We are learning on Noongar land

THE UNIVERSITY OF WESTERN AUSTRALIA

CITS 5506
The Internet of Things
Lecture 08

Smart Products

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Guest Lecture: Looking towards a cloudy future by Martin Abbott

Description: Cloud technology has already transformed the way businesses deliver services, but the level of maturity within businesses has meant that this has not always been successful.

With a set of these technologies now more understood, and even newer technologies already having an impact, there is no better time to look at the cloud and what it can offer.

In this lecture, Martin will talk about the cloud and what it has to offer for digital transformation and will dive into some of the technologies that are really delivering change, such as low code tools, containerisation, IoT, Machine Learning, and AI. He will also discuss his experience in the IT industry, and what organisations are looking for over the next few years as cloud becomes an even greater enabler to their success.

Questions on Guest Lectures

1. The Questions on the Guest Lecture will be uploaded at LMS on Tuesday at folder “Assessment- Qs on Guest Lectures”
2. Question Upload time will be 5:30 pm on Tuesday
3. Submission Deadline: 6:30 pm on Tuesday, through Turnitin Submission at LMS link “Submissions”.
4. Maximum Similarity 10% (don’t copy the questions to keep the similarity down, just write the Question Number while answering)

Smart Products

Smart Products have complex systems that combine

- hardware
- sensors
- data storage
- Computing entity
- software
- connectivity

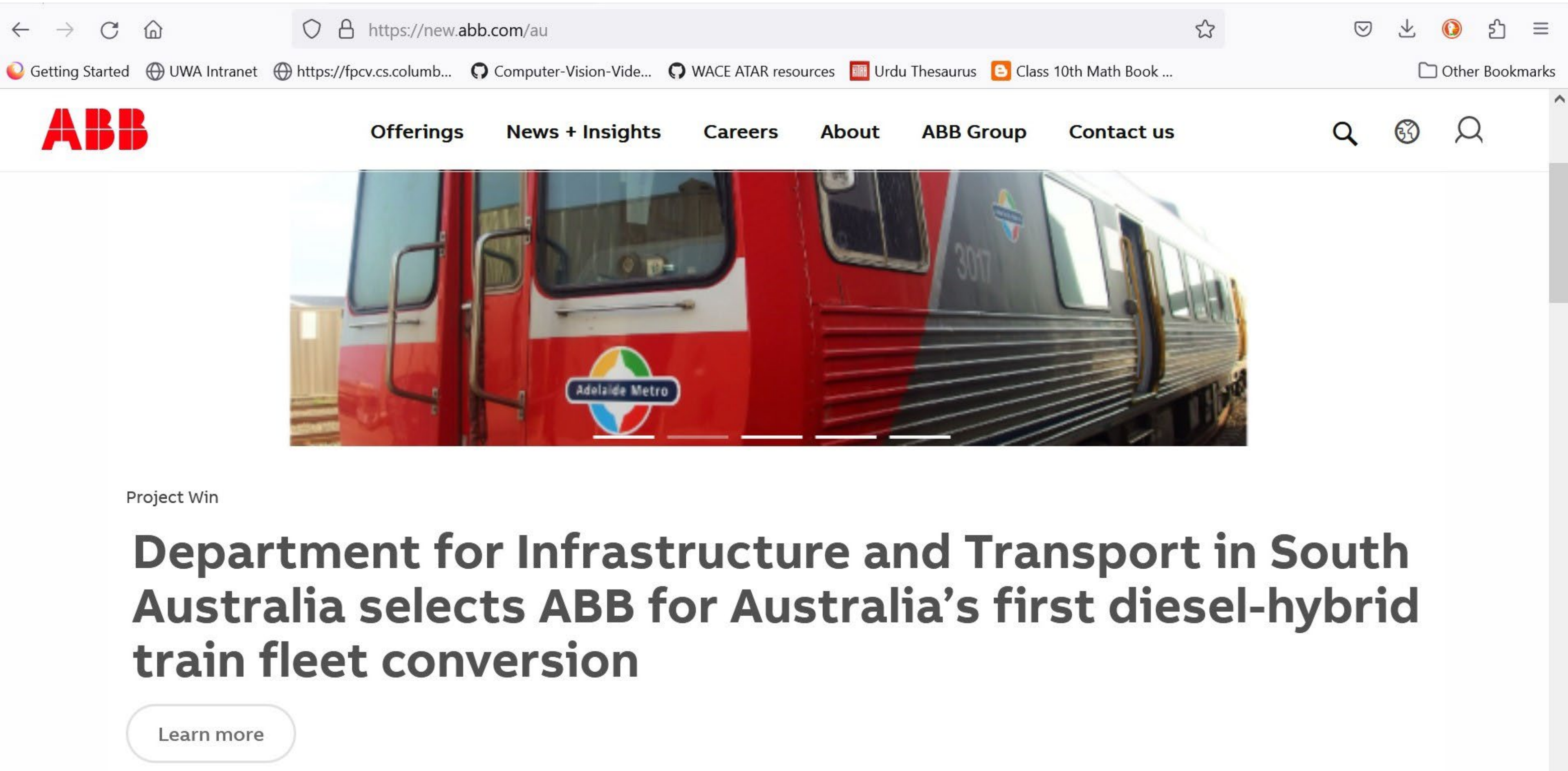
Smart Products

- In the energy sector, ABB's smart grid technology enables utilities to analyze huge amounts of real-time data across a wide range of generating, transforming, and distribution equipment (manufactured by ABB as well as others), such as:
  - Changes in the temperature of transformers and secondary substations.

- This alerts utility control centers to possible overload conditions, allowing adjustments that can prevent blackouts before they occur.

*ABB (ASEA Brown Boveri) Ltd is a Swedish–Swiss multinational corporation headquartered in Zürich, Switzerland, operating mainly in robotics, power, heavy electrical equipment, and automation technology areas.

