New Product Development – A Transformational Perspective with Internet of Things

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Abstract: *There is a fierce competition prevailing in the market due to different aspects that influenced such as globalization. Customers are exposed to the variety of goods encapsulated with complete information. Organizations are constantly on the lookout for means for survival. New product development is one such area where the organizations are concentrating rigorously. New product development is amongst the eight constructs of supply chain and a very important one as the future of the organization depends on the new product launched by the organizations. For a successful product launch, it is vital to be proactive in capturing the customer requirements. Researchers vide this study and in consultation with industry experts in supply chain and Information-technology area recommend the implementation of Internet of Things in this domain. The primary considerations are due to the speed of the Internet and the ubiquitous presence of Internet and Internet of Things. The business value derived with this implementation is discussed along with the recommended architecture for the application.*

Index Terms: *Business Value Realization; EDSOA; Internet of Things; IoT Architecture; New Product Development.*

I. INTRODUCTION

Product development is a one of the eight constructs of supply chain management and is considered one of the most important ones [1]. Markets in terms of competition are getting brutal day by day and organizations are finding out ways and means to survive. The market leaders are the firms that are customer focused, that are manufacturing or offering services as per the customer demand with agility. Hence, there is a positive demand from the market for their product or services [2]. The contribution of new product development is highly appreciated as it is proving to break the nexus and create a market niche for the organization [3]. Traditional ways of business are challenged by the digital transformations creating verticals in the market increasing the competition further. The organizations therefore are under tremendous pressure to embark the innovation path. Surveys have revealed that innovation is the top most agenda of about 80% of the organizations. Digital technologies are defining new ways of doing business replacing the brick and mortar and contributing in the change management of business processes such as product development [4]. Industry 4.0 is a world of cyber physical systems that is revolutionizing almost all the aspects of Information technology brining about a revolution in the way things were done in the past. There is a significant amount of innovation registered in the network domain, where Internet has become the fastest medium of data transfer connecting billions of things. Internet of Things is one such revolution that has transformed the industry. The term "Internet of Things" (IoT) was coined by Kevin Ashton in the year 1999, which created a wave in the market globally [5]. Billions of things got connected globally transferring data over the Internet in an uninterrupted way [6]. Internet of Things is a network of sensors that apart from the sensing have the capability to transmit the information over the network to a central repository from where it is used in the decision support system. In effect, we can observe that the physical and the virtual world connect with each other with Internet being the medium [7]. The forecasts depict an exponential growth in number of connecting devices. Figure 1, shows the current numbers and forecasted growth till the year 2020. There are estimations of 50 billion devices getting connected over the Internet by the year 2020 [21].
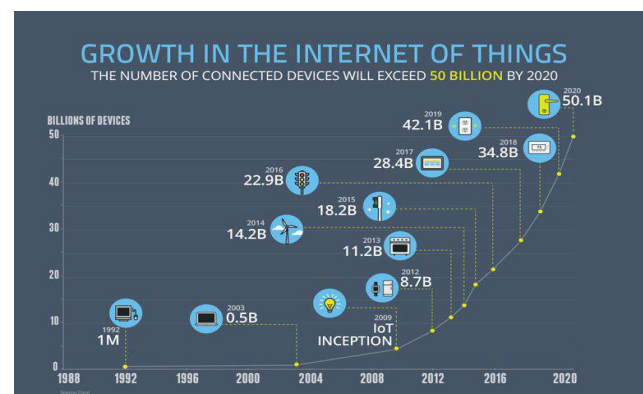

Fig 1: Growth in the Internet of Things [21]

Irrespective of the size of the organization, currently digital revolution has influenced almost each organization. The digital products have transformed the markets completely [41]. In the digital era, healthcare industry, too, has evolved its offerings with SMART wearables. This innovation has created an explosive demand in the market. Wearable devices have sensors affixed to collect data, which aid in processing information for creating insights and threshold basis alerts. The pre-requisite include a light, connected device with long battery lift [39] [40].
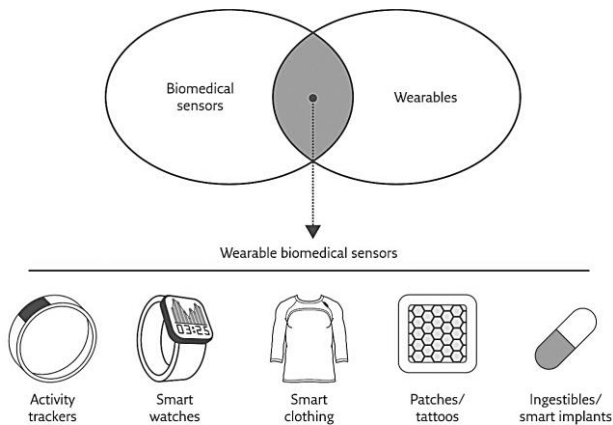
Fig 2: Wearable biomedical sensors on IoT Platform [40]

