IoT has increased in industry and academia, which is based on a network of devices connected together and keeps growing, thus resulting into a lots of challenges to deal with especially in healthcare [8]. The areas of IoT applications are diverse and huge ranging from environments of smart home to monitoring systems in medical field [9]. Usually, physical complexity is not only encapsulated by a single device, therefore system is rendered by combining multiple devices for the reality illustration. Now as the demand for technology and smart systems is increasing the need for systems' integration, is also rising. In many scenarios sub smart systems such as smart homes, smart health, and smart vehicle [10] are working efficiently individually but due to absence of data sharing they do not collaborate (that could reduce manual intervention), although the users, service scope and environment is same. These issues can be overcome by integrating the systems and data sharing automation among these collaborating systems. Another problem in way to collaboration and integration of systems is the heterogeneity of devices and network protocols. Products from multiple vendors and different protocols are used to build the network of smart system, resulting in certain challenges [11].

Process modeling permits reasoning and hypothesizing on how models can be referred by software developers to understand system-as-is prior to the designing of the system-to-be [12]. Therefore, we implemented process modeling technique to represent the integration of the distinct processes of different service systems, that helps to avoid consideration of basic heterogeneous technical infrastructure, as, the highest level of abstraction is to put a set of events and task together in logical flow [13]. Hence, the best possible solution is, to analyze and model the processes of smart systems that will lead to identify the activities of processes need to be integrated for data sharing and collaboration. Moreover, BPMN model development approach apprehend that models are the initial focus and move towards software development instead of computer programs, and the models should present enough details for realization.

2 Background and Related Work

Cities are becoming smarter by implementing the multiple IoT based smart systems in real life to facilitate the citizens in different dimensions of life. Smart system is basically a software solution that is implemented on hardware to make them smart. In under developed countries the concept of integrated smart systems is still in its infancy stage, as individual systems are being implemented gradually in different sectors but the integration is absent. Processes play a vital role in the integration and collaboration of smart system applications of different systems by including a chain of events [14]. Since, the IoT, intelligent control methods of smart facilities, interoperability, operation interface and ubiquitous computing are mainly focused in existing smart systems, therefore, it is important to study process modelling and integration of these systems which results in collaboration. Integration of IoT based smart services' processes leads to integration of IoT devices as well as integrated process modelling [15].

Both industry and academia have widely accepted and executed the Business process modeling notation (BPMN) 2.0 standard language for modeling of processes and systems. BPMN's main objective is to present a notation which is easily understandable by the users who implement the initial drafts of softwares. So, it is significant to use BPMN 2.0 [16] to model processes because models are the main focus of software development. Different services are delivered effectively and efficiently by smart service systems based on IoT and Service oriented architecture (SOA) [17], for example, level of humidity [18], temperature [19], and location of an object. The term SOA refers to a networked, standards-based interface architecture that enables the convergence of business processes as a linked service and a roadmap to innovation. In the classical model of SOA [20], there are clearly identified three main actors: service provider, service consumer and registry of services [21].

2.1 Business Process Modeling and Languages

Three decades before, application of process modelling started relative to development of an information system [22]. Business process modeling permits reasoning and hypothesizing on how the work is organized in the complicated systems [23]. Different purposes are served by blueprints as represented by business process models for multiple stakeholders [24]. Process modeling method provides plethora of advantages as: it exploits opportunities for improvement, transparency, adaptability and flexibility and standardization across systems. There are multiple languages and techniques available for significant service-oriented modelling. Each language has its important benefits and features that are summarized in Tab. 1. Among all languages, BPMN is mostly used language [25], as a standardized connection is created by BPMN to the gap between business process design and its implementation [26]. Fig. 1 shows the fundamental components of BPMN are being in use in general. In particular, events (represented by circles) represent potential process results. A workflow begins with an initial event (a circle with only a thin boundary) and ends with a final event (a circle with a thick boundary), with intermediate events at all times (circles with a double boundary) during the flow. The workflow's distinct activities are the tasks (round-core rectangles), and the gateways (diamonds) form decision-making points for regulating the flow of work. A solid arrow indicates the sequence flow and regulates how activities take place in the process. A flow of messages between entities of processes and roles (for sending and receiving them) are indicated by message flows. Finally, rectangles represent pools and lanes, which symbolize various responsible areas [27].

Table 1: Smart services research comparison

Paper	Smart system/services	Modelling tool
[12]	Patient health monitoring system	BPMN
[19]	Smart home-procurement process	BPMN
[20]	Smart home temperature sensing and management	Unified Modelling Language (UML)
[21]	Temperature sensors management	UML
[28]	Patient health, appointment, ambulance record	BPMN
[29]	Smart grid	BPMN
[30]	Smart pills box	Flow chart
[31]	Smart medicine box	Flow chart
[32]	Noise level management	Flow chart

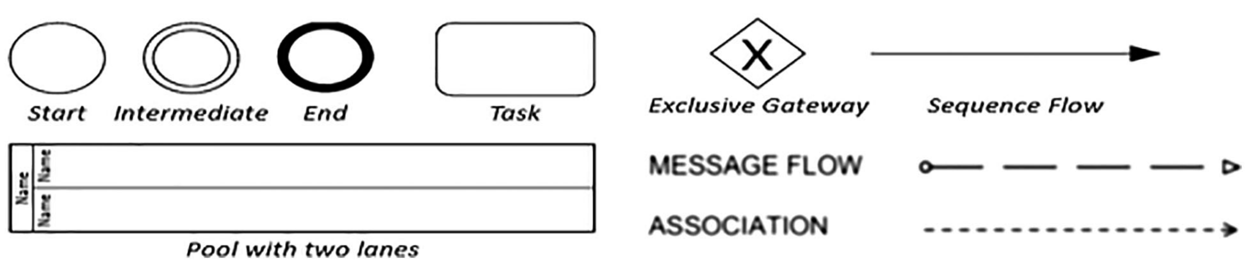

Figure 1: BPMN basic components

The behavior of processes, inefficiencies, anomalies and inconsistencies in the processes can be perceived by analysts with the help of BPMN diagrams [28]. Here a few examples from literature are given to explain that how different systems are benefiting by the use of modeling in different scenarios Tab. 1.

