A Quantum Leap Towards More Effective and Efficient Smart Farming in Rural Areas Using IOT

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Abstract

The widespread adoption of smart farms can drastically improve the effectiveness and efficiency of farming all over the world. The advent of smart farming can be seen as a quantum leap towards the 4th industrial revolution. However, there have been some challenges which need to be tackled in order to ensure the wide scale adoption of smart farming and this study intends to improve the penetration and effectiveness of the IOT devices with a geographic focus on rural areas in developing countries. This study explores the possibility of using a combination of technologies including but not limited to passive IOT devices, micro controller devices and satellite dishes. There would be consideration given to the use of a combination of micro controllers devices which are connected to regional satellite dishes or radio stations as deemed necessary as this will reduce the cost of investing in smart farms as this is also another major hurdle especially in developing countries which rely primarily on agriculture as their primary source of national income. Finally, this study will investigate weather resistant technologies and will aim to produce smart farms which can be reliable in the rural environments.

Keywords
Smart farming, IOT devices, micro controllers , Unmanned arial vehicles UAV , Agriculture 4.0 .

1.Introduction
The so-called 4th industrial revolution is arguably the widespread adoption of smart farming facilitated using IOT devices and data analytics (Ghobakhloo 2020).This is especially important because according to many estimates including the United Nations the global population is estimated to reach the 9 billion mark by 2050 and according to the food and agriculture organization of the united nations this implies that the agricultural production must increase by about 70 % and this means smart farming which can lead to increased agricultural produce and reduced carbon emission is vital to the survival of humanity in this century and is an important stride toward sustainability. The Agriculture 4.0 solutions include the use of IOT devices which gather information later used by decision support systems capable of making accurate predictions. This information can lead to increased effectiveness and efficiency in agricultural production however, there are some challenges which have reduced the velocity of widespread adoption of smart farming among which the most important ones are the initial cost of investment, lack of internet penetration in many rural regions and the lack of security of the collected data. According to the United Nations international telecommunications union around 2.9 billion people lack access to the internet all over the world as of 2021 (*ITU* 2021). This study intends to provide a conceptual framework only with thorough theoretical underpinning based on extensive literature review which aims to increase internet penetration and improve the security of the data collected from IOT devices used in smart farming.

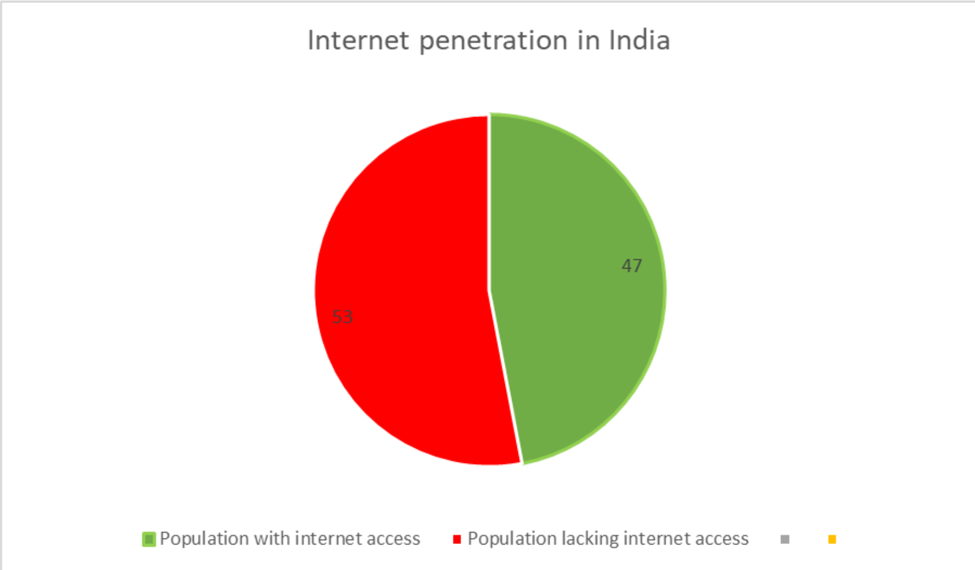

Figure 1. Internet penetration in India

As figure 1 illustrates, according to stastica the internet penetration in India is a little over 47 % in 2021 and this means that there is still 53 % of the Indian population which lacks access to the internet. This is a testament to the dire need for greater internet penetration in many southeast Asian countries including but not limited to India.

