SG:D | TECHNOLOGY ROADMAP

INFOCOMM MEDIA DEVELOPMENT AUTHORITY

THE FUTURE OF SERVICES

SERVICES AND DIGITAL ECONOMY

TECHNOLOGY ROADMAP

In partnership with:

Monitor Deloitte.

Contents

Foreword

22 Nov 2018

We are seeing a confluence of emerging technologies that may potentially disrupt entire industries, business models and jobs. At the same time, these shifts open up new vistas of possibilities for Singapore to transcend our conventional economic constraints, such as its small domestic market and geography. To seize these opportunities, we need to have a better grasp of major technology trends, understand their implications, and respond boldly and nimbly.

This refreshed Services and Digital Economy (SDE) Technology Roadmap builds on previous efforts and provides a view of the digital technology landscape over the next three to five years. The roadmap is an important component of the Digital Economy Framework for Action that was launched in May 2018, and will guide IMDA's industry development plans and regulatory approaches for the Infocomm and Media (ICM) sector. This document will also inform the next tranche of investments in digital technologies under the RIE programme and identify new areas to digitally transform industries under the work of the Future Economy Committee.

In addition to a technology scan, the roadmap provides a point of view on how Singapore can leverage these technologies to transform our services sectors. It paints an exciting vision of the future of services—Services 4.0—where technology lies at the heart of how services are designed and delivered. This, in turn, gives our enterprises and workforce the competitive edge in a digital economy.

We are grateful to the more than 120 representatives in the various Committees and working groups who dedicated time and energy to develop this roadmap. These representatives included captains of industry from the ICM and services sectors, academics from key institutions in science and technology research, as well as government agencies. The Committees and workgroups actively reached out to a wide spectrum of stakeholders—from companies, industry associations, investors, to leading international experts to canvass inputs.

On behalf of the Committees, we thank all our stakeholders for providing their valuable inputs to the development of the SDE Technology Roadmap. We are privileged to have had the opportunity to contribute to this significant piece of work.

Yours sincerely,

TAN KIAT HOW
Co-Chair
Steering Committee of the
SDE Technology Roadmap

WU CHOY PENG
Co-Chair
Steering Committee of the
SDE Technology Roadmap

Preface

In May 2018, the Digital Economy Framework for Action was launched to accelerate Singapore to become a leading digital economy. This Framework complements the work undertaken for the 23 Industry Transformation Maps (ITMs) and Industry Digital Plans (IDPs) that will enable industry-wide digital transformation in the next two years. It outlines a plan of action to enhance Singapore's digital competitiveness and become a global node in Asia.

Underpinning the Framework for Action are the three strategic priorities (Accelerate—Digitalising Industries; Compete—Integrating Ecosystems; Transform—Industrialising Digital), and four critical enablers (Manpower Development; Research and Innovation; Physical and Digital Infrastructure; Governance, Policies and Standards). Singapore's industries have progressively embarked on their digitalisation journeys and are making the transition to the new normal of operating in a digital world. To complement this transition to a digital economy, there was a need to develop a refreshed technology roadmap that identifies technological engines that will be key for Singapore's development in the coming years.

In June 2018, the Minister of Communications and Information, Mr. S. Iswaran, commissioned the development of the Services and Digital Economy (SDE) Technology Roadmap to guide the development of the action plans. The SDE Technology Roadmap outlines a response to help Singapore capture opportunities created by emerging technological trends. It articulates a vision of the future economy—Services 4.0—that will fulfil Singapore's goal to become a leading digital economy of the future. The SDE Technology Roadmap will guide digital transformation as well as future technology investments over the following three to five years.

The purpose of the SDE Technology Roadmap is three-fold:

1. Identify key trends that will impact the digital economy
The SDE Technology Roadmap informs the key trends driven by emerging technologies. A deeper understanding of these trends will help Singapore's stakeholders to formulate appropriate responses to manage the opportunities and the challenges that arise from the trends.

2. Refresh the ICM 2025 Technology and Research & Development (R&D) Roadmaps
In August 2015, ICM 2025 was published to guide Singapore's technology development in six key areas. The SDE Technology Roadmap aims to identify the areas that Singapore should focus on, in the face of the socio-economic and technological shifts impacting the nation's economy.

*3. Recommendations to support the digital transformation of industry sectors*
The Roadmap provides recommendations for digital transformation in view of the technology trends facing the Singapore economy.

This report focuses on the SDE Technology Roadmap Main Report and consists of five chapters. Chapter 1 highlights the impact that emerging technologies have on the services economy, and introduces the need for a new vision for Singapore to excel in the services economy. Chapter 2 describes Singapore's vision for Services 4.0 and the five objectives for the nation. Chapter 3 explains the need for Cloud Native Architecture, a new technology ecosystem. Chapter 4 discusses the impact of the new vision on the economy, companies and workers. Finally, Chapter 5 outlines the recommendations for achieving Singapore's Services 4.0 vision.

The second part of this report consists of the SDE Technology Roadmap Annexes (refer to link here). This part provides a comprehensive view on the technology roadmaps across five key areas: Future Communications and Internet-of-Things (IoT), Immersive Media and Advanced Interfaces (IMAI), Cyber Security, Artificial Intelligence (AI), Data, Blockchain, and Future-Ready Systems.

Executive Summary

The Technology Roadmap has identified nine key trends that will move the digital economy significantly over the next three to five years. They may be viewed either as challenges or opportunities. The biggest impact will be on the services sector as it forms the bulk of the global economy and Singapore's GDP[1].
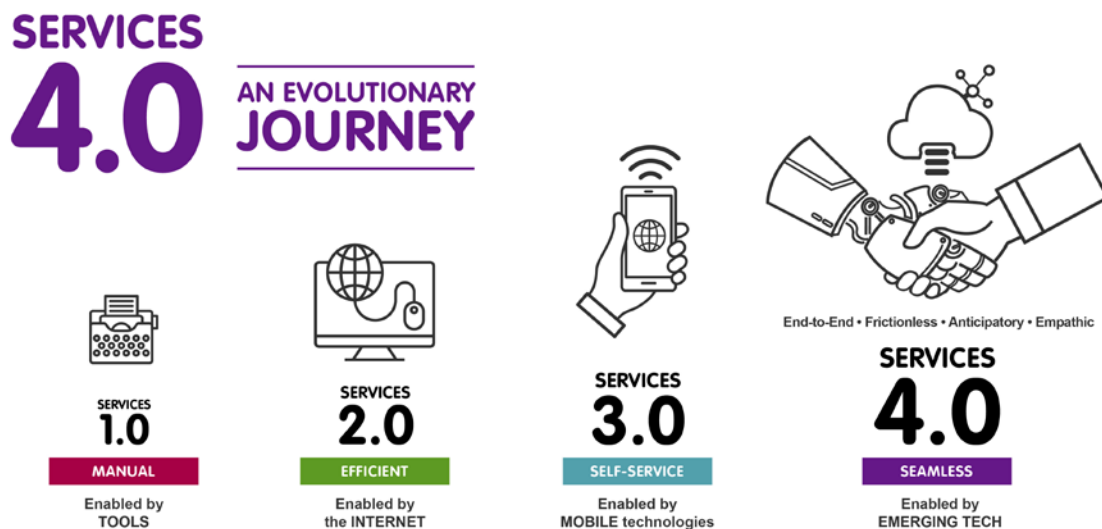
Services 4.0 is the vision that will guide Singapore's response not only to capture the opportunities for the economy but also to manage the risks as well.

