Journal of Information Technology Research
Volume 15 • Issue 1

Internet of Things and Its Significance on Smart Homes/Cities

Sam Goundar, British University, Vietnam
https://orcid.org/0000-0001-6465-1097

Akashdeep Bhardwaj, University of Petroleum and Energy Studies, India*
https://orcid.org/0000-0001-7361-0465

Deepika Bandhana, University of the South Pacific, Fiji

Melvin Avineshwar Prasad, University of the South Pacific, Fiji

Krishaal Kavish Chand, University of the South Pacific, Fiji

ABSTRACT

Smart homes and cities is one of the crucial topics for an individual of any age that requires almost zero computer literacy in order to benefit the leisure and luxury offered by smart homes and cities. Benefits offered by smart homes and cities are not only limited to leisure and luxury but other various areas of an individual's life and to aid them with information and communication, intelligent responses with the information collected and analyzed, environmental protection and public safety with surveillance. Internet of things was invented in 1999. Since then, there has been a huge bloom in technologies, keeping in mind the present systematic development in sensors, wireless technology, artificial intelligence, and machines and devices. This paper outlines the working prototypes that have been developed and deployed in developed countries and recommends to the Pacific Island nations to accept these technologies for the betterment of their countries. It will also compare the usage of energy and cost saving in smart cities and how this can be beneficial to the nations in the Pacific.

KEYWORDS

Artificial Intelligence, Energy Management, Environmental Protection, Information Communication, Public Safety, Surveillance Sensors, Wireless

1. INTRODUCTION

The aim of this paper is to elaborate on internet of things and its significance on smart homes & cities based on the research done so far. In the early 1900, inventions, ideas and theories regarding the world of technology focused on enhancing and perfecting the outside world. With major upgrade to transport industry, enhancement to the manufacturing industry and streamlining our health services,

DOI: 10.4018/JITR.299936 *Corresponding Author

we have achieved or developed solutions to most of our problems. However, we had not focused on prevention of these issues only after early 2000. This is when the Internet of Things (IoT) and the technology within are investigated on a scale where millions of devices that exist today all support the concept of IoT (Samuel, 2016).

In addition, internet of things can be used to make our homes automated and the basic functionalities that could be controlled by mobile phones or sensor utilisation to avoid voluntarily interaction from the human beings. For instance, when returning home from work in the evening, this individual does not have to switch on the lights, as it will be turned on automatically with the help of the sensor. Moreover, this information will be relayed to the kitchen, where the oven will start heating itself. The kettle will start boiling the water, the freezer will display all item it has in stock and it will automatically send the list of items to the mobile for purchasing. In the case of the smart city, it can send the list to the nearest supermarket and the items can home delivered by someone who is allowed to access the house by the owner with smart technology. This makes the life of an individual more relaxing after a stressful day at work. Nonetheless, it can also reduce hassles in the morning for a family to cook and wake up their children on time for school (Kim, 2017). For many years an object (car, watch, PC, etc.) was relatively disconnected from the direct environment in which it was operating. Now, little sensors, and actuators are embedded in the same objects, which suddenly provided these devices with the ability to sense and record information regarding its current state of operation and environment (temperature, etc.).

IoT in its simplest form means the worldwide network of interconnected object uniquely addressable, based on standard communication protocols. This network is made of interconnected devices that transmit data to each other locally or over the internet with the aim of collecting heterogeneous data. This data is further analyzed by the devices itself or by cloud based applications controlling the devices to produce intelligent response to environment, event or human behavior (Khan & Han, 2017).

This paper outlines the working prototypes that have been developed and deployed in developed countries and recommend to the pacific island nations to accept these technologies for the betterment of their countries. It will also compare the usage of energy and cost saving in smart city and how this can be beneficial to the nations in the Pacific particularly in Fiji. In addition, research questions were developed to identify and highlight the key points and contributions made by other researchers.

2. RELIABILITY OF HUMAN INTERACTION AND BEHAVIOUR

In the beginning, internet was mainly used for Human-to-Human interaction (H2H) such as text messaging, social networking and electronic mail. These, now ancient, services were later perfected into Human to Machine (H2M) interaction with the use of Artificial Intelligence. Classic examples of these are, when an intelligent machine tailors a web page for the user accordingly to its browser history and even considering its locations. M. Weiser, over 20 years ago stated that devices with IoT enabled features will be everywhere in almost all of the devices, connected and ubiquitously living amongst living with humans. This is a reality now.

Human interaction is still required to access many of the devices that exist today. However, most if not all are enabled with features that permits interaction between each other with minimum or no human interactions. This makes these devices truly smart. This functionality of the devices to communicate with each other is also known as Machine-to-Machine (M2M) interaction, which is the core concept behind IoT.

