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1. Introduction

The Internet of Things (IoT) is one of the cutting edge technologies in the modern era connecting everyday devices that people interact with, to the Internet and enabling these devices to transmit data. From its initial applications in RFID and embedded systems (Shafique et al., 2020), IoT has evolved into a large interconnected network that influences different aspects of human life, from smart homes to ultra modern industrial automation. At present, IoT is not just a buzzword, but rather a technology that can transform organizations. This report explores the evolution of IoT technology, analyzing its historical evolution, current state, and future prospects. Following this, a case study will be presented showcasing how a leading multinational organization has successfully utilized IoT to achieve strategic advantage. Finally, a business case will be described for a novel IoT use case within a major Australian publicly listed company, aligning with the organization’s strategic goals and culture. Through this analysis, the report aims to showcase the role of IoT in shaping future businesses.

2. IoT Technology: Past, Present, and Future

2.1. Historical Development of IoT

The origins of IoT trace back to the 1970s when electrical grids used remotely monitored meters via telephone lines, showcasing early machine connectivity. Though IoT foundations existed, the term ‘Internet of Things’ was first coined by Peter T. Lewis in 1985 (Saha, Mandal, and Sinha, 2017), describing the integration of people, processes, and technology with connected devices and sensors for remote monitoring and control. The concept gained momentum in the 1990s through Weiser's work on ubiquitous computing and Kevin Ashton’s emphasis on RFID for managing everyday objects (Saha, Mandal, and Sinha, 2017). The rise of wireless technology in the 1990s led to widespread M2M communication in industrial settings, though these systems were limited by size, performance, and reliability (Jaidka, Sharma, and Singh, 2020). By the late 1990s, advancements in wireless communication and sensors led to the development of small, intelligent devices capable of computing, sensing, and communicating over long distances. These developments laid the foundation for today’s IoT, initiating the shift toward interconnected and automated systems.

2.2. Current State of IoT

IoT has become integral to today's world, with around 8.4 billion smart devices connected by 2020 (Gartner Says 6.4 Billion Connected 'Things' Will Be in Use in 2016, no date). This figure was expected to reach 20.4 billion by 2022, showing rapid growth globally. The incremental value of IoT is estimated to exceed $300 billion by the end of this decade (Khanna and Kaur, 2020). IoT applications range from consumer electronics like smart homes and energy management tools to wearable devices like fitness trackers and health monitors, transforming healthcare by enabling continuous monitoring and data transfer (Jaidka, Sharma and Singh, 2020). Beyond personal applications, IoT is promoting significant improvements in industrial automation, paving the way for Industry 4.0, which uses cutting-edge technologies to improve productivity and flexibility (Soori, Arezoo and Dastres, 2023). Smart factories utilize advanced technologies like AI and IoT to enhance productivity, efficiency, and quality (Garrido-Hidalgo et al., 2019). IoT enables optimized processes and reduced downtime, leading to significant cost savings (Soori, Arezoo and Dastres, 2023). IoT sensors detect potential safety hazards, alerting workers and preventing injuries. Additionally, industries like agriculture and energy production improve efficiency and performance with sensor data networked throughout the supply chain (Soori, Arezoo and Dastres, 2023).

2.3. Future Outlook of IoT

The IoT revolution is most prominent in Europe, America, and China, with large-scale changes already underway. The number of M2M connections is expected to grow to 27 billion by 2024. Huawei predicts that by 2025 there will be 100 billion IoT connections, potentially bringing in $11 trillion annually (Huawei's Global Industry Vision 2025: Unfolding the Industry Blueprint of an Intelligent World - Huawei Press Center, no date). This growth is driven by lower device costs, advanced cloud computing, and faster data delivery. IoT is expected to account for 4-11% of global GDP by 2025 (Manyika et al., 2015), indicating its potential across industries. Developed nations are increasingly invested in IoT advancements due to its wide-ranging benefits, such as promoting economic sustainability, supporting urbanization, enhancing infrastructure, boosting employment, improving public health, and elevating service quality (Shafique et al., 2020). These initiatives suggest a future where IoT will be more integrated, secure, and impactful across various sectors, driving significant progress in global economic and social development.

3. Case Study: GE's Big Bet on Data and Analytics

3.1. Overview of GE's IoT Integration

GE, a global industrial MNC, has successfully utilized IoT to transform its business operations and gain significant strategic advantage in its domain. GE, traditionally known for its capabilities in the manufacturing industry has evolved into a digital industrial leader by integrating IoT into its core business. The case study "GE's Big Bet on Data and Analytics" (Winig, 2016) (GE et al., 2014) explores how GE implemented IoT through its digital platform called 'Predix' gaining competitive advantage, improved operational efficiency and access to new business models. The strategic advantages gained by GE are described below.