Smart Products

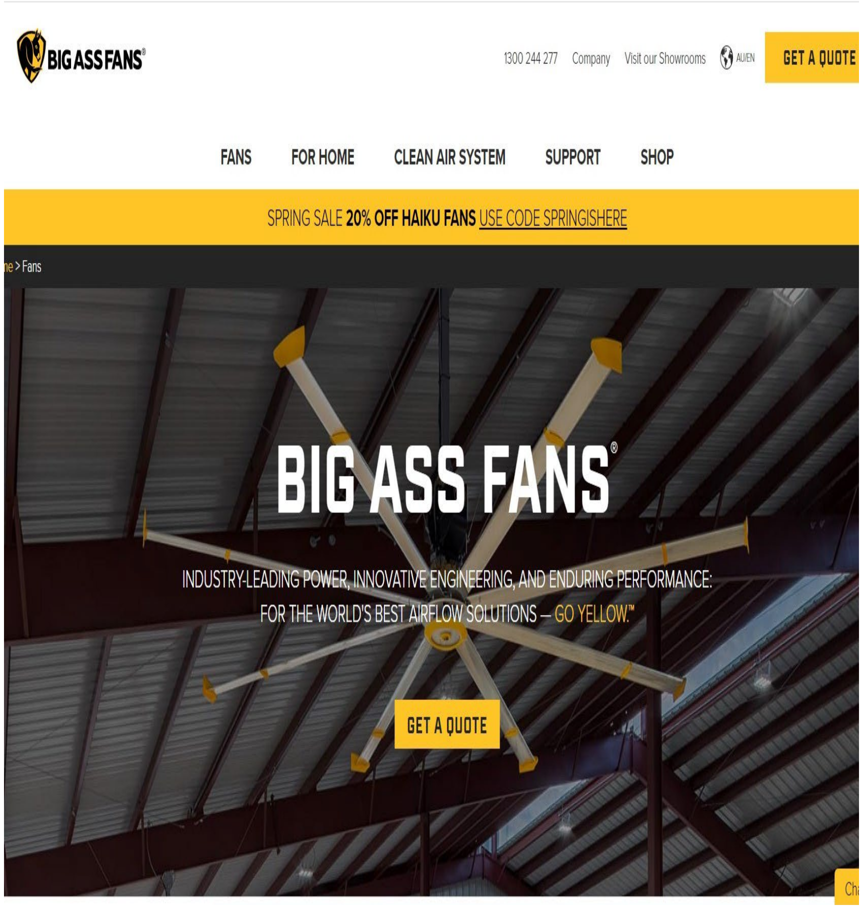


Smart Products

In consumer goods, Big Ass ceiling fans sense and engage automatically:

- When a person enters a room
- Regulate speed on the basis of temperature and humidity
- Recognize individual user preferences and adjust accordingly.

