IJRTBT

WEARABLE INTERNET OF THINGS (WIoT): OPPORTUNITIES, CHALLENGES AND BUSINESS MODELS FOR DIGITAL ENTREPRENEURS

Rajiv Ranjan Singh[1*], **Swapan Kumar Majumdar**[2]

[1]Electronics & Communication Engineering, School of Engineering, Presidency University, India
[2]Operations and Information Systems, School of Management, Presidency University, India

**Corresponding Author's Email: rajivranjansingh@presidencyuniversity.in*

ABSTRACT

Technology is the biggest enabler of change. The technology that is changing our lifestyle is Internet of Things (IoT) and Wearable Internet of Things (WIoT). The fusion of electronics, communication and internet technology have given a new prospect for WIoT. Technological innovation and social engineering are two different things. The enabling power of WIoT is infinite; the progress of adoption of WIoT is relatively slow. WIoT embodies the necessary aspects of sensing, processing and communicating. In this paper we discuss the opportunities and challenges from the developer's and digital entrepreneur's perspective, which influence the business models for WIoT. In the coming years, digital entrepreneurs targeting wearable device markets must focus on innovation, which may lead to the acceptability of the product by a larger section of society, from children to elderly. Additionally, they must strategize in such a way that not only they overcome the fierce competitors but also the legal hurdles, rapidly changing customer demands and technological innovations. Finally, we suggest a business model for budding entrepreneurs to succeed in the WIoT market. This paper recommends the strategies, business models, and action plans to overcome the barriers of WIoT.

Keywords: Wearable Devices, Internet of Things (IoT), Digital Entrepreneurship, Business Models, Innovation

INTRODUCTION

In the recent past, demands for wearable devices have increased rapidly and many devices are expected to be shipped in near future. With the advent of mobile & wireless technologies, internet and cloud computing, conceptualization and development of Internet of Things (IoT) based devices and applications have created a huge interest among various groups such as researchers, technologist, students, enthusiasts and entrepreneurs. The pervasiveness required by an individual demand that wearable devices must be worn by the user, must have internet connectivity and accessibility, provide unobtrusiveness and remain available all the time as well as controllable (Mann, 2001). Although wearable devices are considered as a subset of IoT devices, it has been envisaged that these two areas combined, have given rise to the terminology, Wearable IoT (WIoT). A WIoT device embodies the necessary aspects of sensing, processing and communicating helping a wearer in a variety of tasks (Hiremath, Yang & Mankodiya, 2014).

The impact of IoT could be understood by the fact that by the end of 2011, the number of Internet-connected devices has surpassed the number of human beings on the planet. In 2012, the numbers of interconnected devices were 9 billion and by 2020 there will be approximately 26 billion IoT and wearable devices worldwide (Gubbi *et al.*, 2013). It has been estimated that by the end of this decade, IoT device market will be a trillion-dollar market (Sheth, 2016). The IoT has been identified as one among the 23 technological areas identified by nine IEEE Computer Society technology leaders that will change the world by 2022 (Alkhatib *et al.*, 2015). Some of the key connecting areas where wearable and IoT based devices could find applications by 2022, have been identified as healthcare, education, autonomous vehicles, big data, cloud computing, power consumption etc., involving interdisciplinary research and seamless connections(Alkhatib *et al.*, 2015). Therefore, it is envisaged that the WIoT devices will have a major role to play in digital business market in the coming years. There will be wide range of applications for WIoT that will drive the digital business like person monitoring in enterprises, personal healthcare, etc. (Pricewaterhouse Coopers, 2014).

In this paper we discuss about the opportunities and challenges that a digital entrepreneur would have to face if they venture into the design, development and manufacturing of WIoT devices.

LITERATURE REVIEW

1. WEARABLE INTERNET OF THINGS (WIOT)

- ***Wearable Devices***

Wearable devices are special purpose miniature computers designed for assisting human in various tasks such as equipment maintenance, search and rescue operations, surgery and security surveillance, healthcare, education, sports like golf or skiing etc., designed specifically by considering the 'Human Centered Design' philosophy (Pricewaterhouse Coopers, 2014). In addition, they are also used in infotainment systems, activity tracking, industrial and military systems. One of the major promising applications of wearable devices have been found as health and vital parameter monitoring devices. Many of the chronic diseases like cardiovascular, diabetes, neurological as well as mental health disorders like autism spectrum disorder (ASD), depression, drug addiction and anxiety disorders could be monitored with the help of wearable physiological sensors (Fletcher, Poh & Eydgahi, 2010). In these types of diseases long-term continuous monitoring of vital sign parameters are required. Additionally, wearable biosensors have been researched for alerting automotive drivers when drivers stress, and fatigue level have reached to an alarming stage (Healy & Picard, 2005; Katsis *et al.*, 2008; Patel *et al.*, 2011; Singh, Conjeti & Banerjee, 2013). In a nutshell, wearable find applications in personal activity and/or fitness trackers, smart textiles in the form of jackets, fashion accessories for personal safety, smart eyewear like Google Glass and several other body-worn devices (Wright & Keith, 2014).