For many years now, passive and active sensors embedded in devices such as smart watch, fit bit, etc. have been collecting data on human activities and behaviour and providing feedback based on predetermined algorithms. However, for correct actions to be taken, human interaction is required. For a true deployment of IoT, this interaction has to be reduced or removed. As humans, mistakes or errors are inevitable and this is an issue.

For example, if a family has left their home to travel to work, school or just a family outing for the day. In the process, they have forgotten to switch off some unused appliances and activate alarm. This action may results in loss of valuable energy and property. With the deployment of Smart Home (SH) using IoT enabled devices, sensors can pick or register if any occupant is in the premises and delay the process of switching off appliance and activating the alarm. If no movement is sensed from within the premises and if GPS signal received from car and occupants smart phones confirms the location is away from home SH can activate the alarm and switch off any unused appliance. This not only helps in assisting occupants in protecting their property but also save a few dollars in their next electrical bill (Alliance, 2016).

Another example would be, where a SH measure the water usage of a household and gives a report at the end of the month with suggestions on improving water usage. If there is a faulty valve in the toilet or a faucet in the sink that is leaking water as it is not able to close and recommendation could be worked on to ensure proper utilization of resources.

2.1 Information and Communication

Communication is the fundamentals to relay message from one person to the other or to get things done, in order to relay this message, some form of data is collected which is analysed to provide information, this information can be used to make a decision, with the introduction of internet, communication between two individuals, an off sight employee to its employer and a patient to its doctor has become much easier. Moreover, let us take a present day scenario, which affects every commuter throughout the day at an intersection with the traffic light system. The traffic light system is there to manage the traffic and ensure an efficient flow in the traffic. However, what happens when the traffic light stops functioning, this creates a mess in traffic, conflict between motorists and the traffic stands still. This could have been avoided with the existence of smart city where sensors from the car recognises the problems and transmits the signal to the nearest city council and its traffic control management centre. The data is analysed and information is transmitted with the signals to the approaching vehicles hinting a traffic jam is ahead and suggesting an alternate path to reach its destination.

Meanwhile a traffic controller is sent to the sight to control the traffic until the malfunction is analysed. Other instances where communication and information sharing has let individuals save time and energy is when looking for a parking spot in a mall, as soon as the vehicle enters the parking lot, information is displayed on the car dashboard prompting the motorist which spot is vacant and can be utilised for parking otherwise suggesting the next convenient parking lot. On the same hand, utility of the information becomes more effective with smart grid, which is the core functionality of smart homes and cities to efficiently manage energy consumption. Smart grid gives an opportunity to improve the reliability, availability and efficiency that will contribute towards economic and environmental health. “The benefits associated with smart grids is that the energy transmission becomes more efficient, speedier restoration of electricity after power disturbances, reduced operations and management costs for utilities, and eventually lower power costs for consumers, reduced peak demand will also help lower electricity rates, increased integration of large-scale renewable energy systems, better integration of customer-owner power generation systems, including renewable energy systems and improved security”.

Presently in Fiji power outage due to hurricanes and flooding cause a lot disruption for a large number of population, sometimes it takes months to restore the supply, for instance in the case of Cyclone Winston it took more than three months to restore the power supply. However, in the case of smart cities this effect could have been minimized by containing the outage so that it is not spread to the entire area.

2.2 Environmental Protection and Public Safety

In each household and business, there are many devices used on a daily basis and majority of these devices require electricity for use. Even with the most advanced power management systems, electrical

energy is wasted if these devices are not used optimally. To produce electricity, EFL (formally known as Fiji Electricity Authority) uses hydro generators and diesel generators to provide for the majority of the electrical needs of the nation. The use of such machines leaves its impact on the environment in the form of Carbon Footprint. Even devices contribute to the carbon footprint of the nation, as they are not managed optimally.

Most business in Fiji have printers, which use resources and through observations made by the researchers of this paper. In their respective organizations, these machines are mismanaged in terms of not being switched off after operations have been terminated for the day, the printing requirements of the organization can be optimized. However, these lack expert advice and decision-making abilities as no data is collected for review, etc.

Due to heavy traffic and no optimization of traffic lights, thousands of cars are held up in traffic causing unnecessary burning of fuel, therefore contributing to carbon footprint. According to IoT Alliance report (2016), when Wellington City was handed over to NEC as a laboratory for testing IoT solutions, traffic lights were optimized by embedded sensors which collected data and changed traffic lights to ensure traffic movement was maximized resulting in lower fuel requirements.

Criminal activity is the biggest threat to a country's GDP as it drives away potential investors locally and abroad. Due to this, law enforcement bodies around the globe have started to heavily invest in ways to minimize crime or criminal activities. AI and machine learning applications are being used to collect video data and micro sensors collect audio data too. This data is then analysed for behavioural patterns associated with criminal activities. Such systems can not only detect ongoing criminal activities and assist in apprehending suspects, but also alert the authorities of a potential crime and with quick and smart decisions; such acts could be stopped before they eventuate (Barnaghi, Bauer, Biswas, & Volk, 2015).