•At UWA, the Big Ass fans are in the E-Zone Building



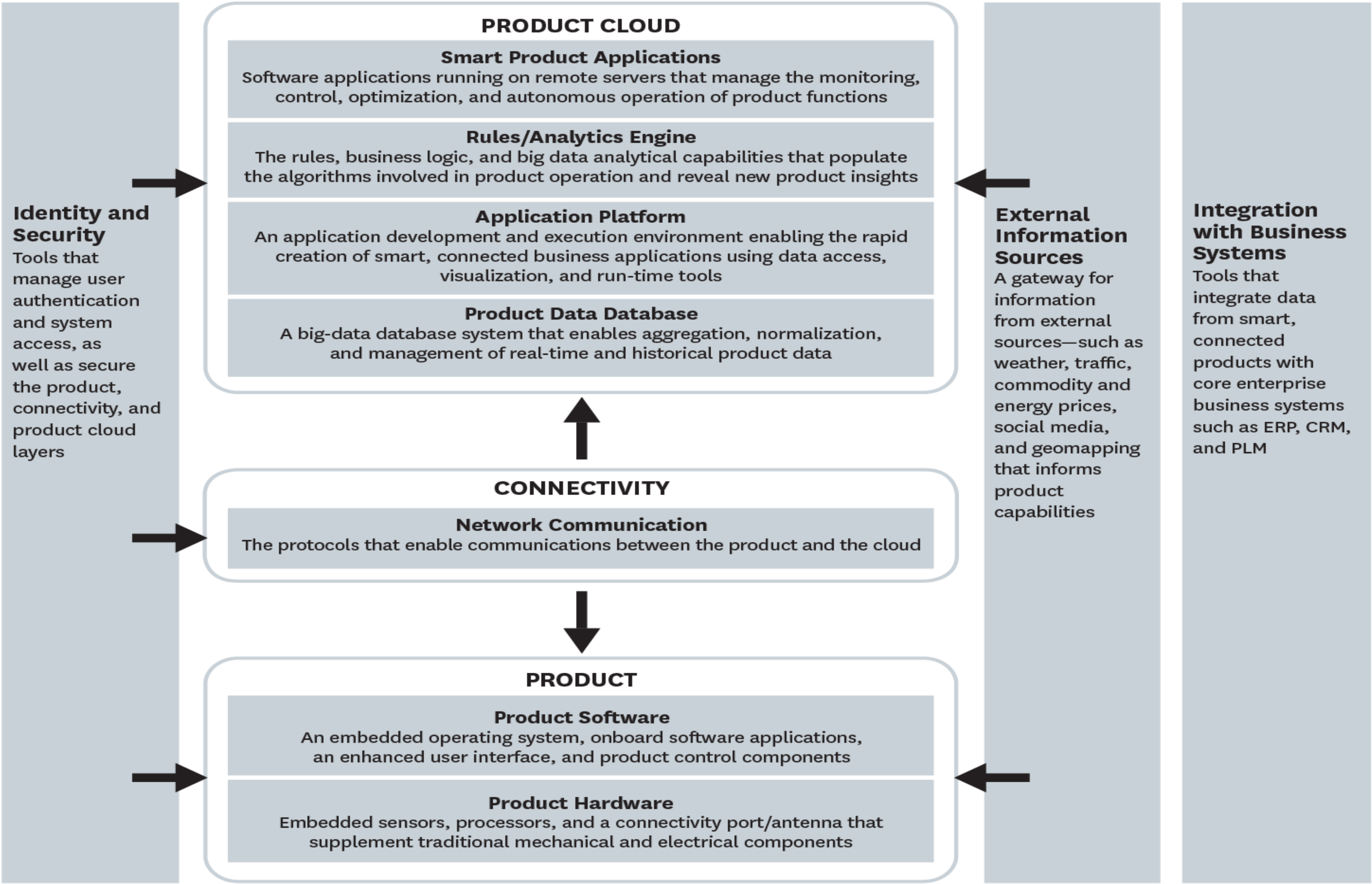
Smart Products : Tech Infrastructure

Smart, connected products require that companies build an entirely new technology infrastructure, consisting of a series of layers known as a “technology stack”.

Smart Products : Tech Infrastructure

This technology stack includes :

- Modified hardware
- Software applications
- Operating system embedded in the product itself
- Network communications to support connectivity
- Product cloud (software running on the manufacturer's or a third-party server) containing the product-data database
- A platform for building software applications
- An analytics platform
- Smart product applications that are not embedded in the product


PRODUCT CLOUD
Smart Product Applications
Software applications running on remote servers that manage the monitoring, control, optimization, and autonomous operation of product functions
Rules/Analytics Engine
The rules, business logic, and big data analytical capabilities that populate the algorithms involved in product operation and reveal new product insights
Application Platform
An application development and execution environment enabling the rapid creation of smart, connected business applications using data access, visualization, and run-time tools
Product Data Database
A big-data database system that enables aggregation, normalization, and management of real-time and historical product data
CONNECTIVITY
Network Communication
The protocols that enable communications between the product and the cloud
PRODUCT
Product Software
An embedded operating system, onboard software applications, an enhanced user interface, and product control components
Product Hardware
Embedded sensors, processors, and a connectivity port/antenna that supplement traditional mechanical and electrical components
