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Smart Home Services Using Cloud and Internet of Things

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ABSTRACT

Today with the advancement of Internet of Things, the utilization factor has shifted from computers to every gadget being used by human. It is important that the end user services across different applications need to be offered at one-stop. In this paper a novel framework is developed based on cloud and internet of things that derives a new business model by integrating heterogeneous applications and devices. The integrated applications and devices are monitored in real time to provide smart services to end users in case of malfunction or repair of appliances to provide a suitable solution. A use case is implemented for smart home using the defined framework to integrate various application services and to monitor the appliances in real-time. Here heterogeneous applications related to smart home are tightly coupled to offer smart services in the event of failure or repair of home appliances and to assist end users to be energy efficient.

Key words: Cloud Computing, Internet of Things, Smart Services, Smart Homes

1. INTRODUCTION

As coined by Marshall McLuhan, today world is a global village where billions of objects and people are connected through global network [1] with comprehensive wireless internet technologies. This wireless interconnectivity between objects and people is coined as Internet of Things by Kevin Ashton in the year 1998 [2]. With the growing wireless communication, there is a persistent development in Internet of Things through smart connectivity and context-aware computation [3] utilizing the existing smart networks. It is expected that 100 million households will be smart by end of this year and it will increase to 300 million over next 10 years [4]. The consumer spends on smart services with respect to households only, will be €90.90 billion by 2018 and will accelerate to €122.77 billion by 2020 [4]. This indicates that the revenue growth and consumers using smart services will propagate rapidly across different applications. Hence it is essential that a seamless integration of smart devices must be done for integration of real-world objects [5] [6] to provide refined smart services across heterogenous applications.

2. LITERATURE SURVEY

With the swift changes in technologies and increasing heterogeneous devices, it is important that humans need to live
smart with wide range of interactions with a highly-networked world [7] which is currently done independently across different applications. But currently most of the services provided by Internet of Things are isolated and are coped with specific application. In [8] heterogeneity of devices and isolated applications that are tightly coupled to a specific context are described as a big challenge and various application scenarios are elucidated including smart home application where a need to manage the services & appliances intelligently anytime anywhere by any device is essential. In [10] integration of cloud computing and internet of things is discussed where service delivery is mentioned as one the key challenge and in [9] smart home is considered as a use case to integrate internet of things with cloud computing for measuring home conditions, managing home appliances. Home environmental conditions are monitored using internet of things and ZigBee wireless sensor network in [11]. In [12] a review of internet of things and its challenges are illustrated for smart home and smart metering where a holistic framework is derived to efficiently integrate objects in cloud-based internet of things and a more sophisticated user interface is required to visualize the data at device level where it will particularly aid consumers to understand the performance of appliances in smart home. Use case for industrial automation and IoT technology for real-time tracking of vehicles is discussed in [13] [14] where the applications are automated based on the threshold values defined in sensors.

The above-mentioned research efforts majorly focused on integration of smart home features, integration of devices, energy management using internet of things and cloud computing which are application specific. But it is important that the services offered in different applications need to be integrated for being smart to realize potential benefits and value by saving time and cost for the end users consuming services. This paper proposes a framework to establish a seamless integration using smart devices and sensors to realize smart services across different applications using cloud-based internet of things where scalable and reliable

services can be offered to end users. The defined framework is implemented using smart home use case that enables business opportunities and potential business benefits to service providers, business users and end users by integrating heterogeneous devices. A sophisticated end user and service provider interface is developed where services of heterogeneous applications can be managed in one single application which maintains high transparency and loyalty in business. The use case enables smart services to end users in case of malfunction or repair of appliances and assists end users to be energy efficient.

The remainder of the paper is organized as follows. Section III presents cloud based layered framework to enable smart services across various applications and in section IV a use case based on smart home is implemented using the defined framework. Section V explains the potential opportunities and business benefits to various users by enabling smart services. Section VI presents the discussions and results of use case implementation and conclusion is drawn in Section VII.