- **Internet of Things (IoT)**

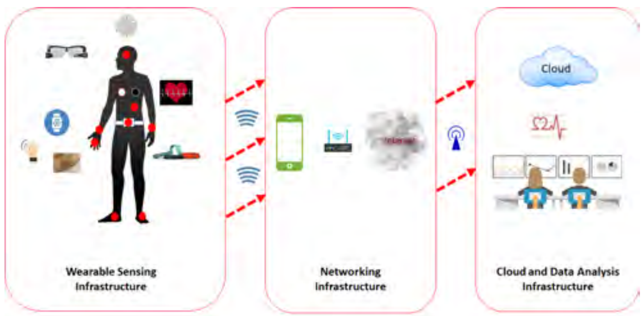
IoT have been defined differently by different research groups. One such comprehensive definition given by Gubbi *et al.*, (2013) states *"Interconnection of sensing and actuating devices providing the ability to share information across platforms through a unified framework, developing a common operating picture for enabling innovative applications. This is achieved by seamless ubiquitous sensing, data analytics and information representation with Cloud computing as the unifying framework"*. In other words, IoT, connects several smart objects (IoT devices), enables communication with these objects, in a manner that the concept of 'anytime, anywhere, any media, anything' is envisioned (Atzori, Iera & Morabito, 2010). The salient characteristics features that IoT devices should have (a) some physical features, (b) communication capabilities, (c) unique identifier, (d) a human-readable name and a machine-readable address, (e) some basic computing capabilities and (f) capability to sense some physical phenomena and actuate (Miorandi *et al.*, 2012).

IoT has variety of applications domain and are categorized ranging from transportation and logistics, healthcare, smart environment and personal and social domain etc. (Atzori, Iera & Morabito, 2010). to personal and home; enterprise; utilities; and Mobile based on the type of network availability, coverage, scale, heterogeneity, repeatability, user involvement and impact Gubbi *et al.*, (2013).

- ***Wearable Internet of Things (WIoT)***

WIoT devices can be visualized as human-centered personal health monitoring and assisting devices that connect wearable sensors, computing and communication infrastructure to a host of big data support and cloud computing infrastructure (Hiremath, Yang & Mankodiya, 2014). Such devices not only help in continuous monitoring of personal health but also augment the quality of life by sharing of the health-related data to caregivers, clinicians and emergency care personnel. The WIoT devices can be visualized as smart wearable systems which can monitor health, activity, mobility and mental status of individuals by measuring physiological parameters with the help of non-invasive miniature biosensors, provide real-time processing and computing capabilities and support for communicating to healthcare professionals via wireless technologies (Chan *et al.*, 2012). The architectural elements of WIoT infrastructure has been shown in Figure 1. Some of the chronic diseases which require continuous monitoring where WIoT could be useful are cardiovascular diseases, diabetes mellitus, renal diseases, respiratory diseases, cancer tumors, postures and gestures, neurological disorders and brain stimulation, muscular rehabilitation, Parkinson's disease, quadriplegia and paralysis, athlete's health monitoring, stress and fatigue monitoring, emotion detection, sudden infant death syndrome (Chan *et al.*, 2012).

Figure 1: WIoT Infrastructure



2. WIOT: REQUIREMENTS AND CHALLENGES FOR DIGITAL ENTREPRENEURS

Majority of the wearable devices available in market as of today provide a single function such as fitness tracking, health monitoring, displaying messages etc., while some devices integrate multiple functions, thereby creating a new era of business opportunity for hardware designers where multiple sensing, computing and actuating infrastructure will influence the WIoT market growth (Wei, 2014). To devise and establish a business model for WIoT devices, one needs to outline the requirements and challenges from developer's perspective and entrepreneur's perspective.

➢ *WIoT: Requirements and Challenges – Developer's Perspective*

- *Optimum Sensing, Computing, Actuating Infrastructure and Processing Algorithms*

Although, for WIoT we may have application domains other than healthcare too, it is imperative that local i.e. on the wearer as well as remote processing i.e. at offline analysis locations will be needed. Local processing will help in providing immediate alarm to the wearer and long-term trends could be analyzed at the remote processing platforms (Park, Chung & Jayaraman, 2015). Therefore, there is a need to design on-body wearable sensing nodes which can sense the required signals effectively without losing the useful information. Any ideal set of wearable nodes must use non-invasive sensors, local processing, facility for user feedback and communication as well as actuating capabilities (Fotiadis, Glaros & Likas, 2006). While selecting the processing core for wearable medical monitoring, during initial years majority of the prototypes were developed using microcontrollers. But in some prototypes where power consumption requirement is more critical, Field Programmable Gate Arrays (FPGAs) and Application Specific Integrated Circuits (ASICs) have been used (Anliker *et al.*, 2004). Research has started for designing many core processors which will consume less power, provide high performance customizable System-on-Chip (SoCs) computing facilities by using a lightweight customizable message-passing substrate for data transfers and run-time customization of cores and network, even suitable for wearable application domains other than health-monitoring (Tan *et al.*, 2017).