Identity and Security
Tools that manage user authentication and system access, as well as secure the product, connectivity, and product cloud layers
External Information Sources
A gateway for information from external sources—such as weather, traffic, commodity and energy prices, social media, and geomapping that informs product capabilities
Integration with Business Systems
Tools that integrate data from smart, connected products with core enterprise business systems such as ERP, CRM, and PLM

Smart Products : Tech Infrastructure

All the layers are accessed through an identity and security structure, a gateway for accessing external data, and tools that connect the data from smart, connected products to other business systems. For example, ERP(Enterprise resource planning), Product lifecycle management (PLM) and CRM (Customer relationship management) systems.

- ERP system track business resources (cash, raw material, production capacity, orders and payroll etc.
- PLM is the process of managing the entire life cycle of a product from its inception through the engineering, design, manufacture as well as service and disposal of manufactured products.
- CRM manages the company’s relationship and interaction with customers and potential customers.

Smart Products : Tech Infrastructure

- IoT enables not only rapid product application development and operation but the collection, analysis, and sharing of the potentially huge amounts of data generated inside and outside the products that has never been available before.

- Building and supporting the technology stack for smart, connected products requires substantial investment and a range of new skills—such as software development, systems engineering, data analytics, and online security expertise—that were rarely found in manufacturing companies in the past.