The first problem is that there is very limited access to internet in many developing countries especially in the southeast Asian regions and according to studies about 50 % of the global population still lacks access to the internet (Pandita 2017). This means the IOT devices cannot function in these areas as of now and this is one of the primary challenges our proposed idea framework intends to solve . The cost of building full scale cellular towers in such areas are not feasible due to logistical, structural, and financial reasons. Given this, this study will intend to increase internet penetration by using satellite dishes which are later connected to a series of interconnected micro controller devices which will form a network of smart IOT devices in rural areas. One of these satellite dishes can be used for about 40 Km radius and this can make this technology very feasible and affordable. The details of this concept will be discussed in detail later in this study with relevant diagram for the purpose of illustration.

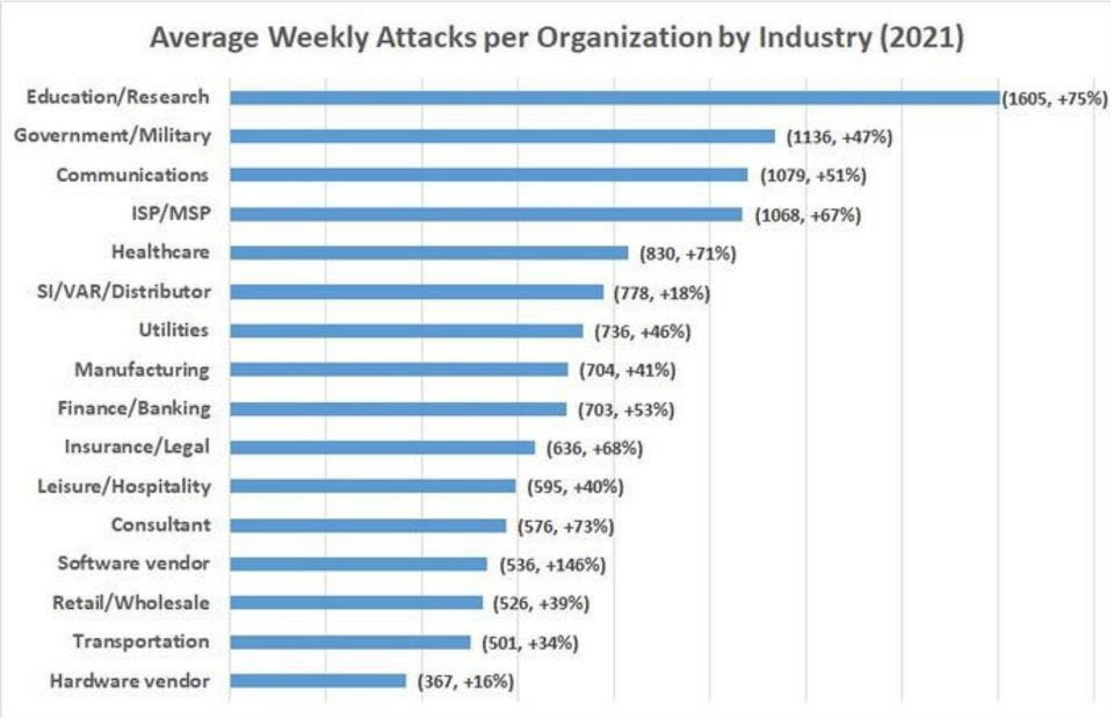

Figure 2. Weekly cyber-attacks by industrial sector

The analysis of big data gathered is of vital important for the accuracy of the decision support systems and the 4Vs are vital for data science. This problem is made clear by the report from the Forbes magazine, which is portrayed by figure 2 , the weekly cyber-attacks against all the major organization industries is on the rise in 2021. It is important to note that the communications sector which is similar to the IOT devices needed for agriculture 4.0 has seen a weekly increase in cyber-attacks by over 50 % and thence this illustrates the major threat of cyber-attacks. As such, the veracity which is affected by the integrity and reliability of the data collected is important and therefore coming to the matter of the security of the data gathered using IOT devices this is a very important challenge because any meaningful information gathered from the data is only useful if the data is reliable and free from manipulation or tampering.