Global Warming heavily affects Fiji and the pacific and solutions working on IoT based technology can easily provide a helping hand in mitigating this. Decision can be taken; however, the correct data is current not available quick enough to take preventive action. Similarly, for enhanced Public Safety, IoT enabled devices could assist in solving cases faster and reduce the number of cases being generated with its predicting modules. Examples of such working solutions are ShotSpotter and Hikvision. They both use sensors, chips embedded in each device that listens and sees data respectively. ShotSpotter is engineered to identify the location of a gunshot whereas Hikvision, scans images like licence plate and face for criminal record and alert authorities accordingly of the location (Bump, 2018).

2.3 Surveillance

(Sruthy & George, 2017), In this paper, the authors have introduced a new revised security system that uses Raspberry Pi and Node MCU (IoT/WiFi module) that provides integration of sensors and video surveillance. "Raspberry Pi is a low cost, low power, single board computer which can handle multiple functions like a normal computer" (Sruthy & George, 2017). The detection of fire and intrusion are the features of this system and is based on the Wi-Fi connectivity. Using Wi-Fi, enables data and information to be gathered and moved to cloud for storage and monitoring purposes and having long range and high bandwidth, makes it easy to stream high quality videos. In addition, the IoT module makes the system cost beneficial, compact, accessible and controllable from anywhere in the world, provided, internet access.

Further, the surveillance controller system consists of webcam for video monitoring; GSM is used for the remote notification of events and buzzers that act as emergency alerts. The system takes care of various controls for example the management of feedback form sensors, cameras, videos, email, SMS and call alerts. (Sruthy & George, 2017) highlighted that NodeMCU is designed to work as a Wifi server and the system uses USB Wi-Fi adapter to connect to the Wi-Fi. The system acts with the updates from the sensor nodes. When the status of the sensor is received, cameras or webcams would be activated and the recording of activities will take place. Users will have access to the live footage using the IP address of the RPi. The GSM modern, as a response, would send messages to

relevant parties such as owners, fire stations and police if any unsuspected activities were seen. Users would feel safe even if they were away from home as their property would be under their surveillance. Cities would also benefit as any dangerous or unsuspected activities going on in cities and this can provide feedback to relevant authorities.

3. PRESENT DEVELOPMENT

Internet connectivity is vital for the implementation of IoT solutions and Vodafone Fiji being the leader in the Telecommunication Industry has confirmed recently that they have 760,000 mobile connections in a country where the total population is only 912,241. They have also confirmed that in the next two years, their team will be focused on developing more cloud-based solutions for its customers. This adds to the potential if IoT solutions becoming a reality in Fiji as most analysis in IoT solutions are executed on the cloud. The fact that Vodafone Fiji is 100% locally owned franchise, any return of investment on such ventures are given back to the locals (Chanel, 2018).

An investigation conducted in New Zealand, highlighted the economic benefits associated with deployment of IoT in mere nine application areas. These included agriculture, cities, utilities, asset management and manufacturing. However, to continue benefiting or to increase economic development, industries implementing IoT must continue to raise awareness, educate to improve knowledge and address to issues such as security and privacy of IoT data. (Alliance, 2016). Buyers or users of IoT solution must note at this point that data collection in the true value of IoT and not the technology/ device itself.

Government is the true catalyst in the development of SH and SC as government tools can be used to create awareness and policies regarding IoT security and privacy. The cohesive government vision of the nation that is developed during budget announcements can also assist local governments, businesses and investors abroad to initiate such setup that can boost the nation's economy as waste is controlled by IoT solutions and savings can be further invested in the same initiatives to increase coverage of such solutions (P & E, 2018).

Moreover, Australia's energy report shows that there was a decline in the energy consumption rate since the 1990's, in 2020. "This indicates a longer-term decline in the ratio of energy use to activity in the Australian economy (energy intensity), which can be attributed to two main factors: improvements in energy efficiency associated with technological advancement; and a shift in industry structure toward less energy-intensive sectors such as commercial and services"("the smart grid,").