With the services economy evolving from the era of manual services (Services 1.0) to the era of efficient, internet-enabled services (Services 2.0), then to self-services enabled by mobile, wireless and cloud technologies (Services 3.0), the next phase will be one of seamless services that are end-to-end, frictionless, empathic, and can anticipate customer needs using emerging technologies (Services 4.0).

In Services 4.0, businesses will need to meet changing customer needs quickly, innovate and create new value in order to differentiate themselves from competitors. Emerging technologies will make it possible for businesses to automate repetitive tasks and achieve higher productivity. However, as customers still demand human interactions, businesses should unlock growth by offering human-centric services enabled by emerging technologies. Both worker augmentation and automation will ultimately lead to the creation of new and enhanced jobs.

To support Services 4.0, the Infocomm and Media (ICM) ecosystem will need to respond collectively to deliver solutions that are as follows:

- More cost effective
- Scalable according to demand
- Provide easier access to emerging technologies
- Support the changing needs of service providers in an agile manner

Cloud Native Architecture[a] is at the heart of the evolving ICM ecosystem. Adopting this architecture will bring emerging technologies closer to service providers and workers, and help realise the aforementioned benefits.
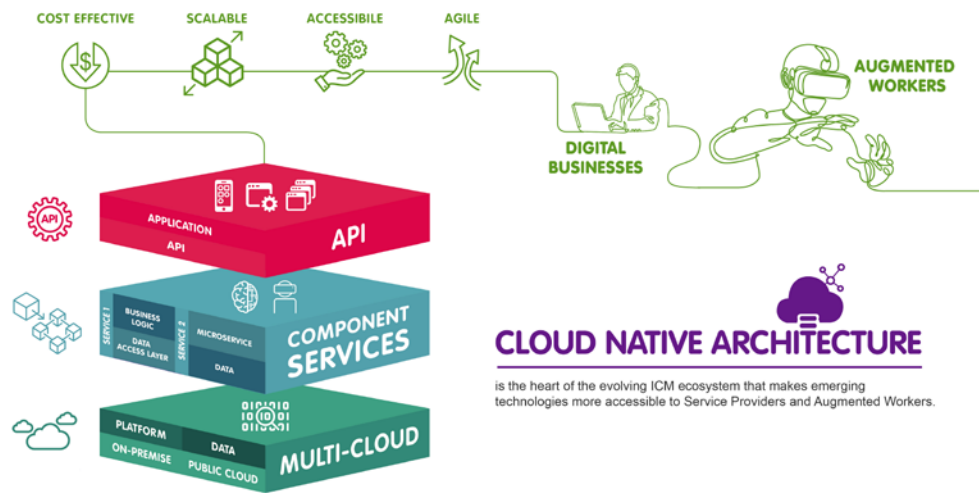
While 71% of global firms expressed that they would like to transition to Cloud Native, only 9% have succeeded[2]. It will be necessary to foster an inclusive ecosystem where all parties move in tandem. The Singapore Government has already made a move to migrate to the Cloud Native Architecture by establishing the Singapore Government Technology Stack.

The Technology Roadmap committees believe that with the support of an inclusive Singapore ICM ecosystem, Singapore is well-positioned to become a Services 4.0 hub for key sectors.

This goal will encompass three ambitions. The first ambition is to make Singapore a launchpad for Services 4.0. The second is to build a competitive workforce in Singapore that is augmented by technology. The third is to establish a vibrant ICM ecosystem in Singapore that delivers Cloud Native solutions that will bring emerging technologies closer to service providers and workers. This will enable faster time to market from concepts to seamless services, and also spur innovation. The realisation of the third ambition is critical as it forms the foundation for the first two ambitions.

To help Singapore reach these three ambitions, a suite of recommendations has been proposed to guide the implementation of the three strategic priorities and four enablers under the Digital Economy Framework for Action, launched in May 2018.

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a   Cloud Native Architecture is envisioned based on three main tenets - Multi-Cloud, emerging technologies offered as component services and APIs.

01 SERVICES ECONOMY
AND THE NEED
FOR A RESPONSE

1.1

A WORLD UNDERGOING BIG SHIFTS

Today we live in a world where macroeconomic trends are unprecedented.

We find it harder to predict the future today than any time in the last millennium.

The rise of technology has reshaped our socio-economic fabric, and led to big shifts in the global economic landscape.

These shifts have far-reaching impact. Legacy models, in particular, have come under pressure, challenged by more powerful emerging technologies.
(See Appendix 1)

Source: Deloitte Insights

4. More Natural Technology Interfaces

5. Greater Use of Codeless Development Tools

3. Greater Human-machine Collaborations

2. More Empathic, Cognitive and Affective AI

6. More Seamless Services enabled by XaaS

1. Pervasive Adoption of AI

7. Cloud Deployment Matures with Hybrid and Multi-Cloud

8. Blockchain Decentralises Trust

9. API Economy takes off

9 Technology Trends

In parallel with the shifts, emerging technologies are on the rise. Fuelled by frequent technological breakthroughs, and rapid commercialisation, their influence today defines our world like never before, and is infiltrating every part of businesses and our everyday lives.

As part of IMDA's efforts to chart the Technology Roadmap, we have conducted a study, and arrived at nine technology trends that are making the greatest impact on the digital economy.

1. Pervasive Adoption of Artificial Intelligence (AI)

Andrew Ng[b], former Chief Scientist of Baidu's AI Group who founded and led the Google Brain (Deep Learning) Project, remarked that AI is the next electricity, poised to profoundly affect the way people live, work, and play.

In the next three to five years, we can expect an exponential increase in commercial AI-based application[3] across three major categories:

- Product applications that embed AI in products or services to provide end-customer benefits.

- Process applications that incorporate AI into an organisation's workflow to automate processes or improve them by augmenting worker effectiveness.

- Insight applications that harness advanced capabilities such as Machine Learning (ML) to uncover insights that inform operational and strategic decisions across an organisation.

2. More Empathic, Cognitive and Affective AI

Machine intelligence represents the next chapter in advanced analytics. Its algorithmic capabilities augment employee performance, automate increasingly complex workloads, and develop "cognitive agents" that can simulate human thinking and engagement.

Already we are witnessing higher level AI deployed in several sectors. In financial services, cognitive sales agents initiate contact with promising leads, then qualify, follow up and sustain the prospects. At Google, Empathy Lab builds emotional intelligence into their AI assistants, allowing them to connect with people, while providing a "framework for human empathy" to their chief scientists[4].

3. Greater Human-machine Collaborations

The gap between humans and machines steadily narrows. As robots become more human-like thanks to advances in AI and sensor technology, they can now respond to ambient cues and intentional movements, analyse moods and sentiments, and even identify lies[5].

Such progress has given rise to new categories of robots, such as humanoid robots and cobots, and will drive the adoption of robots, as well as human-machine collaboration across industries.

As the name suggests, humanoid robots are robots with a human appearance[6] while cobots have sensors that enable them to detect abnormal activities in the environment, and can work alongside humans without physical separation[7]. The humanoid robot market is sizeable, and is projected to grow to US$4 billion by 2023[8]. For cobots, the market is predicted to reach as high as US$12 billion by 2025[9].

