Digital Government Ecosystem: Adaptive Architecture for Digital and ICT Investment Decision Making

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ABSTRACT

Agencies, while operating in the federated digital government ecosystem, need to make significant investments in digital and information and communication technology (ICT) for providing services to people and businesses. A whole-of-government adaptive architecture driven approach seems appropriate for supporting common language and consistent digital and ICT investment decision making. It enables adaptive planning and implementation with a view to make an optimal use of public funds and aligned with the strategic direction and priorities in digital and ICT investments. However, the challenge is how to establish the adaptive architecture for supporting digital and ICT investment decision making in the complex and federated digital government ecosystem. This paper proposes the adaptive enterprise architecture (AEA) meta-framework for digital ecosystems, as a lens, to systematically integrate the Australian Government Architecture (AGA), and Digital and ICT Oversight Investment Framework (IOF) in establishing the adaptive architecture for assisting digital and ICT investment decisions within complex digital government ecosystems. The proposed approach is demonstrated and evaluated with the help of an example scenario for an Australian digital government service. The results of this study indicate that the adaptive architecture driven approach involving AGA and IOF seems useful for architecting and supporting complex digital and ICT investment decision making to deliver the holistic outcomes of data and digital government strategy objectives.

CCS CONCEPTS

• **Architectures**; • **Enterprise information systems**; • **Government technology policy**;

KEYWORDS

Adaptive architecture, ArcOps, Australian government architecture, Digital transformation, Government ecosystem, Investment decision making

1 INTRODUCTION

There is a significant interest in the ecosystem-oriented approaches for architecting, planning, and implementing digital transformation programs. An ecosystem is defined as a "system of systems, which is composed of a distributed and federated network of human and non-human organisms or actors that interact with each other using different interfaces for desired outcomes. These actors and their interactions span across the value chains of an individual enterprise or organisation" [1]. A digitally enabled ecosystem (DE) is fundamentally changing the structure and operations of organisations operating in the increasingly boundaryless, connected, and federated digital environments. There are several definitions of DE. Broadly, DE can be defined as "a set of distributed, adaptive, and open socio-technical systems. Being parts of such ecosystems, individual persons, public and private organisations are becoming increasingly dependent on each other" [2]. This definition provides both the socio-technical and interdependency aspects of the DE. DE can also be defined as a complex value network of individual and organisational actors that interact with each other for a specific purpose and value co-creation such as information sharing, service provisioning and delivery [3]. DE is supported by the underlying digital, information and communication technology (ICT). There are several examples and types of DEs. For instance, Airbnb, Amazon, and Uber can be classified as digital business ecosystems. Xero, a cloud-based accounting system typically used by small-medium enterprises, is also an example of digital business ecosystem that includes integration with the government ecosystem, e.g., for business reporting purposes. Similarly, connected government and federated agencies can be classified as digital government ecosystem or GovTech ecosystem [4]. GovTech refers to government digital technologies.

Drawing on the above discussion and the DE [1-3] and GovTech [4], a digital government ecosystem (DGE) can be considered as a complex value network of government and non-government actors that interact with each other; develop, provide, and consume data and digital services for mutual value and benefits. These actors can include people, businesses, government agencies, universities, and other public and private organisations. Digital and ICT are core to the DGE and as they provide the necessary infrastructure to enable smooth interactions among these actors for provisioning and delivery of data and digital government services to people and businesses [5]. Thus, government agencies need to make significant investments in digital and ICT for provisioning and delivering data and digital services to people and businesses. These digital and ICT investments and related decisions, if made in isolation and independent of other related actors in the DGE, can be counterproductive and may not provide optimal value for public good. A whole-of-government adaptive architecture driven approach seems

appropriate for supporting common language and consistent digital and ICT investment decision making. It enables adaptive planning and implementation with a view to make an optimal use of public funds whilst at the same time aligned with the Government strategic direction and priorities in digital and ICT investments. This draws our attention to the following important research question and challenge:

How to establish the adaptive architecture for supporting digital and ICT investment decision making in the complex and federated digital government ecosystem?

This paper aims to address this important research challenge in the context of Australian government as an example case of a DGE. This paper provides an independent view, and uses the adaptive enterprise architecture (AEA) meta-framework for DE [1], as a lens, to systematically integrate the publicly available Australian Government Architecture (AGA) [6] and Digital and ICT Investment Oversight Framework (IOF) [7] in establishing the adaptive architecture and operations (ArcOps) for assisting with digital and ICT investment decisions in the complex context of Australian DGE. ArcOps is defined as a "connectivity or loop between the architecture-operations, which is important for enabling the mapping and flow of information between architecture and operations for effective decision making and value realisation" [39]. This paper also draws guidance from the well-known actor-network theory [8] and literature on quality decision making [29]. While this paper mainly discusses the Australian DGE case, however, learnings from this paper can be further used in other similar government contexts. This paper is organised as follows. Firstly, it discusses the research background and context. Secondly, it discusses the research method. Thirdly, it discusses the proposed adaptive architecture approach and underpinning integrated AGA contents and IOF states. Fourthly, it discusses the application of the proposed adaptive architecture approach for decision making by using the example scenario of an Australian digital government service – myGov. Finally, it discusses the key insights, limitations, and future research directions before concluding.

2 RESEARCH BACKGROUND AND CONTEXT

DE is a network of interacting actors or entities that create and offer value (e.g., service, data) to their customers for mutual benefits (e.g., profit, public good). DE can be described using the well-known actor-network theory [8], where actor-network is a focal point of interest that operates beyond the boundary of an individual or single enterprise. These actors could be broadly classified as human and non-human actors. In DE, these actors collaborate, compete, communicate, and coordinate their activities for mutual benefit [10]. These actors perform different roles in DE, which could be specific to certain sectors such as the education ecosystem where universities, industry and government actors interact with each other for providing educational services to their student actors for mutual benefits. Similarly, government is also an example of a large DE, referred to as DGE.