3. CLOUD LAYERED FRAMEWORK

The framework devised in Figure 1 is based on cloud internet of things which provides a flexibility for accessing the defined applications anytime and anywhere. It comprises of six layers which are reusable across diverse applications.

Integration Layer: In integration layer the devices that are connected to real world objects are registered using internet services cockpit where real time data is captured and updated in database layer.

Database Layer: The database layer stores the data that comes from real world objects, service provider layer, end user layer and business user layer. Here real-time data is stored in database layer that comes from sensors and actuators that are connected to real world objects through integration layer. The requested and processed service requests which comes from end user layer, service provider layer, business user layer is captured in database layer. Hence the business data is updated in database layer at regular intervals based on actions performed by users across different layers and data that comes from real world objects.

Application Layer: In application layer, business logic is defined as per the application needs and this helps to process the requests that are received from service provider layer, end user layer and business user layer. Application layer provides real-time data to end user layer after a refined business logic is applied and the service requests that are received from end user layer are also processed in application layer which helps to take business decisions. Rules engine defined in application layer monitors the appliances in real-time and enables end users to be efficient in terms of energy consumption.

End User Layer: In end user layer, the end users can monitor their devices and appliances in real-time to understand the performance trends and statistics to initiate appropriate actions. End users will also have the flexibility to raise service requests that will be processed by service providers and business users in collaboration based on the request type.

Service Provider Layer: Service provider layer offers services for the requests that are received from end user layer. Once the service request is received from end user layer, service provider will process the service request and will update the end users with suitable resolution. If the service request is application specific it will be further processed in business user layer.

Business User Layer: Application specific service requests which are received from end user layer to service provider layer are assigned to business users in business user layer for further processing. Once the service request is processed in business user layer it is updated to end users through service provider layer.

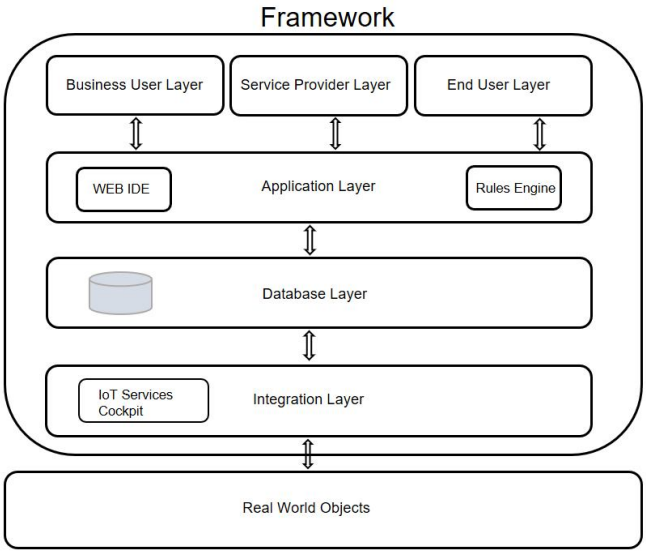


Figure 1:. Layered Cloud Framework to Enable Smart Services

4. IMPLEMENTATION

In this section, a use case with control flow is presented based on smart home with the defined cloud based layered framework which enables smart services and seamless integration to provide business opportunities and potential benefits to various users.