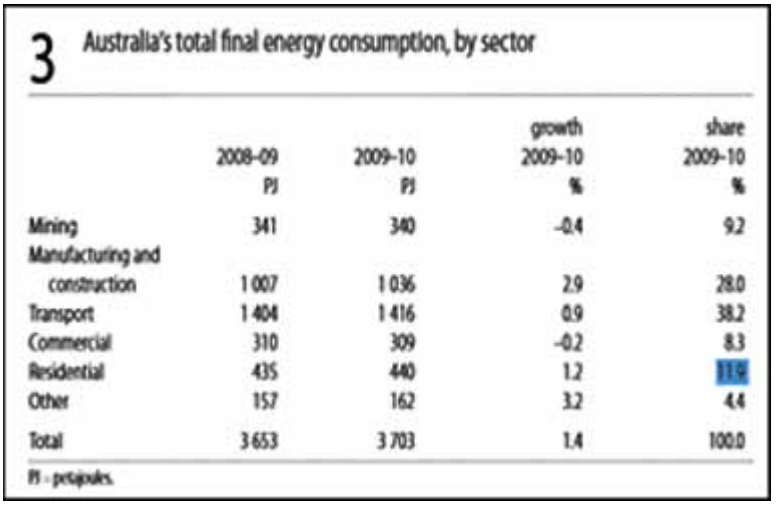
Comparatively, Australian economic growth in 2016 has overtaken energy consumption rate over the past decade, where it was noticed a higher energy productivity over time compared to a lower energy intensity. "This reflects cumulative improvements in energy efficiency as well as a shift in the Australian economy away from highly energy-intensive industries such as manufacturing towards less energy-intensive industries such as services"(2011). To add on, "energy productivity is the measure of economic output divides by energy consumption as per the 2018 report, the productivity was improved by 0.9 per cent in 2016–17, after being flat in 2015–16. Energy productivity has improved by 17 per cent over the past ten years"(*Australian Energy Update 2017*, 2017).

In addition to that a report released by Intergovernmental Panel on Climate Change (IPCC), it was noted that by 2050 the global temperature will raise $1.5 - 2°C$. This is due to human induced warming above pre-industrial levels, with the excess use of coal, fossil fuel and energy. This is a catalytic reaction towards global warming with the increasing population (Special Report on Global Warming of 1.5 °C (SR15), 2018).

3.1 Smart Technology

A research conducted in New Zealand, highlighted that New Zealand's Agricultural Industry has been booming in the recent years due to the introduction of IoT solutions in their farms, which help, give farmers insight on the conditions of the soil and make sound decisions on irrigation and fertilization

Figure 1. Total Energy Consumption in Australia 2020



3 Australia's total final energy consumption, by sector

	2008-09 PJ	2009-10 PJ	growth 2009-10 %	share 2009-10 %
Mining	341	340	-0.4	9.2
Manufacturing and construction	1 007	1 036	2.9	28.0
Transport	1 404	1 416	0.9	38.2
Commercial	310	309	-0.2	8.3
Residential	435	440	1.2	11.9
Other	157	162	3.2	4.4
Total	3 653	3 703	1.4	100.0

PJ = petajoules.

Table 1. Connected device in Australia per year (Australian Energy Update 2018, 2018)

Connected Devices in Australia	
2016	10,000 households
2017	Home market grew 55% AU$583m (13.7 connected devices/house)
2018	17.1 connected device
2020	37 connected device vs 381 m nationally

Table 2. Australian population per year

Population	
2011	22,485,300
2016	24,125,848
2017	24,450,561
2018	24,864,122

requirements with minimum to no waste. Sensors embedded in the soil transmit data on moisture, humidity and current quality of soil. Analytics is performed to this raw data for insight, famers are able to make decisions such as; when to perform irrigation, and for how long to ensure soil is adequately moist and fertilized for achieving quality yield. Some systems are also linked to the weather stations so farmers can avoid the use of water when rain has been forecasted.

In the same research, Wellington was selected to become an IoT Laboratory for NEC and as a result, the city dwellers are benefiting from the solutions provided by NEC. NEC is a global technology company specialising in Smart City, ICT, biometric and network products and services for government and enterprise. In this, sensors, actuators, CCTV cameras on traffic lights, Wi-Fi portals, etc. collected data on the movement of the people and modulated strategies to tackle issues such as traffic, accidents, theft and many more. Adaptive Traffic Lights is an example of this that

has been deployed in Wellington and other parts of New Zealand. Data is received from the cameras and sensors in real-time are analysed. Based on the results the lights operation is altered to reduce traffic congestions. This results in productivity amongst workers and deferred unnecessary cost from construction work for a new road.

IoT metering is a technology that is widely used in New Zealand. This technology is used to monitor electrical and water usage in household, provides accurate readings, and can detect leaks and faults in wiring. This enables providers and consumers with real time data and insight on actual reading unlike in Fiji where estimates are taken more than the actual readings. With real time and accurate data, users are aware of their usage and can act accordingly to modify behaviour towards sensible use of resources (Ghayvat, Mukhopadhyay, Gui, & Suryadevara, 2015).