- *Low Power and Memory*

Since majority of the WIoT devices are miniature devices, developers will have a daunting task of providing a low power battery operated device which may work for a few days to a week if it is used for fitness or activity monitoring, whereas it may require lasting over a month if the device is intended for vital sign monitoring. Due to its small form-factor and size requirement it is also required that the device will have small memory footprint with storage capability of critical health information which may otherwise result in large amount of data. Although disk storage density increased by a factor of 1,200 during the 90s, battery energy density increased only by a factor of three (Starner, 2014). Since the wearer must be alerted in time, due to the low storage space available only the useful information could be saved while any long-term trend data could be sent to the offline processing unit for later use. These contradictory requirements could be achieved with the help of efficient on-node signal processing so that only useful data is stored, and redundant information is discarded.

- *Communication Channels and Network Connectivity*

In a typical WIoT scenario, both short-range and long-range communication technologies are required. Embedding efficient communication channels and network connections will be other important requirements. Sensed data from a variety of on-body sensors must travel to the processing core and the processed data from the core to the transmitting channels. Low power consumption and less transmission overhead requires that provision should be made by designers to share the channels for exchange of data between different tasks and collect data to enable a transmission in the form of bursts (Anliker *et al.*, 2004). Since WIoT devices operate in real-time scenarios designing an efficient wireless protocol will depend on the volume of data transfer, speed and communication range requirements. Additionally, relay of significant data to Cloud in the WIoT architecture will have network connectivity requirements which need to be addressed carefully. Typical short-range communication protocols like Bluetooth, IEEE 802.11g/n, IEEE 802.11ac and ZigBee may be suitable for low-scale WIoT devices, but they may not be suitable for high density wearable deployment scenarios in which mmWave signal based protocols like WiGig standard (IEEE 802.11ad) and ECMA 387 have been found as promising, as they are blocked by human body and objects (Venugopal & Heath, 2016; Pyattaev *et al.*, 2015). Among the medium to long-range communication networks Wi-Fi, Ethernet (wired), Wireless LAN (wireless), WiMAX, Broadband as well as Cellular networks (such as GSM, GPRS, UMTS, HSPA+ and LTE) and satellite communication technologies can also be used depending upon the specific device need (Borgia, 2014).

- *Human Factors and Ergonomic Design*

Inclusion of human factors and ergonomic design is one of the key requirements of WIoT devices. Since, these devices will be worn continuously for collecting vital health parameters from patients, it is mandatory that designers must carefully plan the location and placement of body-worn sensors so that they do not create discomfort to the wearer (Chan *et al.*, 2012). Human factor aspects such as aesthetics, affordance, comfort, ease of use, intuitiveness, user friendliness will have a positive influence on design of such devices, whereas accuracy and availability are essential requirements from a medical perspective (Motti & Caine, 2014). Additionally, it is the designer's responsibility to identify multiple dispositions and transitions, which represent the physical relationship between the device and user's pose and the shifts undertaken between a set of dispositions by user respectively (Lyons & Profita 2014). However, these factors will be dependent on specific needs and available resources of the user.

- *Innovative and Progressive Design*

The market for WIoT has been driven by several aspects like user age groups, fashion trends, social and religious inclinations, demographic, environmental and weather conditions, designer should always think about innovations in their product as user preferences change very quickly. The desire for an innovation often comes much later than the first instantiation of the innovation (Starner, 2014). It is necessary to innovate and refine the product quickly to meet the customer's demand by adopting a short design cycle. Innovation initiatives frequently fail due to lack of an innovation strategy, which employs a set of policies or behaviors in a coherent manner for achieving specific goal (Pisano, 2015).

- *WIoT: Requirements and Challenges – Entrepreneur's Perspective*

In the coming years, digital entrepreneurs targeting WIoT device markets must focus on innovation, which may lead to the acceptability of the product by a larger section of society, from children to elderly. Additionally, they must strategize in such a way that not only they overcome the fierce competitors but also the legal hurdles, rapidly changing customer demands and technological innovations. In the preceding section the discussed requirements and challenges will influence the entrepreneurs' decisions in adapting a business model that best suits a product. We discuss some of the opportunities, real threats or challenges and finally suggest a business model for budding entrepreneurs to succeed in the WIoT market.

- *Manufacturing and Infrastructure Issues*

Manufacturing facilities and availability of input resources like – materials, manpower, skills and costs are the major issues an entrepreneur may face. Government regulations sometimes also add to the difficulty in doing business. For a dynamic market such as WIoT where technological changes will influence the procurement of components, cost of hardware, software development tools, communication infrastructure, and services will influence manufacturing decisions. Technological advancements are happening at a faster rate. Majorly, in next few years several products may be introduced requiring miniature devices to be embedded for providing intelligence support within devices. To keep pace with current market trends, entrepreneurs must identify and hire skilled manpower due to the nature of interdisciplinary nature of WIoT domain.