Therefore, it is evident that the complete supply chain is digitized helping the customer usher into a digital era. The primary objective of the IoT landscape is to connect things anywhere, anytime at any place using a medium such as Internet [43]. Researchers have conducted a focused group discussion with the industry experts from the supply chain domain and interviews with digital leaders to gather data/information. The emphasis was on the applicability of IoT in the field of new product development and further on the appropriate IoT architecture. The pros and cons of the architecture were validated as against the traditional one and benefits were explicitly cited.

II. REVIEW OF LITERATURE

Due to the environmental changes such as globalization etc., customers in the current era are exposed to a variety of products. This enforces a lot of pressure on the manufacturers to keep the products current and competitive. Organizations to ensure longevity of business have to align to the customer requirements and create a niche in the market [8]. Moreover, a paradigm shift is observed since traditional marketing i.e. transactional marketing has transformed into a relationship marketing [5]. Organizations have realized the importance of being customer focused and the need for customer relationship management (CRM). Successful CRM practice generates enormous business value and at the same time imports the market view into the organization [5]. The customer-oriented approach begins with the customer's inputs in the product that the organization develops for the consumption [8]. In addition, product development is the most important stage for the organization as the future sales, reputation and brand image is dependent on the product that is offered by the organization [8]. There are multiple sources from where the information is pooled into the organization for the new product development. The sources include the organization research and development team, sales and marketing team and beyond the organizational boundaries suppliers and customers. There are instances on the basis of which we can quote that quite a few organizations have failed in delivering to the promise of a high quality product or idea in the new product development domain [10]. Therefore, the instances where the products have failed are recorded to be quite high [11]. It is very important that the responsibility of

importing the customer pulse into the organization is taken over by the sales and marketing team as they are the closest to the customer [12]. Profoundly, this reiterates the fact the organizations need to be customer focused, as the customer is the most important entity beyond the boundaries of the organization. The so-called customer century has ticked along with the 21st century as the non – profit organizations and governments are facing tremendous issues selling products to the customers [13]. The customers of this era are impatient and choosy as far as the products are concerned. They expect the organization to fulfill their orders as per the customizations and preferences demanded [14]. Hence, organizations should give first preference to the information gathering from the customer end about their demand. The collected information becomes a stream of customer inputs in the entire new product development process. Researchers, in their previous study, had carried out an empirical analysis. The conceptual model was formed on the basis of the literature review. Fundamentally, the conceptual model consists of agencies which contribute with their inputs in the new product development process. The conceptual model created is demonstrated in fig 3.
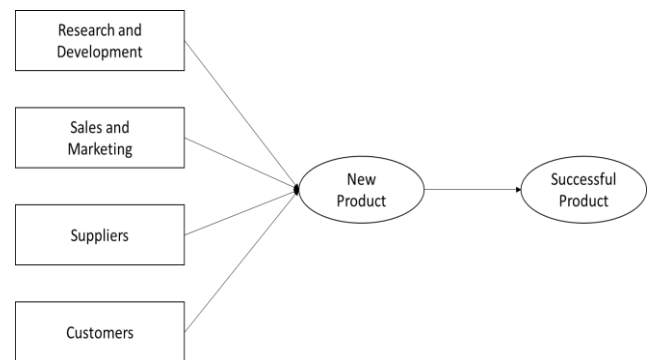

Fig 3: Conceptual Model [8]

The conceptual model was tested successfully with the help of measurement model analysis, which was conducted in two stages post the exploratory factor analysis. The two steps included the confirmatory factor analysis and structured equation modelling. The path analysis unearthed that suppliers and the research & development teams input did not support the effectiveness of the new product development process.

However, the impacts of sales & marketing team and customers were positively influencing the new product development process. Both the inputs were found to have almost equal regression weights concretizing the thought that 21st century is a customer century. Markets will be driven by the customers, and for any organization to survive they need to be customer centric [8].

