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Practical Implementation of Internet-of-Things (IoT) Technology to solve Agricultural Expansion and Automation

Abstract

The Internet of Things (IoT) is a rapidly growing branch of technology that despite being very much still in its infancy, is becoming more commonly widespread as a means of achieving degrees of automation and convenience through a network of interconnected devices. From 2018 to 2025 it is expected the IoT market will grow from $151B to $1,567B – a 1000% increase. (Decker-Lucke, 2021). On the other end of the spectrum is agriculture – an industry which on a global scale has generally been sluggish to adopt new technologies but in non-developed countries represents the primary household occupation of more than 66% of (Roser, 2013) and more than 80% of the food source. Technological advancements that see even modest gains in this field will improve cost and efficiency in developed countries but will result in significant gains in non-developed countries such as India where 42% of the agricultural land sees regular drought (Gogoi, 2019). Additionally, “it is estimated that food production must increase by 70% by the year 2050 in order to meet the needs of an estimated world population of 9.1 billion people” (N. Alexandratos and J. Bruinsma, "World agriculture towards 2030/2050: The 2012 revision", *Global Perspective Studies Team FAO Agricultural Development Economics Division*.) Consequently, it is of ever-increasing urgency that technology and a greater understanding of practical implementation of IoT technology in rural settings is developed to better equip agricultural producers to face these challenges.

Due to IoT still being a relatively young technology it is lively hub of further development and attention as the use-cases and benefits of IoT become more developed and further understood. It may then seem that remote farmland in rural North Queensland would pose as an unlikely testing ground to present a clever use-case of IoT implementation. However, this paper will serve to highlight the usefulness of IoT technology in reducing manual workload, improving efficiency, partial – to full automation of tasks, and allowing users to make better informed decisions through the practical application of interconnected sensors which are of particular strategic benefit when applied to a large property with many responsibilities.

Paddock-to-Plate Farmyard and Café is seeking to expand their family-run business operations to include an additional property located 50 kilometers away. As part of this expansion project, the team is seeking to incorporate an IoT solution that reduces the manual overhead that comes with agricultural responsibilities. The strengths of IoT technology in this scenario can be tangibly demonstrated through practical use of sensors strategically placed to measure environmental conditions in conjunction with non-complex computer logic to determine if the values being submitted from these sensors fall within acceptable parameters.

Solutions to posed problems are submitted using end devices such as Raspberry Pi, router and node configurations such as Tree, Mesh and Star, in conjunction with network standards ZigBee, WiFi, 3G, and BoXmote.

Introduction

This paper provides an in-depth overview of a modern agricultural setting facing problems that can be automated using automation accomplished through use concurrent IoT solutions. The scenario presented here involves Paddock-to-Plate Farmyard café – a business in Northern Queensland that is in the process of expanding its operations to include an additional property approximately 50kms away. As part of this expansion the business is interested in degrees of automation for some of the many manual responsibilities through the use of devices that monitor and test for specific conditions, and then send alerts to their mobile phones and computers.

These tasks include

- crop irrigation,
- livestock welfare,
- harvesting assessment of fruit and nuts
- food storage, and
- farm security

As part of the approach to implement automation of these tasks, it is critical that there are checks in place to ensure that they are executed within the parameters determined by the property managers. Successfully automating a process requires there to be checks in place to ensure that nothing goes awry as they are left unmonitored. In the scenario of water irrigation for example, it is important that the water pumps are not turned on while it is already raining to avoid wasting water and potentially flooding the crops. Conversely, it is also an important condition of successful automation that there are checks in place to ensure that water is provided to the crops when the soil is sufficiently dry to ensure that the vegetation does not wither.

The location for this scenario offers some distinct advantages and disadvantages in comparison to industrial manufacturing plants which are a common site for implantation of IoT solutions. Due to the remoteness and absence of physical obstacles such as buildings, hills, and dense foliage most communication standards such as Bluetooth, ZigBee, and WIFI will see superior performance in terms of range and uninterrupted data transmission - thanks to the open line of site between transmitter to receiver resulting in little to no interference. These physical obstacles pose challenges in building facilities in addition to the crowded environment of other wireless devices – such as mobile phones, other machinery,
However there is a trade-off to contrast the perks gained by the remote location – cellular signal is expected to be less developed and less reliable than the mobile phone recectpion found in metropolitan cities. As a result reliable 4G reception may not be a means of communication that can be used and 5G reception is unlikely to be available for at least decades. (Optus 3G / 4G / 5G coverage in Cairns, Australia - nPerf.com. (n.d.). Optus 3G / 4G / 5G Coverage in Cairns.)
Fortunately 3G signal is still likely to be available and is likely to be of sufficient quality and reliability that it can be depended upon to be a means of communication between the current primary place of residence and the newly-purchased property some 50kms away. The speeds found from this service are expected to be sufficient to transmit small packets received from simple sensors to the more complex and sizeable data provided by surveillance cameras.