GE consists of several interacting agencies that offer government services (e.g., applying for a driving license, getting child support information, applying for a passport, share information) to their citizens [11, 12]. Government agencies need to make different types of complex decisions (e.g., compliance, financial) at different levels (e.g., strategic, tactical, and operational) about investments in digital and ICT architecture and solutions to transform their services for people and businesses. Making such digital and ICT investment decisions by individual agencies, without a whole-of-government ecosystem oriented adaptive architecture and investment approach, may pose several challenges such as redundancies, inefficiencies, inconsistencies, lack of interoperability, lack of reusability and suboptimal value for public funds, including deviating from Government's strategic direction and priorities in digital and ICT investments [1, 6, 13, 14]. An ecosystem oriented adaptive architecture provides a connected view [1], which is important to address the evolving needs of government as well as people and businesses, including industry partners. This draws our attention to the following important research question and challenge:

How to establish the adaptive architecture for supporting digital and ICT investment decision making in the complex and federated digital government ecosystem?

This paper addresses the above-mentioned research question in the context of Australian government as a DGE. Australian government provides the publicly available Australian Government Architecture (AGA) [6]—an interactive, self-service online tool in the form of a library of guidance materials; and Investment Oversight Framework (IOF) [7]—an end-to-end framework providing a way for the Government to manage digital investments. Both the AGA and IOF can be used for investment decision making that aligns with the Government strategic direction and priorities in digital and ICT investments [15]. This section establishes the context for the Australian DGE case and provides an overview of the AGA and IOF.

2.1 Australian Government Digital Ecosystem

Digital Government Ecosystem (DGE) in Australia consists of several agencies and government owned entities, which is organised into three levels: local, state/territories, and federal [16]. Australian DGE can be further divided into sub-ecosystems such as agriculture ecosystem, education ecosystem, finance ecosystem, health ecosystem and transport ecosystem, etc. [17, 37]. Thus, it is a super DGE. Each sub-ecosystem and their individual agencies deliver their services using digital and ICT-enabled capabilities. The Australian Government recently released the Data and Digital Government Strategy (DDGS) that outlines Government's commitment to "deliver simple, secure and connected public services for all people and business through world class data and digital capabilities" [9]. This requires a whole-of-government architecture and investment approach in digital and ICT to deliver this strategy. To deliver the commitments outlined in the DDGS, the Australian Government seems to use its advice and governance mechanisms, specifically the AGA, as the library, and IOF, as the framework, to ensure that good quality investment principles and practices underpin data and digital investment decisions. The AGA and IOF provide a means to identify when and what other related recourses may be applicable such as ICT Investment Approval Process [18], Digital Service Standard [19] and Digital and ICT Reuse Policy [20].

2.2 Australian Government Architecture

The AGA [6] can be seen as a library of artefacts and related materials, which individual agencies can use as a reference to architect connected services through digital and data capabilities [19-22]. The AGA library, i.e., contents, is organised by a Domain and Capability Model (DCM). It specifies domains, capabilities, policies, standards, and designs. The domain is the highest structure, followed by capability, policy, standard and design. A domain can have more than one capability, policy, standard and design, but are exclusive to the one domain only. Strategy is not part of the content hierarchy as a strategy can be the overarching direction for multiple contents. For example, DDGS is providing strategic direction for the Government's digital and ICT investment in general. It has been noted that the "AGA is publicly accessible to agencies, as well as industry and the public, in a way that is searchable and navigable based on user needs. This will encourage standardisation and reuse across government" [6]. The AGA assists the Government in assessing new and existing digital and ICT solutions from several perspectives, by reviewing whether they "fit in" with what the Government already has, if so how; represent a new solution can "fill a gap"; or no longer "fit-for-purpose" and need to be retired. Accordingly, the AGA also provides signals to the industry (as a part of the ecosystem) on the Government's digital and ICT priorities across the portfolio and capabilities expected to be delivered [27, 37]. Once fully operational and matures, the AGA can provide a short-term and long-term view of capabilities delivery at a whole-of-government level and thus, level of reuse. As such, the AGA can also be used as a guidance for agencies' internal, business-as-usual initiatives, moving away from siloed architecture and inconsistencies, arising from making investment decisions in isolation. Therefore, the AGA library provides guardrails and guidance with a view to achieve alignment to the DDGS to support Government digital transformation. The AGA is a way to enable whole-of-government approach to the design and implementation of digital government transformation [6, 23]. While the AGA library provides resources and architectural artefacts to guide the design of a proposed digital and ICT-enabled capabilities, the investment decision-making process [24] can be guided by the IOF [7].

2.3 Investment Oversight Framework

The Australian Government aims to become one of the leading digital government, economy, and society by 2030 [9]. This requires significant investments and good quality decision-making [29] for digital and ICT-enabled digital government [25]. Australian government developed the IOF [7] for supporting the decision making related to digital and ICT-enabled investments. The IOF is organised into six states that provide end-to-end process from early planning through to project delivery and realisation of planned benefits of digital and ICT-enabled capability as proposed investment is used in real life operation. The IOF is administered by the Digital Transformation Agency (DTA), which is part of the Finance Portfolio. The DTA is mandated to provide leadership on whole-of-government digital and ICT investment through the IOF. The AGA and IOF are developed and maintained by the DTA.