The path analysis is represented in table 1 which was derived in the previous study by researchers with the help of structured equation using tools such as SPSS 20 and AMOS 21:

Table 1: Path Analysis [8]:

Path	Standard Regression Weight	Significance Level	Status
RD → NPD	0.1	0.718	Not Supported
SM → NPD	0.35	***	Supported
SU → NPD	0.19	0.213	Not Supported
CU → NPD	0.30	***	Supported

Organizations are subjected to continuously evolving customer demands and it becomes crucial to imbibe agility in customer response. Customers expect organizations to be proactive and responsive to the customization expected [15]. Organizations have to make abundant efforts to balance between the organizational objectives and meeting the customer demands. The goal is to achieve a competitive edge over the competition in the market [17]. It would be nearly impossible for the organizations to adapt without the information technology support. In the current era, Internet is the fastest medium for information exchange. Revolutions in the network domain have been experienced in the past decade transforming a small micro network to a global one connecting billions of things [16]. Internet of Things (IoT) is one such innovation, which has revolutionized the business processes bringing the physical world closer to the virtual world. IoT connects with different system and creates a landscape consisting of heterogeneous devices, which connect with each other seamlessly. All sensors in the system have unique identifiers to trace the source of data, which is stored in a central repository. Various business models are deployed to derive useful and interesting real time analytics for the managers to take fact based decisions [7] [20]. Market value forecasts for the growth in the number of IoT devices show a significant rise in the coming years [18]. Year 2014 global market value of IoT was about 600 billion USD mark which is expected to surpass one trillion USD mark by the end of 2018 [18]. Similarly, the connected devices globally are projected to reach a level of 50 billion by 2020 from about 18 billion in 2015 [21]. It is also expected that there will be a steep growth in the installed base of IoT device from a mere 5 billion in the year 2015 to 31 billion in 2020. Forecasts state that the consumer sector will dominate this growth. Studies reveal that in the year 2014, sensor data consumption was mere 8% of the "target rich data", which will reach to a level of 21% by 2020 [19]. On the consumer /customer front, digital innovations have made in-roads enabling the customer to remain connected to the organization for the after sales processes [22]. Some of the starching facts about the Internet and social media penetration revealed in a report named "Digital in 2016" were [23]:

- 3.42 billion Internet users in the year 2016, equalling 46% global penetration;
- 2.31 billion social media user population, delivering 31% global penetration;
- 3.79 billion unique mobile users were reported, representing 51% global penetration;
- 1.97 billion number of Mobile social media users, equating to 27% global penetration

Further analysis was conducted in this domain for the source of Internet users. The stats reported that the desktop source remained behind at 43.3% to the mobile source, which was at 56.7% when compared over a period of three years (2014 – 2017) [24]. The mobile data traffic is forecasted as an average of 366.8 Exabyte's for the year 2020. This is equivalent to 120X of the global traffic generated in 2010 [25]. These facts not just encouraged but motivated the researchers and the panel exposed to the focused group discussion to recommend the IoT implementation strongly for this very important organizational objective of new product development

III. INTERNET OF THINGS ENABLED BUSINESS TRANSFORMATION: DERIVING THE BUSINESS VALUE

Business opportunities with Internet of Things: Organizations are diverting their attention and trying to figure out new ways using digital technologies. New product development results in 40% sales turnover and 30% of the profits for a company [31]. Ubiquitous presence of the Internet and Internet of Things has provoked its implementation in various domains including new product development. [32] [42]. Apart from the other tools of new product development, the data originated from the IoT landscape is also proving to be an important contributor [33]. Organizations in the digital age have to change their business processes in order to adapt to the best practices. Disruptive ways have emerged to handle some traditional problems, which have the potential to derail some of the bigger players in the market who hesitate to adapt. Organizations have to rejuvenate their business processes with the help of IoT based innovations in order to survive [32]. The organizations need to explore ways to exploit and extract the intelligence from IoT based systems. Real time data related to the different operations originated from the IoT landscape combined with the analytics proves to be a signification advantage for the organization [17]. Organizations need to evaluate the data and the insights derived from the data to draw inferences and accelerate innovation. IoT helps design products with interconnectedness and interoperability. Real time inputs help design products allowing them to adapt to the changes in the environment. Traditionally, the success of the product was known to the organization through sales figures and complaints from the customers resulting in product callbacks and redesign [32]. For an innovation to become a successful product, the lead-time was very high. Organizations in the previous era were reactive to the market performance of the product. Moreover, the warranty costs for the product failures were very high. This affected the brand image negatively and negatively influenced customer retention since the customer satisfaction was very low [15]. Internet of Things gives the competitive edge to the organization by virtue of the proactive approach that gets imposed.