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b   Andrew Ng founded and led the Google Brain (Deep Learning) project and was a chief scientist at Baidu's AI Group. Currently, he is a Stanford University Computer Science faculty member, the co-founder and co-chairman of Coursera, the founder of deep learning.ai, and the founder and CEO of Landing AI.

4. More Natural Technology Interfaces

Mixed Reality (MR) elevates the potential of Augmented Reality (AR), Virtual Reality (VR), and Internet-of-Things (IoT) by combining the best of our digital and physical realities.

More than just layering virtual reality onto physical reality, MR adds intelligence to digital content. It takes into account physics, gravity, dimensions and personality, blurring what is real, and what is imagined[10].

Market leaders are heralding a new era of engagement by integrating experiences with connectivity, cognitive and analytics. Unity[c], for instance, is supporting industry customers in automobile design, equipment failure diagnostics, employee training, and retail merchandising. Many US-based technology leaders such as Facebook[d], Apple[e] and Google have been actively investing in mobile AR, a market that is expected to reach US$60 billion by 2021[11].

Meanwhile, total spending on AR and VR products and services is predicted to reach US$209 billion in 2022 (72% CAGR from 2017)[12].

5. Greater Use of Codeless Development Tools

Not too long ago, building a website required coding knowledge. Today, with tools such as Squarespace and Wix, anybody can build websites. The democratisation of technology has given everyday people the power to accomplish tasks as if they are technology experts[13].

Technology giants such as Google, Amazon Web Services (AWS) and Microsoft are leading the charge in this field. Launching cloud-based emerging technology solutions and tools, they simplify complexity, making applications and services creation a breeze.

These solutions are increasingly based on the microservices architecture, such as AWS's Lambda, Microsoft's Functions and Google's Functions platforms.
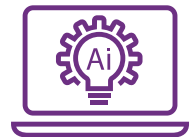
6. Digital Platforms and As-a-service Architectures

At the core, every service delivery model aims to satisfy different customer needs, and to deliver a seamless experience across the customer journey.

Technologies today are realising such goals by harnessing the convergence of emerging technologies, most notably digital platforms and as-a-service architectures.

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c   Unity Technologies is a leading game development platform, known for its Unity creation engine, which reaches more than 2 billion devices worldwide. Given that many initial forays into VR/AR being video games, Unity is also turning their attention to enterprises and created a development platform for 2D, 3D, VR, and AR experiences.

d   Facebook indicated AR and VR technologies to be their top three technology priorities along with connectivity and AI.

e   Apple announced its AR kit for iOS in 2017 as "the largest AR platform in the world."

7. Cloud Deployment Matures with Hybrid and Multi-Cloud

The future of cloud can be described in two words: Hybrid and Multi-Cloud[14].

Together, Hybrid and Multi-Cloud combine multiple public and private cloud capabilities to create a flexible ecosystem. The vision will be one of seamless simplicity, where users can migrate between working applications fluidly, even between environments.

This approach to cloud computing benefits businesses in many ways. They can plan for seasonal upswings, support sustained growth, collaborate with partners, launch new business models, support business continuity plans, and make acquisitions and divestiture activities seamless.

8. Blockchain Decentralises Trust
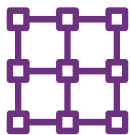
Trust is the foundation of all business dealings. Maintaining it in a digitalised global economy, however, can be expensive, time-consuming and inefficient.

Blockchain offers a solution by assuming the role of a trusted gatekeeper and the purveyor of transparency[10].

In the emerging "trust economy", where a company's assets or an individual's online identity and reputation are equally valuable and vulnerable, the traceability and immutability of blockchain may prove to be its valuable qualities yet.

9. Application Programming Interface (API) Economy Takes Off

APIs have made it possible for solutions and systems to communicate with one another. More recently, companies are valuing them for another capability: Exposing technology assets for reuse across and beyond the enterprise[10].

Not only does reuse drive higher return on investment (ROI) for IT investments, it can ignite creative new ways for businesses to use existing data, transactions and products.

As part of the growing API imperative trend, organisations have begun exploring ways to expose, manage and control APIs. To date, there are more than 19,000 APIs published and submitted for use, and growing at 11% year on year (YoY)[15].

> **"Artificial Intelligence is the next electricity."**
>
> **ANDREW NG,**
> **Founder,**
> **Google Brain**
> **(Deep Learning) Project**

1.2
OPPORTUNITIES AND CHALLENGES FOR SINGAPORE

Emerging technologies are accelerating changes across the world, and Singapore is no exception.

As a small nation of 5.6 million, our growth depends on our ability to adapt and evolve with global shifts. This strategy has been effective throughout our history, and will remain so in the coming future.

The rise of emerging technologies will bring about its own suite of opportunities as well as challenges to Singapore's economy, businesses and our workers' community.

CHALLENGES

Growth Saturation
Global growth has been subdued and is expected to be lower than in the previous decade . . .CFE, Singapore

ECONOMY

Business Disruption
1 in 5 SMEs in Singapore view disruptive technology as their key business challenge . . . Singapore Chinese Chamber of Commerce

Race to the Bottom
66% of Singapore businesses expect to lose customers to their competitors due to tech adoption . . . Fujitsu

COMPANIES

Job Disruption
Large % of jobs in Singapore expected to be replaced by automated processes and robots . . . OECD

WORKERS

OPPORTUNITIES

Value Creation
In 2016, value-add due to services was **74%** of GDP in Singapore up from **66%** in 1996 . . . World Bank

Higher Growth
Top innovative companies grow by **3.5-5.5 percentage points** faster compared to laggards . . . Doblin

Productivity
Workplace automation will be 2X in 3 years in Singapore to improve human performance & productivity . . . The Global Future of Work

New, Enhanced Jobs
25% of businesses expect tech to create new roles while **38%** expect to augment workforce with higher skilled roles . . . WEF: Job Report

Economy

New solutions, capabilities, and businesses will arise as Singapore embraces new technologies. This will unlock and generate new value for our economy and is especially true for the services economy.

Conversely, the global economy has reached the saturation point. Innovations, new products and new services no longer lead to higher growth, and customer demand has become stagnant. This trend was noted in Singapore's Committee of Future Economy report. It highlighted that global growth has been subdued, and is expected to remain lower than that in the previous decade[16].

Singapore needs to devise a response that embraces new technologies, and yet generate growth against a sluggish global backdrop.

Companies

Investing in innovation will create new revenue streams and higher profitability. It can also help organisations compete better, differentiate from rivals, and win over more customers.

According to the Deloitte State of Cognitive Survey, the "Fast Lane", innovative companies consider emerging technologies as opportunities. Nearly half of the "Fast Lane" respondents benefitted from emerging technologies, and 26% found that they could create new products or pursue new markets[17].

However, not every organisation will be able to leverage on digital innovations. In the same survey, only 12% of Waders in the "Slow Lane" said that they had gained substantial benefits from emerging technologies[17].

In Singapore, 1 in 5 Small and Medium-sized Enterprises (SMEs) views disruptive technologies as their key business challenge. A FUJITSU Digital Transformation PACT survey[18] predicted that 66% of Singapore businesses stand a chance to lose customers to their competition if they don't undergo digital transformation.