- *Innovative Engineering Design Issues*

Designing such a system poses several challenges like hardware design of small form-factor devices, integrating and packaging of small hardware in a small space, providing reliable and optimum communication, secure and private data, signal processing and sensory data fusion, robust firmware as well as application software and last but not the least providing robust fail-safe methods to the end user, as the device would be worn by the users most of the time.

WIoT technology is still considered to be in nascent stage, thereby has disruptive innovation characteristics in a way that due to rapid technological advancements newer wearable products may outperform a little older product as due to non-existence of an established product (Sultan, 2015). This indicates the potential of WIoT health care products will emerge as a new market.

Any kind of digital innovation taking place must have three unique characteristics of *reprogrammability* (to allow a variety of computational functions), *homogenization of data* (for storing, transmitting, processing, and displaying of data from heterogeneous sources), and the *self-referential nature* (utilization of available and affordable digital technology) (Yoo, Henfridsson & Lyytinen, 2010). However, one must not forget to understand what has been done so far due to technological advancements and what could be done to some of the organizational and societal needs which have not been addressed till date, so that a new valuable product could be developed with the digital technology (Fichman, Dos Santos, & Zheng, 2014).

- *Data Handling and Data Mining Issues*

WIoTs will generate huge amount of data from personalized to social in future as against the current point-to-point data. Not only ownership of data will become a challenge for digital entrepreneurs but also, they will have to face the classic big data challenges due to increased volume, variety, increased complexity, rapid transformations (velocity), and more veracity thereby requiring intelligent data processing techniques to be employed so that high-quality and useful data will be retained (Sheth, 2016). The complex sensing environment of WIoTs has given rise to a unique research problem which can detect events and activities at multiple layers, to which deep learning techniques have been suggested as a possible solution (Gubbi ., 2013).

- *Pricing and Styling Issues*

Customer is the key for success of any product. Acceptability of a product increases if it adds value to the customer's ego as the customer may see a pride element while in possession of such a product due to maybe an aesthetic design, brand name etc. However, there is likelihood of a minimal acceptance too if the product does not perform technically with respect to the expected performance outcome. Another aspect which will influence the customer's buying decision is whether the device is a single functioned device or multifunction device as well as the packaging considerations. Use and adoption of WIoT devices could be influenced by personal preferences and individual characteristics of users (Shih *et al.*, 2015). Additionally, customer's decisions are influenced by their affordability and style consciousness. If the product's cost is within the reach of the customer and has aesthetical design according to current fashion trends, the acceptability increases.

- *Privacy and Security Issues*

Initial WIoT devices had single-functioned usage, whereas nowadays customers prefer multifunctional interfaces. Considering the case when several users with WIoT devices worn on their body come in contact within their shared network infrastructure, privacy and security issue will arise. Security protocols could be implemented at both the hardware as well as software levels. However due to their complementary nature if hardware platform is insecure, the software also become vulnerable (Arias *et al.,* 2015). Any security provision with cryptography techniques will lead to computational overhead with respect to the choice of memory and processor requirements. Although it seems that privacy and security concerns are design related concerns, but from time-and-again it has been proved that this could become a big social challenge for an entrepreneur.

- *Safety, Reliability and Standardization Issues*

WIoT devices will be potentially used in critical healthcare and hazard situation where users' safety, product reliability will be important. Use of inefficient and ineffective product in life-critical scenarios will be threatening. Moreover, due to its heterogeneous nature of hardware and software requirements, standardized components and software standards must be employed which is a big concern due to non-availability of standardization.

- *Social Engineering Issues*

Any product's lifecycle depends on its demand and supply ecosystem. Entrepreneurs must comply by the policy regulations, taxations, ease of doing business, marketability restrictions of the targeted country or region. Several entrepreneurs have ventured into the WIoT product development business due to their market potential. This has led to fierce competition among their peers. The five influencing characteristics which drives competitions among business groups have been identified as bargaining power of buyers, nature and intensity of the rivalry among existing competitors, threat of new entrants, threat of substitute products or services, and bargaining power of suppliers (Porter & Heppelmann, 2015). These five guidelines will help in identification of potential customers, customization of products as per customer's need, adjust prices of the product so that the benefit goes to the customer and in return to the entrepreneurs if the volume is large. Another perspective in this domain could be how a new product is going to capture a market share with that of the incumbent products, whether there is likelihood of replacing the incumbent product with the new one which is possible if innovative techniques have been used in the product design which will deliver more value. A feedback mechanism must be followed to collect and analyze the product usage data so that it could be refined in a way to deliver value to the customer considering the cost constraints.

No matter, how much their viewpoints may have distinguishing nature, a mutual understanding of the key requirements and challenges will guide both the developer and entrepreneur through innovation and development phases of the WIoT device and will act as the guiding principle for adopting a business model.