4.1 Use Case Design for Smart Home Services

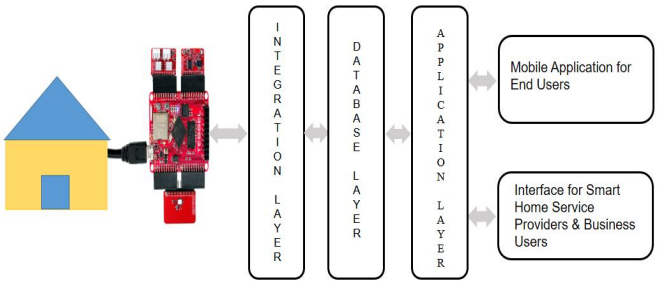


Figure 2: Smart Home Integration to Enable Smart Services

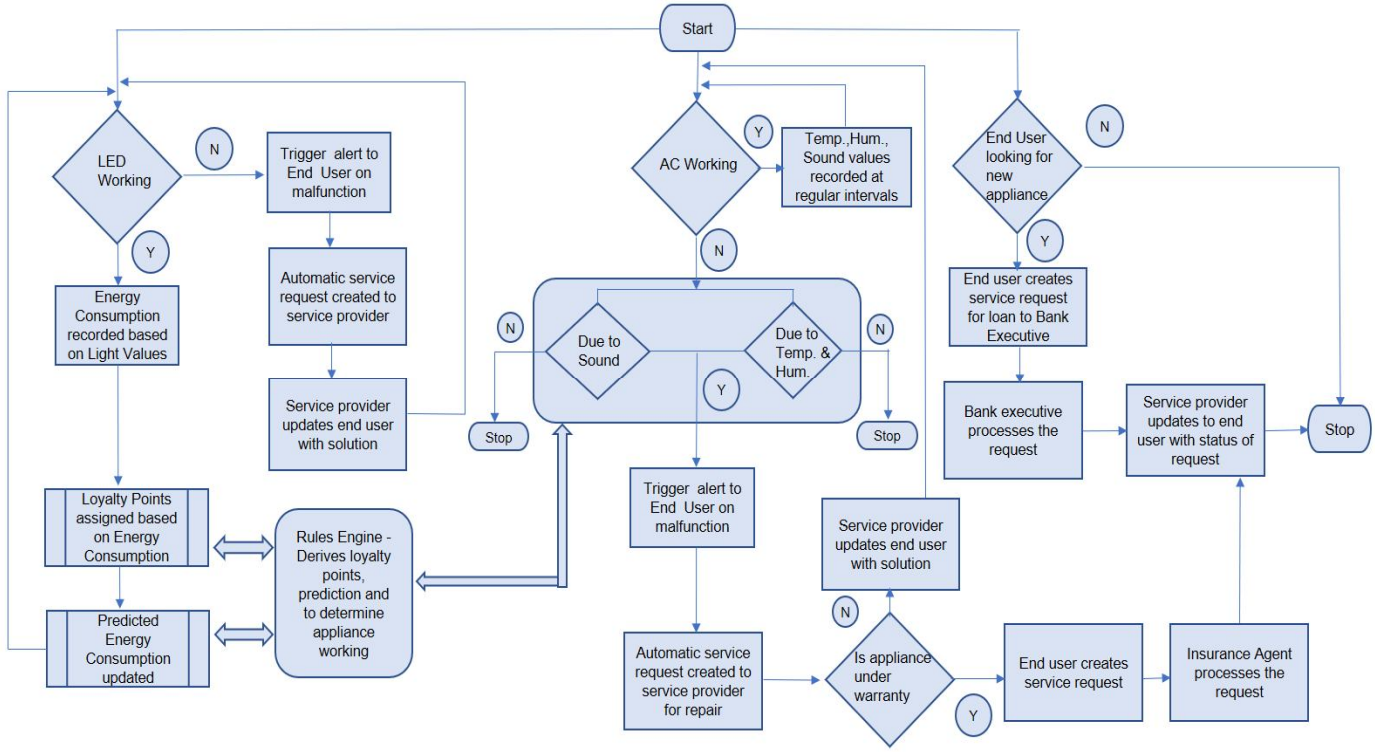


Figure 3: Control Flow for Smart Home

Based on the devised cloud layered architecture, smart home is considered as a use case to enable smart services to end users (home owners) through a mobile application. A unified web interface is provided to smart home service providers and business users (application specific service providers) as shown in figure 2 which will be an aid to enable ease of business across different applications. Control flow for smart home is defined as shown in figure 3 where heterogenous services like insurance, banking and consumer services are tightly coupled to provide services to end users with ease and flexibility. The appliances in smart home are monitored in real time to take appropriate actions based on the performance and functioning.