Besides growth, emerging technologies will democratise access to many benefits. These include employment, entrepreneurial opportunities, greater customer knowledge, etc. Productivity will be enhanced too. Software, smart machines and chatbots will automate[19], augment and optimise repetitive tasks and processes. Machine learning and predictive analytics will also help businesses anticipate customer needs by giving managers deeper insights to prioritise actions and solve problems.

Workers

Workers too will feel the impact of technologies. Studies have shown that adopting technologies will give rise to new specialist jobs[20] that require more skills. Jobs such as AI and Machine Learning Specialists, Big Data Specialists, Process Automation Experts, and Robotics Engineers are expected to grow in numbers, and their share of employment will increase from 16% to 27% across all sectors[20].

Emerging technologies will help service professionals, offering deeper insights for relationship building. "Hyper-personalised" services will soon be a possibility. This creates a new demand for workers with strong human skills, to co-exist with existing professionals like Data Analysts and Application Developers[20].

25% of businesses expect technology to create new roles, while 38% expect it to augment their workforce to perform higher skilled roles. In another survey conducted by Deloitte, 77% of HR and business leaders across the world mentioned that workers will be retained and reskilled to use new technologies or that jobs will be redesigned to enhance the role of human skills[21].

We must prepare for significant changes to job and skill requirements. Certain human skills will be essential, such as analytical and innovative thinking, active learning, creativity, originality and taking initiative, complex problem-solving, leadership, social influence, emotional intelligence, etc. Also in demand will be technical skills, ranging from technology design and programming to systems analysis and evaluation[28].

Retraining and upskilling will therefore be necessary, to meet the highly dynamic needs across sectors disrupted by technologies. A survey conducted shows that 74% of businesses identified the availability of skilled local talent as the key determining factor behind job location decisions[20], dwarfing factors such as labour costs, the flexibility of local labour laws, industry agglomeration effects, and proximity of raw materials. Singapore is expected to face similar challenges, where talent availability is central to job location decisions.

In order to capitalise on these opportunities as well as address these challenges, a proper response needs to be developed, and hence, a good understanding of Singapore's unique positioning in the global market is crucial. Singapore has inherent strengths and weaknesses that are still relevant in the digital age. We have identified the specific strengths, weaknesses, opportunities and threats for selected emerging technologies which can be further analysed to develop a focused set of strategies.

Refer to the link here for the SDE Technology Roadmap Annexes which include detailed technology reports in the five emerging technology areas.
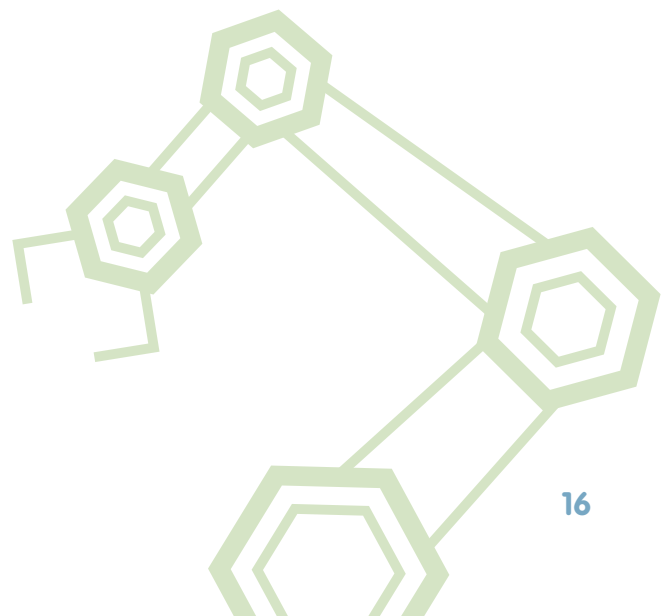
1.3
THE NEED FOR A RESPONSE

While opportunities and challenges will impact all industries and sectors, the services industry will be impacted the most.

The sector forms the bulk of the global GDP, and its share is expected to increase in the coming years.

In Singapore, a predominantly service-oriented nation, further growth will entail broader exposure to technological changes.

Services Share of GDP[1]

	In the past		Current
WORLD	59%[2]	+10%	69%[2]
ASEAN	48%[2]	+5%	53%[2]
SINGAPORE	66%[3]	+6%	72%[3]

Services Share Employment[1]

	In the past		Current
WORLD	39%[2]	+10%	49%[2]
ASEAN	34%[2]	+12%	46%[2]
SINGAPORE	69%[3]	+5%	74%[3]

1 Nominal value. Estimated via projections wherever actual data is unavailable; 2 For world and ASEAN, past reflects 1996 numbers while current reflects 2016 numbers; 3 For Singapore, past reflects 1996 numbers while current reflects 2017 numbers obtained from Singstat (GDP) and Ministry of Manpower (employment)
Source: Singstat, Ministry of Manpower, World Bank, Monitor Deloitte Analysis

In 2017, services commanded 72%[22] share of Singapore's GDP and 74%[23] of employment came from services, compared to 66% and 69% in 1996 respectively. This indicates the growing importance of services in the Singapore economy and in the lives of Singaporeans.

Servitisation on the Rise

As the services economy grows, it will also transform. Even today, as we enter the era of Next-Gen services, we see products being servitised, and old services being reimagined to provide better customer experiences.

Servitised products offer services, software or complementary products along with the original product. This caters to a shift in consumer preferences. Characterised by the trend of dematerialisation, servitisation happens when customers forgo physical product ownership in exchange for software-enabled services.

This is true for both consumers (e.g. streaming audio, ride-sharing) and businesses (e.g. access to Amazon's internal capabilities such as their warehouse systems)[f].

By offering outcome-based pricing, servitisation also allows for lower upfront costs. To keep pace with this shift, service providers in Singapore will have to design and deliver more immersive, hyper-personalised experiences to meet changing and unique customer expectations.

PRODUCT → 'NEXT-GEN' SERVICES

SERVITISATION along the product-service continuum for both product & service providers