The IOF, in principle, applies but not limited to Non-Corporate Commonwealth entities (e.g., agencies), starting from when developing a proposal for digital and ICT-enabled investments (Pre-Budget), bringing forward the proposed investment for Government consideration (Budget) and when delivering the agreed investments (Implementation). Investments that are subject to the IOF are digital and ICT-enabled investments, which use technology as the primary levers for achieving expected outcomes and benefits. A proposed investment is considered in-scope for IOF if it cannot be delivered without the absence of digital and ICT-enabled capability. Further assessment under the IOF is required for in-scope proposed investments [33], which is determined based on multiple factors covering the extent of risks, complexity, strategic importance, and the consequences of delivery failure of digital and ICT-enabled components, as well as compliance to the IOF requirements [34].

While Australian government provides both the AGA and IOF; the question is how agencies can use these two for architecting and supporting investment decision-making for ICT-enabled digital government. This paper proposes the AEA meta-framework for digital ecosystems [1], as a lens, to systematically integrate AGA library [6] and IOF [7] for establishing the adaptive architecture for assisting with the digital and ICT investment decisions in the complex digital government ecosystems.

3 RESEARCH METHOD

This research used the well-known design science (DS) research method [26, 30], which provides a practical approach and guidance to develop and evaluate an approach or method as an artefact such as the proposed adaptive architecture approach in this paper. DS research method is organised into 5 phases or stages [31]: (1) problem identification, (2) suggestion, (3) development, (4) evaluation and (5) conclusion. The problem was identified based on the review of academic and government recourses as noted in the research background and context section. Here, the main problem or concern is around the digital and ICT investment decision making in the complex and federated digital government ecosystem. Based on the initial research, it is suggested to integrate and use the AGA and IOF for supporting digital and ICT investment decision making. This covers the first two phases of the DS research method, which produced two outputs: the research proposal and tentative design (see Figure 1).

Development phase uses the existing knowledge and artefacts such as concepts, frameworks, models, and theories to develop the detailed artefact as proposed in the earlier phase of the DS research method. Thus, here in the development phase of the DS research method, AEA meta-framework [1] for DE is used as a core or kernel theory or theoretical lens including the underpinning supporting actor-network theory [8] and quality decision making [29]. Actor network theory [8] recognised the multi-agency or stakeholders' aspect of the connected or networked DGE in the decision making, whereas the quality decision making literature [29] provided guidance on "what constitutes a good decision". AEA meta-framework [1] provides overarching six major components for establishing an adaptive architecture: architecture principles, metamodel, layers, capability, pipeline, and services. The AEA pipeline is used to integrate the Australian government AGA and
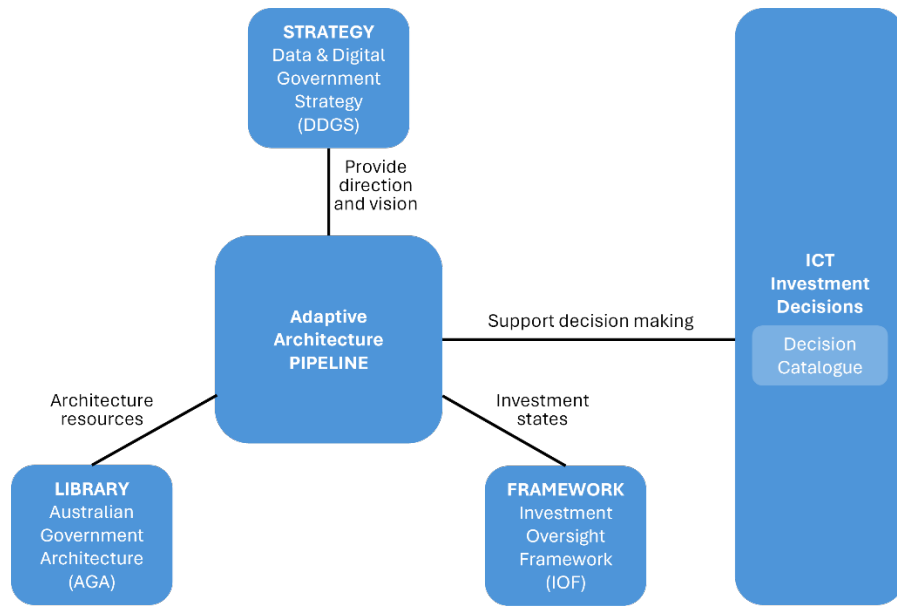
Figure 1: Adaptive Architecture for Digital and ICT Investment Decision Making

IOF to establish the adaptive architecture approach for supporting digital and ICT investment decision making.

Evaluation phases uses the evaluation criteria (e.g., applicability, completeness, effectiveness, generalisability, novelty etc.) and techniques (e.g., case study, expert evaluation survey, experimentation, illustrative scenarios) to ensure that the developed artefact is fit for purpose. Thus, in the evaluation phase of the DS research method, the proposed adaptive architecture approach has been applied to an example scenario of the Australian government digital service. The aim is to provide an initial evaluation and working example ensuring that the proposed approach is fit-for-purpose and appropriate to address the identified research question in hand. Further, such an adaptive approach can be generalised, scaled, and tailored to agency specific architecture practice needs, whether small, medium, or large. Conclusion phase finalises the research results with options for future work as noted in the conclusion section of this paper. The following section discusses the proposed adaptive architecture approach for digital and ICT investment decision making.