3.2. Predictive Maintenance and Cost Savings

One of the most significant strategic advantages GE gained from its investment in IoT is the ability to offer its customers predictive maintenance services. By predicting the likely failure points of an asset, GE can schedule maintenance early, reducing unplanned downtime and minimizing maintenance costs. For example, in aviation, predictive maintenance allows GE's customers to keep their assets running longer services, reducing costs associated with grounded aircrafts.

3.3. Enhanced Operational Efficiency

Adoption of IoT has enabled GE to enhance operational efficiency of its products and services offered to customers. By leveraging real time data received from the assets, GE can optimize the performance metrics such as adjusting the operational parameters of gas turbines to achieve maximum fuel efficiency and life thereby lowering operational costs, improving overall performance and reliability of GE' products and making them more competitive and attractive to customers.

3.4. New Business Models

GE's investment on IoT has made it capable of transitioning from a traditional product based business model to a service oriented business model. With the new model, GE can offer customers outcome based services, where customers pay for performance and results rather than just the physical product. For example, in aviation, instead of simply selling jet engines, GE can now offer a comprehensive service package that includes engine monitoring, predictive maintenance and performance optimization, all enabled by IoT.

3.5. Competitive Differentiation

The ability to provide a fully integrated digital solution, combining hardware, software, and analytics, positions GE as a leader in the industrial IoT space differentiating from its competitors. This differentiation has not only strengthened GE's market position but also opened up new opportunities in various sectors where the adoption of IoT is still in its early stages. GE's strategic use of IoT through its Predix platform has transformed the company to a digital industrial manufacturer. By integrating IoT across its operations, GE has gained significant strategic advantages, including cost savings, enhanced operational efficiency, and the ability to offer innovative, outcome based services.

4. Business Case: Implementing IoT in Energy Production at Origin Energy

4.1. Company Overview

Origin Energy Ltd, is an energy company based in Sydney, Australia established on March 4, 1946 focuses on the production and sale of natural gas and electricity. Origin operates in key segments which are energy markets, integrated gas and origin corporate. Energy markets include power generation and energy retailing, integrated gas manages LNG assets and related trading activities and corporate handles business development activities and operations support that are not directly related to the primary key segments (Origin Energy | Company Overview & News, n.d.). Research on the company indicates that the company currently exhibits low maturity in its adoption of IoT and related technologies. Consequently, there is significant potential for IoT to greatly enhance the business.

4.2. Strategic Pillars and Cultural Values of Origin Energy

Origin Energy focuses on leading the energy production through the adoption of clean energy and innovative customer solutions. The approach is supported by three strategic pillars, which are, providing excellent customer solutions, accelerating the growth of renewable and cleaner energy, and ensuring reliable energy delivery throughout the supply chain (Who We Are - Origin Energy, 2024). This strategy aligns with its overarching goal of decarbonization that benefits customers, communities, stakeholders and the planet while stimulating sustainable growth and innovation in the energy sector. Origin Energy's culture is focused on getting energy right for its customers, communities, and planet. The company's strategy focuses on three key areas. Firstly, providing tailored, safe, reliable, and energy efficient solutions for its customers. Secondly, commitment to environmental sustainability and social responsibility by expanding renewable energy projects and reducing emissions and finally, prioritizing reliable energy delivery while driving long-term value for its shareholders through sustainable growth and innovation. Origin Energy's values emphasize teamwork, customer focus, responsibility, continuous improvement, and accountability, motivating employees to work collaboratively, prioritizing environmental impact, and taking ownership of their actions (Our purpose, no date).

4.3. Strategic Objectives for IoT Implementation

Vision: Establish leadership in the energy sector by adopting IoT solutions to drive operational efficiency and accelerate the transition to clean energy.

Goal: Integrate IoT technology across Origin Energy's operations to optimize energy production, improve reliability and propose innovative solutions that align with its decarbonization goals.

Strategic Objectives:

- Utilize IoT to improve the performance of assets generating energy, increasing efficiency and reliability while minimizing environmental impact.
- Enhance the reliability of energy delivery through predictive maintenance and real time monitoring thereby reducing downtime and ensuring consistent energy supply.

4.4. Proposed IoT Use Case for Origin Energy

The proposed use case of IoT is to deploy IoT sensors and devices across Origin's renewable energy assets such as solar farms, power stations, and LNG basins to monitor performance in real time (Batcha and Kalaiselvi Geetha, 2021). Unlike standard IoT deployments, this proposal integrates advanced AI-driven analytics to predict not only maintenance needs but also to optimize energy dispatch in real-time based on fluctuating grid demand and weather patterns. This novel integration allows Origin

Energy to maximize renewable energy usage and minimize reliance on fossil fuels during peak periods, a capability not yet fully exploited by competitors. Additionally, using advanced data analytics and machine learning, the data gathered from IoT devices can be analyzed to optimize energy production, reduce inefficiencies, and predict maintenance cycles, ensuring maximum output and reliability (Batcha and Kalaiselvi Geetha, 2021). The modular design of the proposed IoT system allows for easy scalability across Origin Energy's entire portfolio. Initially deployed in power plants, this technology can be adapted for solar and wind farms. This IoT implementation is directly aligned with Origin Energy's strategic vision of leading the transition to clean energy. The integration of real-time data analytics and IoT devices ensures that renewable energy assets operate at peak efficiency, supporting the company's decarbonization targets. Similar IoT innovations have been successfully implemented by companies such as NextEra Energy (Preventing outages with drone technology, no date), which used IoT to integrate predictive maintenance with drone inspections (Pheasant, 2024), resulting in reduction in operational costs.