Smart Products Capabilities Areas

Capabilities of Smart Products

The capabilities of smart, connected products can be grouped into four areas:

- Monitoring
- Control
- Optimization
- Autonomy

Capabilities of Smart Products

1. Sensors and external data sources enable the comprehensive monitoring of:
   - the product's condition
   - the external environment
   - the product's operation and usage

   Monitoring also enables alerts and notifications of changes

2. Software embedded in the product or in the product cloud enables:
   - Control of product functions
   - Personalization of the user experience

3. Monitoring and control capabilities enable algorithms that optimize product operation and use in order to:
   - Enhance product performance
   - Allow predictive diagnostics, service, and repair

4. Combining monitoring, control, and optimization allows:
   - Autonomous product operation
   - Self-coordination of operation with other products and systems
   - Autonomous product enhancement and personalization
   - Self-diagnosis and service

Monitoring

- Smart, connected products enable the comprehensive monitoring of a product’s condition, operation, and external environment through sensors and external data sources.

- Using data, a product can alert users or others to changes in circumstances or performance.

- Monitoring also allows companies and customers to track a product’s operating characteristics and history and to better understand how the product is actually used.

Monitoring

- The collected data has important implications for design (by reducing over-engineering), market segmentation (through the analysis of usage patterns by customer type), and after-sale service (by allowing the dispatch of the right technician with the right part, thus improving the fix rate).

- Monitoring data may also reveal warranty compliance issues as well as new sales opportunities, such as the need for additional product capacity because of high utilization.

Monitoring

- In some cases, such as medical devices, monitoring is the core element of value creation.

- *Medtronic's* digital blood-glucose meter uses a sensor inserted under the patient's skin to measure glucose levels in tissue fluid and connects wirelessly to a device that alerts patients and clinicians up to 30 minutes before a patient reaches a threshold blood-glucose level, enabling appropriate therapy adjustments.

Monitoring

- Monitoring capabilities can span multiple products across distances.

- Joy Global, a leading mining equipment manufacturer, monitors operating conditions, safety parameters, and predictive service indicators for entire fleets of equipment far underground.

- Joy Global also monitors operating parameters across multiple mines in different countries for benchmarking purposes.

Control

- Smart, connected products can be controlled through remote commands or algorithms that are built into the device or reside in the product cloud.

- For example, “if pressure gets too high, shut off the valve” or “when traffic in a parking garage reaches a certain level, turn the overhead lighting on or off, or display the filled capacity”.

Control

- Control through software embedded in the product or the cloud allows the customization of product performance to a degree that previously was not cost effective or often even possible.

- The same technology also enables users to control and personalize their interaction with the product in many new ways. For example, users can adjust their Philips Lighting hue lightbulbs via smartphone, turning them on and off, programming them to blink red if an intruder is detected, or dimming them slowly at night.

- Doorbot (now named as ***Ring,*** *https://ring.com*), a smart, connected doorbell and lock, allows customers to give visitors access to the home remotely after screening them on their smartphones.

Optimization

- The rich flow of monitoring data from smart, connected products, coupled with the capacity to control product operation, allows companies to optimize product performance in numerous ways, many of which have not been previously possible.

- Smart, connected products can apply algorithms and analytics to dramatically improve output, utilization, and efficiency.

Optimization

- In wind turbines, for instance, a local microcontroller can adjust each blade on every revolution to capture maximum wind energy. And each turbine can be adjusted to not only improve its performance but minimize its impact on the efficiency of those nearby.

- Real-time monitoring data on product condition and product control capability enables firms to optimize service by performing preventative maintenance.

- Advance information about what is broken, what parts are needed, how to accomplish the fix reduces the repair costs.

Autonomy

- Monitoring, control, and optimization capabilities combine to allow smart, connected products to achieve a previously unattainable level of autonomy.

- At the simplest level is autonomous product operation like that of the iRobot Roomba, a vacuum cleaner that uses sensors and software to scan and clean floors in rooms with different layouts.

- More-sophisticated products are able to learn about their environment, self-diagnose their own service needs, and adapt to users' preferences.

Autonomy

- Autonomy not only can reduce the need for operators but can improve safety in dangerous environments and facilitate operation in remote locations.