1.1 A numerical analysis of the dire need for adopting smart farming in India.

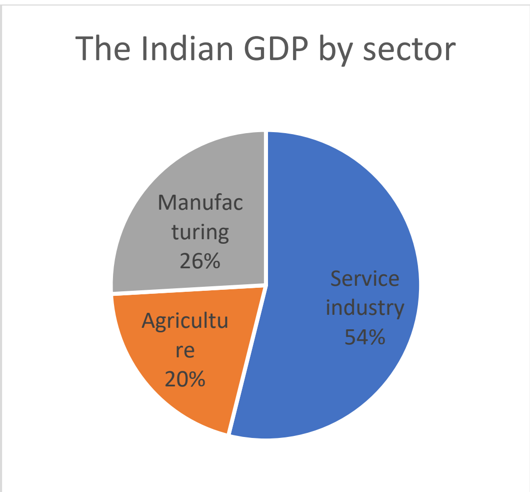

Figure . 3

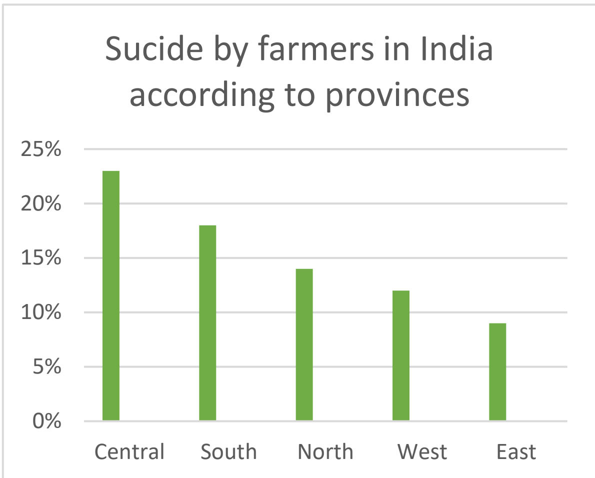

Figure 4.

This will lead to increased accuracy and precision of the decision support systems which use the relevant data. It is clear from figure 3 which portrays that agriculture accounts to about 20 % of the Indian economy as measured by the GPD according to the report released by statics times in 2022. This is illustrating with scientific precision that agriculture is vital to the India economy. Moreover, the service industry contributes to more than half of the GDP of the nation. However, the suicide rate amongst farmers in India is very high with more a little less than 25 % suicide rate in the central provinces and a little less than 10 % in the eastern provinces of India according to surveys conducted by the centre for study of developing societies. This illustrates that the current farming sector in India is in efficient and does not provide the farmers with economic prosperity.

As such, the conceptual model put forth by this study will improve the stability of agriculture by reducing crop damage, water consumption and most importantly reducing the mis prediction of demand and supply for agricultural produce. This is because, a major cause for suicide amongst farmers in rural India is the inability to predict the demand for the produce and hence this leads to huge amounts of crop wastage leading to such tragic incidents. Therefore, our proposed conceptual framework will intend to inform the farmers regarding the correct amount, time and type of crops to plant. This will reduce crop wastage to the farmers and hence improve the stability of their income and act to reduce this currently high level of suicides.

1.2 Objectives

The primary objective of this study is to introduce a conceptual framework which intends to increase internet penetration and data security regarding smart farming in developing countries in the most effective and efficient manner possible considering cost and reliability. Coming to the first point, internet penetration in rural areas in southeast Asian countries such as India is still less than 50 % and this is the primary issue our study intends to resolve (Pandita 2017). This study intends to find a novel application of already existing technology and conceptual frameworks hence is an applied research study. The metric used to measure the internet penetration would be square kilometres of agricultural land that can be reached by our proposed system, and this will ensure that there can be accurate and precise measurement of our objective of increasing internet penetration in the needed areas.

The security of data gathered is vital for the accurate and precise decisions that can be derived from it. Therefore, this study intended to use artificial intelligence-based decision support systems to increase the security of data gathered and the effectiveness of our idea would be measured by using ratio of data to errors and amounts of dark data which wills serve as key performance indicators regarding data security. This will ensure that our objectives are quantifiable and measurable with scientific precision. This will provide the framework for reporting and analysing these data security breaches and hence can be a tool used to measure the effectiveness of the proposed conceptual framework.