IoT aids continuous engineering due to which the designers are able to learn during the process while it further simplifies the complicated processes. Products continuously address the dynamic requirements thus improving the customer satisfaction [32]. Within the business, new product development proves to be a vehicle of innovation. IoT generates opportunities for the business in four categories i.e. iteration, micro-segmentation, continuous product improvement and increased complexity.

Iteration: IoT origin real time data emerged from a smart device (sensor with sensing and data transferring ability) of an existing launched product can be used to improvise the quality of the product under development [34]. Smart devices fitted on the vehicles that transmit the warranty data, testing data, engine data etc. can be used as an input while designing a new product. The usability of the data is critical to draw conclusions basis the analysis and various correlation that are built [35]. This method establishes the best fit of the new product with the customer requirement and hence it is followed by most of the organizations, which are looking for a new product to be developed and have an established product in the market [34].

Micro-segmentation [34] [35] [36]: The other opportunity for business is to identify the requirement of a specific customer segment. The data from the smart device helps the organization gather all the relevant insights and map it against the targeted customer segment. Product development team considers this information while designing the product. Data from smart products allow a high degree of customization in the product design that the customers desire, which otherwise would not have been possible. Organizations adopt specialized ways of segmenting the customers so that the personalization demands of different segments can be achieved. This adds tremendous business value and helps in customer retention.

Continuous product improvement [34]: This subject seemingly similar to the iteration process has a fundamental difference of making this process distinct. Continuous product improvement adds value to the existing product during its life cycle instead of contributing to the future product. Instead of depreciation, there is an increase in the value of the product over its life cycle. This process aids the changes in design for the product to perform and improve the reliability of the product.

Increased Complexity [33] [34] [36]: The aspect of increased complexity pitches in when the smart data is clubbed with external third party data which can be accessed to derive meaningful insights. The challenge for the organization is to handle large volumes of data over the complete process increasing the complexity. By combining the data from third party with the internal data and smart device data, business can extract full potential from the data by way of different correlations that would establish during the analysis.

Impact of smart data on cost and cycle-time [34] [36]: Smart data emerging from the sensors of the IoT landscape impacts the cycle time of the new product development process. The efficiency of the process is determined by the parameters such as cost and cycle time. Previous studies have revealed that faster decision-making is one of the ways to lower the costs. Complexity of products is at times bound to increase with the data input from smart products. However, at the same time the data recorded by the product can throw insights about the challenges faced. Mitigation plans can be made proactively while developing new product and assemblies. This reduces the cycle time for the new product and eventually results in cost reduction. The time to market for the product reduces improving the visibility of the brand in the market increasing its market share. Data generated by the smart devices helps identifies failures and its patterns aiding the organization with ways to avoid the same. Design efficiencies are achieved with the smart product data inputs retrieved from already launched products. Real time performance data helps in fine-tuning the specifications during the process. While the cost of the smart products is augmented to the new product development process as a fixed cost, it reduces the variable cost of the process substantially. Usage of smart product data effectively works in favor of the organization improving the customer satisfaction. With real time data there is a better collaboration amongst the various departments in the organization eradicating the inefficiencies due to the involvement of multiple stakeholders.

Previous studies have mentioned about the formation of metrics to measure the success of IoT based product development. Researchers in this study have identified the areas where there is a need to monitor and measure the different parameters to determine the efficiency of IoT based new product development [37]:

- Research and development expense and total development cost
- Time to market for the new product
- Profit percentage from the sale of new products
- Customer lifetime value (CLTV)
- Product Quality as volume of returns and costs associated with warranty
- Net promoter score measuring customer satisfaction
- Recalls in a stipulated period
- Complaints registered with response and resolution time for the same.

IV. INTERNET OF THINGS: RECOMMENDED ARCHITECTURE

The fourth industrial revolution marked the world of cyber physical systems. The spread of Internet was rapid wherein it surpassed the traditional usage of just being a publication platform. Distributed computing took over the entire business as an environment. The innovations in the network domain also brought about a revolution in the things such as sensors, RFID etc. which are connected to the physical world [26].