End User Services: A new mobile application is developed for smart home owners which enables the following services:

a) Energy consumption of LED is measured in smart home and loyalty points are assigned based on the energy consumed. Energy consumption is predicted based on historical readings which enables end users to be energy efficient. Here loyalty points and predicted energy consumption are derived based on the rules defined in rules engine. In the event of LED failure an alert will be sent to end user and a service request is created automatically to service provider for further course of action.

b) Appliance performance and functioning is monitored based on the room temperature, humidity and sound where an alert with be sent to end user if the functioning of the appliance is inappropriate. Here rules engine will check the functioning of the appliance at regular intervals as shown in figure 3 and it will derive the reasons of failure for creating an automatic service request to service provider for further course of action.

c) End users can raise insurance claims/renewal for non-working/working appliances where a service request will be triggered to service provider. As the service request is application specific the service provider will further process the request with business users in business user layer to provide a resolution. Here service provider will be the single point of contact for all the services that are offered to end users. In the event of air conditioner failure, end user can check if there is warranty for the appliance and can raise service request to business users for the claim as applicable.

d) Provision to request loans for purchase of new appliances is enabled where end users can raise service request for new loans. These requests will be further processed by business users (bank executive) in business user layer to provide a suitable solution to end user in collaboration with service providers

Smart Home Service Providers: A unified web application is developed for smart home service providers where service requests received from different end users (home owners) can be tracked in a single interface and this helps service providers to maintain transparency with end users. Once the service request is received for a repair or service of an appliance, it will be handled by service provider and if the request is application specific like insurance claims and new loans it will be processed by business users.

Business Users: Business users will process the service requests which are application specific in collaboration with service providers and the status of the request is updated to end users.

4.2 Using Tessel for Programming Internet of Things

Currently there are several platforms available for programming internet of things. Here Tessel 2 is used for implementing the use case, which is an open source robust development platform for Internet of Things, which enables to interact with real world objects through sensing and actuation [15]. Tessel 2 runs on java script and it has main features of
executing the programs faster, simple and wirelessly in a programmable environment. Easy to setup sensors and actuators, adequate RAM enables plenty of space for coding and execution with real time input/output and power management and more than this, it is a plug and play module ecosystem [15]. Ambient and Climate sensors are embedded with Tessel board to enable real time monitoring of devices. Ambient sensor ATTX4 is used to detect ambient light and sound [16] where light values are considered for measuring energy consumption and sound values are used to check if any noise is generated during the functioning of air conditioner. Climate sensor SI7020 is used to measure temperature and humidity [17] where these values are used to monitor the functioning of air conditioner.

4.3 Cloud Platform

It is important that the applications deployed in any sector need to be available anytime anywhere with high flexibility and this is facilitated with cloud platforms. Today there are lot of open source cloud platforms available and to implement the use case SAP Cloud Platform (SCP) trail account is used. SAP Cloud Platform provides an agile business application development offering myriad capabilities like improved user experience, easy integration, real-time analytics, hybrid mobile applications, internet of things services and HANA database [18] [19]. The devices that interact with real world objects are registered in internet of things services cockpit of integration layer and the data that comes from real world objects is stored in HANA database which is an in-memory database enabling the development and deployment of real-time analytics [20]. The communication between the real word objects and cloud is established using JSON which is easy and light weight data representation for storing and exchanging data [21]. Business application development is done using Web IDE in application layer and it is a web-based development tool which enables users to develop front end web applications [22]. The data that is updated in database layer is consumed in end user layer via application layer in real-time using REST-based OData service which is an open data protocol and this protocol helps to enable applications to share data across wide range of devices and platforms in way that is easy to understand and consume [23].