2.Literature Review

There is more than enough precedent in academic literature that agriculture 4.0 is arguably the 4th industrial revolution which intends to lead to increased agricultural produce, more efficient allocation of resources, tacking the challenges faced by climate change and reducing food wastage. In order to achieve these for goals of agriculture 4.0 there needs to be widespread adoption of smart farming which intends to take agriculture to the next level by using decision support systems to turn the agricultural industry proactive and therefore increase both the efficiency and effectiveness of food production (Doshi and Patel 2019). This means that the collection of big data and analysing it using decision support systems is vital and there are several challenges faced by smart farming including the high cost of adopting the practice as agriculture is the primary source of revenue for developing countries and they can ill afford the infrastructure needed for adopting the information systems needed for smart farming.

Coming to the second point, according to the United Nations international telecommunications union circa 50 % of the world still does not have access to reliable internet connections which are vital for the implementation of smart farming. This due to a variety of reasons including lack of infrastructure in many developing countries and terrain which is affected by weather conditions in rural areas. Finally, the security of data gathered from the vast sources of IOT devices is vital to make accurate and precise decisions because reliable data is the very foundation for the effective operations of decision support systems. This is a major problem since the emergence of cybercrimes and terrorism which aim to alter or tamper the data used in smart farming and hence this can effectively nullify the accurate decision-making power of decision support systems, and this is a major challenge faced my smart farming and has precedent in reputable academic literature.

This study intends to solve the challenge of lack of internet penetration in rural areas and the security of the data gathered from IOT devices in such settings. This will be conducted using a combination of information system technologies decision support systems, unmanned aerial vehicles, satellite dishes, IP packet routing algorithms, micro controller devices and decision support systems. The effective and efficient implementation of agriculture 4.0 needs integrated and seamless functioning of these devices and related technologies working in tandem according to the report " Agriculture 4.0 : The future of farming technology" released in 2018 (Matthieu De Clercq 2018).

Given this, our study intends to use a combination affordable micro controllers , satellite dishes, suitable unmanned arial vehicles and routing algorithms to create a flexible, reliable, cost efficient and responsive supply chain system. There is precedent for the use of satellite dishes to gain internet connection in rural areas according to the US military. The primary gap in the currently available technologies is affordable and flexible nature of our proposed integrated supply chain system. Although there have been similar applications of smart farms in developed countries such as the USA there are none in developing countries such as India, Cambodia , Vietnam, Indonesia, and many other southeast Asian countries. As such, this study will propose the conceptual framework of a combination of information systems which are affordable, reliable, and implementable in developing countries especially in the southeast Asian region with a more specific focus on the Indian sub-continent.

3.The Methodology

This study aims to propose a stringing conceptual framework for an affordable, weather resistance and practical solution to increase the adoption of smart farming in India. This is because, India is a country which rely heavily on agriculture for it economic development and is evidenced by the fact that agriculture accounts to more than 20 % of the nation's GDP and more than half of India population relies on agriculture for employment. As such, the solutions in this study are intended for the environment of India and comprises a system of interconnected information systems devices which will improve the internet penetration in rural India because more than half of India does not have access to the internet. Moreover, there is a lack of affordable technologies which suite India' consumer attitude and terrain and this conceptual framework will serve as the foundation for cost effective, weather resistant, reliable, flexible, and adaptable smart farming solutions which will enable the agriculture 4.0 revolution.

3.1 The schematics and inner technical workings of this conceptual framework is detailed below

This entire conceptual framework intends to solve two problems which includes increased internet penetration and reliability while minimizing costs. As such, the source of power for these devices can be from photovoltaic solar power cells which are now affordable for the intended customers in India. This power source is another testament to the commitment to sustainability as these photovoltaic panels can power the entire system for periods of up to 10 years without the need for replacement if these panels and associated equipment are maintained properly. This make the system very energy efficient and sustainable in regards to every aspect of the conceptual framework.

The Micro Controller

The most distinguishing part here is the use of the micro controller as a standalone system to function as the communicating device. This conceptual framework intends to use ESP32 as the micro controller and this can communicate between the same type of micro controller within 400 meters . Moreover, the ESP32 used 802.11 wireless communication which has built in encryption, and this means the data collected from these items can be transported to other IOT devices as most other Wi-Fi routing technology is compatible with the 802.11 wireless protocol and hence this increases the flexibility and compatibility of data transferred. This is very important because the fundamental element of a smart supply chain is that it needs to seamlessly integrate with other elements in the entire supply chain in order to function effectively. This was chosen because of the cost implications as the ESP32 is affordable and reliable. Hence, the use of the ESP32 and connecting them as a network router is the foundations of our smart supply chain and this will use the open shortest path first routing protocols, and this will increase the reliability of the system. There are two major roles played by the micro controller which are the host and the provider which are described in detail below.