Ownership of assets

Low cost, high volume with standardised output

One-off transaction; up-front payment
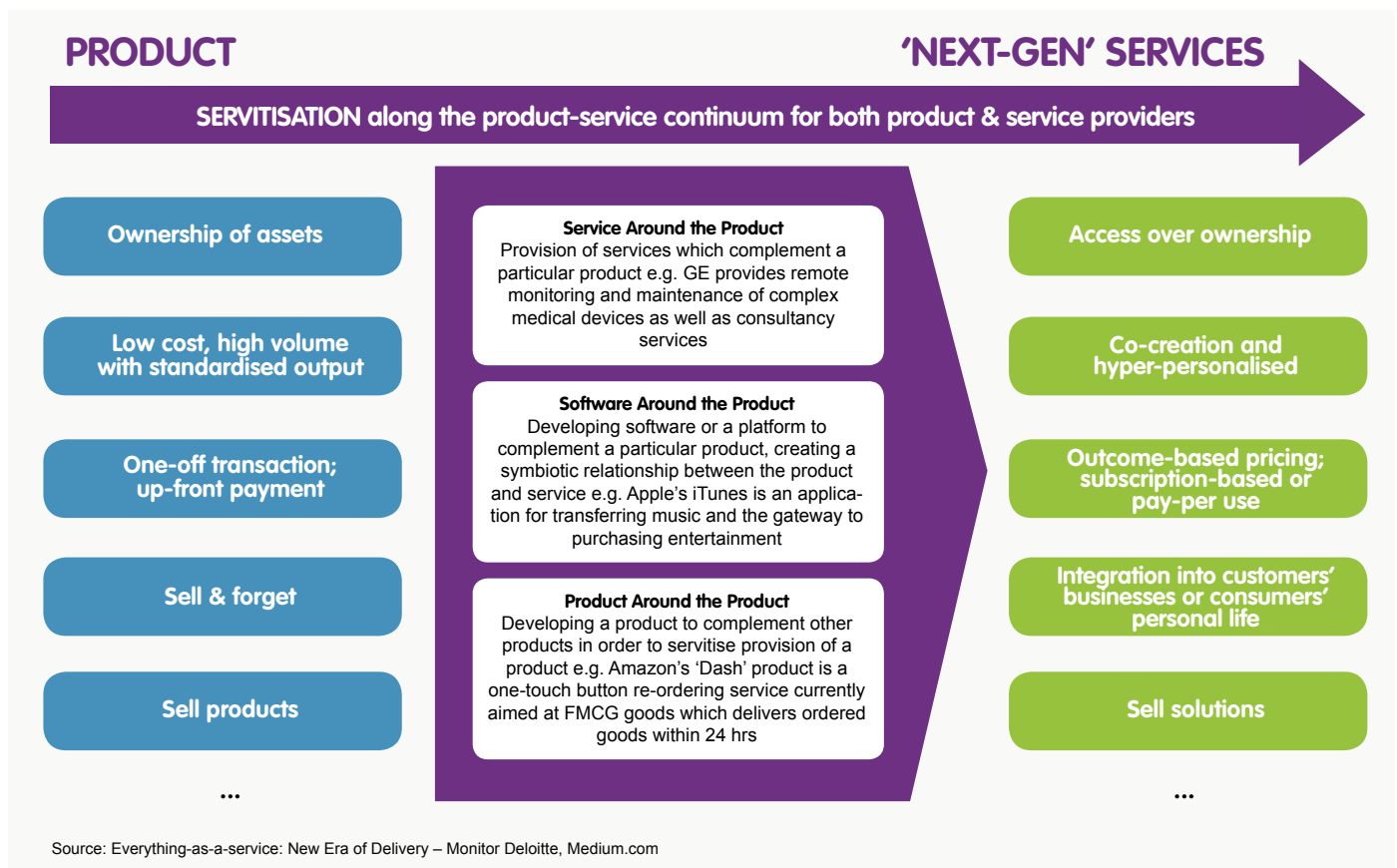
Sell & forget

Sell products

...

Service Around the Product
Provision of services which complement a particular product e.g. GE provides remote monitoring and maintenance of complex medical devices as well as consultancy services

Software Around the Product
Developing software or a platform to complement a particular product, creating a symbiotic relationship between the product and service e.g. Apple's iTunes is an application for transferring music and the gateway to purchasing entertainment

Product Around the Product
Developing a product to complement other products in order to servitise provision of a product e.g. Amazon's 'Dash' product is a one-touch button re-ordering service currently aimed at FMCG goods which delivers ordered goods within 24 hrs

Access over ownership

Co-creation and hyper-personalised

Outcome-based pricing; subscription-based or pay-per use

Integration into customers' businesses or consumers' personal life

Sell solutions

...

Source: Everything-as-a-service: New Era of Delivery – Monitor Deloitte, Medium.com

f   Amazon has packaged internal operations such as customer service, financial services, fulfilment, and warehouse systems for external customers. The company is reportedly even laying the groundwork for its own shipping business.
(Source: Deloitte, "Everything as a Service: A paradigm shift for consumer products")

Developing a Response

To develop an effective response, Singapore must look beyond its shores.

Liberalised global economic policies have blurred geographical boundaries. Country borders are now permeable, making way for borderless data, borderless services and borderless people.

Borderless Data

Technology enables cross-border data flows for **~50%** of all traded servcices[1]

The NHS processed **635,000** MRI scans across **200** imaging sites across Europe[2]

Borderless Service

1 in 5 e-commerce purchases globally are cross-border[3]

1-2 e-commerce purchases in Singapore are cross-border[4]

86% of cloud revenue is generated by **7 companies** headquartered in 2 countries[5]

Borderless People

Digital nomads* will account for **1 billion** people in 20 years[6]

Cross-border travel will increase by **35%** over the next 10 years[7]

*Digital nomads are individuals who choose mobility over desk-bound arrangements to work; as they are not limited to working out of a physical office, they often travel across the globe

[1]World Economic Forum, Cross-Border Data Flows, Digital Innovation, and Economic Growth; [2]Alliance Medical; [3]DHL, The 21st Century Spice Trade; [4]E-Commerce IQ, Opportunities and Challenges with Singaporean Cross Border Commerce; [5]AcloudA, WS Still Dominating Cloud Market, but Azure, Google and Alibaba are Growing Faster; [6]HRM Asia, Digital nomadism is the future of work; [7]Lonely Planet, International travel set to increase by 35% over the next decade
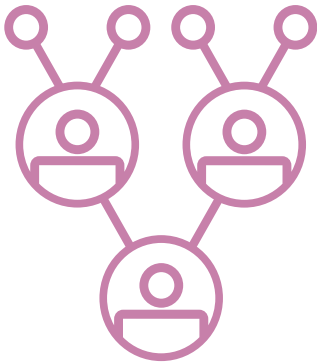
Borderless Data

Data, once contained within countries, now flows across the globe to meet business and operational needs. For example, in order to optimise costs and reduce time, the National Health Services in the United Kingdom transfers MRI scans to radiology centres across Europe[g] for processing.

In fact, cross-border data flows have become so common that it enables 50% of traded services[24]. Borderless data has transformed business ecosystems, and given rise to the concept of borderless services.

Borderless Service

Cross-border data flow has made it unprecedentedly easy to offer services across national borders.

E-commerce is a prime example. One in five e-commerce purchases globally is cross-border[25]. In Singapore, the trend is even more evident, where half of all e-commerce purchases are cross-border[26].
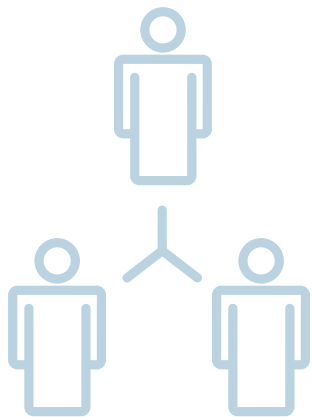
Borderless People

Like data and services, people have become borderless too.

Cross-border travel is expected to increase by 35% over the next ten years. More interestingly, Information and Communication Technologies (ICT) such as platform computing have spawned a new reality: the gig economy.

In it, freelancers and digital nomads[27] carry out their livelihoods from anywhere in the world and are not constrained to working out of a physical office. It is predicted that digital nomads will account for one billion people in the next 20 years[28].

Additionally, technology will further facilitate international travel which is projected to increase by 35% over the next decade[29].

As the concept of borders fades to irrelevancy, Singapore's response to the changing tide cannot be inward looking. Instead, Singapore must think big and look far, taking into account the great shifts happening worldwide and be as global as the world we now live in.

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g   Alliance Medical outsources MRIs from NHS to other countries in Europe to meet demand.