4 ADAPTIVE ARCHITECTURE FOR ICT INVESTMENT DECISION MAKING

Decision making is a complex undertaking that requires the engagement of multiple parties or actors [32] for good decisions and desired outcomes [29]. The adaptive architecture pipeline integrates the AGA and IOF to support the ICT investment decision making and is guided by the Australian Government DDGS [9] (see Figure 1). A decision, such as the investment, can be defined as "a choice between two or more alternatives that involves an irrecoverable allocation of resources" [29]. It is important to mention here the six elements that exhibit decision quality: (1) the decision maker, (2) a frame, (3) alternatives to choose from, (4) preferences, (5) information and (6) the decision logic [29]. The decision

maker has the authority to make decisions. A frame provides a point of view such as whether to establish own cloud or use the public cloud services? The selected frame is then used to identify the alternatives or options to choose from. Preference needs to be considered among the alternatives. Information is all about the evidence in hand to support the decision making. Information can be obtained by analysing the data from different sources such as architecture and operations (business and IT). This information is used for decision making. Finally, the decision logic explains the process used for arriving at the decision. The adaptive architecture pipeline captures the decisions and related elements in the Decision Catalogue (DC) for audit, good governance, and transparency. This integrated approach ensures the alignment of the architecture, related digital initiatives, or proposals, and required digital and ICT investment decisions with the Australian Government's vision to deliver simple, secure, and connected public services for all people and business, through world-class data and digital capabilities. The whole integrated adaptive architecture centric approach is mapped in Figure 1 and Table 1. This section first discusses the adaptive architecture pipeline followed by the AGA and IOF in detail.

4.1 Adaptive Architecture Pipeline

The AEA meta framework [1] provides the adaptive architecture pipeline (ArcOps), which is organised into 5 key stages (Figure 2): (1) vision and scope (initiate), (2) discover, (3) implement, (4) govern and (5) adapt. The adaptive architecture pipeline can be tailored for a specific agency context for delivering the end-to-end architecture.

4.1.1 Vision and Scope. This stage, based on the strategic direction of the DDGS, defines the vision and scope of an architecture project. This specifies the stakeholders and their concerns related to transforming individuals and businesses interactions with the Australian Government for operational efficiency, effectiveness and

Table 1: Adaptive Architecture Pipeline: Integrated AGA and IOF

| DDGS Missions	Architecture Pipeline Stages	AGA Library Contents	IOF States
Delivering for all people and business	Vision and scope	Domains	Strategic Planning
Simple and seamless services	Discover and implement	Capabilities	Prioritisation
Government for the future	Govern and adapt	Policies	Contestability
Trusted and secure		Standards	Assurance
Data and digital foundations		Designs	Sourcing
			Operations
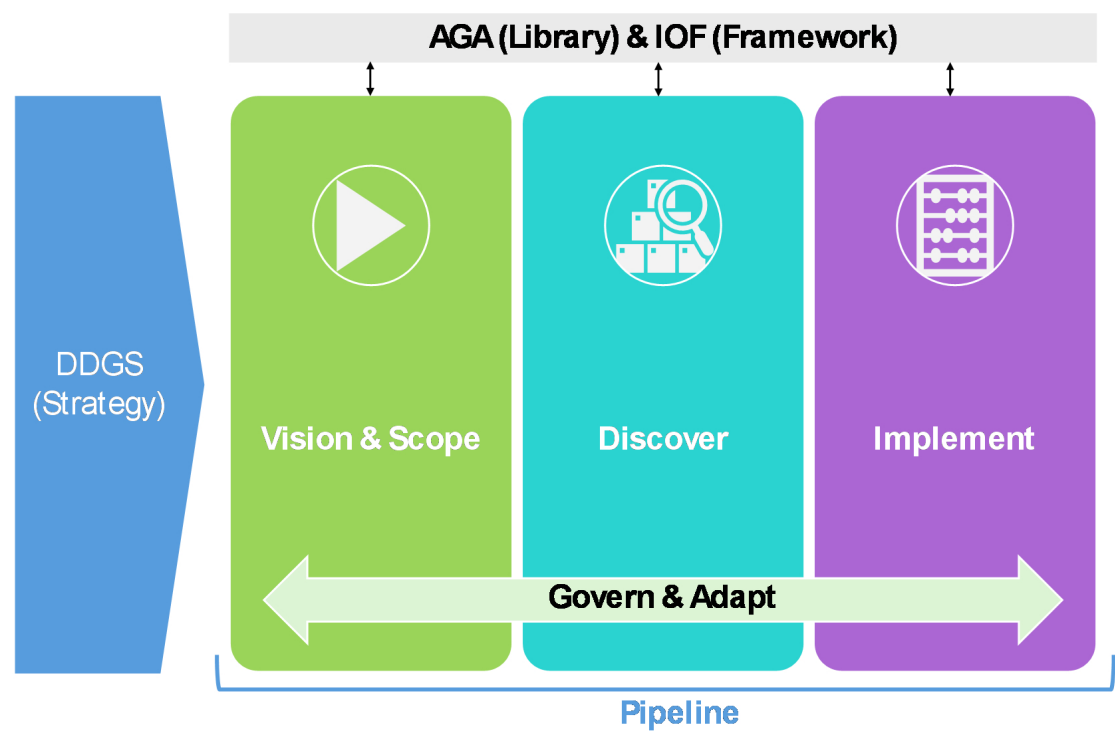
Figure 2: Adaptive Architecture Pipeline with Integrated AGA & IOF (based on AEA, AGA, IOF, DDGS)

automation of operations using the digital and ICT-enabled capabilities. As shown in Figure 2 below (adapted based on [1, 6, 7, 9]), once the vision and scope of the architecture project is established, then it triggers the next stage of the architecture pipeline.

The vision and scope stage commences with an initiative for architecture project. It begins with the identification and analysis of stakeholders as well as understanding the strategic context and stakeholders' concerns to identify solution ideas and information views and viewpoints in scope for assisting with the decision making. In the context of Australian Government's digital and ICT investment process, this is part of identifying capability gaps when determining the future objectives of the Government's digital and ICT-enabled investment portfolio. This aligns with the IOF's first state, "Strategic Planning". At this state, Australian Government entities will align their own strategies to the DDGS's missions. As such, the AGA and IOF are used as guardrails from early planning of a digital and ICT proposed investment. For example, the AGA includes information on Digital Service Standard (DSS), which plays an important role in the DDGS vision to deliver simple, secure, and connected public services, for all people and business by 2030. DSS provides guidance on a set of best practice principles to help agencies design and build public-facing digital services that puts people and business at the centre of government digital service delivery. The AGA and IOF are consulted as the AGA outlines the policy requirements, applicability as well the IOF state where a proposed investment will be assessed against the DSS and the IOF provides further guidance on the assessment process [7, 36].