4.4 Web Applications

This section elucidates the web applications that are used to implement the use case based on the defined framework. The web applications are categorized based on the users consuming and providing services. Mobile application is developed for end users and cloud based launchpad is deployed for service providers and business users.

Mobile Application for End Users: A unified mobile application is developed for end users to monitor home appliances in real-time and to raise service requests as per the need. IOS application is developed using SAP Cloud Platform SDK that facilitates the users to develop native applications using Apple's modern programming language and provides flexibility to integrate applications and business processes [24] [25].

Launchpad for Service Providers and Business Users: A web-based cloud launchpad is developed using UI Development Toolkit for HTML 5 [26] that will enable better responsiveness across browsers and devices like smart phones and tablets [27]. The cloud launchpad enables an environment running on cloud platform where service providers can access applications related to service requests and business users can provide services to end users.

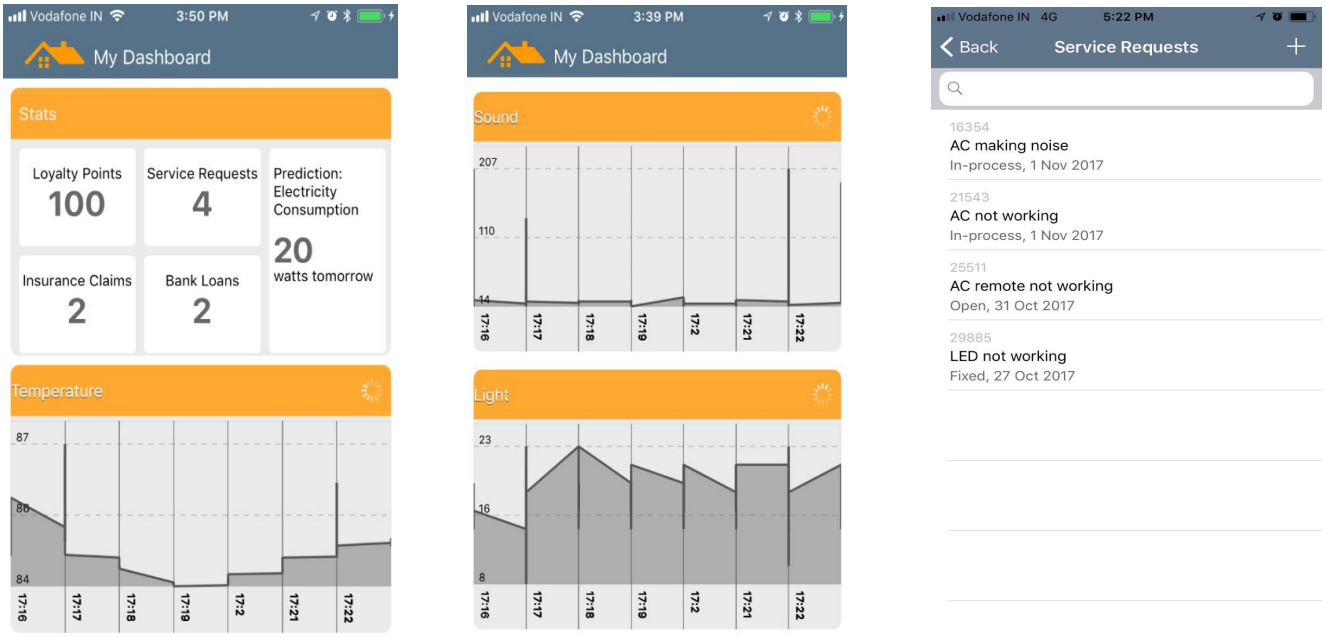
5. POTENTIAL OPPORTUNITES AND BENEFITS

There are several business benefits and potential opportunities that are realized after implementing smart home prototype using cloud layered framework. The opportunities and business benefits will vary based on the type of users. These users are classified into three categories – End Users (Smart Home Owners), Smart Home service providers, Business Users (Application specific executives and agents).