- Autonomous products can also act in coordination with other products and systems. For example, the energy efficiency of the electric grid increases as more smart meters are connected, allowing the utility to gain insight into and respond to demand patterns over time.

Autonomy

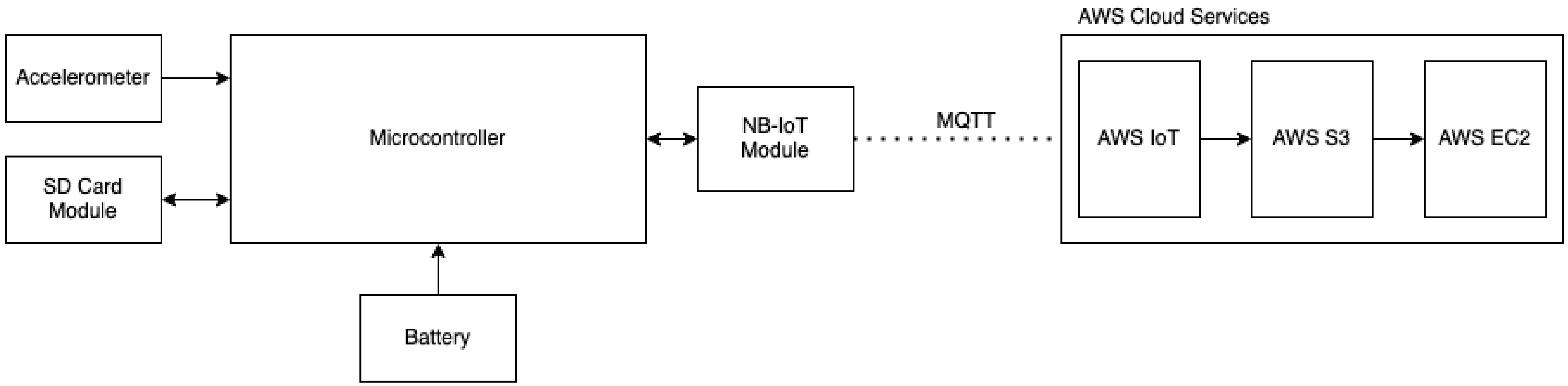
- Ultimately, products can function with complete autonomy, applying algorithms that utilize data about their performance and their environment—including the activity of other products in the system—and leveraging their ability to communicate with other products.

- Example, The Google self-driving car project , Waymo.

Research Project : Bridge Health Monitoring using IoT

Develop IoT-based pipeline for cost effective, easy to install and timely collection, transmission and visualization of vibration response data that can predict the bridge health.

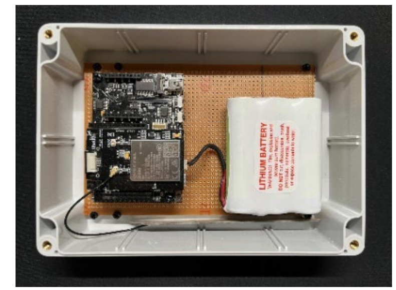
Block Diagram

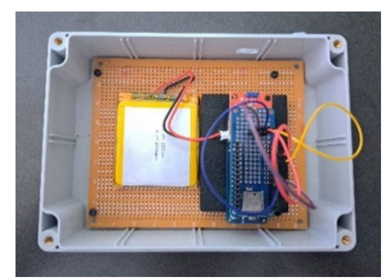


ACCELEROMETER BOARDS

Three different platforms tested

- Libelium Waspmote microcontroller board
  - Discarded due to limited software libraries support and limited SRAM on the microcontroller
- RAKwireless WisTrio RAK5010
  - Discarded due to connectivity issues over the NB-IoT
- Arduino MKR NB1500
  - SD card shield and the ADXL345 accelerometer