4.1.2 Discover and Implement. The discover and implement stages continue to use the AGA and IOF as guardrails. The discover stage analyses the current state and proposes the future state architecture based on the gap analysis. Future state adaptive architecture is decomposed into incremental transition architecture states. The discover stage can use the AGA contents (e.g., domains, capabilities, policies, standards, and designs) for specifying the future state architecture and underpinning transition state architectures and proposed digital and ICT initiatives, ensuring consistency, reusability and avoiding duplication across the government digital landscape. The proposed digital and ICT initiatives need to be prioritised from an investment perspective and for an optimal use of public fund. That is, digital and ICT initiatives will be considered by the Government following alignment with the Government's strategic direction and priorities in digital and ICT investment. Thus, prior to Government consideration, i.e., pre-budget, it is critical to ensure such alignment. Thus, two pre-budget states of the IOF are integrated within the discover stage of the pipeline to guide (1) "Strategic Planning" and (2) "Prioritisation" of digital and ICT-enabled investment portfolio to deliver digital outcomes for Government.

The implement stage focuses on developing the adaptive strategic roadmap and implementation plan based on the prioritised proposed digital and ICT initiatives from the discover stage (pre-budget). The proposed digital and ICT initiatives from the roadmap and implementation plan are put forward for budget and investment decision making. Here, the IOF state (3) "Contestability", ensures that the proposed digital and ICT initiatives are feasible and in compliance with the Whole-of-Government Digital and ICT policies and standards (e.g., Reuse Policy and alignment with the AGA) [20] and (4) "Assurance" ensures that governance is in place throughout the implementation stage. Once the proposed digital and ICT initiatives are funded, they then enter the IOF implementation state (5) "Sourcing", which ensures that Government gets the optimal value for money for their ICT investments.

4.1.3 Govern and Adapt. The govern and adapt stages, across the pipeline, focus on implementation governance and adaptation to changes based on the operations (connected loop of ArcOps). These stages involve the AGA as well as IOF (6) "Operations" and (4) "Assurance" states. IOF Operations state continuously collects and analyses data about the size, health, and maturity of the digital and ICT investments, and provides insights and intelligence for adaptation. Assurance state tracks and provides governance of digital and ICT investments ensuring they deliver expected outcomes and that benefits are realised. Feedback loop is used to adapt the architecture, AGA and future investment based on the digital and ICT investment performance and evolving stakeholder needs. The adaptive architecture pipeline (ArcOps) provides the overarching integrated view of the AGA and IOF and shows its alignment to DDGS for digital and ICT investment decision making. The following sections further discuss the internal details of the AGA and IOF.

4.2 The Australian Government Architecture (AGA) Taxonomy

The AGA content is broadly categorised into two main groups, unendorsed and endorsed. For example, a domain and a capability

may be endorsed, but the policy may still be unendorsed. Specifically for the policy content, when a policy content is unendorsed, the Policy Elements section of a capability provides recommended better practice (i.e., agencies should); and if endorsed, the Policy Elements section will have a list of mandatory requirements (i.e., agencies must). For each type of content, when unendorsed, the status is either drafting or consulting; and if endorsed, the status is either emerging, core, contain or retire. For example, Identity Management Capability for Individual (DOM1, CAP17) does not yet have an endorsed policy governing it although the domain and capability have been endorsed. It provides an extensive list of recommended better practice under the capability's Policy Elements section, whereby agencies are recommended to, i.e., should, for example, "use accredited providers through the Services Australia Identity Exchange under the Trusted Digital Identity Framework (TDIF) when verifying identity of Australian businesses or their authorised representatives". On the other hand, Hosting Capability (DOM2, CAP28), has an endorsed policy in place. Therefore, it requires, i.e., agencies must, for example, "ensure that PROTECTED and whole-of-government systems are hosted in certified sovereign or certified assured data centres". The following Figure 3 (adapted based on [6, 21]), referred to as the AGA Taxonomy, provides the hierarchy of the AGA contents as discussed.

4.3 The Nature of Investment Oversight Framework (IOF)

The IOF, as discussed earlier, is an end-to-end framework that provides a way for the Government to manage its digital and ICT-enabled investments across the entire project lifecycle, from early planning through to project delivery and realisation of planned benefits [7]. It consists of six linear but interactive states. As shown in Figure 4 (adapted based on [7, 28]), the six different states are *Strategic Planning, Prioritisation, Contestability, Assurance, Sourcing* and *Operations* reflect a lifecycle across an entire project. Although the latter state is primarily triggered by input from the previous state, each state's output can provide input into any relevant state. The aim is to improve how each state informs other states and thus, improve the overall IOF and how it informs a digital and ICT-enabled project in the future. This indicates the IOF, like the AGA, is iterative and adapts to changes. This is to ensure that the Government makes the right digital and ICT-enabled investments, at the right time and in the right way to drive transformation of public services, leading Australia as one of the top digital governments [38] in the world by 2030 [9].