The host is an important function of the micro controller, and this primarily relates the activities related to the connection between the GPS module which functions on a frequency of 1575.42MHz and the internet service provider. This includes the signals and systems analysis related to the connection between the satellite and the smart farms. This means, the micro controller needs to be integrated with the soil moisture sensors and the water pump. Coming to the provider role of the GPS module, this includes the important function of creating a stable connection between the host device and the satellite or telecommunications provider. In this case the role of the provider is to act as a slave device as the provider lays dormant and relays data packets between host devices and the internet service provider. This combined and synchronized functioning of the host and provider is needed to ensure the effective and efficient functioning of the irrigation water pumps activated by the soil moisture sensors. Moreover, the seamless functioning of this coupling is needed to gain access to real time data which an important part of the conceptual framework of smart farming.

The soil moisture sensor is used to measure the moisture level of the soil, and this will ensure that the water sprinklers operate in the most effective and efficient manner possible. Further, the data gathered from the soil moisture sensors will be gathered and analysed for trends locally through the use of geographic segmentation and regional average for each square kilometre will be computed. This information will be shared with regional data hubs which collect information for each 40 square kilometres. This will ensure that there is not too much redundant big data because there is already an explosion in the amount of big data available and hence this filtering will reduce the burden on the decision support systems related to smart farming. The soil moisture sensor will need a small power source with less than 5V and hence this is another advantage of using such IOT based sensors.

Now coming to the Hub these devices need to be connected to the internet in areas with little or no internet penetration and hence a GPS module will be used. The GY-GPS6MV2 would be used to connect to the internet via connecting with the satellites (Tripathi and Nitin 2021) . This will use high gain antenna as part to communicate with the satellite and has a ceramic coating on its antenna for weather resistance. This GPS module was specifically chosen due to its low cost and the weather resistance of this device. Further, this device possess a EEPROM with a built in back up battery and this means the devices configurations would be stored in memory in case of power interruptions and this is very important in the case of India because, the nation’s power grid infrastructure is not very reliable as evidenced by intermittent power outages all over India. This is another important consideration regarding the security of the data gathered because, in some cases if there are long power interruptions and there is a lack of reliable backup batteries to for the BIOS. The BIOS password becomes set back to default factory setting and this is another security vulnerability for the GPS module and hence this was addressed clearly with the long-lasting default backup battery. Moreover, the ceramic coating for the antenna is very useful in the case of rain and other weather issues as India sees significant rainfall during the monsoon season.

The transport layer communication protocol used by the GY-GPS6MV2 is the TTL which stands for time to live protocol. This uses the time to live as measured by hop counts to determine the lifetime of the IP packet. This will ensure that the data packets are not rerouted to potentially malicious routes and this will also increase the reliability of the smart farming network. This is because, as the TTL packets have specific times to live they will not be carried forward after a certain distance has passed and this will reduce the network traffic reducing the burden on the smart farming network. Finally, the GY- GPS6MV2 has an LED signal receiving indicator and this will ensure that there is easy maintenance and operations of the device. This is very useful because, the user of these smart farming devices would be menial agricultural workers and highly trained technical workers are not affordable in rural India. This will ensure that easy pictographic manuals can be written and hence increase the adoption of smart farming in rural India where the digital literacy rates is lower than 20 % according to independent studies. This is another benefit of this conceptual framework as this is very easy to use and will need very little training to operate and maintain the devices needed for the operations of the smart farms.