End Users (Smart Home Owners): End users are the users who consumes smart home services offered by services providers with less investment and more control on home appliances. There will be a single point of contact to end users for consuming various services across different applications without the need to approach multiple service providers. The new mobile application enables home owners to be energy efficient, monitor the appliances in real-time and provides a single platform to process repairs, insurance, loans related requests. This aids to take smart home business a leap ahead.

Smart Home Service Providers: With the new framework, a new business model is enabled to smart home service providers with a simple and easy to access user interface enhancing new business opportunities. Smart Home Service providers can check and process the service requests which have come from multiple end users in real-time and they are available to end users for service anytime anywhere.

Business Users: Insurance agents and bank executives will have transparency in business with the new business model. Smart home service providers will be the single point of contact where all the service requests received from end users will be processed in collaboration and this will help business users to get enhanced business opportunities.



(a) (b) (c)

Figure 4:. End User Mobile Application

Figure 5: Service Provider and Business User Interface

6. RESULTS AND DISCUSSIONS

There are several business benefits and potential opportunities that are realized to offer smart home services after implementing smart home prototype using cloud layered framework. The study conducted in South Korea to understand the process of adapting smart home services to end users and its importance in ICT industry [28] and to reduce CO2

emissions indicate the importance of smart home services to various users at different categories. Users for offering smart home services are classified into three categories – End Users (Smart Home Owners), Smart Home service providers, Business Users (Application specific executives and agents).

Experiments are conducted on smart home prototype with the define framework using sample data sets from last three years and data is also generated in real-time.

End User Services

a) Energy consumption of LED is monitored in real-time by end users using the developed mobile application. Based on the energy consumed, the loyalty points are assigned and expected energy consumption is derived as shown in figure 4 (a). Here energy consumption is derived based on the light values generated from ambient sensor where lesser the energy consumed the more loyalty points are assigned for the user to be energy efficient and energy prediction is updated in real time based on historic readings of light values as shown in figure 4 (b). An alert is triggered to end user in the event of LED failure where no light values will be shown in mobile application and an automatic service request creation to service provider is tested successfully. The status of the created service request is tracked in mobile application as shown in figure 4 (c).

b) Performance of automated air conditioner is monitored and controlled in real-time. Here temperature, humidity and sound values are generated from climate and ambient sensors as shown in figure 4 (a), (b) and these values are used to monitor the functioning of appliance at regular intervals. Automatic alert creation to end user and service request creation to service provider in the event of malfunction or failure of appliance depending on the pattern of temperature, humidity and sound values based on the defined conditions in rules engine is tested is several cycles. The status of the created service requests for repair of appliance can be tracked by end user as shown in figure 4 (c).

c) Service requests are created for claiming insurance of an appliance that is under warranty and the status of the request is tracked by end user using insurance claims section in mobile application as shown in figure 4 (a).

d) Loan request for purchase of new appliance is tested by creating a new service request in mobile application. This request is processed by service provider and bank executives in collaboration. End user can track the status of loan service requests using bank loans section as shown in figure 4 (a).

Service Requests

New Service Request

4
All Service Requests

Work Items (23)

Search

Service Request ID	Customer ID (Req By)	Title	Description	Status	Date
16354	26354	AC making noise	AC making noise too much	In-process	1 Nov 2017
21543	36452	AC not working	AC is turning-on at all	In-process	1 Nov 2017
25511	46264	AC remote not working	remote stopped working	Open	31 Oct 2017
29885	37461	LED not working	smart LED is not working	Fixed	27 Oct 2017

Figure 6{ Open requests for service provider in Service Requests application

Insurance Requests

2
All Insurance Requests

Insurance Request ID	Title	Description	Requested By (Customer ID)	Date	Status
27365	AC repair/replace	AC is not functioning	36452	30 Oct 2017	Open
31625	LED repair/replace	LED not working	37461	1 Nov 2017	Open