Literature Review

Paddock-to-Plate has several key responsibilities that need to be accounted for when developing an IoT solution tailored for them. These responsibilities are dissimilar to each other and will separately require the use of individual communication standards and sensory devices to see the most benefit so have consequently been listed as distinct items in this and the following section.

Crop Irrigation

Paddock-to-Plate grows a wide variety of fruit, nuts, and vegetables on their property, each requiring specific irrigation plans to ensure they receive the right amount of water. In order to achieve an IoT solution on this front the optimal outcome will allow the family to be able remotely control the pumps for each irrigation system. There will also need to be a comprehensive array of sensors installed, monitoring for humidity, temperature, rainfall, as well as moisture sensors installed in every 100m2 of crops. (IoT-Based Smart Irrigation Systems: An Overview on the Recent Trends on Sensors and IoT Systems for Irrigation in Precision Agriculture., 2020) The readings from these sensors will need to be overlayed a digital map showing clearly where each of the readings are coming from and what the conditions are like for each location, these readings are to be taken hourly and made accessible via mobile phone. Finally, it is a requirement that in the instance that readings from any of these sensors exceed defined parameters an alert is triggered and issued to mobile phones.

The proposed solution will consist of applying learnings gained from prior successful implementation of IoT-based solutions that cater to the aforementioned requirements.
As explored in
(IoT-based monitoring and data-driven modelling of drip irrigation system for mustard leaf cultivation experiment., 2020) “An IoT-based monitoring framework is implemented using ESPresso Lite V2.0 module interfaced with different soil moisture sensors (VH-400), flowmeter (YF-S201) as well as Davis vantage pro 2 weather station to measure soil moisture content, irrigation volume, and computation of the reference evapotranspiration (ETo).” There is an availability of both irrigation control valves and environmental sensors to detect nearby conditions sold on a commercial scale. The main chip board used for this application involved a Raspberry Pi 3 – the second newest generation of highly extensible and scalable boards that can be applied for a wide range of commercial and personal IoT projects (Raspberry Pi IoT Projects.)
Because of the requirement that the sensor readings be superimposed over a geopgrahic map of the area the solution requires thought given to how this should be best created. Using still-shots from Google Earth as the underlying image, nodes will be programmatically “placed” on the map and aligned to the sensor readings using a method described and demonstrated (fig 1) as “using a structure of services deployed as containers that exchange messages through the IWARE NGSI unified data model” (Togneri, 2019)