We agree with the authors of [33] to develop mathematical frameworks along with graphical models to explain the main components of smart services, the properties of these components and the relationships between them. According to this approach a smart service 'S' can be represented in the form of relation as in the following Eq. (1):

$$S \subset \{V_i : i \in I\} \tag{1}$$

where, $\overline{V} = \{V_i : \text{ i } \in \text{ I}\}$, is set of properties of a smart service and I is index set. By taking into account the three participants of SOA i.e., provider, consumer and registry, and then exploring the smart services (as shown in Eq. (1)) in addition to the relationships between the participants, following relations are defined for SOA participants as S_C for service consumer in Eq. (2), S_P for service provider in Eq. (3), and S_R for service registry in Eq. (4);

$$S_C \subset \{V_i : i \in I_C\} \tag{2}$$

$$S_P \subset \{V_i : i \in I_P\} \tag{3}$$

$$S_R \subset \{V_i : i \in I_R\} \tag{4}$$

where $I_C \subset I$, $I_P \subset I$, $I_R \subset I$. Note that I_P, I_R and I_C are not the divisions of 'I' but are corresponding indexes because few elements of V_i can be similar as in the provider, consumer and registry. Similarly, the sets for the input 'X' and output 'Y' are shown in Eqs. (5) and (6) respectively;

$$X \subset \{V_i : i \in I_X\} \tag{5}$$

$$Y \subset \{V_i : i \in I_Y\} \tag{6}$$

Then smart service can be expressed as a system in terms of *input-output* Eq. (7).

$$S \subset X \times Y \tag{7}$$

It is important to take into account the results of this proposition (as given in Eq. (7)), during the subsequent formalization of the functional properties of smart services, where there is need to use the sets of inputs (*X*) and outputs (*Y*) for modeling and integration.

2.2 Limitations and Challenges in Related Work

Tab. 2 describes and summarizes the limitations of the previously widely accepted modelling techniques and languages. Overall problems and weaknesses are summarized from related work.

Table 2: Comparative analysis of different modeling techniques

Languages	Advantages	Limitations
UML [18]	• Universal • Model processes, software components and database	Due to object-oriented prototype not applicable for traditional modelling approach
Flow charts [11]	• Simple graphical means	Provide only basic functionalities in process representation
Data flow diagrams [23]	• Simple data modeling • Easy analysis	Static system representation and no information on decisions and events

(Continued)

Table 2 (continued)

Languages	Advantages	Limitations
Petri nets [27]	• Assist in the structure analysis • Behavior of modeled system	Not concise or controllable enough for modelling complex business processes
Integration [31] definition (IDEF)	• Hierarchal decomposition supported	Static diagrams that lack both implicit and explicit temporal representations

3 Methodology: Business Process Modeling and Integration

Contrary to the previous work, proposed approach is, to model not only individual processes but also to model the integration of the related processes consequently leading towards maximum automation. In a vast variety of domains, business process integration (BPI)'s problem is ubiquitous. BPI enables; business processes to be automated, existing systems to be integrated, and data to be securely shared across multiple applications avoiding manual interventions [34]. From literature data sets having common device data and user are identified and given in Tab. 3 revealing that these systems can be integrated.

Table 3: Shared device data of various smart service groups

Data/Service	Smart home	Smart health	Smart vehicle	Smart grid	Smart office
Medicine box [30,31]	Yes	Yes	Yes	No	Yes
Ambulance [28]	No	Yes	No	No	No
Health monitoring wearables [12], [34]	Yes	Yes	Yes	No	Yes
Utility meters e.g., smart meter [29]	Yes	No	No	Yes	Yes
Environment factor sensors [19–21]	Yes	No	Yes	No	Yes
Security tags [19]	Yes	Yes	Yes	No	Yes

In an ideal world, one would want to automate or streamline the surrounding environment's whole processes, which is enabled by three distinct kinds of integration types as discussed below.

i. **Process Trigger:** In this approach, events occurring in another system cause a new process to be initiated. For example, if a user in a smart home switch on the Television (TV), user may wish to initiate a process that will adjust the curtain and lights accordingly in the room.
ii. **Pull Capability:** Pull capability means a smart system should receive data automatically from any given system, enabling participants in the process to make use of the information that has been transmitted. For example, getting information from the weather service providers and adjusting the room environment accordingly.
iii. **Push Capability:** Push capability refers to the capacity to transmit data from one system to another. For example, the transmission of patient's information to the online health systems may be a part of that transfer process.

The proposed integration process modeling solution is divided in two parts as mathematical formalization and graphical model. The focus of this research is the graphical modeling based on mathematical formalization using BPMN [35].

3.1 Mathematical Formalization for Smart Services Network Systems

By using the set theoretic approach [33], definition for the set of smart services is proposed as follows: Let a family of sets of smart service networks $\overline{N} = \{N_i:\ \mathrm{i}\ \in\ \mathrm{I}\}$, where 'I' is an index set that may be finite or infinite. A smart service 'S' is represented as a relation on given sets of networks

$$S\ \subset\ \{Ni: i \in I\} \tag{8}$$

Hence, a smart service can be defined as a relation on given sets of the networks and properties, avoiding the implementation technology and domain of smart-service. In order to explore the appearances of the smart-service (as defined in Eq. (8)) as well as to clarify the relationship between these appearances, following is introduced.

3.1.1 Smart Service Definition as Combination of SOA & IoT

A set of IoT is set of specifications for hardware infrastructure of a smart service (S) and SOA is set of software platform properties for different participants of network as represented in Eqs. (10) and (11) respectively. Eq. (10) represents IoT as a network of hardware devices and Eq. (11) shows SOA as a network of different services working collectively. Hence it can be said that a smart service is a relation on product of sets of IoT and SOA as in Eq. (9).

$$S \subset IoT\ \times SOA \tag{9}$$

IoT = {D, N, DP} where D = Devices, N = Networking, DP = Data Processing

SOA = {C, P, R} where C = Consumer, P = Provider, R = Registry

$$IoT\ \subset\ \{Ni: i \in\ \mathrm{I}_{\mathrm{IoT}}\} \tag{10}$$

$$SOA\ \subset\ \{Ni: i \in\ \mathrm{I}_{\mathrm{SOA}}\} \tag{11}$$

where the sets $\mathrm{I}_{\mathrm{IoT}} \subset \mathrm{I}$ and $\mathrm{I}_{\mathrm{SOA}} \subset \mathrm{I}$ are partition of index set, i.e., $\mathrm{I}_{\mathrm{IOT}} \cup \mathrm{I}_{\mathrm{SOA}} = \mathrm{I}$ and $\mathrm{I}_{\mathrm{IoT}} \cap \mathrm{I}_{\mathrm{SOA}} = \varnothing$

