1. The Internet of Things in NSW

Key takeaways from this module

- ☐ The Internet of Things (IoT) refers to an infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and react.
- ☐ Although we have only seen the tip of the iceberg, IoT is already so pervasive that most people do not notice its presence and take for granted the services that it makes possible.
- ☐ Many projects may not be recognised as involving IoT, such as infrastructure projects like building a bridge or tunnel, but if they have sensors capturing data then they are IoT-enabled projects.
- ☐ The true value of IoT lies in the ability of organisations to use the information generated by IoT to gain insights for better decision-making and providing better services.
- ☐ No single IoT device or network can function alone as each component plays an interconnected role in the IoT ecosystem.
- ☐ Data needs to be considered at all stages of the project cycle if the benefits promised by IoT are to be achieved. This includes the security, collation and storage of data in a cohesive and consistent manner.
- ☐ The NSW Government is keenly focused on improving customer service, and IoT has potential applications for many services delivered by government.
- ☐ Effective deployment and use of IoT across the NSW Government requires a consistent approach, built on common understanding of opportunities, risks, obligations and best practice.
- ☐ This policy aims to give you a foundational level of IoT knowledge to enable you to have informed conversations with relevant experts.

1.1 Introduction to IoT

1.1.1 What is IoT?

The Internet of Things (IoT) refers to ‘an infrastructure of interconnected objects, people, systems and information resources together with intelligent services to allow them to process information of the physical and the virtual world and react’ (21823.1:2020, Internet of things (IoT) - Interoperability for internet of things systems, Part 1: Framework, 2020)

This means physical devices that are connected to the internet, collecting, and sharing data. It is the global network of infrastructure, vehicles, wearable devices, home appliances, medical technologies and other objects that are embedded with electronics, software, sensors and actuators, enabling these ‘things’ to share and exchange data to perform their functions more efficiently and effectively.

Being connected to the internet means that a ‘thing’ can:

- collect information and send it, or
- receive information and act on it, or
- do both.

Collecting, sending, receiving, and acting on information allows us to make more intelligent decisions with less human intervention. This can save time and money while also improving services.

IoT is likely to disrupt every aspect of our lives. In the coming decade IoT will be the driving force for innovation in all major economic sectors: health, education, agriculture, transportation, construction, manufacturing, utilities, entertainment. It will also create innovation opportunities between and across these traditional sectors.

The potential application of IoT is almost limitless. Although we have only seen the tip of the iceberg, IoT is already so pervasive that most people do not notice its presence and take for granted the services that it makes possible.

For example, Sydney commuters can access real-time information about their train journey on their smartphones thanks to complex IoT applications. They can access information like the train’s location, projected arrival time at individual stations and the commuter capacity of each carriage. Behind the scenes, IoT sensors assist transport staff with tasks like track and train maintenance and performance management.

IoT is emerging to add value everywhere but there is often a low understanding of how it works and its implications. Rapid growth and the potential of technology is often accompanied by high risk and uncertainty.

For the purpose of this document, projects that involve IoT are referred to as IoT-enabled projects or solutions. While you may not consider your project to be an IoT-enabled project, it is important to recognise IoT elements in your project where they exist. Many

projects may not be defined as IoT-enabled, such as infrastructure projects like building a bridge or tunnel even though they use IoT sensors.

You may also find it useful to refer to the glossary of IoT terms published in the IoT European Large-Pilots Programme handbook. Note however that not all terms are relevant to the Australian context.

1.1.2 Why use IoT?

The application of IoT technologies has the potential to deliver significant benefits to government, industry and citizens, but its value is not guaranteed by its use alone. The true value of IoT lies in the ability of organisations to use the information generated by IoT to gain insights for better decision-making and providing better services.

The information, or 'data', collected through IoT sensors or smart devices can drive sustainability, liveability, workability, productivity improvements, economic efficiencies, and innovation. This data can also be used to drive other advanced technologies such as artificial intelligence (AI), augmented reality, digital twins and machine learning.

1.1.3 Applications of IoT

IoT solutions can be used for a wide variety of purposes. This is demonstrated in the diagram and in the case studies below.