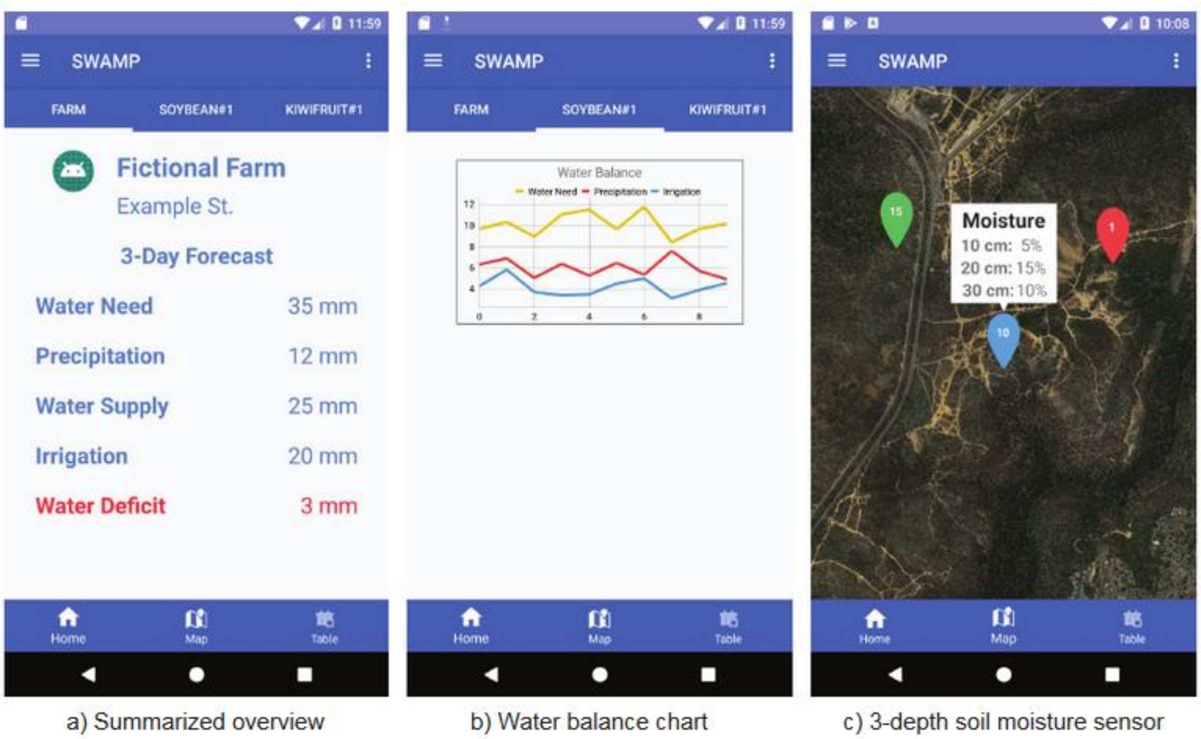

Figure 1: *view of the water readings overlayed on map*

Livestock Welfare

Water stations are placed in key locations across the property to provide water to livestock. It is a requirement that there is a solution to ensure that the water in these stations is both of suitable quality and quantity and should be measured every 15 minutes with alerts sent to the family's phone when the measurements fall outside of acceptable limits. The measurements from the most recent sensor reading from each station also needs to be available for the family to monitor from their phones.

There is an additional requirement that there is a system in place to monitor their chickens to provide visibility on their location to ensure they have returned to roost each night. The expectation that this will be done by placing a discrete bracelet on a leg on each of the chickens, with their location updated every 10 minutes and then made available on a map accessible through the family's phone.

Accurate and timely measurements of water quality sensor readings are important in all settings, but of utmost importance in the humid temperate conditions encountered in Northern Queensland. Ensuring that the livestock on the property has access to clean water is a key requirement, with the water sensors in prior implementations of similar solutions being comprised of measuring "…pH value, the turbidity in the water, level of water in the tank, temperature and humidity of the surrounding atmosphere" (Smart water quality monitoring system with cost-effective using IoT, 01)

The configuration of these sensors is placed on an architecture enabling a "…Raspberry PI B+… as a core controller." (Vijayakumar, 2015)

Although not a requirement for this solution it is worth noting that there have been prior implementations of water quality sensors in place that both measures, and then actively corrects the water level if it falls below a predefined value automatically by engaging a pump and measuring the amount of water provided through a flow sensor. (Vaishnavi, 2017)

Harvesting Assessment

Paddock-to-Plate manages a variety of fruit and nut trees and are seeking to trial a solution that provides coverage of their mango trees to monitor the fruit and send an alert to their mobile phones and computers when the fruit is ready to be picked. For this scenario there are 100 trees with the expectation that one camera monitors 5 trees – resulting in a requirement of 20 cameras to be installed. Each of these cameras must also take a photo of their trees and upload to a server each day so the family can monitor remotely.

Additional cameras are also needed to monitor locations where their chickens are expected to lay eggs – commonly in several nesting boxes as well as beneath a disused truck located on the property. The footage from these egg-monitoring cameras should be available in real-time and accessible through their phones.

Successful adoption of cameras used to provide data for modelling methods to determine when mangos are ready to be picked is a niche, but not unexplored area of IoT technology.

Implementation of such a use-case has been achieved by means of "A novel LiDAR component automatically generates image masks for each canopy, allowing each fruit to be associated with

the corresponding tree. The tracked fruit are triangulated to locate them in 3D, enabling a number of spatial statistics per tree, row or orchard block (Stein)
“the use of unmanned aerial vehicles for crop surveillance and other favorable applications such as optimizing crop yield…State-of-the-art IoT-based architectures and platforms used in agriculture are also highlighted” (Ayaz, 2019)

Farm Security

Spread across the two properties are vehicles owned by the family, generally stored in unlocked and unprotected sheds. In addition to the cameras used in the previous sections there is a need to install motion-detection security cameras to watch over this machinery. Real-time footage from these cameras need to be me made accessible through the family’s phones, while large movements detected should automatically trigger alerts sent to their phones and then uploaded to cloud storage for future reference.
Unlike some of the other sections in this paper, the matter security is a consideration that most businesses – both rural and metropolitan – must account for. Because this problem is more common, there is similarly a greater availability of research and devices available for use when tackling this. Advanced security techniques such as “RFID cards or biometrics sign such as fingerprints or faces that have been recognized by the system” (Fushshilat, 2020) are applied in areas where sensitivity and security of information is heightened, while the use of DIY Raspberry Pis with secondary video-capable modules installed to record sound and video are shown to be more than capable for use in homes and smaller businesses (Fushshilat, 2020)