3.1.2 Smart Services Integration Function

To integrate multiple smart services, it is required to integrate their SOA and IoT infrastructures sets. It can be described as below in Eqs. (12) and (13).

$$Integrate\ (IoT) = \sum_{i=0}^{n} Model\ (\mathrm{IoT_i}) \tag{12}$$

$$Integrate\ (SOA) = \sum_{i=0}^{n} Model\ (\ \mathrm{SOA_i}) \tag{13}$$

The integrated smart services are a relation of S on the sets of integrated IoT and SOA. It can be represented in Eq. (14) representing the integration approach as binary sets of IoT and SOA.

$$\mathrm{Integrate(S)} \subset \mathrm{Integrate\ (IoT)} \times \mathrm{Integrate\ (SOA)} \tag{14}$$

The IoT and SOA systems are need to be modeled in their respective environments. At first which in return will yield a model of smart services as it has been observed previously in Eq. (2). Hence it can also be represented as follows in Eq. (15).

$$\mathrm{Model(S)} = \mathrm{Model\ (IoT)} \times \mathrm{Model\ (SOA)} \tag{15}$$

It is important to take into consideration the results of these propositions during the modeling and formalization of the smart services integration, where there is need to use the sets of IoT and SOA.

3.2 Graphical Formalization for Smart Services Network Systems

3.2.1 Integration Process Model for Smart Services Network System

The integration of IoT (hardware platform) part of a smart service is not a big challenge, as the only requirement is to identify and to provide a data sharing link among two or more smart systems. The real challenge is to integrate the SOA parts of the smart services that involves the collaboration of software solutions, without interfering the existing hardware platforms. System developers and analysts can get benefit from modeling of the existing individual systems to determine the common data sharing points and then to integrate them in a cost effective manner. The steps for smart systems' process modeling and yielding cost-effective integration solution are devised in the proposed integration process model in Fig. 2.

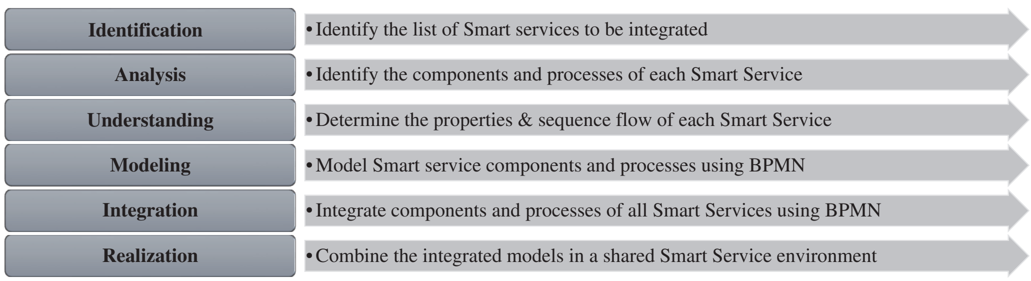

Figure 2: Integration process model for smart services modeling and integration

The stages involved in the realization of the research topic are discussed in this section. First the smart services should be identified and listed which are required to be integrated based on common data. Then smart services should be analyzed such that to determine the service elements i.e., relevant business processes in detail for better understanding of process and data flow. The activities involved of these elements are then identified in detail and ordered form, for modeling these individual systems by using BPMN notations. After modeling process, the integration requirements are explored and highlighted using BPMN approach. The integration requirements are determined by discovering the common data and resources that can be integrated to escalate the automation. Then finally the integration process is executed by integrating activities/tasks of smart services that will result into a smart system network. The aim of the research is to integrate the smart services, abstracting the IoT (heterogeneous hardware part of the systems), as the goal is to improve the collaboration and communication inside and across the network.

3.3 Case Studies: Smart Services Modeling and Integration Using BPMN

In this paper the case studies of smart home, health and vehicle systems will be used with their traditional architectures. Thus, based on the idea of traditional smart home, an extended architecture is presented by integrating smart home with different service provider's networks and other home/building networks Fig. 3. The traditional architecture of the smart home can be extended by integrating with the online service of the smart health [36] Fig. 4. Home gateway is used to control facilities of home and to execute local service programs by home residents. But the most convoluted process includes interaction among home residents, service providers and remote residents, such as remote assistance and remote administration etc. similarly remote health monitoring of patients rather than visiting hospitals physically.

Here, as an example, a case study is devised to use the above proposed extended smart home architecture and to connect with smart health systems for health emergencies and monitoring of patients at home by medical consultants and attendants. A patient or elderly person at home, for example, who needs regular health monitoring, timely dosage administration, consultant's appointments, or an ambulance service to hospital in case of emergency, in that case it will help to automate and integrate these systems to avoid any delay or loss. Although most of these services are in practice in certain areas but the need is to interconnect the relevant services to avoid any delay that may degrade efficiency and performance of system.