Examples of applications of IoT

Using IoT for research

Case Study – NSW Department of Primary Industries using IoT for research

Through the **World-Class Food and Fibre Infrastructure Program,** the NSW Department of Primary Industries (DPI) is investing in IoT enabling infrastructure at its research sites. This creates the opportunity for DPI researchers to be more efficient in the delivery of research, and to solve problems through research that they previously could not solve. It also ensures that DPI remains in the top one percent of science institutions worldwide.

Since 2017 DPI has deployed low-power wide-area network (LPWAN) connectivity on nine of its research stations across NSW. This enabled DPI to trial established and emerging sensor technologies to see how they enhance decision-making on farms. The connectivity networks are open networks available for use by surrounding farms, universities and towns. Some of the applications being trialled include:

- solid state automatic weather stations
- salinity monitoring in fisheries research
- leaf wetness measurement as an indication of disease
- bore and water tank level monitoring
- beehive temperature, location tracking, and damage alerts
- irrigation channel level monitoring and pump operation alerts
- irrigation equipment GPS tracking
- greenhouse temperature and humidity monitoring
- low power GPS tracking of livestock.

The program commenced with a pilot to deploy IoT connectivity to six sites to test the technology and identify user needs for adoption. As at January 2020, 11 sites including Orange, Wagga Wagga, Tamworth and Griffith have IoT connectivity deployed, with the focus now shifting to DPI's remaining sites, and initiatives to accelerate capability, adoption and research impact.

The pilot has enabled DPI researchers to easily and remotely capture, store and analyse on-field data to make more efficient and data driven scientific decisions. This led to improved research outcomes and impact, and more effective farm management.

The pilots also seek to improve digital capability in primary industries by delivering training to local tech developers, universities, business suppliers and IT businesses, with a focus on climate adaptability and resilience.

DPI's IoT trials have delivered valuable insights around the complexity of the technology, gaps in technical skills of users and evidence of unclear or inconsistent value propositions for broad-scale primary industries adoption.

Using IoT for Green Infrastructure

Green infrastructure is the network of green spaces, natural and semi-natural systems in place to support a good quality of life for communities in the urban environment. Such infrastructure includes waterways, bushland, tree canopy, green ground cover, parks and open spaces.

IoT can be used in green infrastructure to:

- capture data on localised temperature, humidity and air quality and visibility to support proactive measures to protect people's health and safety while enjoying green open spaces.
- aggregate and analyse environmental data from IoT devices to provide real time insights on the environment to drive biodiversity and sustainability outcomes. Examples include tree health, soil moisture, water and air pollution levels, urban heat, threatened species monitoring and irrigation management.
- provide water monitoring IoT solutions that support water asset maintenance, contributing to water efficiency and waterway health.

Case Study - Wollondilly Shire Council's using IoT for a better community experience

Wollondilly Shire Council sponsored a smart parks project from the 2019 Digital Western Parkland City Pitchfest. IoT technology was trialled to improve the community's experience of public open space and operational efficiencies for council maintenance staff.

At the time, the Shire had poor mobile and internet connectivity, making it challenging to monitor and maintain council owned public open space.

Telopea Park in Buxton was chosen as the trial site. Technologies trialled included 'smart pole' infrastructure to support Wi-Fi, LoRaWAN and mobile connectivity, and IoT sensors to monitor parking, waste, and BBQ and amenities block usage.

During the height of COVID-19 restrictions, Wollondilly Shire Council used the IoT network and sensors to monitor park usage to ensure compliance with public social distancing and self-isolation requirements.

Case Study - Liverpool City Council using IoT for environmental care

As part of the 2019 Digital Western Parkland City Pitchfest, Liverpool City Council and the Department of Planning, Industry and Environment co-delivered a digital tree register and tree monitoring project in the Casula Parklands.

IoT sensors were placed in the ground next to 10 trees to monitor soil temperature and humidity. The data captured from these sensors was directed to a dashboard where it was visualised as a traffic light system to indicate when a tree needed watering, accompanied by weather forecasting that included predicted rainfall.

After the success of the trial, Liverpool City Council is now looking to scale the solution to monitor 245 trees as part of the Liverpool Urban Forest Strategy. The expansion will create individual tree profiles on an open platform to encourage tree care from the community.