Food Storage

Once the food is harvested and collected it must be stored in conditions to promote its shelf life. To do so the family stores the eggs, dairy, vegetables etc. in smart produce boxes that have temperature and humidity controls. The family wish to have several improvements made so that these boxes can be remotely controlled and viewed from their phones, also to have alerts configured so that in the instance the temperature or humidity exceeds acceptable parameters they receive automatic alerts to their phones notifying them.

Ensuring that food is kept in conditions that promote longevity is something that is taken very seriously by businesses whose profits rely on their produce being fresh and untainted. This problem has borne solutions to reduce the necessity of manual “…monitoring and to develop an internet based real time monitoring of temperature and humidity using the very available DHT-11 sensor and ESP-8266 NodeMCU module.” (Monitoring food storage humidity and temperature data using IoT., 2018)
Being able to automate the environmental conditions inside a food storage box such as temperature and humidity removes a significant component of the risk attached, however there is still need to ensure that if these checks do fail that users are made aware of the problem. To this end there has been observed success via the use of “…SMS and email alert system to alert the owner regarding the food storage level and the information related to the food spoilage.” (Shariff, 2019)

Solution

For consistency the Solution aspect of this paper has been broken down into the categories and regions of the farm described in the previous section as these requirements are tailored to each scenario. Commercial sensors targeted towards agricultural measurement systems are expensive and this high price point makes it difficult for smaller operations to justify; which has been taken into consideration for this paper driving focus on devices and sensors is primarily orientated towards cheaper alternatives than common devices used on large-scale agricultural operations.

Crop Irrigation

Continuing with the theme of affordable alternatives to commercial products the proposed sensors will reflect a lower price-point while adhering to their expected functionality. To measure the soil moisture level of the crop-producing paddocks the proposed implementation will consist of an inexpensive FC-28 sensor connected to an Arduino board (Divyavani, 2016). with an using a wireless Xbee module as the basis of communication standard to transmit readings to an internet router which acts as the coordinator – to then relay messages back to the main property building. Adopting the Xbee communication standard will result in lower power requirements to alternative communication standards such as a WIFI transmitter and has a proven track record of effectiveness when used in this setting (Kumar)
Keeping in line with a consideration to a low price-point the installation of humidity, rain, and temperature sensors the approach here is guided towards a somewhat DIY solution consisting of a Raspberry Pi 2, the aforementioned sensors, and a weather-durable case to constitute an entire weather monitoring station in a single device. The advantage here is a significantly lower price point – (maximum $250 AUD for all components) and a large degree of scalability and flexibility thanks to the modular configuration of the Raspberry Pi. An older model raspberry pi has been selected here to again further reduce the price point and as the additional features included on newer models will not be utilized in the operation of these devices. It will also result in a much simpler and convenient installation and maintenance having a single board responsible for the readings gathered from each device – as opposed to 3-4 different types of multiple devices dispersed over large paddocks. One notable disadvantage is that there will need to be an accompanying battery pack connected to each raspberry pi and will need to be replaced every few weeks (Sleepy Pi 2 – Micro USB B, 2021). To assist with lower power consumption the communication standard selected in this instance is ZigBee, so chosen due to the low power requirements and required average distance between the device and receiver

not exceeding 50 metres. A ZigBee cluster tree mesh network configuration has been selected as the most appropriate choice here to account for the dimensions and shape of the environment the devices will be placed upon. These devices will transmit data periodically to a nearby router, which will relay this data via WIFI back to the main property building. A rough diagram of the proposed implementation can be seen in figure 2.