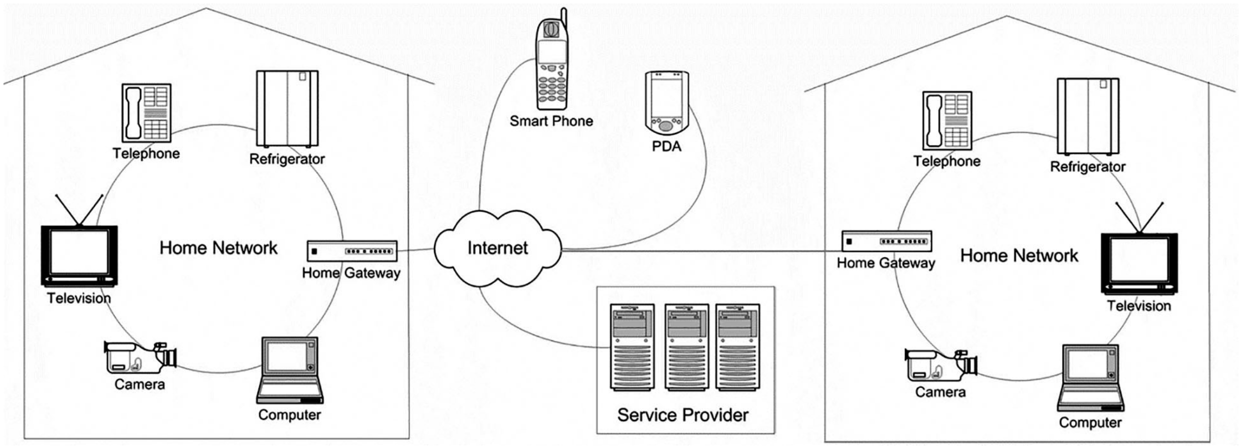

Figure 3: Extended smart home architecture for integration

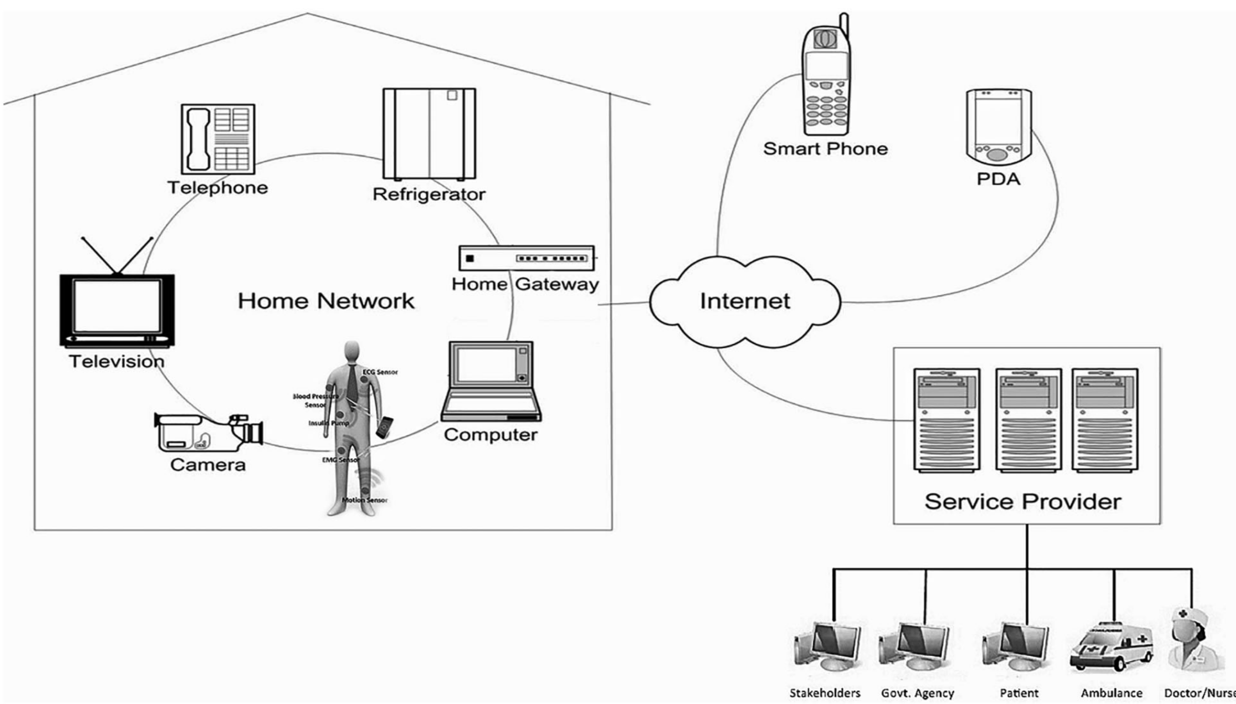

Figure 4: Smart home and smart health integration service scenario

Following steps are applied on the devised case study to develop BPMN based smart system's business process models according to the integration process model (Fig. 2) for modeling and integration [37].

3.3.1 Identification

The first step is to determine the smart services required to be integrated. Here in the case study, smart home is to be linked with smart health as well as with smart vehicle (ambulance) for medical emergencies and routine health monitoring. Hence the identified participants in this case study are given in Tab. 4.

Table 4: Service participants

Service participants
Smart home
Shared (Smart health & Smart home)
Smart health
Smart vehicle (Shared by smart health)

3.3.2 Analysis

Identified service participants are analyzed and consequently components are determined as business processes (given in Tab. 5) which are to be modeled accordingly for understandability in next steps.

Table 5: Service participants & business processes

Service participants	Business processes (BP)
Smart home	Noise management
	Temperature management
Shared (smart health & smart home)	Medicine box
	Remote health monitoring
Smart health	Online health consultation
	Online appointment
Smart vehicle (shared by smart health)	Online ambulance

3.3.3 Understanding

Each service participant's events are determined and then different service activities and tasks (given in Tab. 6) are defined precisely in the form of sequence flow for developer's understandability to avoid ambiguities.

The results of first three steps including service participants, processes and tasks are arranged in the Tab. 6. These are the individual processes working in different environments and systems that have been taken from the literature and made some modifications accordingly to extend the functionality.

Table 6: Service participants, business processes and service activities

Services	Business processes (BP)		Tasks/Activities
Smart home	Noise management	BP1	1. Sense alert type (alarms, doorbell, phone ring) 2. Analyze noise source and threshold level 3. Save current status of device (source of noise) 4. Adjust noise/volume (TV, stereo/sound system) 5. Analyze status of alert 6. Resume earlier device status (volume)
	Temperature management	BP2	1. Check current room temperature 2. Check room size 3. Check number of persons 4. Analyze temperature threshold 5. Adjust temperature
Shared (Smart health & smart home)	Medicine box-dosage alert	BP3	1. Analyze dosage time 2. Dosage time alert/alarm 3. Analyze dosage stock 4. Dosage stock alert/alarm
	Medicine box-consultancy alert	BP4	1. Analyze consultancy schedule 2. Scheduled consultancy alert before tc time 3. Scheduled consultancy alarm 4. End alarm after tea time
	Remote health monitoring	BP5	1. Analyze health data 2. Emergency health alarm 3. Alert message to caretaker 4. Check severity 5. Adjust room environment (temperature, noise) 6. Alert message to medical consultant
Smart health	Online health consultation	BP6	1. Analyze consultant schedule 2. Share data to consultant on duty 3. Analyze report severity level 4. Issue prescription 5. Schedule online session 6. Call emergency service e.g., ambulance or rescue
	Online appointment	BP7	1. Check patient details 2. Check doctor's availability 3. Send appointment details
Smart vehicle (Shared by smart health)	Online ambulance	BP8	1. Receive alert with contact details (office) 2. Check ambulance availability (office) 3. Check driver's availability (office) 4. Short list available drivers of requested area (office) 5. Send pickup details to driver (office) 6. Pickup details received by available driver (ambulance) 7. Select best route to pick patient (ambulance) 8. Locate nearby hospital (ambulance) 9. Select best route nearby hospital (ambulance)

3.3.4 Modeling

Modeling of activities of selected processes using BPMN language is done in this section by considering minute details and sequence flows. Each business process is defined as a sequence of activities and then the information exchanges are determined and represented using modeling.