1.1.4 The IoT ecosystem

It is easy to focus on the physical device when thinking about IoT. However, this is just one element of the IoT ecosystem. Like the human body, no single IoT device or network can function alone as each component plays an interconnected role within the IoT ecosystem. Broadly, an IoT ecosystem includes:

Things: Machines, equipment, devices and other physical assets to which IoT hardware is applied, allowing them to sense and affect the surrounding physical environment, receive and transfer data and interact with control units and other enabled things.

IoT hardware: Sensors, actuators, instruments and other components that capture and relay contextual information and real-world data and enable the 'thing' to communicate with its environment.

IoT backbone: The capture and storage of the raw data received from the connected 'things', and the processing, storage (cloud, servers, data centres) and management of this data.

Communication and network: network hardware, software, protocols and services that connect IoT hardware to the internet, whether that is:

- Backhaul connectivity: long-haul communications; GPS, cable, LPWANs, cellular
- Local connectivity: short-range and machine-to-machine communications; WLAN, mesh networks, Bluetooth, Wi-Fi
- IoT gateways: intermediaries between the sensors/actuators and the cloud to process the collected data locally before sending it to the cloud.

See Appendix D for a table of key wireless network options available in NSW.

Visualisation and communication: Data visualisation is about the visual representation of data as a means of communication. Data needs to be delivered to the organisation in a meaningful way to support decision making. Examples include dashboards, push notifications, interactive public displays, enhanced 3D spatial platforms and digital twins etc.

*Solution services: S*ervices that integrate the components of the system into the business and physical environment, including the development of solutions, platforms, devices, and vertical applications, and system integration, testing, managed services and support.

IoT platforms: Software that turns the raw data into a common language and connects the other elements of the IoT ecosystem to each other. Interoperability is crucial when choosing your IoT platform. See Chapter 3.8 Technology for IoT for information on interoperability.

Identity and security (platforms): Software and hardware that enable identity authentication and management, cyber security and end-point protection.

Data transfer management and processing applications: Software that facilitates transfer, manage and process data, comprising of middleware (e.g. Service Bus), backend data processing (e.g. database and decision units), and frontend user and Business-to-Business (B2B) interfaces. These applications provide intelligence and insights generated from data such as:

- Analytics: Aggregate, analyse and package data to extract insights. This includes big data analytics that enables applications to aggregate and acts on large amounts of data generated by devices. Aggregated data can drive innovation, research, and marketing, as well as optimise the services that generated it.
- Enterprise and consumer apps: Applications that leverage IoT data and algorithms to solve problems and address needs. An example is the train tracking application in Section 1.1.1 What is IoT?.

For further information on the IoT ecosystem, see the Australian Computer Society (ACS) Report prepared by PwC, Australia's IoT Opportunity: Driving Future Growth (2018).

Refer to the IoTAA: IOT Reference Framework for identifying and positioning elements of the IoT ecosystem. See also the National Code of Practice which is a voluntary set of measures the Australian Government recommends for industry as the minimum standard for IoT devices.

1.1.5 IoT and data

Data is a critical element of IoT and a core output of any IoT-enabled project. In the IoT ecosystem, observations made by connected devices or sensors are transmitted, stored, processed and analysed as data. Data needs to be considered at all stages of the project

cycle if the benefits promised by IoT are to be achieved. Individual sensors may be cheap, but data is not.

Data in IoT initiatives can mean a range of things. Data can be text, binary, structured, freeform, data processed into rules and policies or trained machine learning models. Data can also flow in a range of ways. For example, sensors can send their data to a central cloud server for analysis and storage, or data can flow from peer to peer like a sensor supplying data to an actuator.

1.1.6 Trends in IoT

The number of deployed IoT devices in the world is expected to grow exponentially. The International Data Corporation (IDC) estimates there will be 41.6 billion connected IoT devices by 2025 worldwide compared to an estimated 14.2 billion connected things in 2019. The IDC also estimates that worldwide technology spending on IoT will reach US$1.2 trillion in 2022 compared to US$745 billion in 2019. For 2019 it is predicted that the largest IoT market will be discrete manufacturing (US$119 billion), followed by consumer retail (US$108 billion), process manufacturing (US$78 billion), transport (US$71 billion) and utilities (US$61 billion).