Sensors in IoT devices or solutions are being used to track, monitor and manage assets for households and businesses. Every household and Business in Fiji relies on some sort of transportation or logistic. For asset tracking mostly, RFID technology is used to receive data on current location of asset and the condition (integrity) of the asset (Chen, Azhari, & Leu, 2018). Predictive maintenance is the biggest driving factor of Asset tracking as sensors embedded in devices measure current state of the device to determine the next logical maintenance instead of following the scheduled maintenance plans. This is done as the schedule maintenance plan could be either too frequent, resulting in high unnecessary maintenance work or too infrequent leading to breakdowns. Asset Tracking, which is available in some companies in Fiji have seen the full benefits derived from this technology. Tracking of resources with the use of GPS transmitters gives insight on use versus productivity of resources and predicts maintenance schedules to ensure longer life for these resources and adequate use.

Bluetooth is a short-range wireless technology that allows devices to communicate with each other at a certain distance, approximately 10-100 meters while being inexpensive. It was developed with an aim of connecting devices in wireless personal area network (WPAN) that would enable the exchange of data at high data rates. (Madakam et al., 2015) highlights that the channel of communication that Bluetooth devices use is known as 'Piconet' which has the capability of hosting 2 - 8 devices at a time for sharing data such as text, pictures, sound and video.

With the introduction of Bluetooth (BT) 4.0, a new technological enhancement emerged with it termed as 'Bluetooth Low Energy (BLE), originally known as 'Wibree'. This technology is the IoT version of Bluetooth since according to (Montori, Bedogni, Di Felice, & Bononi, 2018), "it preserves its communication range by reducing the data rate down to 1 Mbps and, consequently, the power dissipated down by 20–100 times." BLE is reliable for personal area networks dedicating communication in short distance, for example, UriBeacon applications that checks for the available devices around the owner which is helpful for context awareness and location based applications. Within the context of smart homes/cities, users can connect their Bluetooth devices such as phones, laptops tablets etc. with each other and other appliances that support Bluetooth for an interaction between the user and the object to provide interaction of real time data.

Zigbee has been developed to enhance the sensing capabilities of wireless networks. (Yan, 2018) points out that the level of security performance for wireless technology is at the highest because of Zigbee technology using 'advanced encryption standard' (AES) technology. The mesh structure that it uses makes it possible to communicate with other devices, increasing the network's stability. (Yan, 2018)also highlights that Zigbee technology can contain thousands of nodes which would be able to support the family needs effectively. In addition, the two-way communication improves the experience of using Zigbee devices. To add on, the advantages of Zigbee technology include low cost, less usage of power, more efficient and strong networking with high security, which makes it a reliable technology to be used in smart homes and cities. (Montori et al., 2018) also claims that Zigbee is one of those protocols that could be used in automating homes with energy and load management capability.

3.2 Devices & Machines

Introduction of Smart Homes/Cities means production and utility of numerous devices and machines. For instance in a medical industry where there are so many wearables and connected devices that needs to store, process the obtained data. In a situation the data can be sent to the cloud to process it, however keeping in mind the latency delay associated with cloud computing, the idea of using this devices and adoption of smart homes and cities will become insignificant. Nonetheless, fog computing will be an essential paradigm that will offer the benefits of cloud computing but also minimize the delay time for the data to be sent to the cloud, processed and returned. This will be an added advantage for the users as the concept of fog computing will lessen the bandwidth usage for the transmission of data across the medium (Rahmani, et al., 2017).

In the IoT structure, the hardware that identifies the objects (things), detecting the bounds of it, carrying out information communication, processing and computation of information within an IoT. (Khajenasiri, Estebsari, Verhelst, & Gielen, 2017) states that objects are identified using different addressing methods that are based on internet protocols such as IPv4, IPv6, and 6LoWPAN. In the identification process, it is necessary to make out that the objects identification is different from its address. Although, Objects in the IoT system can be recognised locally, the objects, public IPs are used in the global network to identify the objects within it.

Adding on, integrating IoT with RFID, enables the addition of authentication mechanisms in enhancing the security of devices connected. (Tewari & Gupta, 2018) has pointed out that in the recent years; there are authentications structures that are in the proposal phase for RFID that would lead to the devices in IoT, free from security threats.

3.3 Artificial Intelligence/Response

Intelligent response in Smart Home (SH) and Smart Cities (SC) refers to the ability to predict behaviour of humans based on the collection of raw data, learning outcomes from experiences, information management and live data of the surrounding, which is collected from the deployed sensors and actuators. The challenge here is to rely on good management practices and intelligent use of the vast amount of data generated from IoT devices. Artificial Intelligence (AI), ambient technology and sematic reasoning technology transforms raw data into information/ knowledge and previous research has shown tremendous progress in this. In addition, research on deep learning has shown results in machine intelligence that match or even surpass human capabilities, however, the final intelligent action required based on the derived knowledge is executed by a human in human based technology such as SH.