3. EXISTING BUSINESS MODELS FOR WIOT

➢ *Business Models*

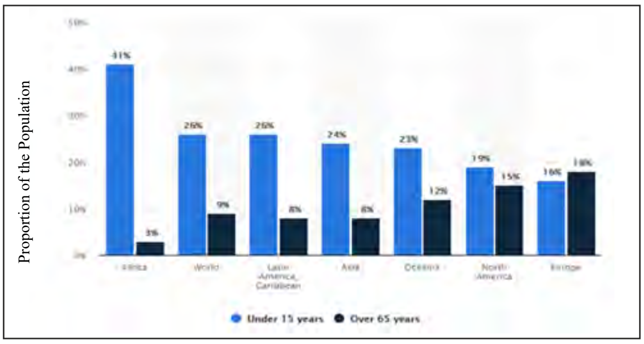
It is imperative to have a common and precise understanding of the business methodologies to be followed in the context of WIoT business domain for digital entrepreneurs. To achieve high success rates in their business endeavors, entrepreneurs must adopt certain business models which provide some guidelines to do businesses, by identifying potential customers and the value additions required for the growth of their businesses. Although it is difficult to find an acceptable definition for business models, two of the highly cited definitions are given by (Chesbrough & Rosenbloom, 2002; Osterwalder, Pigneur & Tucci, 2005). Chesbrough & Rosenbloom, 2002. defines business models as *"a blueprint for how a network of organizations cooperates in creating and capturing value from technological innovation"*. Whereas, Osterwalder, Pigneur & Tucci, (2005) defines business model as, *"a description of the value a company offers to one or several segments of customers and of the architecture of the firm and its network of partners for creating, marketing, delivering this value and relationship capital, and generating profitable and sustainable revenue streams"*. Nine key components of a business model were identified as: customer segments, value propositions, channels, customer relationships, revenue streams, key resources, key activities, key partnerships and cost structure (Osterwalder, 2004).

However, these components in the context of WIoT business models will have a different set of projections with some commonalities. WIoT inherits some of the important features from several domains like telemedicine, smart objects, IoT, wearable medical devices etc. Therefore, the business models for WIoT will have some of the overlapping as well as distinguishing characteristic features of all these areas. A business model for telemedicine service focuses on 'value' and identified three key aspects: value creation (the benefit being offered), value delivery (activity systems) and value capturing (financial structures) (Acheampong & Vimarlund, 2015). A business model framework for smart and connected product has been proposed consisting of value propositions, revenue stream, and the offered architecture and technologies (Onar & Ustundag, 2018). Whereas, the business models for IoT have three important building blocks namely the value proposition, the customer relationships and key partnerships, out of which the value proposition is the most important component (Dijkman *et al.*, 2015). A case study comprising of five wearable medical device manufacturing companies revealed that they followed some common methodologies such as (i) they follow user-oriented methodologies in the product development phase, (ii) order of key-activities to be followed was similar (iii) in initial phase they establish direct contact with their potential customers, later the relationships depends on the customer's preferences and buying cycle (Almeida, 2015).

4. PROPOSED BUSINESS MODELS FOR WIOT

Wearable IoT is a disruptive innovation. It is changing the way we live and take care of ourselves. From a humble beginning in 2000, it is rapidly sweeping the market. Its market potential, specially, in personal healthcare segment is enormous. World Population statistics shows that number of aged population is increasing. It is evident from figure 2 that globally 9% of aged population is over 64 years of age and in Oceana, North America and Europe, 12 to 18% of its population are above 64 years of age and are close to retirement. The twin effect of retirement is decreased income and increased cost of health care demands innovative ways of reducing the cost of health care worldwide. In the backdrop of such demographic economic situation the demand for wearable health devices are bound to increase.

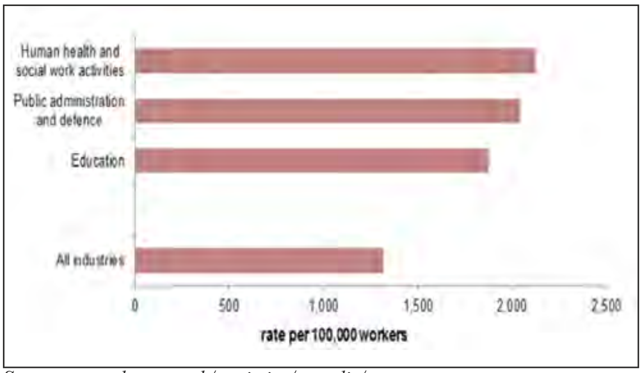
Figure 2: Age Groups of World Population



Source: Statista- The Statistical Portal

Similarly, globally, business is becoming more complex and stressful. The workplace stress is the biggest threat to executives' health. It is evident from figure 3 that 45% executives suffer from workplace related stress. The increased stress brings many health-related problems like high BP, high level of blood sugar and many other diseases. Health conscious executives need to monitor their vital health parameters and thereby pushing the demand of Wearable health care devices worldwide.