Domestically, the Australian Computer Society (ACS) Report prepared by PwC, Australia's IoT Opportunity: Driving Future Growth (2018) found that IoT has potential annual benefits for Australia of $194-308 billion over 8 to 18 years. This translates to approximately two percent per annum in productivity improvements in the construction, manufacturing, health, food/agriculture, and mining sectors.

According to Gartner, the top technology trend for IoT is an increase in artificial intelligence (AI) being applied to data and information that is collected through IoT devices. IoT service providers are expected to invest heavily in AI in the coming years. It is widely agreed that AI will increasingly drive IoT development and deployment, as the number and complexity of IoT systems, and the data collected and analysed, exceed human capability.

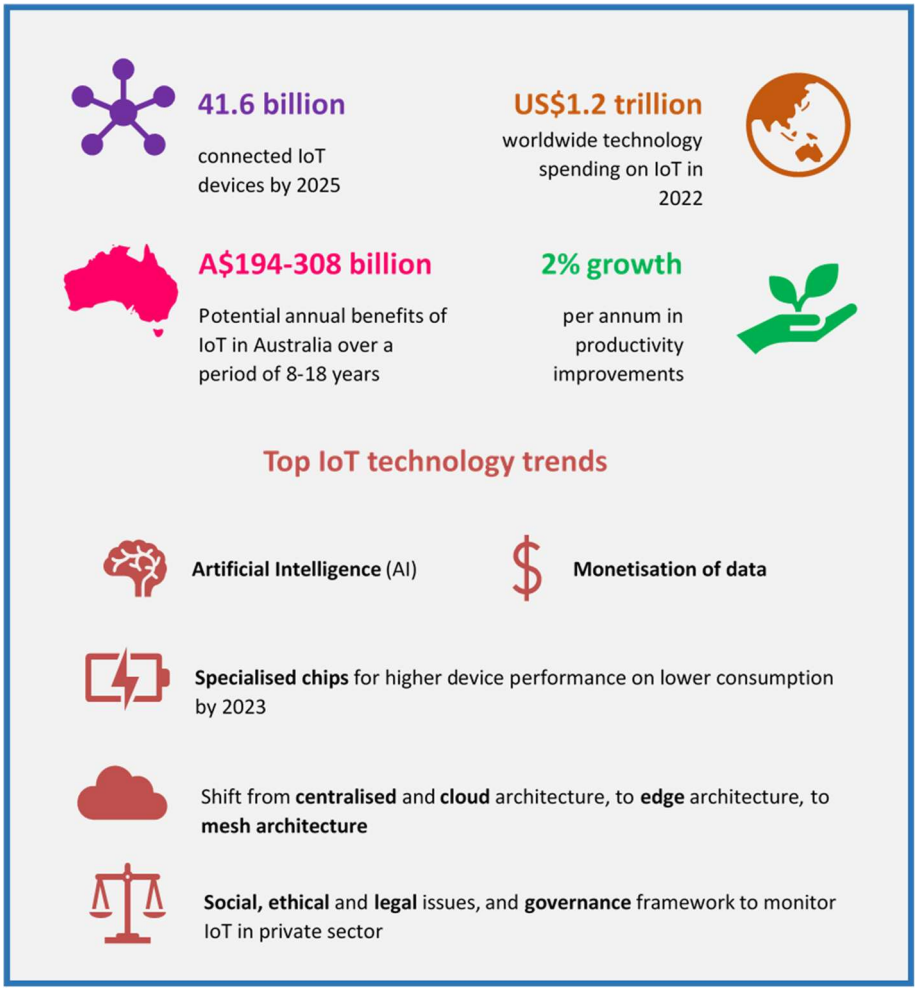
Gartner predicts the monetisation of data becoming a strategic business asset and that it will become an essential part of many IoT ecosystems by 2030. As IoT matures and becomes more widely deployed, social, ethical and legal issues will become more important. An IoT governance framework that ensures appropriate behaviour in the creation, storage, use and deletion of information related to IoT-enabled projects in the private sector will also become more vital.