02 | **SINGAPORE'S RESPONSE TO SERVICES 4.0**
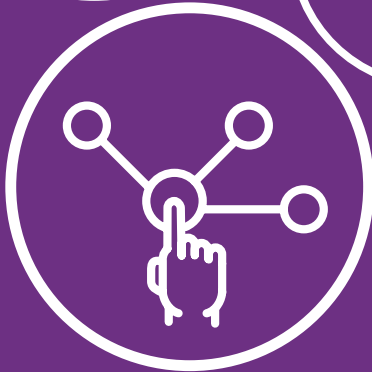
The convergence of emerging technologies and servitisation has opened the doors to a new era in the services economy: Services 4.0.

Frictionless, anticipatory, empathic and end-to-end. It is the future of services, and it holds the key to Singapore's response.

Services 4.0 is a modern service concept that leverages technologies to meet changing customer needs, and to deliver higher quality experiences.

Using technologies, it automates repetitive, mundane tasks, freeing humans to play more valuable roles. At the same time, it augments workers' capabilities, empowering them to be more creative, analytical, innovative and emotionally intelligent.

By elevating the nation to Services 4.0, Singapore can overcome the impact of global shifts, and capture opportunities in a borderless world driven by technology. Services 4.0 is the vision to capture the opportunity of the Future of Services.

The 5 Objectives

To achieve the Services 4.0 vision, our efforts will have to be grounded on objectives that strengthen Singapore's competitive position in the arena.

SERVICES 4.0

Seamless Experience | Value | New Jobs | Accessible Technology | Inclusivity

1. Meet Changing Customer Needs

Increasing customer satisfaction is the best business strategy of all. The overarching objective of Services 4.0, hence, is to meet ever-evolving customer needs by delivering superior experience via emerging technologies. This is particularly relevant to the services economy.

2. Create New Value and Achieve High Productivity

For businesses to thrive, value creation is essential. For this reason, it is important for service providers to continuously improve the productivity of their service model.

> **" Productivity isn't everything, but, in the long run, is almost everything. "**
>
> **PAUL KRUGMAN**
> **NOBEL LAUREATE**

3. Create and Enhance Jobs

For businesses to thrive, value creation is essential. For this reason, it is important for service providers to continuously improve the productivity of their service model.

4. Make Emerging Technologies More Accessible

Although Services 4.0 is founded on technology, it must be accessible to all within an organisation, and not limited to the technically trained. Democratised access to technology is thus important for Services 4.0 to be sustainable and pervasive.

5. Create Inclusive Ecosystems for Large and Small Companies

Just as technology must be accessible by all in an organisation, Services 4.0 must be achievable by all within an industry. SMEs should have the same ability to leverage Services 4.0 as MNCs and large corporations.

The 5 Objectives Must Cater to the 3 Stakeholders of Services 4.0:
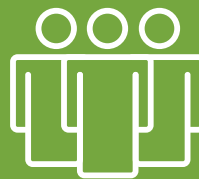
Users and consumers of services

Service providers

ICM solution providers

OBJECTIVE 1

MEET CHANGING CUSTOMER NEEDS

Through Services 4.0, service providers will be able to offer customers superior, seamless experiences to meet the ever changing customer needs.

Services 4.0 can be seen as the evolution of services into "Seamless Services", enabled by the confluence of emerging technologies and servitisation of products.

Technology has been a key enabler across everystage of the services evolution, improving the service experience of customers.

An Evolutionary Journey

SERVICES

1.0

In this early stage, tools were used to assist services that were performed manually, which require human intervention. For example, using electronic typewriters to fill entries for traditional book keeping.

SERVICES

2.0

By now, the Internet has revolutionised the services economy. Web-based innovations like portals and online databases made services more efficient, and helped with industrialisation and the development of labour-intensive industries.

SERVICES

3.0

In the age of mobile devices, higher connectivity through wireless technology and cloud computing enabled self-services. This automation reduced labour-intensive activities significantly.

SERVICES

4.0

Accelerated by emerging technologies, it enables services that are **end-to-end, frictionless, anticipatory** and **empathic** to customer needs. Services 4.0 caters not only to business-to-consumer industries such as retail and restaurants but also for business-to-business (such as logistics) and intra-business functions (such as human resource and finance).

SERVICES 4.0 AN EVOLUTIONARY JOURNEY

SERVICES 1.0 — MANUAL — Enabled by TOOLS

SERVICES 2.0 — EFFICIENT — Enabled by the INTERNET

SERVICES 3.0 — SELF-SERVICE — Enabled by MOBILE technologies

End-to-End • Frictionless • Anticipatory • Empathic
SERVICES 4.0 — SEAMLESS — Enabled by EMERGING TECH
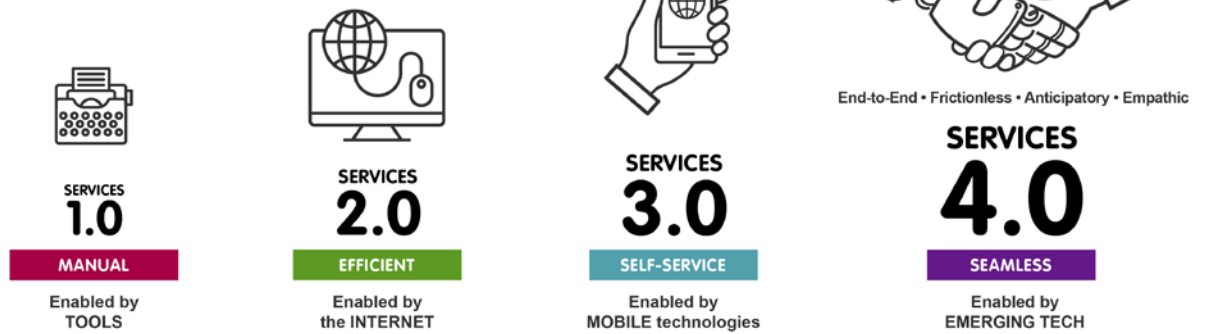
While Services 4.0 provides a visionary, well-defined depiction of how services should be offered, businesses need not deliver services at that level to participate in Services 4.0.

Depending on the type of services offered, and their customers' preferences, some organisations may choose to remain at Services 3.0, or provide Services 4.0 selectively. For example, airports may automate their boarding procedures using biometric scans, while retaining self-service kiosks for check-ins.

Rather, Services 4.0 is a mindset towards serving customers. It is a transformative journey that can be taken on at a pace suitable to individual businesses.
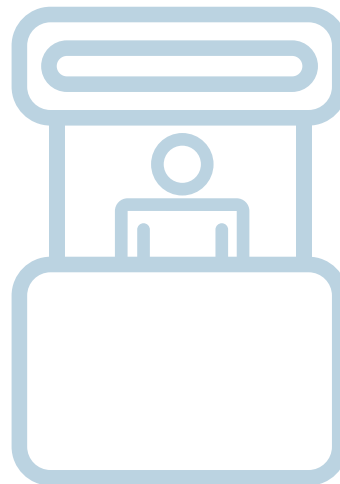
EXAMPLE # Banking

Take a typical banking scenario where credit card transactions are rejected once customers' credit limit has been reached.

In the past, customers would be inconvenienced until they have taken action with the bank, either by repaying the balance or requesting for a credit limit increase.

In Services 4.0, the bank anticipates the situation. It takes proactive, automated actions like notifying the customers before their credit limit is reached, reminding them to take action. The bank is empathic to the customers' need, and ensures their end-to-end experience is pleasant and frictionless.