4. RESULTS OBTAINED

Locally collected data is sent to the cloud applications for analysis. This data is processed using various algorithms (WaaS – Wisdom as a Service and DIKW – Data, information, Knowledge, Wisdom hierarchy on a cloud platform introduced by Chen et al. 2014) and sent back to the user (Mauro, 2016). For full automation in SH, Human behaviour and habit tracking is critical. Intelligence on user habit tracking in SH may be derived from browser history and activity logs stored on individual devices, and should be continuously explored to improve user experience. AI in SH uses two categories for decision making which are content based filtering and collaborative filtering. Content based filtering uses data on experiences to modulate or propose new actions. However, Collaborative filtering uses data on similar situations and provides the best possible action. The best practice of AI uses a hybrid of the two filtering options to ensure that every decision is desirable and successful.

By comparing data from both the tables, it was obvious that the development in Smart Appliance (*SA*) was directly proportional to Energy Management (*EM*) with revenue generation and penetration

Table 3. Research questions

Research Questions	Papers	Other Sources
How would the application of IoT in homes and cities be reliable for the people?	6	
What are the issues faced by people in their daily life?	7	
What could be the possible solutions to problems associated with IoT that would lead to homes and cities adapting IoT?	9	6
When could the IoT be adapted to homes and cities in developing countries like Fiji and the rest of the Pacific?	10	
If many do adapt IoT, where could it stand in the years to come and how would the globe see it?	6	
What is the present development is Smart Homes, Internet of Things.	10	2

Table 4. Satistics penetration rate of smart homes in Australia

Penetration Rate (%)	2016	2017	2018	2019	2020	2021	2022
Control and Connectivity	6.02	8.53	12.07	16.30	20.70	24.99	29.23
Comfort and lightning	4.61	6.42	8.89	11.85	15.08	18.47	22.02
Security	4.48	6.10	8.25	10.72	13.28	15.82	18.39
Home Entertainment	3.99	5.38	7.22	9.34	11.57	13.86	16.21
Energy Management	***2.66***	***3.81***	***5.45***	***7.48***	***9.78***	***12.24***	***14.88***
Smart Appliances	***4.03***	***5.58***	***7.67***	***10.17***	***12.91***	***15.81***	***18.91***

Table 5. Average revenue generated by smart homes in Australia

Average Revenue (USD)	2016	2017	2018	2019	2020	2021	2022
Control and Connectivity	158.18	171.79	179.92	180.70	176.96	173.04	172.03
Comfort and lightning	92.46	100.03	103.16	103.02	101.29	99.38	98.90
Security	191.52	209.27	216.51	216.03	212.41	209.24	210.02
Home Entertainment	173.17	180.07	176.42	165.18	152.07	141.02	136.72
Energy Management	***161.76***	***174.44***	***175.77***	***169.08***	***158.82***	***148.64***	***141.77***
Smart Appliances	***287.95***	***316.08***	***320.78***	***309.40***	***291.49***	***273.97***	***262.00***

rate of smart homes $SA \propto EM$. Conversely, it is possible to postulate that the introduction of smart appliances has led to improvement in energy efficiency and productivity in Australia.

After observing Australia's development in energy management with smart homes, we would like to draw attention to Fiji, a small island nation that is progressively moving towards development in infrastructure, with an increase in infrastructure industry the Energy/Electricity usage also increases. This graph shows the consumption of electricity in billion kilowatts units.

Electricity usage in Fiji has increased since the 1980s.It is obvious to note the spur is due to the usage of advance technologies and increased growth in infrastructure in the contemporary society then the past two decades. Nevertheless, with an evolution in technology, a lot of devices and machines are manufactured energy efficient; in this circumstance, electricity consumption must have reached

Figure 2. Electricity Consumption in Fiji

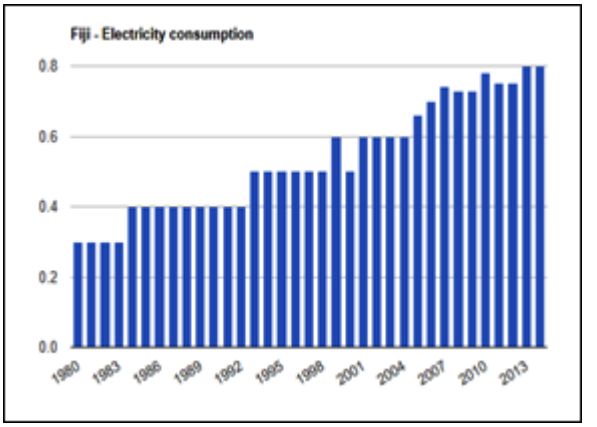


Table 6. Electricity value and cost (0.3310/unit) against the year in Fiji

Year	Electricity Value (billion kW)	Cost (FJD)
1980	0.32	99,300, 000
1985	0.41	132,400,000
1990	0.48	132,400,000
1995	0.52	165,500,000
2000	0.57	165,500,000
2005	0.66	218,460,000
2010	0.78	258,180,000
2014	0.81	264,800,000
2016	0.87	277,500,000
2018	0.91	291,850,000

a peak and declined after that which is obviously not noted as per the observation. We can assume that a significant wastage in Electricity is due to ignorance and lack of initiative from the people to efficiently utilise resources. For instance, lights and other household appliances are not switched off even though it is not in use, on the same note there is a power outage in an area due to a disruption however the grids are not able to contain it or automatically divert power to the area of outage.