The Internet of Things facilitates integration of physical world and the information world [7]. Intelligent input is provided to the users by the sensors deployed in the IoT landscape that are responsible to capture the change of state in the physical world. The process of decision-making changes to decision basis data instead of decision basis guts. Collaborative intelligent services are available that form the base for understanding of the different meanings of changes in the physical world. There are certain inherent characteristics that differentiate the IoT based decision-making system from the traditional information management system. They can be elaborated as [27]:

a. A dynamic and adaptive system interacts with the sensing layer as the next step for the captured data. Based on the application for which the IoT is deployed, the sensory layer supports the intelligent layer. Hence, it can be quoted that contextual information is passed by the sensory level to the next layer that is adaptive to such information.

b. Business events drive the execution, which eventually means that the IoT service layer is event driven. Internet of Things becomes widely used application as it aids the business processes by managing the events by controlling the event driven services. The sensing layer captures the data real time and the algorithm responds to the events. User needs to query the traditional systems while in case of IoT based system triggers are created by the user for the relevant information of the events.

c. IoT based systems are characterized mainly by the heterogeneity in the landscape, which operate collaboratively to give the desired output whereas in case of traditional systems the linkages are query based.

d. Keyword based search is executed by the search engine in case of traditional systems. While in IoT landscape the values retrieved by the sensing layer is basis the matching of an event, which is actually lifelong.

e. Proactive systems fall into the Internet of Things landscape while reactive mechanisms work in the traditional systems. Agility is imposed on the system with the help of real time information. This real time information converts the application into a predictable system for events orchestrating the business activities. Connectedness and collaborative framework form an IoT landscape wherein the underlying construct is a shared information platform which traditional system lack.

The researchers deliberated on the applicability of the relevant architecture for the new parts development. The experts from the information technology working for digital strategy endorsed the use of Event Driven Service Oriented Architecture (EDSOA) for the chosen domain. Event based capture of data, expected heterogeneity and interoperability demanded at different layers formed the basis of the recommendation. EDSOA currently is discussed as the architecture for the future that would support Internet of Things [28].

Researchers in the past have identified the challenges in the traditional SOA. Fundamentally the non-customized web services form the basis of the traditional SOA, while carry an integral risk to the entire architecture. Once put to use the web services cannot be changed. The life-cycle management of services needs to be activated along with the overhead of version control etc. that adds complexity to the entire eco-system. In case of web services, certain inefficiencies are noticed such as response time, dependencies on other services, built in rigidity etc. [27]. Traditional SOA differs from the EDSOA on four fundamental parameters i.e. Degree of coupling between the different systems, mode of communication, stimuli or trigger and the response from the system [28].

Table 1: Difference between traditional SOA and Event Driven SOA [28]:

Characteristics	Traditional SOA	EDSOA
Coupling Degree	Loosely coupled exchanges	Decoupled exchanges
Mode of Communication	One-to-One	Many-to-Many
Trigger/Stimuli	User based (Query)	Event based (Event)
Response	Synchronous	Asynchronous

The essential components of an event driven SOA are:

a. Sensing layer: This layer consists of components and sensors, which are vital parts of the EDSOA architecture. Numerous advantages of such a component-based development include algorithms for exception handling, intricacy management, and reduction in configuration time. The components are reusable without compromising or sacrificing on the quality [29]. Components based architecture integrates with all the third party systems enabling the business processes. Since every event is associated with a component, event-based workflows form the output from this module. The communication between the different layers is enabled using messaging BUS along with the event orchestration engine [27]. Careful handling of the two basic components is essential in a component model. First component is of unified communication that is triggered with the events for which it is important to have an integrated master data. Secondly, for the services to be highly available with reduced latencies, the provisioning of component proxies is required.

b. Communication layer: This layer mostly consists of a messaging Bus, which has a common data model, set of commands and an infrastructure for messaging communication for different systems [27]. To ensure the performance of the system asynchronous mode for the communication of the information transmitted by every component is configured [27]. The information gathered and transmitted by the components is related to the business events. An inbuilt security is automatically inherited by the system as the components have to subscribe for the want of information from the other components. The information delivery is ensured with the help of subscription.