SERVICES **1.0**	SERVICES **2.0**	SERVICES **3.0**	SERVICES **4.0**
MANUAL SERVICES	**EFFICIENT SERVICES**	**SELF SERVICES**	**SEAMLESS SERVICES**
Customer manually writes in to the bank, requesting for a credit limit increase. Process may take days.	Customer calls the hotline where credit limit can be increased immediately. Re-transact.	Instead of calling the hotline, customer uses his mobile app to increase his credit limit temporarily. Re-transact.	Bank knows spending habits of customer. System analyses and predicts it as a case of credit over-limit, informs the customer and increases the limit temporarily. Inconvenient situation of 'Transaction Not Approved' is avoided.

Everything-as-a-Service Paradigm

The ideal service provider ecosystem for achieving Services 4.0 can be found in the Everything-as-a-Service (XaaS) paradigm.

XaaS can be interpreted as a new revenue stream or a business plan for service providers, transforming what they offer (and how) as services.

More importantly, XaaS is a strategic and operational blueprint, redefining the goals of modernisation.

Everything-as-a-Service envisions business capabilities, products and processes not as discrete vertical offerings that operate individually in silos, but rather, as a collection of horizontal services that can be accessed and leveraged across organisational boundaries[30].
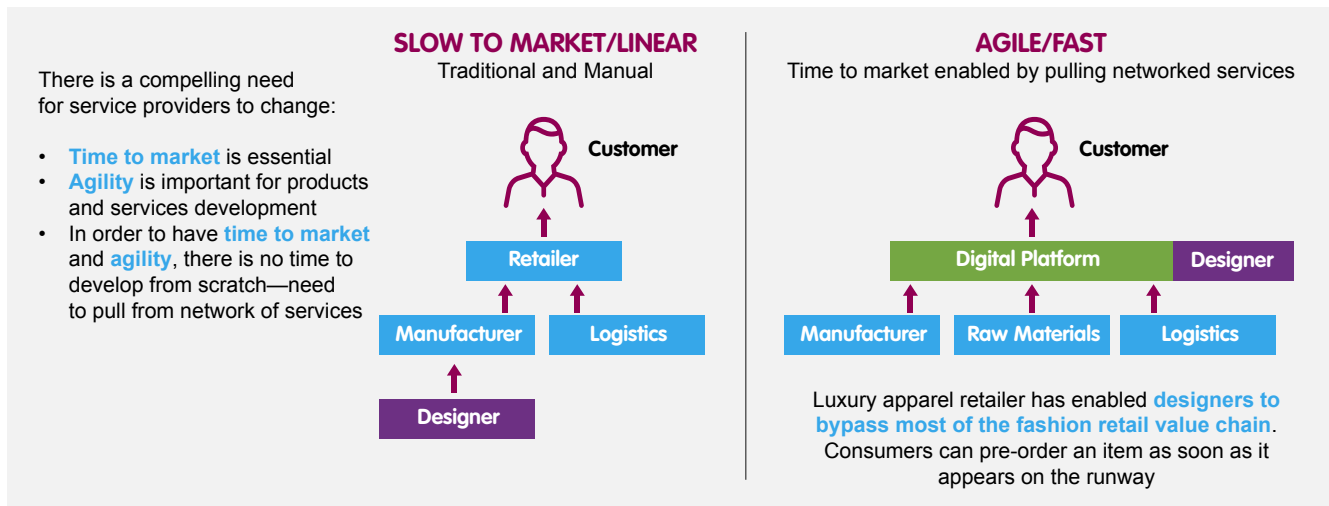
With XaaS, companies can even extend their internal services to regional operations, newly acquired assets and beyond organisational boundaries for use by customers and business partners.

EXAMPLE

Services 4.0 in the Fashion Industry

The fashion industry typically involves a multi-step value chain that extends from the designer to the customer. With "fast fashion" becoming increasingly relevant, a luxury apparel online retailer turned to an online digital platform that enabled designers to bypass most of the steps in fashion retail. The result was an increase in ability to get designs to the market quicker and more efficiently.
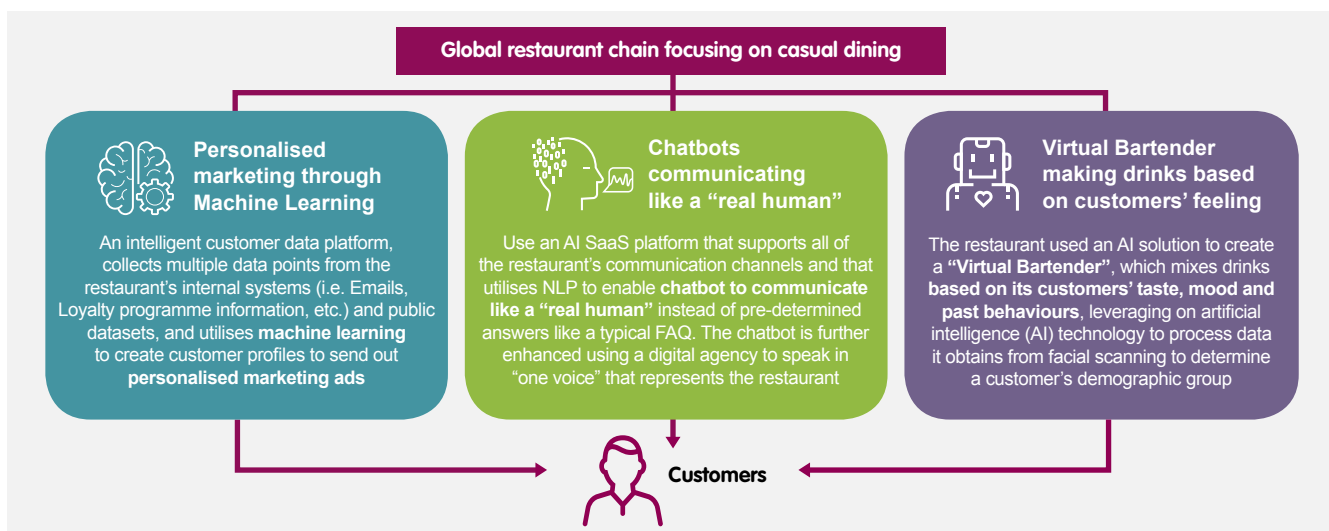
There is a compelling need for service providers to change:

- **Time to market** is essential
- **Agility** is important for products and services development
- In order to have **time to market** and **agility**, there is no time to develop from scratch—need to pull from network of services

SLOW TO MARKET/LINEAR
Traditional and Manual

Customer
↑
Retailer
↑   ↑
Manufacturer | Logistics
↑
Designer

AGILE/FAST
Time to market enabled by pulling networked services

Customer
↑
Digital Platform | Designer
↑   ↑   ↑
Manufacturer | Raw Materials | Logistics

Luxury apparel retailer has enabled **designers to bypass most of the fashion retail value chain**. Consumers can pre-order an item as soon as it appears on the runway

EXAMPLE

Global Restaurant Chain

A global restaurant chain focusing on casual dining was able to double its off-premise business over the last year. Off-premise business is essentially business that comes from customers who engage with the chain outside the restaurants.