In addition, random interview questions were asked to ensure the claim that electricity in Fiji is mismanaged. Most of the interviewees agreed that they often forget to switch off the power supply when the lights, TV, Fan/AC and other electric appliances are not in use. In this circumstance, introduction of smart homes/cities could save a lot of energy, cut the cost and bring leisure to the people after a busy day at work or even in the hectic morning where commuters are rushing to avoid the traffic and be at work on time.

CONCLUSION

In comparison with Australia, Fiji's economy was initially noticed to be 11 to 4 times weaker; however, as per the data given in the table Fiji's economy is increasing its strength against Australia. Therefore,

Table 7. GDP comparison

GDP per Capita	Fiji (USD)	Australia (USD)	Ratio (Fiji: Australia)
2015	4,921.90	56,554.04	1:11
2016	5,153.35	49,927.82	1:9
2017	7,103.12	54,286.29	1:7
2018	8,286.47	51,378.29	1:6
2019	8,553.81	42,121.54	1:4

this will substantiate the adoption of smart home concept in Fiji, which can possibly generate good revenue and increase energy/electricity management. Smart homes and Cities offer various advantages to the people who choose to live a smart life. This paper has brought light to the benefits associated with smart homes and appliances. It also indicates present development in a south pacific country; Australia where the revenue and penetration rate of energy management increased with an increased usage in smart appliances. In comparison of Australia's GDP against Fiji; where Fiji has gradually improved its GDP in recent years, it can be inferred that the concept of smart homes/cities can also bring a positive change in Fiji with Energy/Electricity management and perhaps escalate the smart market revenue contributing towards a better GDP. IoT solutions not only controls waste of energy, but also provide a platform to make better investment decisions.

FUNDING AGENCY

The publisher has waived the Open Access Processing fee for this article.

REFERENCES

Alliance, N. Z. (2016). *Accelerating a Connected New Zealand*. digitalnation.nz.

Australian Energy Update. (2017). Department of the Environment and Energy.

Australian Energy Update. (2018). Department of the Environment and Energy.

Barnaghi, P., Bauer, M., Biswas, A. R., & Volk, M. (2015). IoT Analytics for Public Safety. *ResearchGate*, 246-252.

Bump, P. (2018, March 8). *AI for Crime Prevention and Detection – Current Applications*. Retrieved from techemergence: https://www.techemergence.com/ai-crime-prevention-5-current-applications/

Chadwick, J. (2018, May 18). *Australian smart home device market grew 55 percent in 2017: Telsyte*. Retrieved from zdnet: https://www.zdnet.com/article/australian-smart-home-device-market-grew-55-percent-in-2017-telsyte/

Chanel, S. (2018, August 5). *Vodafone Fiji Subscriber Numbers Soaring*. Retrieved from FIJI SUN: http://fijisun.com.fj/2018/08/05/vodafone-fiji-subscriber-numbers-soaring/

Chen, Y., Azhari, M. Z., & Leu, J. (2018). Design and Implementation of a power consumption management system for smart home over fog-cloud computing. *IGBSG*, 1-5.

Fiji: Electricity Consumption. (n.d.). Retrieved from The Global Economy: https://www.theglobaleconomy.com/Fiji/electricity_consumption/

GDP per capita (current US$). (n.d.). Retrieved from The World Bank: https://data.worldbank.org/indicator/NY.GDP.PCAP.CD

Ghayvat, H., Mukhopadhyay, S., Gui, X., & Suryadevara, N. (2015). WSN- and IOT-Based Smart Homes and Their Extension to Smart Buildings. *Sensors (Basel)*, 10350–10379.

Khan, S. B., & Han, K. (2017). INtegration of big data analytics embedded smart city architecture with restful web of things for efficient service provision and energy management. *Future Generation Computer Systems*, 1–13.

Kim, E. (2017). Smart city Service platform associated with smart home. *ICOIN*, 608 - 610.

Madakam, S., Ramaswamy, R., & Tripathi, S. (2015). Internet of Things (IoT): A literature review. *Journal of Computer and Communications*, *3*(05), 164.

Mauro, A. D. (2016). A formal definition of Big Data based on its essential features. Emerald Group Publishing Limited.