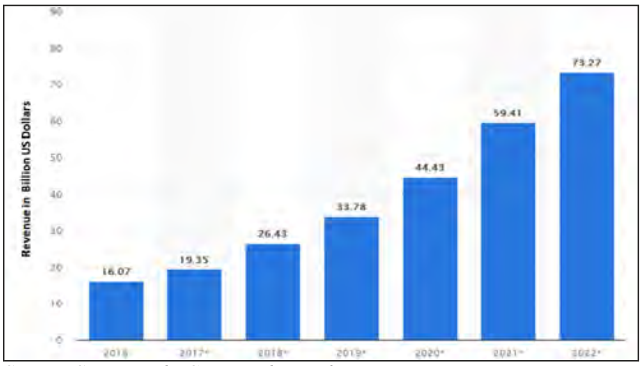
Figure 3: Impact of Workplace Stress



Source: www.hse.gov.uk/statistics/causdis/stress

It is evident from figure 4 that the sales revenue of wearable devices is increasing in leaps and bounds and the same is likely to touch 73.27 billion USD in 2022. Therefore, it can be concluded that the factors that are pushing the demand for wearable are very strong. And if product developers package these wearable devices with fashion features, this is likely to be the beautility (combining the beauty and utility features together) that will create special appeal for young generation.

Figure 4: Sales Revenue Forecast for WIoT



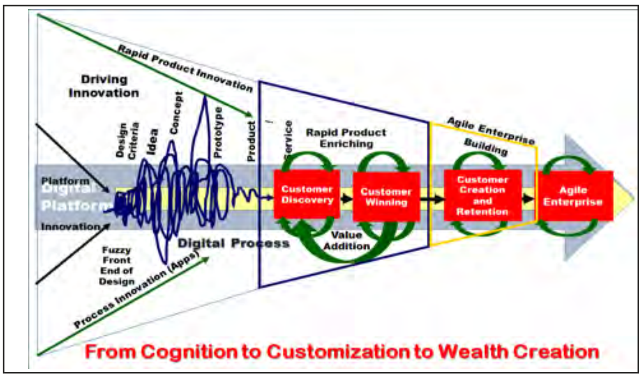
Source: Statista- The Statistical Portal

Nevertheless, most of wearable devices are single functional devices, and is in its early stage of development. This can be termed as the dawn of new era of disruptive innovation. Today's single functional devices will converse and would most likely evolve as multifunctional, powerful and more fashionable. Worldwide startups are working towards this direction. The questions are (a) how many of these startups will evolve as grownups, (b) how the future market will unfold, (c) and what would be their business models.

These are million dollar questions, no one of us have the exact answer, but what we know for sure are: (a) all wearable IoT devices are innovative products, (b) innovation will not see the light of success, if these devices fail to adapt and add value rapidly (i.e. product enrichment) and winning customers' faith and confidence, (c) finally all these innovator will face tremendous market competition from their global peers. Initial positive market response or partial success may not translate into successful scale-ups.

The model that finally captures all the ethos and pathos of Wearable IoT devices are depicted in figure 5 is the business model of Wearable IoT. It has three discrete interconnected phases and inherits the typical characteristics of digital platform like velocity, veracity and ubiquity. The critical success factors of wearable digital entrepreneurship depend on entrepreneurs' ability and zeal for 'Rapid Innovation', 'Rapid Product Enrichment' and 'Agile Enterprise Building'. Statistics shows that 75-90% startups fail to emerge as scale-ups. Death may happen in any of these three compartment/phases (Gage, 2012; Blank, 2013).

Figure 5: Agile Business Entrepreneurship Model



The Agile Digital Entrepreneurship business model advocates a rare combination of three different skill sets for the success of Digital Entrepreneurship. First phase is dominated by power of innovation and invention often guided by the principles of 'Design Thinking', which calls for perseverance, passion and enough knowledge of the market, Traits of Target Customers (TOTC) and technical know-how of product innovation. The second phase is dominated by emotional intelligence, market awareness and acumen to discovery of customer's preference and passion. The third and the final phase is guided by managerial and organizational leadership in managing innovation, maintain agility, and different kind of strategic leadership to outperform the competitors in their global competitive landscape. The authors believe that digital enterprise need to nurture innovation, remain agile and 360-degree commitment for creating superior customer experience are the keys to success.

CONCLUSION

This study reveals that despite huge potential for WIoT, it is yet to be acceptable as mass-scale consumer goods due to lack of appropriate social engineering. It also appeared that many of the digital entrepreneurs of WIoT are hungry enough to take it to the next level. The observations are – the entrepreneurs are yet to perfect their business models. Enough research is required to understand the socio-dynamics of the target customers. The pricing is an issue. Lack of promotion is another bottleneck. Finally, small, slick and affordable and powerful multi-functional WIoT with right customer value optimization strategy will do the needful.

REFERENCES

Acheampong, F. & Vimarlund, V. (2015). Business Models for Telemedicine Services: A Literature Review. *Health Systems*, 4(3), pp 189-203. DOI: 10.1057/hs.2014.20.

Alkhatib, H., Faraboschi, P., Frachtenberg, E., Kasahara, H., Lange, D., Laplante, P., Merchant, A., Milojicic, D. & Schwan, K., (2015). What will 2022 look like? The IEEE CS 2022 Report. *Computer*, 48(3), pp 68-76.