The interactive and iterative nature of the IOF involves integration with the AGA. Through close integration with the IOF, the AGA is implemented throughout the project lifecycle. The AGA interacts with every state of the IOF, providing *architectural guidance* that agencies 'must' or 'should' adhere to; *a common language* to describe digital capabilities, improve collaborations and streamline government's service delivery; *economies of scales* arising from streamlined and shared services across government; and *mechanism for strategic use* of technologies, especially emerging ones, to manage government's digital and ICT-enabled investments portfolio. The integration of AGA and IOF, therefore, will lead towards a composable platform architectures at a whole-of-government level,
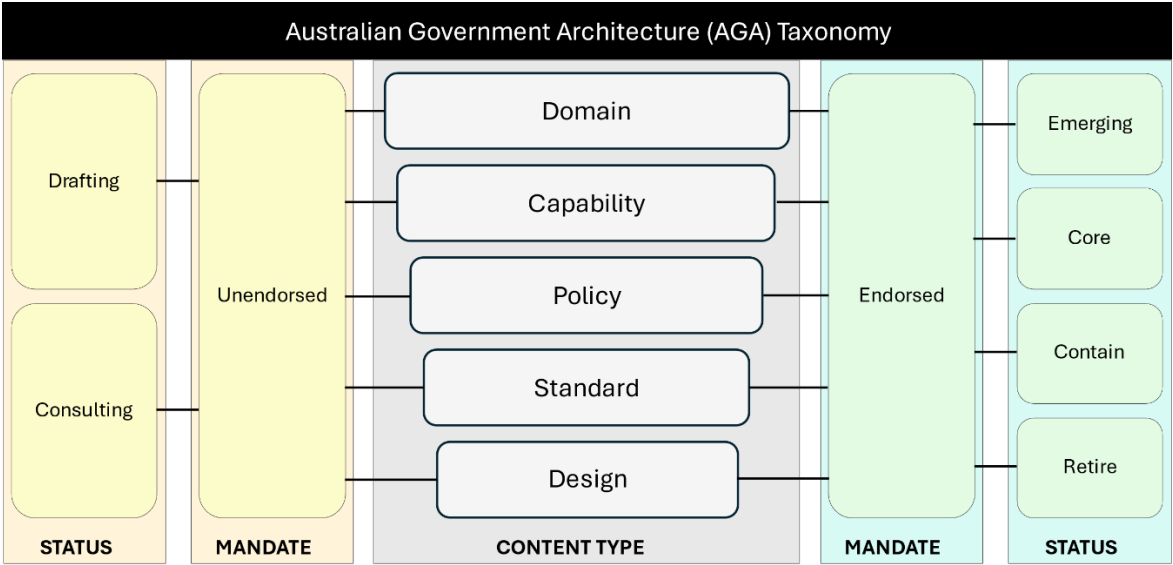
Australian Government Architecture (AGA) Taxonomy

STATUS	MANDATE	CONTENT TYPE	MANDATE	STATUS
Drafting	Unendorsed	Domain	Endorsed	Emerging
		Capability		Core
Consulting		Policy		Contain
		Standard		Retire
		Design		

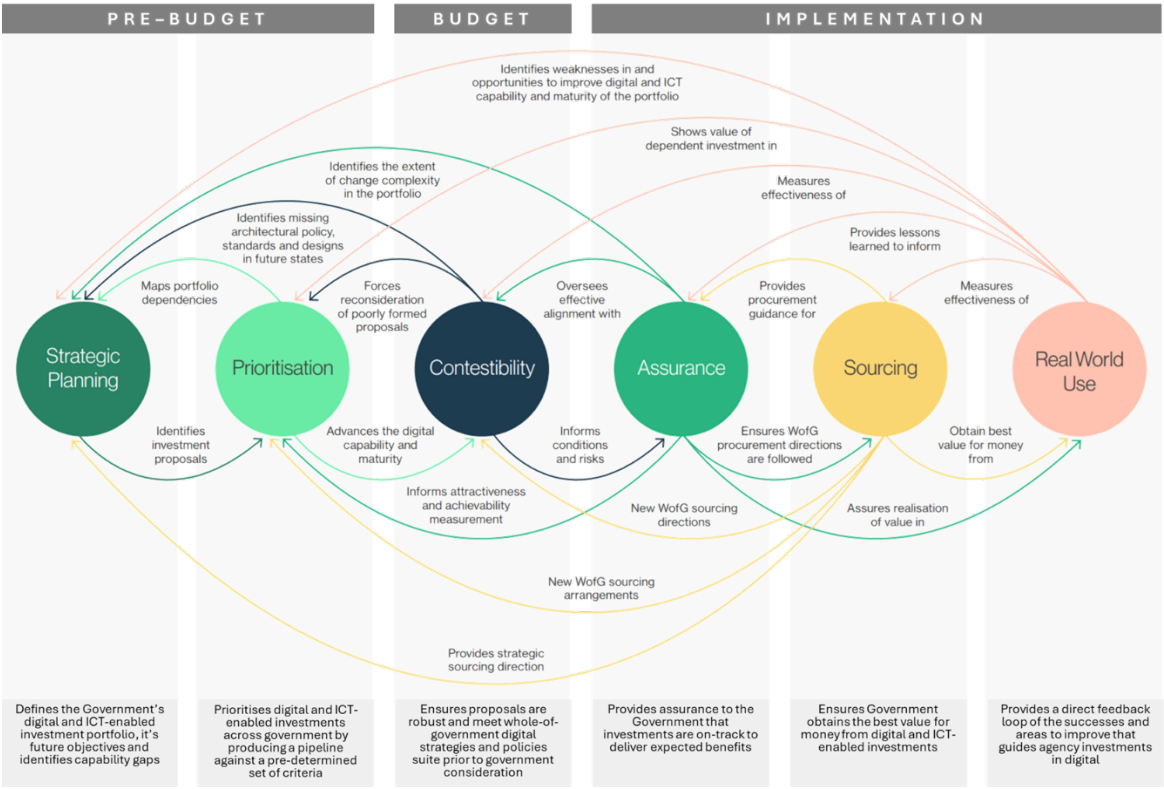**Figure 3: The AGA Taxonomy (based on AGA content library)**

Figure 4: Investment Oversight Framework (based on IOF diagram)

i.e., the DGE, where knowledge is shared, and services are efficient, transparent, and interoperable, enabling a more consistent and adaptive decision making to make an optimal use of public funds.