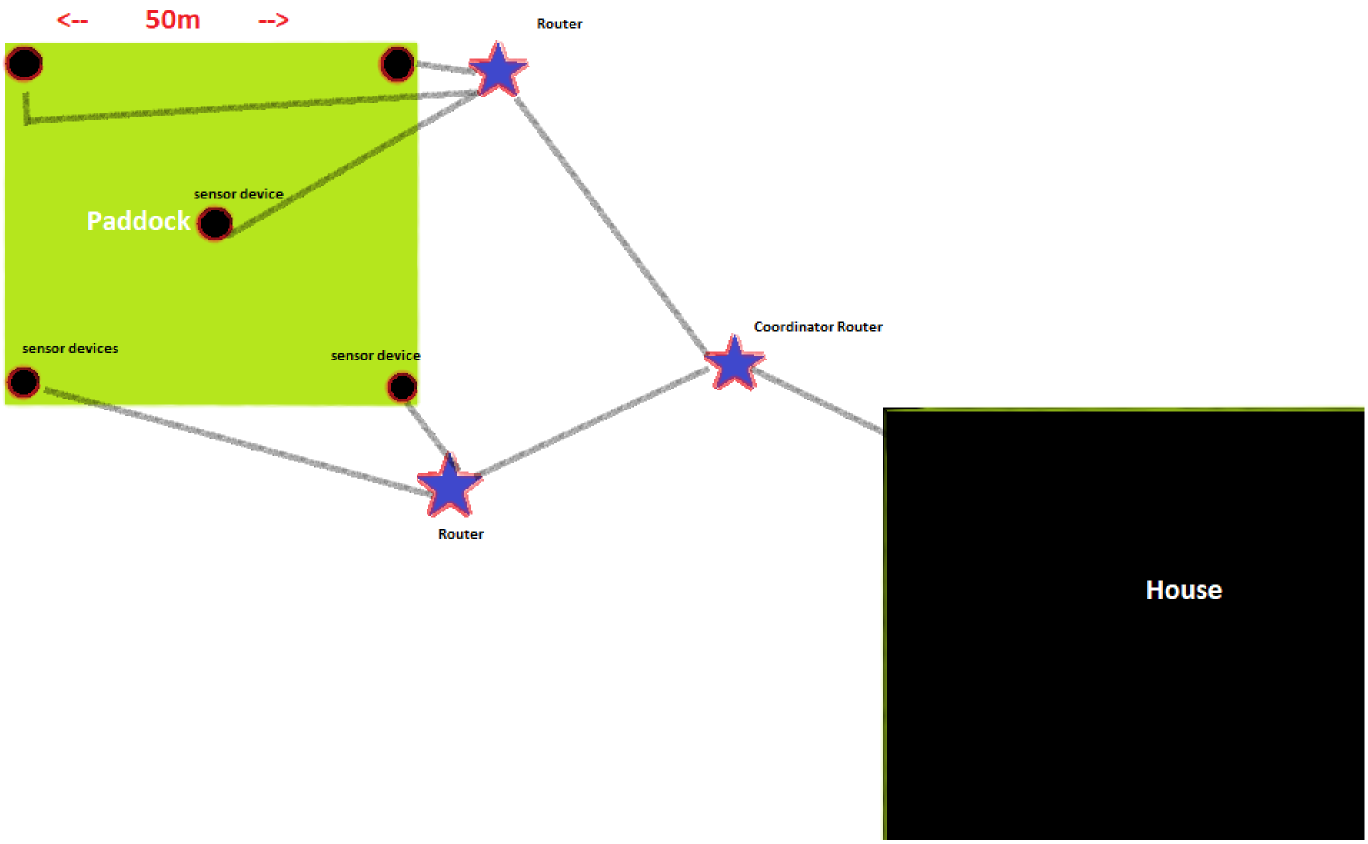

Figure 2: Diagram of the proposed device and router configuration

Livestock Welfare

For the purposes of measuring water quality and water levels, again a single device has been selected with dual sensory capabilities to reduce the maintenance requirements and for a simpler installation. The proposed solution consists of a PH sensor, a SEN0219 C02 sensor, and a water level sensor adhered to an Arduino board along with a low-power wide-area network communication standard titled BoXmote module as the chosen communication standard and data transmission method. BoXmote falls under the long-range wide-area network (LoRaWAN) technology umbrella referring to low-power devices that can transmit data with efficiency over extended distances. This particular communication standard is selected here as the water troughs are expected to be some distance away from the main buildings which would exceed the functional range of other common wireless standards such as Bluetooth and WIFI, but would fall well beneath the maximum range recommended for BoXmote of 10kms. Accompanied with its low-power requirements and proven track record in implementation of wireless sensory devices specifically used for water quality/quantity measuring, this makes an ideal choice of data transmission method (An Autonomous Wireless Device for Real-Time Monitoring Water Needs, 2020)

This approach along with the specific devices have a proven record of being waterproof, anti-corrosion, severe weather tolerant, high sensitivity to environmental conditions, and require relatively low-power. Installation of the device and sensors will be comprised of adhering to the side of the water station with the probes of each sensor dipped into the water to check for water quality via the dual-channel C02 and PH sensor. The data will be collected and relayed via the BoXmote module from the enddevice back to the main property building where it will be collected by a receiver installed on the roof. (Smart water quality monitoring system with cost-effective using IOT, 2020) (Madhavireddy, 2018)
Expected cost for these devices is not expected to surpass $300 per completed unit.