Almeida, R.M.R.P. (2015). Characterization of Business Models in the Medical Devices Industry-The Case for Wearable Technologies. Faculty of Engineering of the University of Porto, Portugal. Retrieved From: https://core.ac.uk/download/ pdf/ 143399223.pdf.

Anliker, U., Beutel, J., Dyer, M., Enzler, R., Lukowicz, P., Thiele, L. & Troster, G. (2004). A systematic approach to the design of distributed wearable systems. *Institute for Electrical and Electronics Engineers (IEEE) Transactions on Computers*, 53(8), pp 1017-1033. DOI: 10.1109/TC.2004.36.

Arias, O., Wurm, J., Hoang, K. & Jin, Y. (2015). Privacy and Security in Internet of Things and Wearable Devices. *IEEE Transactions on Multi-Scale Computing Systems*, 1(2), pp 99-109. DOI: 10.1109/TMSCS.2015.2498605.

Atzori, L., Iera, A. & Morabito, G. (2010). The Internet of Things: A Survey. *Computer Networks*, 54(15), pp 2787-2805. DOI: 10.1016/j.comnet.2010.05.010.

Blank, S. (2013). Why the Lean Start-Up Changes Everything? *Harvard Business Review*, 91(5), pp 63-72.

Borgia, E. (2014). The Internet of Things vision: Key features, applications and open issues. *Computer Communications*, 54, pp 1-31. DOI: 10.1016/j.comcom.2014.09.008.

Chan, M., Estève, D., Fourniols, J.Y., Escriba, C. & Campo, E. (2012). Smart Wearable Systems: Current Status and Future Challenges. *Artificial Intelligence in Medicine*, 56(3), pp 137-156. DOI: 10.1016/j.artmed.2012.09.003.

Chesbrough, H. & Rosenbloom, R.S., (2002). The Role of the Business Model in Capturing Value from Innovation: Evidence from Xerox Corporation's Technology Spin-Off Companies. *Industrial and Corporate Change*, 11(3), pp 529-555. DOI: 10.1093/icc/11.3.529.

Dijkman, R.M., Sprenkels, B., Peeters, T. & Janssen, A., (2015). Business Models for the Internet of Things. *International Journal of Information Management*, 35(6), pp 672-678.

Fichman, R.G., Dos Santos, B.L. & Zheng, Z. (2014). Digital Innovation as a Fundamental and Powerful Concept in the Information Systems Curriculum. *Management Information Systems (MIS) Quarterly*, 38(2), pp 329-353. DOI: 10.25300/MISQ/2014/38.2.01.

Fletcher, R.R., Poh, M.Z. & Eydgahi, H. (2010). Wearable Sensors: Opportunities and Challenges for Low-Cost Health Care. *Engineering in Medicine and Biology Society (EMBC), 2010 Annual International Conference of the IEEE*, pp 1763-1766. Retrieved From: http://alumni.media.mit.edu/~zher/papers/Fletcher-etal-EMB C2010.pdf.

Fotiadis, D.I., Glaros, C. & Likas, A. (2006). Wearable Medical Devices. *Wiley Encyclopedia of Biomedical Engineering*. pp 3816–3827. DOI: 10.1002/9780471740360.ebs1326.

Gage, D. (2012). The Venture Capital Secret: 3 Out of 4 Start-Ups Fail. *The Wall Street*.Retrieved From: https://www.wsj.com/articles/ Sb100008723963 90443720204578004980476429190.

Gubbi, J., Buyya, R., Marusic, S. & Palaniswami, M. (2013). Internet of Things (IoT): A vision, architectural elements, and future directions. *Future Generation Computer Systems*, 29(2013), pp 1645-1660.

Healey, J.A. & Picard, R.W. (2005). Detecting Stress during Real-World Driving Tasks using Physiological Sensors. *IEEE Transactions on Intelligent Transportation Systems*, 6(2), pp 156-166.

Hiremath, S., Yang, G. & Mankodiya, K. (2014). Wearable Internet of Things: Concept, Architectural

Components and Promises for Person-Centered Healthcare. *2014 4th International Conference on Wireless Mobile Communication and Healthcare - Transforming Healthcare Through Innovations in Mobile and Wireless Technologies (MOBIHEALTH).* DOI: 10.1109/ MOBIHEALTH. 2014. 7015971.

Katsis, C.D., Katertsidis, N., Ganiatsas, G. & Fotiadis, D.I. (2008). Toward Emotion Recognition in Car-Racing Drivers: A Biosignal Processing Approach. *IEEE Transactions on Systems, Man, and Cybernetics-Part A: Systems and Humans*, 38(3), pp 502-512.

Lyons, K. & Profita, H. (2014). The Multiple Dispositions of On-Body and Wearable Devices. Institute of Electrical and Electronics Engineers *(IEEE). Pervasive Computing*, 13(4), pp 24-31. DOI: 10.1109/MPRV.2014.79.

Mann, S. (2001). Wearable Computing: Towards Humanistic Intelligence. *IEEE Intelligent Systems*, 16(3), pp 10-15.

Miorandi, D., Sicari, S., De Pellegrini, F. & Chlamtac, I. (2012). Internet of Things: Vision, Applications and Research Challenges. *Ad hoc networks*, 10(7), pp 1497-1516.