4.5. Financial Analysis of IoT Implementation

4.5.1. Implementation Costs

IoT implementation has different cost components associated with it and they are hardware costs, software costs, integration and installation costs, testing and security costs, operational and maintenance costs, regulatory and compliance costs (Thomas, 2024). Origin Energy's power generation is done in numerous power stations across Australia and it is the largest owner of natural gas fired power plants. For estimating an average cost, it is assumed that Origin is implementing IoT solutions in one of its largest and critical power plants located in Eraring, NSW. The station consists of four 720 MW coal-fired generator units and a 42 MW diesel generator, providing a total generating capacity of 2,922 MW (Eraring power station, no date). Below table depicts the breakdown of the estimated costs.

Cost Element	Estimated Cost Range
Hardware Layer	
Sensors and actuators	$50 - $500 per unit
Prototyping platforms	$50 - $200
Communication Layer	
Wi-Fi modules	$20 - $50 per device
Cellular modules	$50 - $100 per device
Data transmission	$5 - $20 per GB
Cloud Services	
Data storage	$0.05 - $0.20 per GB/month
Data processing	$0.20 - $1.00 per hour
Software Application	
Development costs	$50,000 - $500,000
Maintenance and updates	$5,000 - $50,000 per year
Security	
Encryption and protocols	$5,000 - $50,000
Regular security updates	$2,500 - $25,000 per year
Installation and Integration	
Installation of sensors	$10,000 - $100,000
Integration with systems	$20,000 - $200,000
Training and Support	
Training for staff	$5,000 - $50,000
Ongoing support	$5,000 - $50,000 per year

Total estimated cost: $548,000 approx (Christian, 2024). This is a rough estimate and actual costs can vary significantly based on the specifics of the power plant and the scale of the IoT implementation.

4.5.2. Return on Investment (ROI)

Based on research conducted by GE, similar real-life projects in the energy sector have demonstrated significant financial benefits from IoT implementation. These savings are attributed to a 3% increase in fuel efficiency, a 2% increase in output, a 20% reduction in startup fuel usage, a 6%–9% decrease in carbon dioxide emissions, a 10% reduction in nitrogen oxide emissions, a 5% decrease in unplanned downtime, and a 25% reduction in operations and maintenance costs (Annunziata et al., 2013). The initial investment of $548,000 is expected to be recovered within 3 years, based on projected savings of $200,000 per year in fuel efficiency, $50,000 in reduced downtime, and $75,000 from enhanced output. This results in an estimated total savings of $900,000 over 5 years, yielding an ROI of approximately 164%.

5. Conclusion

The Internet of Things has evolved from its origins in machine-to-machine communication to a comprehensive network of interconnected devices that significantly impacts various industries. The case study of GE illustrates how IoT can be leveraged to gain strategic advantages, including enhanced operational efficiency, reduced costs, and the creation of new business models. GE's adoption of IoT through its Predix platform has enabled the company to transition from a traditional manufacturing model to a service-oriented approach, setting it apart from competitors and solidifying its market position. For Origin Energy, IoT presents a crucial opportunity to align with its strategic objectives, particularly in enhancing customer solutions, expanding renewable energy, and ensuring reliable energy delivery. The detailed financial projections and the unique aspects of the proposed IoT use case demonstrate that Origin Energy stands to gain significantly in terms of operational efficiency, cost savings, and strategic alignment with its long-term goals.

6. Recommendations

Based on the analysis presented in this report and from industrial research (Batcha and Kalaiselvi Geetha, 2021) , the following recommendations are proposed to maximize the benefits of IoT for Origin Energy.

1. **Implement IoT Solutions Across Key Assets**: Origin Energy should deploy IoT sensors and devices across its renewable energy assets, such as solar farms and LNG basins, to facilitate real-time monitoring and optimize energy production.
2. **Leverage Advanced Data Analytics:** The company should use advanced data analytics and machine learning to analyze data from IoT devices, which will enhance energy production efficiency and predict maintenance cycles, reducing downtime.
3. **Focus on Automation and Control:** Origin should enhance automation and control systems enabled by IoT, minimizing manual intervention, improving operational efficiency, and reducing costs.
4. **Enhance Energy Efficiency and Load Management:** By using IoT to understand consumption patterns, Origin can improve load management, predict demand, prevent system overloads, and ensure reliable energy distribution.

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