Harvesting Assessment

The use of IoT cameras installed in crop-producing properties to monitor fruit readiness is an immature branch of IoT technology but is not without practical success ((Ayaz, Internet-of-Things (IoT)-Based Smart Agriculture: Toward Making the Fields Talk, 2019)
The architecture proposed for this scenario will consist of 20 cameras strategically placed around the paddocks to ensure that their vision is orientated towards 5 trees and of a suitable height to ensure the mangos are easily visible. These cameras will operate on a WIFI protocol, relaying images once daily at exactly midday when there is maximum sunlight to improve visibility. WIFI has been selected here to allow users to view the trees in real-time at any point in time desired, which would be a difficult undertaking using a low-powered and low-range communication method such as Bluetooth.
The data once submitted from each camera will be received by a nearby router, to be then once more relayed back to the main building on the second property – to be then transmitted via 3G to the computer in the main building on the current property. The primary challenge with this solution will come in the form of data processing to be undertaken once the data is received by the computer at this location, which will need to undergo modelling techniques to determine which – if any – mangoes meet the criteria of "ready". Discussion of the statistical approach and modelling methods to be best applied for this purpose are outside the scope of this paper, however it is worth noting that success has been found applying a KMEANS clustering method (Stein M.)
The unedited photos will be stored in a suitable database management system and then made available on a personal server to allow users to also manually view the photos and determine if they are ready.
The expected overall pricing for this is difficult to gauge due to the significant work required in developing a sufficient model, however for the devices alone the expected cost for 20 cameras as well as required routers is expected to be approximately $5000.

Farm Security

Dissimilar to the other solutions offered in this paper the proposed results for this section will consist of a commercially available, off the shelf camera to monitor the machinery located at the property. The communication method to be used for this scenario will involve WiFi due to the large amount of data that needs to be transmitted which will also allow users to view the footage in real time without delay (as opposed to an alternative standard which sends and receives data periodically such as a low-powered ZigBee configuration) (Fushshilat Y. , 2020) The cameras will require a constant power source and a nearby router will relay the data received back to the main property building. Depending on the distance from each cameras location to the main property it may be necessary to adopt a Mesh-style network configuration where a camera is connected to a router, which then transmits data to another router, before being received by a coordinator router at the main property building. This contrasts the more scalable Star network configuration where the cameras are connected directly to the coordinator router located in the primary place of residence. (Sruthy. S, 2017). Once the data is relayed back to the main building at the new property, this information will be then further sent onto the main computer at the current property via 3G signal.

To ensure that the footage taken by the cameras to be installed at the property is of sufficient quality to identify individuals, commercially available Samsung outdoor cameras have been selected. There is a higher price point on selected cameras compared to some cheaper brands however there is a notable upshoot here where there is no additional 3rd party software required, which has the possibility of ongoing subscription costs. Additionally, it is expected that in the instance where theft does occur there may be some difficulties in raising insurance or police claims using footage gathered from a device built on premises.
Expected cost for these devices will be near $1000.

Food Storage

Unlike the previous subsections which highlighted solutions geared primarily towards IoT technologies applied to problems faced in agricultural centers, applying IoT ideas to food storage is a somewhat ubiquitous concept with considerable case studies and resources available. To ensure that these boxes are at a constant chilled temperature with less humidity than the outside muggy Queensland air, the refrigerated food storage boxes in this scenario are presumably equipped with battery packs that allow them to be transported for at least 60 minutes without an external power source attached. The expectation here is that after delivery, the storage containers would then be taken back and reconnected to a mains power supply which would then recharge the battery. Leveraging this internal battery pack allows an IoT solution that doesn't require its own external battery source, removing the need to maintain
The proposed solution for this item will once again involve the use of a Raspberry Pi 2 model, which deviates slightly from some available literature and case studies that instead opt for the use of an Arduino board or NodeMCU extensible board to install their external modules on. Raspberry Pi 2 has once again been selected here so as to reduce the total volume of distinct apparatus' operating in isolation which will make maintenance and implementation less complex. On to these boards will be installed both a ESP-8266 (Introduction & Programming of

the ESP8266 NodeMCU Board, 2020) chipset to monitor the humidity along with a DHT-11 sensor to monitor the temperature (Campbell, 2020). These two microchips have seen successful implementation in the measurement of temperature and humidity for food storage boxes previously and were found to perform well due to the very low power requirements and accuracy of readings (Monitoring food storage humidity and temperature data using IoT, 2018). As stated the power supply for this unit will leverage the battery expected to be already present on the storage boxes, however if this is not feasible there is precedence in instead using a rechargeable 5Volt battery to power the board for up to 14 hours.