5 APPLICATION

Using the AEA pipeline as a lens, which integrates the AGA and IOF to support the digital and ICT investment decision making by
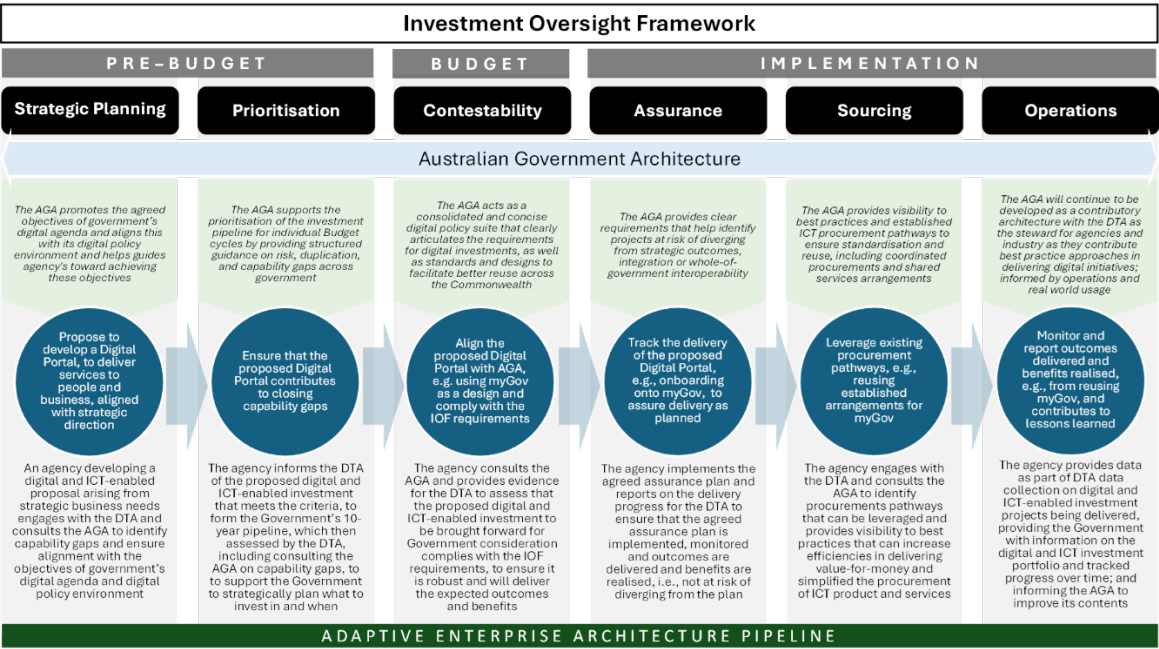
Figure 5: Integrated Adaptive EA Pipeline, AGA, and IOF (based on AEA, AGA, IOF Diagrams, and Information)

agencies, can be tailored for a specific context, and supported by different architecture roles, tools, and technologies (see Figure 5). This section only provides an independent example view of this proposed approach based on the publicly available information. There could be multiple ways of tailoring and using the proposed integrated approach. Guided by the Australian Government DDGS [9], the AEA pipeline intends to ensure the alignment of proposed digital initiatives with Australian Government Architecture and IOF requirements to deliver Australian Government's vision of simple, secure, and connected public services for all people and business, through world-class data and digital capabilities. Using a hypothetical case, this paper aims to provide an illustrative application of AEA pipeline for a digital initiative or an ICT architectural project.

An agency identifies strategic needs to develop digital capabilities for delivering services to the people and business effectively and efficiently. Throughout the project lifecycle, the agency uses the AGA as a library, which provides architectural guidance through close integration with the IOF requirements, to ensure that proposed solution is aligned with the DDGS and Government's digital agenda and policy environment. It enables the agency to identify whether the vision and scope of the strategic business needs can close capability gap at whole-of-government and to discover the right solution that aligns with government priorities. For example, the agency identifies that developing a digital portal is the solution to delivering services to the people and the AGA provides guidance for the agency to ensure compliance with the IOF requirements when delivering the digital portal and alignment with Government direction. The guidance is anchored on the policy elements of the digital portal capability, which stipulates the recommended better practice, and includes standards and designs for developing a digital portal. The agency can identify suitable designs to develop the

solutions, for example myGov, and it may involve exploring other capabilities such as using myGovID as the preferred digital identity management capability for the proposed solution. If a variation in the design is needed, the agency can use the AGA as a guidance to ensure compliance with relevant policies and standards, such as designing for reuse, so the new design can be shared through AGA for reuse in any future proposed investments with similar requirements.

During the project implementation, the AGA continues to provide guidance following the IOF states, whereby once funding sought is agreed by the Government, the agency can leverage existing procurement arrangements to ensure simplified and value-for-money procurement of the required ICT products and services. The implementation of the digital and ICT-enabled investment is tracked to assure the delivery of outcomes and realisation of benefits remain as planned. Lessons learned from the real-world operations are fed back into the AGA and IOF to improve the process. This adaptive process can be considered as an architecture value stream, that is, where the AEA pipeline supports the delivery of architecture artefacts, products, and services by connecting the strategy in the upstream to the solution development and operations in the downstream. The following figure (based on [1, 6, 7, 32]) shows the overall integration of the IOF and AGA for digital and ICT investment decision-making from the lens of AEA pipeline [1].