Figure 7: Open requests for Business User (Insurance agent) in Insurance Requests application

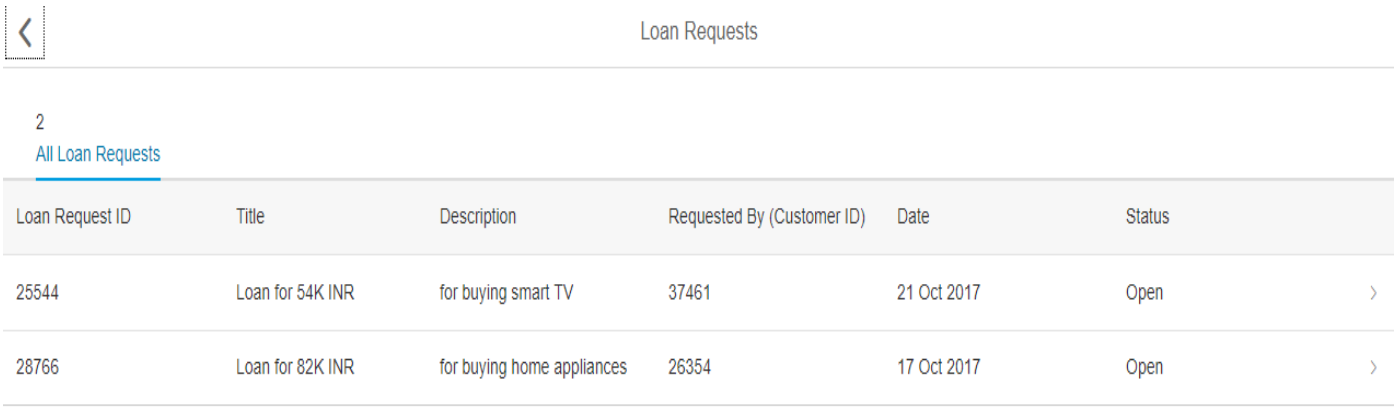


Figure 8: Open requests for Business User (Bank Executive) in Loan Requests application

Smart Home Service Providers

A sophisticated user launchpad is developed for service providers and business users as shown in figure 5. The customer's application in the launchpad will indicate the total number of customers that the service provider is serving, and the service requests application will show the total number of requests that are open based on the application area. The service requests that were created by end user in figure 4 (c) for repair of appliance and LED failure are updated in service requests application as shown in figure 6 where the service provider provided the resolution and have set the status of the request to complete. Once the request is completed, triggering of automatic notification to provide an update on completed requests to end users is tested successfully.

Business Users

Smart Home service providers will be the single point of contact to business users for processing application specific requests. Application specific requests created by end users in mobile application are updated in service provider launchpad - insurance requests and loan requests application as shown in figure 5. Service requests raised by end users in figure 4 (a) for insurance claim of an appliance under warranty is updated in insurance requests application as shown in figure 7. Here service provider and insurance agent processed the requests in collaboration and an automatic alert is triggered to end users at regular intervals to update the status of the request successfully. Service requests created by end users for purchase of new appliances in figure 4 (a) are updated in loan requests application as shown in figure 8. The created requests are processed by service provider and bank executive in collaboration and alerts are sent to end user on the status of the request at regular intervals.

7. CONCLUSION

This paper explored various options for integrating industry specific applications using layered architecture based on cloud internet of things which facilitates the accessibility anytime anywhere and using this a new business model is defined which enabled potential business benefits and opportunities to various users. The approach consisted of providing smart services to end users across different applications, monitoring of appliances and automation, assisting end users to be energy efficient using Tessel, SAP cloud platform, OData and JSON for data exchange. The approach is successfully demonstrated using smart home as a service use case based on the users consuming and providing services. The infrastructure can be adopted to industry specific solutions if there is a need to integrate cross applications.

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