Motti, V.G. & Caine, K. (2014). Human Factors Considerations in the Design of Wearable Devices. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting, SAGE Publications*, 58(1), pp 1820-1824. DOI: 10.1177/ 1541931214581381.

Onar, S.C. & Ustundag, A., (2018). Smart and Connected Product Business Models. *In Industry 4.0: Managing the Digital Transformation, Springer, Cham., Switzerland*. pp 25-41. DOI: 10.1007/978-3-319-57870-5_2.

Osterwalder, A. (2004) The Business Model Ontology—A Proposition in a Design Science Approach. PhD Thesis, University of Lausanne, Switzerland. Retrieved From: http://www. hec. unil.ch/aosterwa/PhD/Osterwalder_PhD_BM_Ontology.pdf.

Osterwalder, A., Pigneur, Y. & Tucci, C.L. (2005). Clarifying Business Models: Origins, Present, and Future of the Concept. *Communications of the Association for Information Systems*, 16(1), pp 1-25.

Park, S., Chung, K. & Jayaraman, S., (2015). Chapter 1.1 - Wearables: Fundamentals, Advancements and a Roadmap for the Future. Wearable Sensors, pp 1–23.

Patel, M., Lal, S.K.L., Kavanagh, D. & Rossiter, P. (2011). Applying Neural Network Analysis on Heart Rate Variability Data to Assess Driver Fatigue. *Expert Systems with Applications*, 38(6), pp 7235-7242. DOI: 10.1016/j.eswa.2010.12.028.

Pisano, G.P. (2015). You Need an Innovation Strategy. *Harvard Business Review*, 93(6), pp 44-54.

Porter, M.E. & Heppelmann, J.E. (2015). How Smart, Connected Products are Transforming Companies. *Harvard Business Review*, 93(10), pp 96-114.

PricewaterhouseCoopers, B.V. (2014). Consumer Intelligence Series: The Wearable Future. Retrieved From: https://www.pwc.com/us/en/industries/consumer-markets/library/retail-consumter-cis-wearable-future.html.

Pyattaev, A., Johnsson, K., Andreev, S. & Koucheryavy, Y. (2015). Communication Challenges in High-Density Deployments of Wearable Wireless Devices. *Institute for Electrical and Electronics Engineers (IEEE) Wireless Communications*, 22(1), pp 12-18. DOI: 10.1109/MWC.2015.7054714.

Sheth, A. (2016). Internet of Things to Smart IoT through Semantic, Cognitive, and Perceptual Computing. *IEEE Intelligent Systems*, 31(2), pp 108-112.

Shih, P.C., Han, K., Poole, E.S., Rosson, M.B. & Carroll, J.M. (2015). Use and Adoption Challenges of Wearable Activity Trackers. *IConference 2015 Proceedings*. March 24–27 2015; Newport Beach, CA. Retrieved From: file:///C:/Users/LUC /Desktop/Shih-FitBit-iConf15.pdf.

Singh, R.R., Conjeti, S. & Banerjee, R. (2013). A comparative evaluation of neural network classifiers for stress level analysis of automotive drivers using physiological signals. *Biomedical Signal Processing and Control*, 8(6), pp 740-754.

Starner, T. (2014). How Wearables Worked their Way into the Mainstream. *IEEE Pervasive Computing*, 13(4), pp 10-15. DOI: 10.1109/MPRV.2014.66.

Sultan, N. (2015). Reflective thoughts on the potential and challenges of wearable technology for healthcare provision and medical education. *International Journal of Information Management*, 35(5), pp 521-526. DOI: 10.1016/j.ijinfomgt. 2015.04.010.

Tan, C., Kulkarni, A., Venkataramani, V., Karunaratne, M., Mitra, T. & Peh, L.S. (2017). LOCUS: Low-Power Customizable Many-Core Architecture for Wearables. *ACM Transactions on Embedded Computing Systems (TECS)*, 17(1), pages 16. DOI: 10.1145/2968455.2968506.

Venugopal, K. & Heath, R.W. (2016). Millimeter Wave Networked Wearables in Dense Indoor Environments. *Institute for Electrical and Electronics Engineers (IEEE) Access*, 4, pp 1205-1221. DOI:10.1109/ACCESS.2016.2542478.

Wei, J. (2014). How Wearables Intersect with the Cloud and the Internet of Things: Considerations for the developers of wearables. *IEEE Consumer Electronics Magazine*, 3(3), pp 53-56.

Wright, R. & Keith, L. (2014). Wearable Technology: If the Tech Fits, Wear It. *Journal of Electronic Resources in Medical Libraries*, 11(4), pp 204-216. DOI: 10.1080/15424065.2014.969051.

Yoo, Y., Henfridsson, O. & Lyytinen, K. (2010). Research Commentary—The New Organizing Logic of Digital Innovation: An Agenda for Information Systems Research. *Information Systems Research*, 21(4), pp 724-735. DOI: 10.1287/isre.1100.0322.