BP1: An illustrative noise management IoT process is given in Fig. 5. Whenever there will be an alert from the connected devices (in a smart home) then at first the alert type will be checked to identify the source whether the alert is an alarm, doorbell, or phone ring. For example, if an alarm is initiated then after the identification of alarm the system will analyze whether any other connected device (TV, stereo or sound system) is producing any noise/sound, if yes, then the volume level will be assessed otherwise process ends. If volume of the noise is higher than the defined threshold level then the current volume level and other necessary parameters will be saved and volume will be lowered. The system will then keep on checking whether the alarm is ended (as a signal will be sent when the alarm will be attended or ended) to resume the earlier status of volume of the devices that will lead to end the process as well.

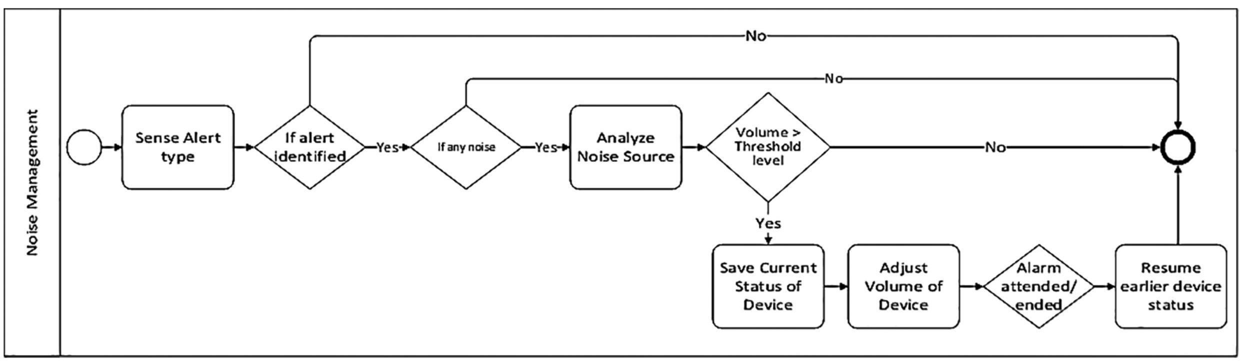

Figure 5: Noise management process model

BP2: In Fig. 6 the process model for room temperature management using smart Air conditioner (AC) is given. This business process is executed by a smart AC, in which, at first the room temperature is checked, then room size is measured and number of persons present in room are counted. Afterwards, an algorithm is executed to assess the required minimum room temperature i.e., temperature threshold, according to the room size and no. of occupants. After that room temperature will be compared with the calculated threshold level, if there is any deviation then temperature of the AC is adjusted accordingly and the process ends.

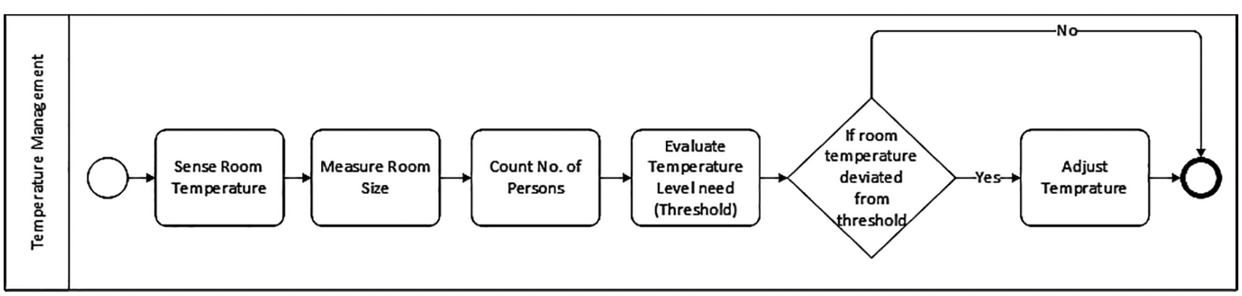

Figure 6: Temperature management process model

BP3: A process model for smart medicine box's dosage alert is shown in Fig. 7. The medicine box can be configured for analysing the dosage stock along with dosage time and then initiating an alarm and message alert.

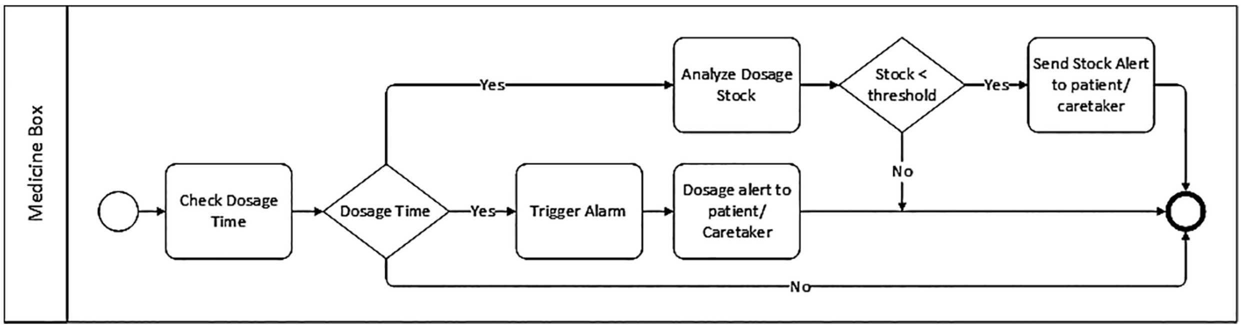

Figure 7: Smart medicine box-dosage alert process model

At first the dosage time is checked if the time for dosage is started then a message is sent to the patient and simultaneously to caretaker on the mobile, whereas, at the same time an alarm is also initiated to alert the persons/caretaker at home.