DATA COLLECTION

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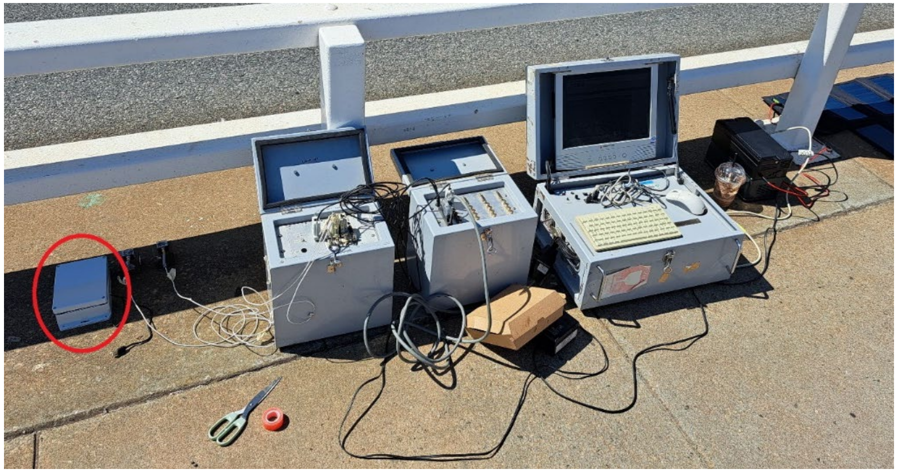
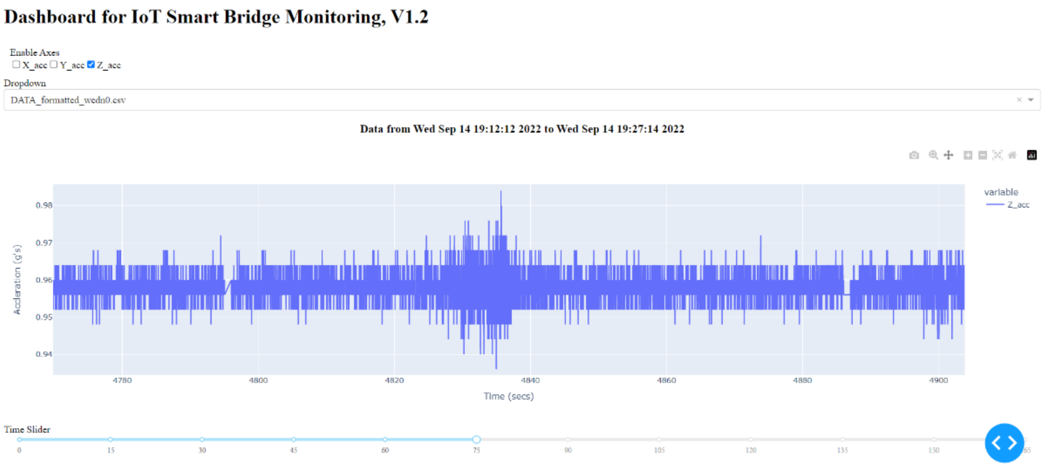


- Data collection in Sept, 2022 on the Stirling Bridge in Fremantle, Perth for 03 days

- Three modalities, visual (video) data, wired sensor data and data from the IoT prototype.

DATA COLLECTION

- The data collected by IoT system was sent using a MQTT broker over the Telstra network and received by AWS IoT core.
- Messages were published to a topic and then stored in a Simple Storage Service (S3) bucket.
- A dashboard was developed to display the incoming data using the Dash/Plotly python library with options of time sliding, zoom in and out, individual axis and multiple axes selection.



DATA TRANSMISSION

2kB messages can be sent reliably in approximately 1.5 seconds.

Experiments have shown that one minute of 3 axis (x, y, z acceleration) data requires 80 seconds to send to AWS

The recording and transmitting only Z-axis data of one minute duration takes 40 seconds to upload to AWS.

There is need to further investigate with aim to reduce data transmission through edge computing at the source.