The measurements taken by these modules will subsequently be processed by the Raspberry Pi and sent via a WiFi module to also be installed on the Raspberry Pi (onboard WiFi adapters were not included until 3rd generation Raspberry Pis so an external adapter will be used here). As these boxes are stored and recharged at a consistent location with access to a mains power supply, there should be minimal difficulty in setting up a nearby router which will receive data from these food storage containers. The advantage of WiFi being that these updates can be very regular with little downtime between updates if set to do so – a desirable advantage when considering food storage as hot conditions can spoil food quickly and would have a direct impact on the business' profits as these items are expected to be used in the nearby café.

The nearby router will relay this data back to the main building at this new property, which will be received and processed by a computer, and then consequently sent via 5G back to the current property.
Expected pricing for this proposed solution is determined to be approximately $800.

Once the data from these varied devices and communication standards has been sent from each end device and received back at the main building at the new property, this data will be collated and organized by a desktop computer. The assumption has been made that this new property does not have internet access via conventional methods such as NBN or ADSL so this computer will need to have a module be

As the requirements for data processing for this scenario are verbose with emphasis on scalability and observance to the unique necessities specificized by the business, there is unlikely to be a single out-of-the-box solution that can be applied to handle the storage, data processing/cleaning, analysis, visualization, and alert-issuance without some degree of modification. Although in depth discussion of the software implementation to tick these boxes is outside the scope of this paper, an appropriate solution would most likely involve use of a database management system to store the data (such as SQL/Oracle), as well as a program developed in an extensible and scalable language such as Python – which has many packages to assist with analysis, geographic visualizations, in addition to the ability to configure alerts sent to mobile phones and computers when sensor readings fall out of defined limits. A strong advantage to these software nominations is there is no price tag attached and if the users wish to alter the lower and upper bounds on the parameters used to trigger alerts from each sensory device it is relatively easy to do so, with no technician or outside assistance required.

Because of the existing bespoke 3G network used already to communicate data between the two properties, we are able to again leverage this network plan to send alerts to the mobile phones when readings are received from any of the individual end-device locations that fall outside the defined parameters. To reduce the chance that an alert is missed, it is only a small additional matter to configure an email alert to also trigger and be sent to the family members at the same time.