Sensors and technology will continue to evolve and innovate. By 2023 it is expected that new special-purpose chips will be developed to operate on high-performance networks with lower power consumption. These will support new functions such as data analytics integrated with sensors.

IoT architecture trends will continue to shift from centralised and cloud architecture to edge architecture, and then towards unstructured and connected dynamic mesh architecture enabling more flexible, intelligent and responsive IoT systems.

The below diagram illustrates the trends outlined in this section.

Predicted trends in IoT



1.2 IoT in NSW Government

New South Wales will embrace IoT to be the most innovative, integrated, intuitive Smart State in Australia. We will lead the way in employing IoT to deliver better, more accurate and evidence-based services which improve the lives of citizens.

1.2.1 IoT opportunities for NSW Government

The NSW Government is keenly focused on improving customer service. IoT has potential applications for many services delivered by the government which can help agencies to:

- collect and analyse data on citizen's needs, priorities and interactions with government, contributing to evidence-based policy and service delivery
- access more accurate real-time data, which can, for example, enable the delivery of on-demand services tailored to individual needs
- model changes to policy and services in a safe environment to better understand the impacts of decisions prior to implementation
- integrate and redesign services in ways that save citizens time, increase productivity and improve the customer experience.

The NSW Government has an obligation to its citizens to boldly experiment, collaborate and learn. Through experimentation and innovation, we deliver better services more efficiently. Through collaboration, we break down siloes to deliver seamless services for our customers. When we share what we learn, we lift capability across the sector and community.

While IoT presents many exciting opportunities for the government to better serve its customers, these opportunities are not without risk. The NSW Government is committed to the safe adoption of IoT, which means protecting privacy, minimising risks and ensuring citizens' security.

1.2.2 The current state of IoT in the NSW Government

The NSW Government is regularly ranked as the most digital-ready government in Australia. However, taking advantage of opportunities presented by IoT requires upskilling across the sector to ensure we innovate efficiently, effectively and safely.

There are small passionate teams in various agencies undertaking IoT-enabled projects. Some of these teams are very experienced, whilst others learn as they go. This means that often the projects are ad hoc, have a narrow focus on operational efficiency rather than a strategic opportunity, and experiences and learnings are not shared. Projects are developed in silos, so they aren't designed for interoperability and cross-silo benefits.

There is a growing interest in taking advantage of the efficiency gains and decision-making enhancements presented by IoT. This excitement is tempered by a lack of confidence in planning and executing an IoT-enabled project in a way that will maximise benefits and

keep risks within tolerance levels. This policy provides guidance to address these concerns and risks.

1.2.3 Other relevant NSW Government policies and strategies

The NSW Government has suite of existing policies and strategies that support IoT.

Smart Places Strategy

Smart Places integrate technologies into the built environment to capture and convey data and insights. This includes using IoT devices to collect and analyse data about an asset or local environment. The data can help NSW Government to make evidence-based decisions to improve infrastructure, services and liveability for the NSW community.

The Smart Places Strategy sets out the NSW Government's vision for Smart Places, in particular how it will work collaboratively with local government, Australian Government and private sector partners to harness the power of digital technologies and realised the substantial benefits being delivered by technological change.

Smart Infrastructure Policy

The Smart Infrastructure Policy sets the minimum requirements for smart technology (including IoT) to be embedded in all new and upgraded infrastructure from 2020. The Smart Infrastructure Policy applies to all new NSW Government capital and ICT projects subject to the Investor Assurance Framework (IIAF) and the ICT Assurance Framework.

Artificial Intelligence Strategy and User Guide

Artificial Intelligence, or AI, is intelligent technology, programs and the use of advanced computing algorithms that can augment decision making by identifying meaningful patterns in data. AI in this context should aim to help the NSW Government free up our workforce for critical and frontline tasks, cut costs and enable us to deliver better, more targeted services.

The NSW Government AI Policy and User Guide provides clear guidance on the safe use of AI, finding the balance between opportunity and risk, while putting in place those protections that would apply for any service delivery solution. A new body, the AI Advisory Committee, chaired by the NSW Government Chief Data Scientist, can assist agencies with AI project plans to ensure consistency with the AI Ethics Policy.