Montori, F., Bedogni, L., Di Felice, M., & Bononi, L. (2018). Machine-to-machine wireless communication technologies for the Internet of Things: Taxonomy, comparison and open issues. *Pervasive and Mobile Computing*.

P, L., & E, S. K. (2018). Complex IoT systems as enablers for smart homes in a smart city vision. *Sensors*, 1-14.

Rahmani, A. M., Gia, T. N., Negash, B., Anzanpour, A., Azimi, I., & Jiang, M. (2017). Exploiting smart e-Health gateways at the edge of healthcare. *Future Generation Computer Systems*, 3.

Samuel, S. (2016). A review of connectivity challenges in IoT-smart home. *ICBDSC*, 1 -4.

Schultz, A., & Petchey, R. (2011). *Energy update 2011*. Australian Bureau of Agricultural and Resource Economics and Sciences.

Smart Home. (n.d.). Retrieved from The Statistics Portal: https://www.statista.com/outlook/279/107/smart-home/australia

Special Report on Global Warming of 1.5 °C (SR15). (2018, October). Retrieved from ipcc: https://www.ipcc.ch/

Sruthy, S., & George, S. N. (2017). *WiFi enabled home security surveillance system using Raspberry Pi and IoT module.* Paper presented at the Signal Processing, Informatics, Communication and Energy Systems (SPICES), 2017 IEEE International Conference on.

Tewari, A., & Gupta, B. (2018). Security, privacy and trust of different layers in Internet-of-Things (IoTs) framework. *Future Generation Computer Systems*.

The Smart Grid. (n.d.). Retrieved from smartgrid: https://www.smartgrid.gov/the_smart_grid/smart_grid.html

Yan, H. (2018). *Design of Smart Home Gateway Based on ZigBee Technology*. Paper presented at the 2018 International Conference on Intelligent Transportation, Big Data & Smart City (ICITBS).

Sam Goundar is an Editor-in-Chief of the International Journal of Blockchains and Cryptocurrencies (IJFC) – Inderscience Publishers, Editor-in-Chief of the International Journal of Fog Computing (IJFC) – IGI Publishers, Section Editor of the Journal of Education and Information Technologies (EAIT) – Springer and Editor-in-Chief (Emeritus) of the International Journal of Cloud Applications and Computing (IJCAC) – IGI Publishers. He is also on the Editorial Review Board of more than 20 high impact factor journals.As a researcher, apart from Blockchains, Cryptocurrencies, Fog Computing, Mobile Cloud Computing and Cloud Computing, Dr. Sam Goundar also researches in Educational Technology, MOOCs, Artificial Intelligence, ICT in Climate Change, ICT Devices in the Classroom, Using Mobile Devices in Education, e-Government, and Disaster Management. He has published on all these topics. He was a Research Fellow with the United Nations University.He is a Senior Lecturer in IS at The University of the South Pacific, Adjunct Lecturer in IS at Victoria University of Wellington and an Affiliate Professor of Information Technology at Pontificia Universidad Catolica Del Peru.

Akashdeep Bhardwaj achieved his PhD from University of Petroleum & Energy Studies (UPES), Post Graduate Diploma in Management (PGDM), Engineering graduate in Computer Science. He has worked as Head of Cyber Security Operations and currently is a Professor in a leading university in India. He has over 24 year experience working as an Enterprise Risk and Resilience and Information Security and Technology professional for various global multinationals.

Deepika Bandhana received her Masters in Information Systems in 2020, her Post Graduate Diploma Information Systems in 2020 and her Bachelor of Science (Mathematics & Computing Science) in 2013 from the University of the South Pacific. She worked for the University of the South Pacific in 2013, for Webmedia South Pacific in 2013, for the Fiji National University in Human Resources in 2014, for the Fiji National University College of Engineering, Science & Technology in 2014 and for the Fiji National University Department of Quality Awards in 2018.

Melvin Avineshwar Prasad was born in Fiji and educated in two universities with over 9 years of industrial experience in IT Support, Networking, DBMS, etc. Currently he is attached with USP with the position of Facilitator IT Programs and is also pursuing his Masters Degree with USP in Information Systems. He is fascinated with technology, primarily in the areas of IoT, Big Data, Data Analytics and AI. He is considering a change in location to further his career in academic writing and teaching with recognized RTO's.

Krishaal K. Chand was born in Labasa, Fiji. He accomplished his BSc degree in Information Systems from The University of the South Pacific, Fiji, in 2018. He also got honored with a postgraduate in information technology and is currently pursuing his master's degree in information systems from the same university. His research interest includes IoT, AI, and data mining. As of work experience, he is currently employed at a telecommunication firm as an IT engineer and works on new technologies that enable the organization to maintain its standards with technological trends.