BP4: Another business process that a smart medicine box is supposed to perform in our case study is to inform before t_c time (consultancy appointment time) as a consultancy alert (scheduled with the doctor). This medicine box can be configured to store the t_c time and the alert time i.e., how many hours before t_c the alert should be generated. A process model for this scenario is given in Fig. 8. At first the consultancy schedule is analyzed, if there is a scheduled appointment configured in medicine box then an alarm will be initiated accordingly, followed by a message alert sent to the patient and caretaker before t_c time.

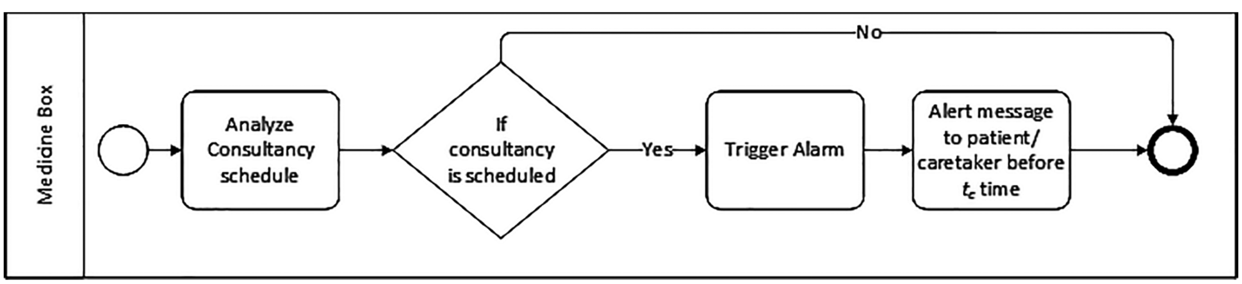

Figure 8: Smart medicine box-consultancy alert process model

BP5: In Fig. 9 remote health monitoring scenario is illustrated as a process model. This process is initiated when patient's basic health vitals' data is collected using some device (that could be a smart mobile with sensors)/wearables (bands with sensors) and sent via cloud. This data is at first analyzed using machine learning algorithms and then the patient's condition is being verified. If the value is deviated from the normal ratio, then an alarm is triggered and alert message is sent to the caretaker followed by a process to assess the severity of the condition. Given the analysis, the process ends or the room temperature adjustment (accordingly e.g., to avoid humidity and weather severity) message is sent to the caretaker/patient or a message is sent to a doctor (who is supposed to monitor the health conditions in case of chronical diseases e.g., sugar, blood pressure, heart problems etc.) on his/her mobile for medical assistance, and the doctor will take appropriate action accordingly e.g., will talk to caretaker or give consultation on phone or ask to visit him depending on the health data.

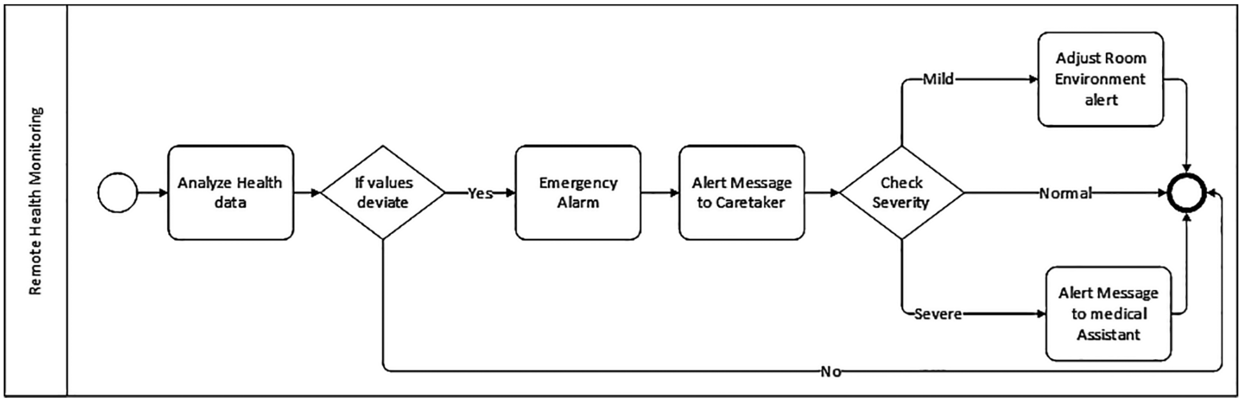

Figure 9: Remote health monitoring process model

BP6: A process model for online health consultation is modeled in Fig. 10. When this process is initiated then after receiving the query, at first the consultant schedule is analyzed to check the availability of medical officer/assistant online. Afterwards data of the patient is shared with online available short listed medical officer and condition of the patient is also analyzed using machine learning algorithms. Depending on the analysis report the process offers one or more of the three different facilities as: issue prescription, schedule online session, or an emergency service is recommended which is called by an operator of the system on duty and then the process ends. The doctor can compare his analysis with the analysis report of process and can alter the solution offered accordingly using available system options e.g., online session or change in prescription etc.

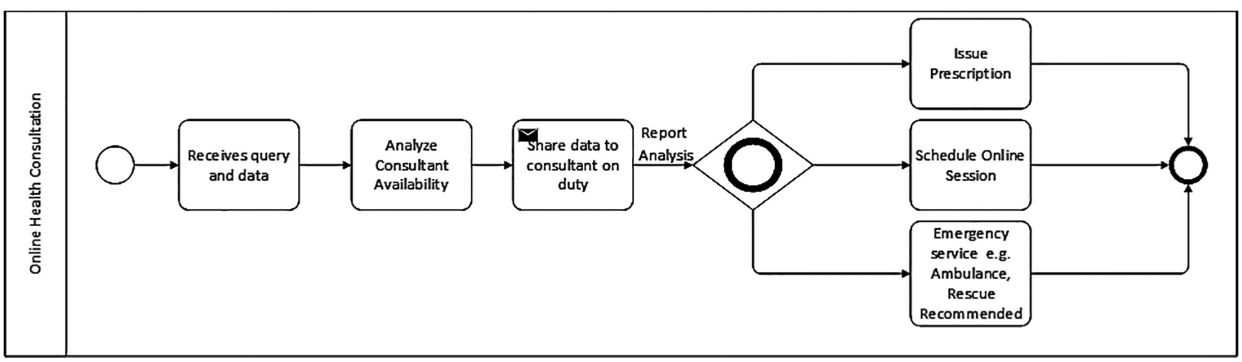

Figure 10: Online health consultation process model

BP7: The process model for taking an appointment of any medical officer or specialist using online facility through an app or web services is given in Fig. 11. The user sends query with details of the required services and particulars of the patient. Depending on query the consultants are short listed and availability is also analyzed. If the requested or relevant medical officer is available then the appointment details are sent for online session or live session as per requirement otherwise the non-availability message is sent.