Infrastructure Data Management Framework

The Infrastructure Data Management Framework (IDMF) is a set of guidelines, procedures, and standard approaches to support consistent management of infrastructure data across the NSW Government sector. The IDMF is aligned with the NSW Information Management Framework (IMF), which provides more general guidance on the management of government data and information. Broad adoption of the principles and guidance of the IDMF will ensure that NSW has a coordinated, standardised and trusted framework to harness infrastructure data to better plan and operate the State's infrastructure systems.

Spatial Digital Twin

The NSW Spatial Digital Twin is upgrading the state's Foundation Spatial Data Framework (FSDF) from a two-dimensional map to a four-dimensional model (3D + time). That is, a full three-dimensional model of the state's physical environment, capable of recording past conditions and visualising future scenarios to create a digital real-world model of our cities and communities which will facilitate better planning, design and modelling for NSW's future needs. The NSW Spatial Digital Twin will provide the platform upon which government, developers and residents are able to visualise, plan, develop and assess infrastructure (such as transport links), new community facilities, public spaces, and homes. For further info see Spatial data requirements

1.3 Purpose of the IoT Policy

IoT is a new, complex and rapidly changing environment. There are pockets of the NSW Government with experience in designing and rolling out IoT solutions however, the sector's maturity is generally low.

Effective deployment and use of IoT across the NSW Government requires a consistent approach built on a common understanding of the opportunities, risks, obligations and best practice. The potential of IoT to improve customer service across all categories of goods, services and infrastructure will only be realised through greater investment and experimentation.

This policy has been designed to:

- demystify IoT
- encourage innovation with IoT solutions
- build understanding and capability across the sector
- provide practical guidance for those responsible for delivering IoT-enabled solutions.

1.3.1 Scope of the IoT Policy

The IoT Policy provides:

- practical guidance to help organisations design, plan and implement IoT solutions
- advice on standards and obligations where available and practical
- tools and templates to help effectively manage an IoT-enabled project
- guidance on where and how to source additional advice if required.

The diversity of applications – and potential applications – of IoT across the NSW Government makes it impossible to provide prescriptive guidance suitable for every IoT solution. Rather, this policy provides IoT solution-agnostic advice and recommendations for where to find additional information.

Navigating the successful development and rollout of an IoT-enabled project requires a wealth of diverse technical knowledge which cannot be conveyed in a single policy. This

policy aims to give you a foundational level of IoT knowledge to enable you to have informed conversations with relevant experts.

1.3.2 Audience of the IoT Policy

The primary audience for the IoT Policy is NSW Government agencies that are planning or currently implementing IoT solutions, or that are interested in learning more about the applications of IoT.

Local government will also find the IoT Policy useful. While some of the obligations outlined in the IoT Policy may not apply to organisations outside of the NSW Government, most of the advice in the policy is relevant to local government.

1.3.3 How to use the IoT Policy

This policy is divided into eight standalone modules which contain chapters. Each module relates to a step of the reader's 'IoT journey' in implementing an IoT-enabled project.

At the beginning of each module, you will find a checklist of key takeaways (for modules 1 and 2) or best practice considerations (for modules 3 to 8).

You can read the policy in its entirety or select the module relevant to the step in your IoT journey.

1.3.4 Case studies in the IoT Policy

Case studies are used throughout this policy to illustrate the concepts and uses of IoT.

1.3.5 How the IoT Policy relates to other NSW Government policies

This policy refers to other NSW Government policies, frameworks, and tools that provide context and information relevant to IoT in NSW. They are listed in the table at Appendix F.

This policy does not override existing agency policies and standards where they exist. It is important that you contact the subject matter experts in your organisation for guidance on any organisation-specific policies and standards.

1.3.6 Maintaining the IoT Policy

The IoT ecosystem is rapidly evolving. Associated policies should be flexible and adaptable enough to accommodate changes.

To ensure its usefulness, this policy will be regularly updated as technologies change, opportunities and risks are better understood, standards develop, and IoT maturity across NSW Government grows.