DATA ANALYSIS

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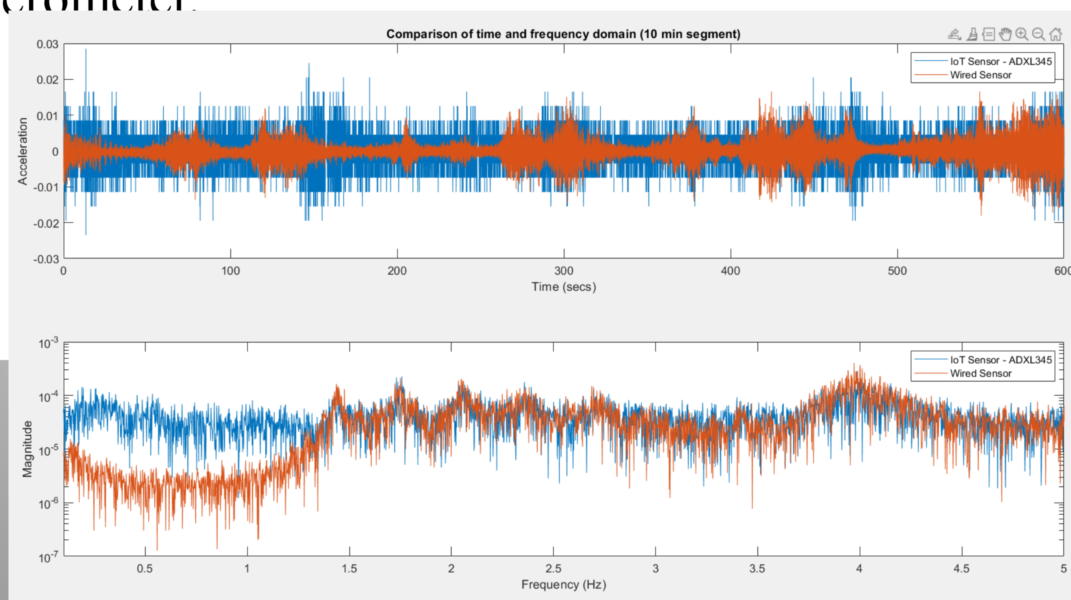
- The responses of digital IoT sensor (ADXL345) and the analog industrial wired sensor (Kistler 8330A3) were compared using the data collected from the Stirling bridge.
- A time domain analysis proved difficult due to synchronization issues in the two data sets, though it is obvious from following figure that both sensors had a similar time domain response.
- The frequency domain results do show similarities in the frequency and magnitude to the Kistler spectrum, particularly from 1.5 Hz to 5 Hz. Team felt need for sensitive accelerometer.



CONCLUSION

Successfully developed a hardware and software pipeline for collecting, transmitting and visualizing vibration response data that can aid in Structure Health Monitoring of the bridges.

The proposed system is cost effective, easy to install and has additional communication component that can quick transfer the data to the cloud for further analysis.

Along with the bridge health information, the system has the research potential to give valuable information related to traffic class, weight and traffic load.

PUBLICATIONS

- Structural Health Monitoring and IoT: Opportunities and Challenges, International Conference on Intelligence of Things, Mar 21, 2022, Lecture Notes on Data Engineering and Communications Technologies, Springer.

  Access to Document: 10.1007/978-3-031-15063-0_1

- Development of IoT based Bridge Health Monitoring System: A Work in Progress, Accepted Paper, Australasian Transport Research Forum 2023

FUTURE WORK

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- The IoT-based sensor data transmission to AWS needs further investigation to reduce the transmission rate. Edge computing at the source will reduce the amount of data to transmit to AWS, thus reducing the transmission cost and energy consumption.

- The above research work need to be in line with bridge health monitoring parameters such as shifts in the fundamental frequency etc.

- The future research work further encompasses comparison of digital accelerometer against analog wired accelerometer.