BP8: Online ambulance process model is illustrated in Fig. 12. This process starts when a request is received with contact details of any patient/accident via a mobile app or web service. The process will then identify the location of received request using geo-positioning and short list the available ambulances in nearby areas. Afterwards it will send the message to shortlisted ambulance driver to confirm the availability. If the availability is not confirmed then that driver is dropped from the shortlisting and shortlisting is updated otherwise the pickup details will be forwarded to the ambulance driver. Now the ambulance driver's process (that could be integrated in driver's mobile or vehicle's smart system) will select the best route to pick the patient, extracting the information from pickup details and using map algorithm. Next, after pickup, it will locate/search the nearby hospital and then again locate the best route to nearby hospital for immediate arrival leading to end of the online ambulance process.

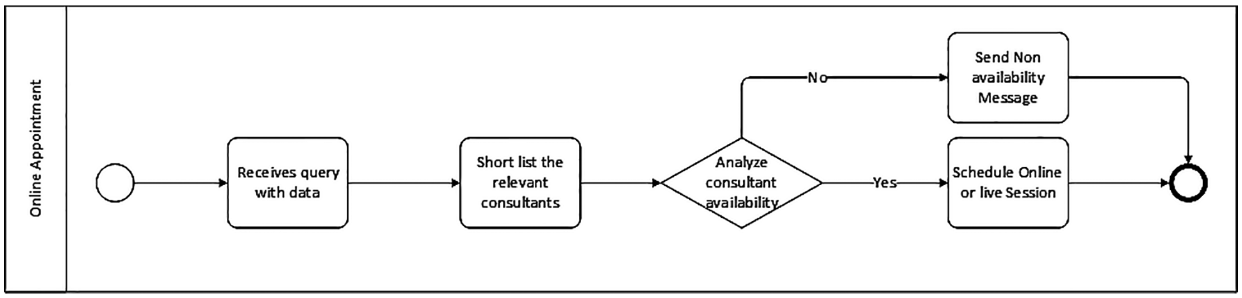

Figure 11: Online appointment service process model

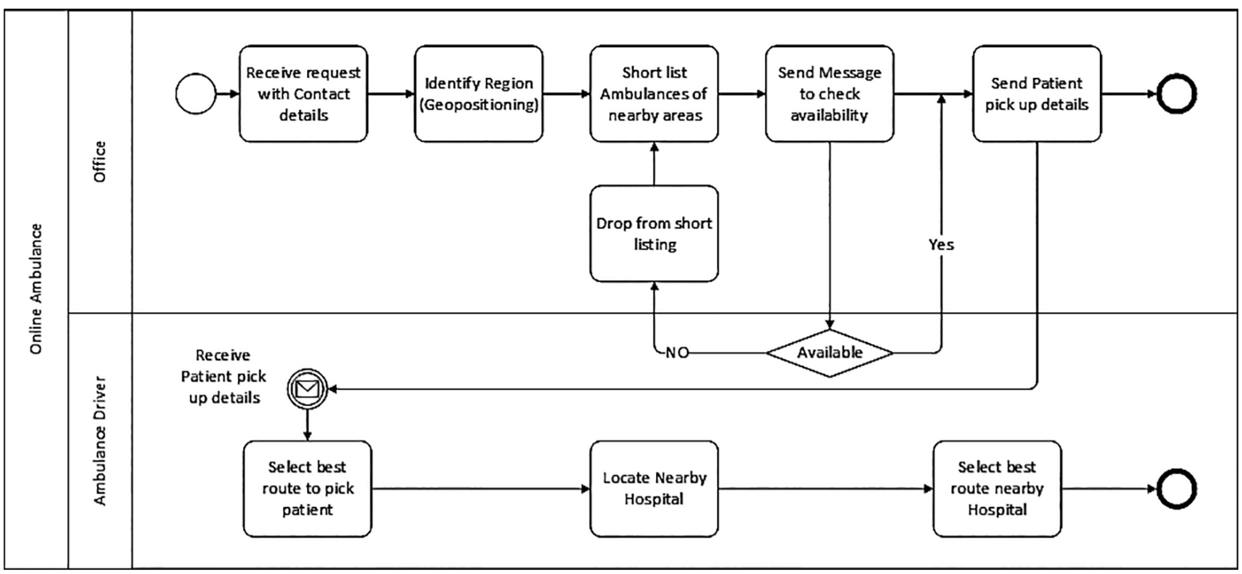

Figure 12: Online ambulance service process model

3.3.5 Integration

By studying and analyzing these modeled processes it is determined that there are certain points from where these processes can be integrated to further automate and reduce the manual intervention. By applying the integration approaches as discussed above, the types of integration are determined as shown in Tab. 7.

In this way, a complete process framework for services is made including both horizontal and vertical exchanges of information between participants as shown in Fig. 13.