The configuration aids a synchronous way of delivering the data and therefore there is a flexibility of setting any protocol [29].

c. Event orchestration engine [27]: The event orchestration engine enables the delivery of the communication since similar messages are exchanged between varieties of components. As the data flows in the system the event based business rules are configured in this layer. The responsibility of the event orchestration engine is to copy and forward the messages to all subscribers in an agreed syntax which could be EDI, XML, flat or binary.

d. Composite UI [27]: The information of all types is consolidated in a single console i.e. the composite UI for the end users. The quality of the information is ensured while the complete information is compressed in a single view of a dashboard. Different users of the system get different types of information basis the access held by them. The dashboard has the capability to give the complete information of all the entities that are deployed in the landscape. The information is stored as system of records (SOR) which the end users can get access to via navigation.

e. IT security [27]: Due consideration is given to the important pieces such as IT security with the implementation of component model. Multiple components can be monitored with a single sign on. With user access controls implemented, the information passing through the different layers need to be secured. This ensures a complete holistic experience.
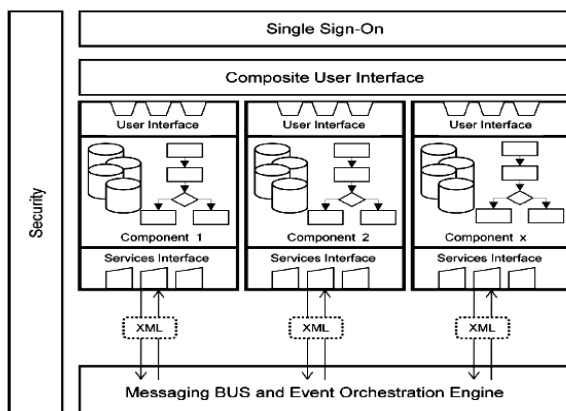

Fig 4: The EDSOA architecture [27]

Event Driven SOA Benefits [28] [29] [30]:

EDSOA is a completely scalable architecture capable of interacting with brick and mortar system in the landscape, in contrast to the traditional SOA. Developer is awarded with flexibility to configure messaging services that are multi-dimensional in this system. Multiple requests are generated the moment a user fires a query, in a parallel mode between the different components, which can lead to latency issues in case of a traditional SOA. Messages are handled asynchronously while the events trigger automatic requests in case of an event driven SOA. Over the landscape, EDSOA safeguards that there are quick and seamless responses. Traditional SOA fails at peak loads while processing requests with agility, creating user experience issues many times. In case of EDSOA, multiple components get added and the peak load scenario is mitigated. This further transforms the system in a predictable and proactive environment wherein augmenting of new business processes can be carried out with ease. As discussed earlier, EDSOA provisions the master-data-management component separately, that helps resolve any dependency conflicts. Since asynchronous messaging creates, a system of record the event orchestration engine can direct to a particular record directly. Content validation is seamlessly done by just interrupting the message flow as a part of trouble shooting. Even in case of a breakdown the maintenance of the components can be ensured by replacing / upgrading it preventing any disruption to the normal operations. The debugging of an EDSOA architecture system is much faster than any other architecture as the components are decoupled and interaction is enabled by way of publication and subscription. Business logic changes or new logic configuration is much faster in a decoupled component setup and event handling is therefore, done in an efficient manner

V. CONCLUSION

With the experiences provided by global players in a digital way, the customer expectations have rapidly progressed [15]. It depends upon the organization whether to take it as a setback or an opportunity to introspect and action to come out with a viable and demanded product in the market to remain competitive [32]. There are many emerging standards in the product development domain to look for which have all the possibilities of promising a niche market acceptable product [8]. The organizations have to devise different ways and means to cater to the volatility in demands keeping speed and agility at their core attention. Typically, the experience of the experts quotes that developments by way of the waterfall method may not result in innovation [38]. The need for the organizations to implement digital solutions such as Internet of Things is imperative. Internet of Things helps the organizations derive the business value and at the same time reduces costs helping achieve higher customer satisfaction. Researchers vide this study have elaborated on the need for implementation of IoT along with the architecture that will best suit the new product development application. With IoT providing higher level of interconnectivity and the integration between the heterogeneous systems, customer insights are derived seamlessly from the data. It is crucial from the point of view of organization to have the information about the customer demands and the changing trends in the market. IoT helps the organization to get these insights and take appropriate fact based decisions that impact the future of the organization. Internet of Things due to its wide applicability in the business can soon become the next big thing influencing all the business processes [44].

VI. PRACTICAL IMPLICATIONS

The organizations involved in the product development business can implement IoT based new product development to ensure customer satisfaction and customer retention. The decrease in costs and reduction in lead-time in the product development will help organizations in maintaining the relationship with the customer and remain profitable simultaneously. The challenge of high warranty costs etc. is also mitigated with the input of IoT origin real time data into the product development process.

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