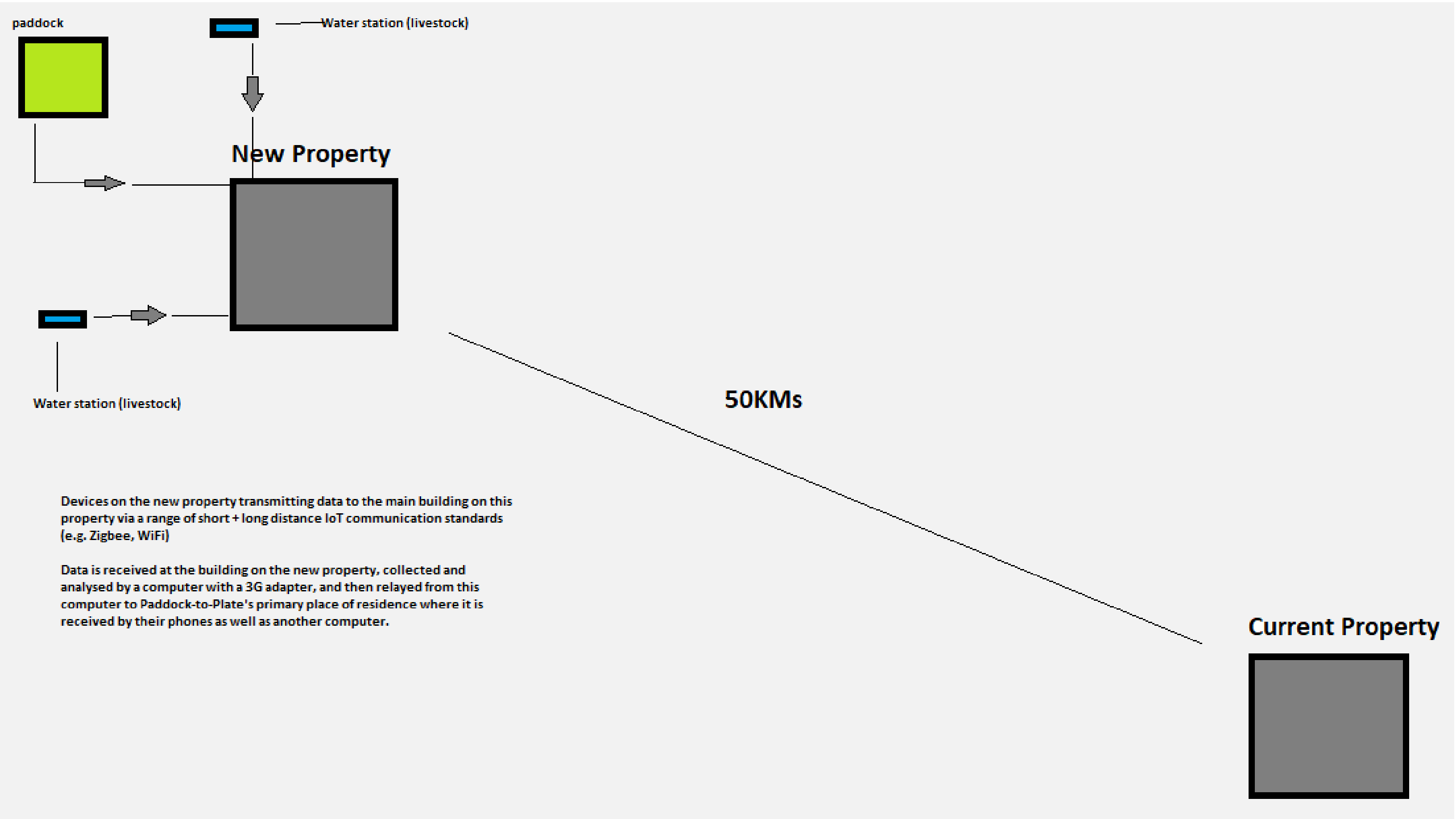

Figure 3: bird's eye view of the proposed scheme
including Water Stations and Paddocks

Limitations & Recommendations

Considerations to be made in these recommendations will require careful examination of the terrain on which the property lies on, taking into account whether there are any significant dips or hills in which sensors in the above subcategories might be installed in as these may present potential natural obstacles and obstruct transmission between transmitter and receiver.

Security protocols are generally considered an essential inclusion in the development and implementation of IoT solutions due to the network not requiring a physical connection and can be viewed by anyone with a suitable device. For this paper security options have not been taken into consideration due to the remote location and unsensitive data being transmitted. However, if in the future the business wishes to protect their networks and data one of the most-common, most secure, and easiest to setup block ciphers used for IoT technology is advanced encryption standard 256 (AES 256). (Guy-Cedric, 2018)

It is worth noting that in the future once improved cellular communication networks become available in the area, it would be of significant benefit to upgrade from the 3G network coverage adopted here

Finally, although most of the communication standards and sensors recommended in this paper have low power requirements and will have long life spans, the batteries in these devices as well as the devices themselves should be inspected often to check for required replacement. For some use cases – such as the raspberry PIs discussed in the Crop Irrigation component – can be configured to send alerts when their batteries are running low which remove the necessity to make regular checks, but this shouldn't be relied upon as wet and warm conditions can have significant impacts on even the most durable of device enclosures. A good IoT implementation is accompanied by a maintenance schedule that ideally checks upon these devices every 1-4 weeks depending on expected battery life.

Conclusion

This report serves to help highlight the wealth of existing technology and research available already that can be applied to solve significant problems that exist in an industry that is essential for life and growth. The gap between industrial automation in major metropolitan centers and small rural locations is significant, particularly in non-modernised countries, but is ever reducing.

As increased use of IoT technology becomes more widespread in agricultural facilities and farms it is inevitable that advancements in this technology will increase in their frequency and benefits, as well as driving down the cost of technology making it more widely available to non-commercial food producers.
Although there are tailored recommendations to suit the exact conditions found at this property, the solutions offered here are to problems that are universal and not localized to this specific business; from food-storage containers, to water quality sensors, to harvesting assessment.

The total overall price point for all prior listed items and configurations is expected to not surpass $10,000. This quote is considerably lower than a complete solution employing the use of only commercially available, store-bought products that fit these purposes thanks to the adoption of DIY alternatives – that not only lower the costs but improve the ability to scale these devices further in the future by adding on additional sensory apparatuses. It is hoped that this low price point encourages rural agriculture businesses – particularly small businesses – to consider using the ever-developing field of technology that is IoT.

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