Table 7: Integration type between processes of case study

Process 1	Integration approach	Process 2
Medicine box	Trigger	Room noise management
Remote health monitoring	Trigger	Room noise management
Remote health monitoring	Trigger	Room temperature management
Remote health monitoring	Push & pull	Online health consultancy
Online health consultancy	Push & pull	Online appointment
Online health consultancy	Push & pull	Online ambulance

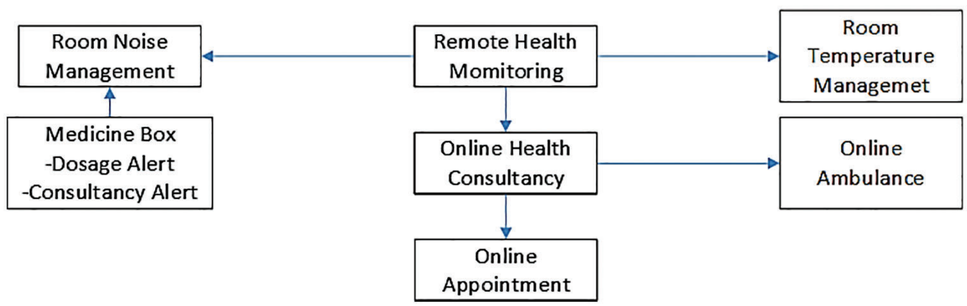

Figure 13: Business process integration framework for smart home, vehicle and health systems

For example, in service process of online health consultation and smart home, a family user will receive a prescription message from an online remote health consultant in response to the data sent by wearable or patient itself. The business process integration framework for the case studies based on the diagnosed type of integration (Tab. 7) is represented in Fig. 13. It can be observed that medicine box and remote health monitoring processes can be directly integrated with noise management to detect the alarms of the respective system and then to reduce the surrounding noise by lowering the volume of other noise producing devices as discussed in noise management process. Similarly, the remote health monitoring process, instead of just informing about the need for room environment adjustment, can be directly linked with the temperature management process for automatic adjustment according to the need and analysis.

3.3.6 Realization

The whole illustration, for complete integration of all individually discussed systems, using modeling technique is shown in Fig. 14. Accurate and complete representation is ensured by checking the consistency, correctness and integrity of model. Implementation of modeled processes needed to integrate in any environment is the step next to modeling, but implementation is not the scope of this article.

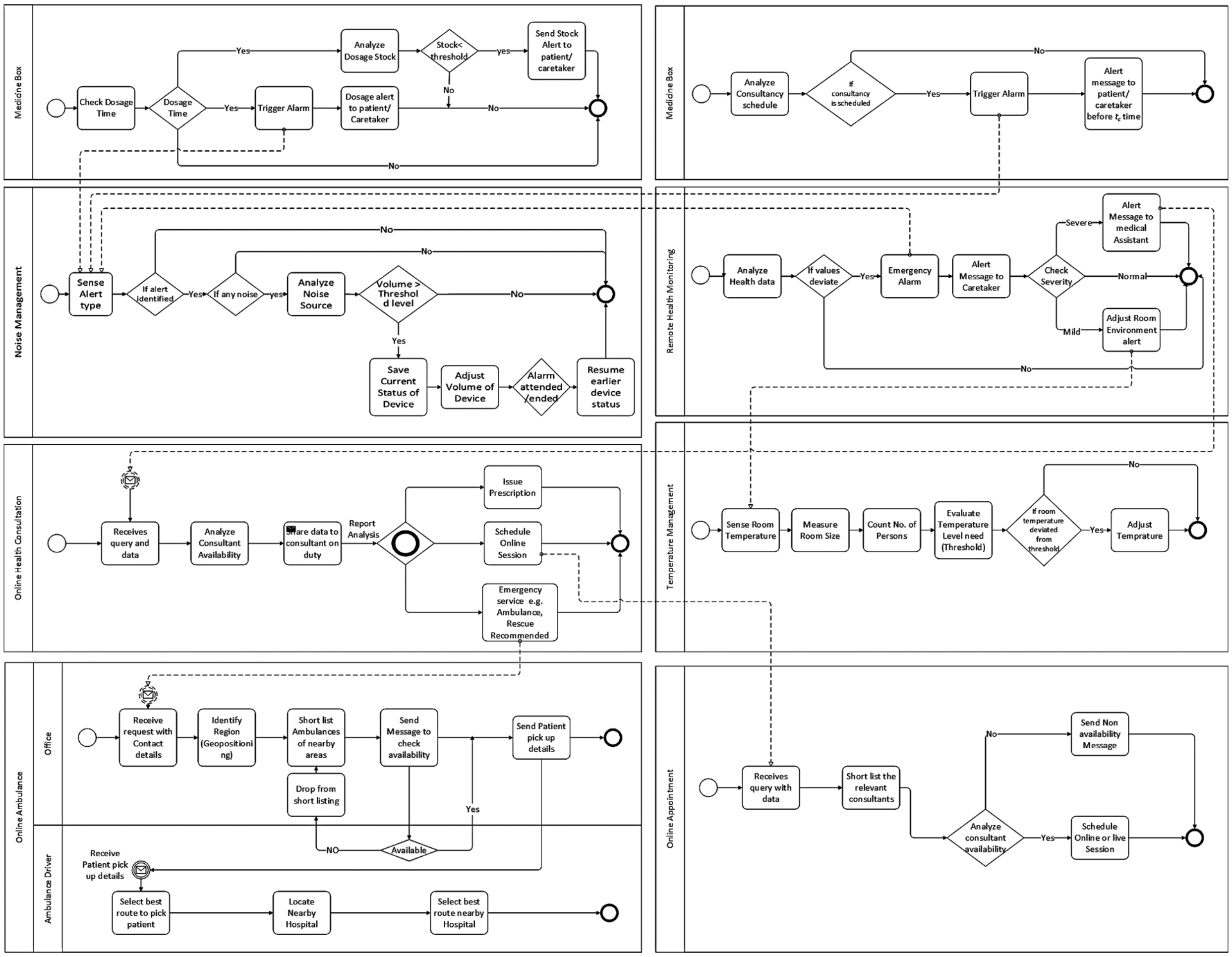

Figure 14: Business process integration modeling for smart home and smart health systems

4 Conclusion

An approach to the definition of business processes and modelling with consideration of integration is presented in this research paper. In particular, potential relationships have been discovered between various process models' elements. Furthermore, steps required to integrate process models are determined and specified in detail. Likewise, reduction rules are also identified for the simplification of integrated process model. BPMN based modelling and design of business processes is discussed on the grounds of detailed study and analysis of traditional vehicle, home and health services. Some new ideas related to the architecture of system, process modelling and integration of processes for smart systems are briefly presented in this paper. Moreover, a case study is devised from the smart home, smart health and smart vehicle, to apply this approach of process modelling for the demonstration of approach applicability. Approach can also be used for other languages of process modeling accordingly. In future work, tool support can be provided to integrate business process models and enhance accuracy.

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