4.The Conceptual Framework Diagrams

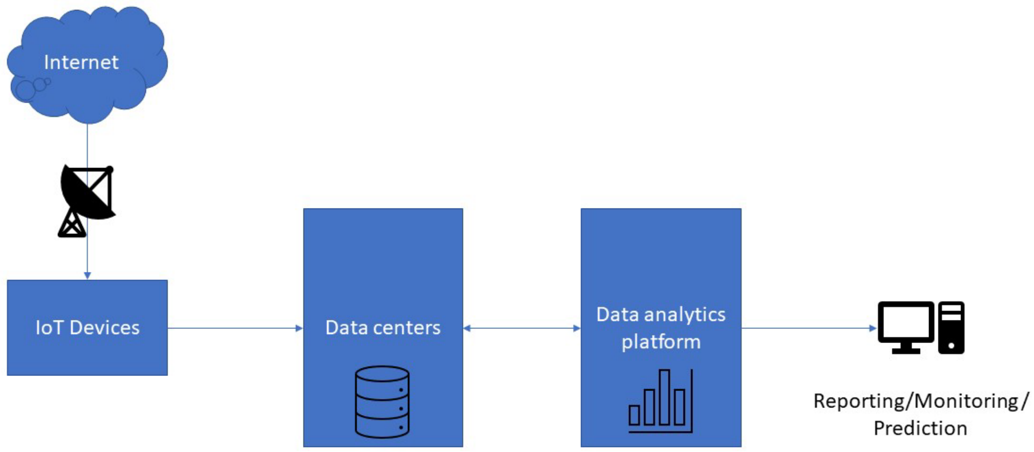

Figure 5 The conceptual model

The summary of the conceptual framework illustrated by figure 5 is that this idea will facilitate the agriculture 4.0 revolution by increasing the adoption of smart farming in rural India. There would be connection between the internet and the IOT devices using satellite dishes and if needed suitable un manner aerial vehicles. This will provide an umbrella of internet coverage for an area of about 40 square kilometres in rural India. Coming to the next step, the IOT devices will consist of cheap but effective micro controllers namely ESP32 and they will function as standalone IOT devices. These ESP32 devices will create a meshed network of smart IOT devices which will aid the smart farming and supply chain management efforts in India.

The data gathered from these IOT sensors will be accumulated in data centres which have our data tampering detection protocols including but not limited to error detection in order to improve the security of data. To reduce the costs further, these data centres will use regional decision support systems which use virtual machines, when possible, to increase the efficiency and effectiveness of decision making. This is because, if we use regional data centres with decision support systems this can help in pinpointing any in efficiencies by increasing both the accuracy and precision of information available for decision making. This takes advantage of economies of scale and hence will create a more flexible and lean smart farming and supply chain in India. This will be similar to the lean manufacturing and six sigma principles developed my Toyota in Japan and this can lead to the 4th agricultural innovation.

Finally, the information gathered from these data centres would be reported to regional government bodies and suitable organization with proper protocol to ensure the safety of data. This is very important because the information regarding agriculture needs to be protected and cannot be shared with malicious organizations or individuals. This is another topic of its own and need further study and exploration.

4.1 Suggested Improvements

It is acknowledged that in this study there is lack of exploring other data protection methods like the use of a combination of block chains and UDP as this is an entire study of its own and is out of the scope of this study for the time being. However, it is encouraged that there needs to be more tangential and derivative studies to explore this possibility of the combination of block chains and UDP in data security as this will increase the speed of the network. This will increase the efficiency of the network and at the same time increase the security of the information that is transmitted.

5.Conclusion

The benefits of using our conceptual framework stem primarily from waste reduction and is an elements in the implementation of the agriculture 4.0. This is especially the case since lean production techniques need to be applied to the agriculture 4.0 revolution to improve both efficiency and effectiveness. This is because, IoT in agriculture allows for greater production control and cost-efficient management through the use of smart devices such as the micro controllers. As such, producers can accurately identify anomalies in crops and prevent infestations that harm yields by improving the disease prediction capabilities. The sensors installed in agricultural machinery can also help save on irrigation and fertilization costs. Additionally, these sensors can be programmed to notify producers of the ideal harvest time, leading to less waste in the crop. Therefore, this will result in proactive agricultural farming, and this will reduce waster waste and crop damage.

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Biography

Mr. Rubalavanyan Vamadeva, is a BBA enterprensuhip student in the final year at the University of Dubai.Heis a qualified from the chartered institute of marketing also known as the CIM from the UK for the purpose of professional marketing. Moreover, he has won many business competions in the UAE most notably , the BCC

Curtin business cup challenge for twice in a row which is an incredible feat. He would like to thank his wonderful father Mr. Kandiah Vamadeva and his two sisters Ms. Jananay Vamadeva and Ms. Hamsahanabiha vamadeva along with this mother Mrs. Kausalya Vamadeva. This family has been all the inspiration for his academic and professional success. It is important to note that his father always encouraged him to purse an education in engineering and sciences as such he wishes to thank his father for all the support and guidance.

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