From the AEA pipeline perspective, the illustration discussed indicates that the integration of the AGA and the IOF can assist the Government in making digital and ICT investment decisions across multiple projects and agencies whereby the design of the architecture can be iteratively and incrementally discovered, by connecting solution development and operations. This avoids the up-front big design of architecture for each project that may be

disparate across projects and agencies, which may go against the Government direction. For example, one of DDGS missions, "simple and seamless services", envisions that the Australian Government provides service delivery to people and business as a unified enterprise, i.e., it is digital by design, deploying scalable and secure architecture and tell us once (interoperable and integrated at a whole-of-government level). Using the hypothetical case discussed earlier, the policy elements of the digital portal capability capture alignment with DDGS requirements, such as to avoid building new capabilities and instead leverage existing digital portals as well as to ensure public-facing services are made available digitally. The agency can use the AGA to explore and discover the potential of reusing existing designs of a digital portal capability and other relevant capabilities that are already in use in operations to align with DDGS of delivering a simple and seamless services to the people and businesses whilst at the same time ensuring compliance with relevant policies and standards.

The approach that the Australian Government agencies apply in delivering its digital and ICT investments, which resembles the operationalisation of an AEA pipeline, can be applied in other countries with similar context. For example, the United Kingdom (UK) [40] and New Zealand (NZ) [41]. The UK (e.g., Digital, Data and Technology Playbook or DDaT Playbook) and NZ (e.g., Government Enterprise Architecture New Zealand or GEA-NZ) have similar digital and ICT investment decision-making processes to Australia. It seems that in both the UK and NZ, an architecture library and digital and ICT investment framework have been and continue to be developed as resources appropriate to their context. For instance, NZ has developed a comprehensive library of architectural guidance, which includes layered architectural framework. It provides information and tools to support Government in making transformation across and within organisations towards coherent digital government [41]. Despite the different countries and their local contexts, the overall intent is the same, to promote a better decision-making that complies with policies and standards and aligns with the Government direction in digital and ICT investment.

The key element to Australia's approach is the whole-of-government integration of strategy, architecture library and investment framework, enabling agencies to make good quality digital and ICT investment decision. Such integration enables the Government to manage its digital and ICT investment portfolio that aligns with its priorities and promote better governance of digital and ICT investment spending that meets Government direction [35]. This includes mechanisms to make good quality investment decision and effective oversight. The absence of such an integrated approach may restrict the capacity of the government to better understand and respond to the digital needs of the public sector, including timely risks management [35, 37].

In summary, the IOF is viewed at a whole-of-government level in Australia, from the perspective of Government's investment states in managing digital and ICT investment. In the proposed approach, using AEA pipeline as a lens, the IOF states correspond to end-to-end projects lifecycle, from early planning through to project delivery and realisation of planned benefits as the delivered capabilities are used in operations. It seems that the IOF, through close integration with AGA, can assist the Australian Government to approach its digital investment expenditure decision-making at both whole-of-government and portfolio or agencies level. Based on limited comparative analysis using publicly available data, both the UK and NZ [40, 41] seem to have similar intents, however detailed analysis of their approaches are required to determine the use of architecture library (empirical evidence) that is closely integrated with an investment framework to promote the delivery of architecture artefacts, products, and services by connecting the strategy in the upstream to the solution development and operations in the downstream. Thus, further studies will need be conducted to better understand how Australian context can be applied in other countries with similar context like the UK and NZ.

6 DISCUSSION AND CONCLUSION

This paper discusses an important challenge of digital and ICT investment decision making in the complex and federated digital government ecosystem in the context of Australian digital government ecosystem. One way to address this challenge is to establish an adaptive architecture pipeline (ArcOps) for supporting and evolving digital and ICT investment decision making in alignment with the government strategy. The Australian government provides Data and Digital Government Strategy (DDGS) and several related resources to support the establishment of adaptive architecture for decision making such as the Australian government Architecture (AGA) library and Investment Oversight Framework (IOF). This paper proposed the adaptive enterprise architecture (AEA) meta-framework for digital ecosystems, as a lens, to systematically integrate the AGA and IOF in establishing the adaptive architecture for assisting digital and ICT investment decisions for the Australia digital government ecosystem context.

The AEA meta-framework consists of six major components for establishing an adaptive architecture: architecture principles, meta-model, layers, capability, pipeline, and services. This paper only used the AEA pipeline to integrate the AGA and IOF to establish the adaptive architecture approach for supporting the digital and ICT investment decision making for the Australian context (Figure 5). The AEA pipeline has 5 key stages (Figure 2): (1) vision and scope (initiate), (2) discover, (3) implement, (4) govern and (5) adapt. These stages provide an overarching structure for the underpinning IOF and AGA. Further, it is important to note here that the initiate stage of the pipeline is also integrated with the upstream DDGS to ensure the downstream pipeline stages and integrated IOF and AGA are in alignment with the overall government strategy. This, as a whole, provides an adaptive architecture driven approach intends to guide the digital and ICT investment decision making in the Australian government ecosystem.

The proposed approach is demonstrated and evaluated with the help of an example scenario for an Australian digital government service. The results of this study indicate that the adaptive architecture driven approach involving AGA and IOF seems useful for architecting and supporting complex digital and ICT investment decision making to deliver the holistic outcomes of data and digital government strategy objectives. Further, it also demonstrates how to integrate architecture, and digital and ICT investment oversight framework for configuring a comprehensive adaptive approach to decision making and for the delivery of data and digital strategy objectives. While this study has been conducted in the Australian

government context, however, it is intended that the learnings from this study can be customised and applied to other similar government context and their digital transformations, which is subject to further research. Future work will further investigate the integration of other related recourses or artefacts for evolving the proposed adaptive architecture driven approach to digital and ICT investment decision making.

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