The chain leveraged the powers of AI by relying on emerging technology ICM partners, rather than building solutions on its own. They built an intelligent customer data platform to collect multiple data points from internal CRMs and public data sets, and then used machine learning to create personalised ads. They also used Natural Language Processing (NLP) to develop bots that were more human-like, and could communicate with customers more naturally. More impressively, it used AI solutions to analyse customers' tastes, moods and past behaviours, to create virtual bartenders that mixed drinks customised to individual needs.
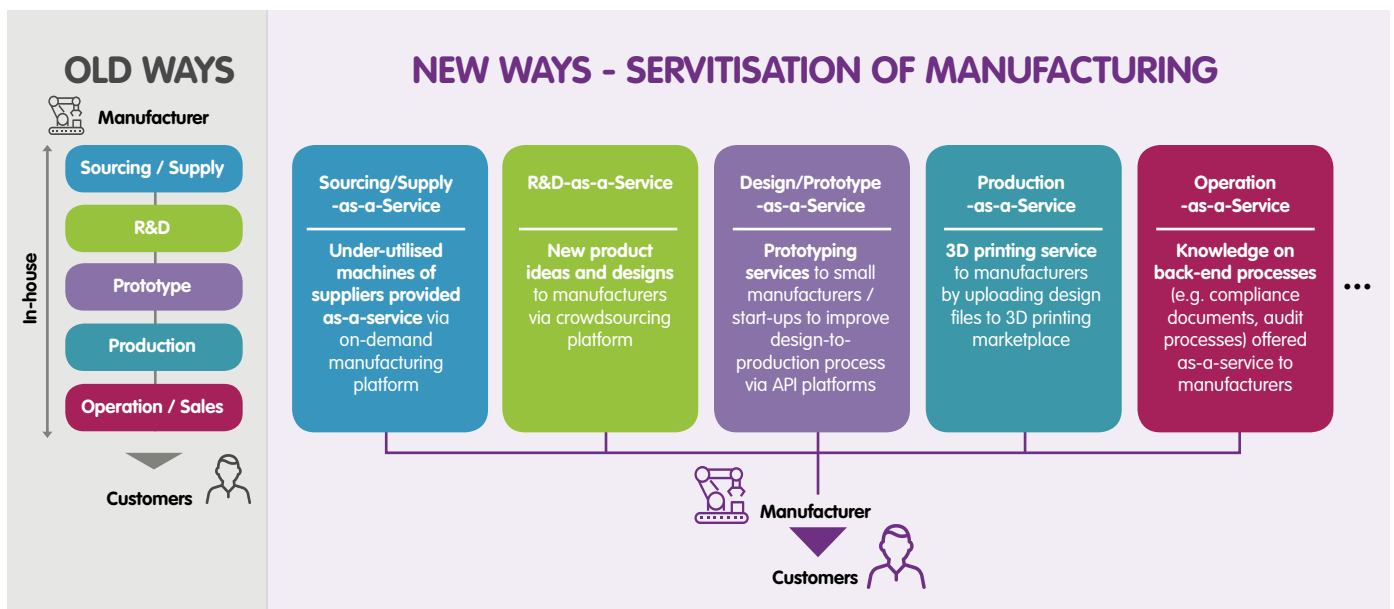
Global restaurant chain focusing on casual dining

Personalised marketing through Machine Learning

An intelligent customer data platform, collects multiple data points from the restaurant's internal systems (i.e. Emails, Loyalty programme information, etc.) and public datasets, and utilises **machine learning** to create customer profiles to send out **personalised marketing ads**

Chatbots communicating like a "real human"

Use an AI SaaS platform that supports all of the restaurant's communication channels and that utilises NLP to enable **chatbot to communicate like a "real human"** instead of pre-determined answers like a typical FAQ. The chatbot is further enhanced using a digital agency to speak in "one voice" that represents the restaurant

Virtual Bartender making drinks based on customers' feeling

The restaurant used an AI solution to create a **"Virtual Bartender"**, which mixes drinks **based on its customers' taste, mood and past behaviours**, leveraging on artificial intelligence (AI) technology to process data it obtains from facial scanning to determine a customer's demographic group

Customers

EXAMPLE # Servitisation of Manufacturing

Traditionally, the entire value chain of the manufacturer, from sourcing and supply, R&D, prototyping, production to operation and sales, was executed linearly in-house. Today, with servitisation, manufacturers can outsource the partial or the entire value chain.

Manufacturers are now able to leverage under-utilised machines of other suppliers via on-demand manufacturing platforms. Instead of hiring full-time experts, manufacturers can gain access to knowledge about back-end processes, as and when required, via Operation-as-a-Service platforms.

OLD WAYS

Manufacturer

In-house

- Sourcing / Supply
- R&D
- Prototype
- Production
- Operation / Sales

Customers

NEW WAYS - SERVITISATION OF MANUFACTURING

Sourcing/Supply -as-a-Service	R&D-as-a-Service	Design/Prototype -as-a-Service	Production -as-a-Service	Operation -as-a-Service
Under-utilised machines of suppliers provided as-a-service via on-demand manufacturing platform	New product ideas and designs to manufacturers via crowdsourcing platform	Prototyping services to small manufacturers / start-ups to improve design-to-production process via API platforms	3D printing service to manufacturers by uploading design files to 3D printing marketplace	Knowledge on back-end processes (e.g. compliance documents, audit processes) offered as-a-service to manufacturers

•••

Manufacturer

Customers

Source: Secondary Research; Monitor Deloitte Analysis

CREATE NEW VALUE AND ACHIEVE HIGH PRODUCTIVITY

Services 4.0, delivered through an XaaS ecosystem, will allow businesses to unlock new value and increase productivity.

To do so, however, businesses must first relook at two things: Their service delivery model, and how their workers work with machines.

9 Innovative Approaches

We have identified nine approaches[31] [32] that can help businesses move towards a more service-oriented value delivery in the XaaS paradigm. Between them, businesses can choose to transform the value-price equation, or to harness network effects for their operations.

Source: Deloitte University Press: Patterns of Disruption

1. Shorten the Value Chain
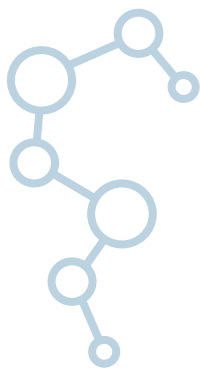
Changing economics is a challenge for incumbents with long, complex value chains. New technologies allow entrants to eliminate whole stages of their value chain, often dramatically reducing capital and infrastructural costs.

EXAMPLE

A European meal-kit company shortened its value chain and eliminated the middleman by sourcing food ingredients directly from producers, and delivering them pre-proportioned to consumers in "meal-kits". Their revenue grew nearly 100% in three years, and they have close to 1.5 million active subscribers[33].

2. Align Price with Use

The flexible consumption model, often employed by utility and telecommunications companies, is gaining traction in other industries too. It creates value for both customers (flexibility, convenience and affordability) and companies (financial predictability, lower unit costs and better customer relationships).

EXAMPLE

An American insurtech company offered disaggregated pricing to individuals, allowing them to pay their property insurance on an "on-demand, micro-duration" basis. Individuals upload details of possessions they want to be insured to the cloud, then turn the insurance for the items on or off at will. It attracted over US$80 million in funding and investments, and their cloud application has seen over 100 million items added with a total value exceeding US$10 billion.

3. Converge Products

"Bundling" functions—turning previously distinct products into a single offering— give customers a more economical and convenient way to access those products. It disrupts conventional approaches to making and selling, and gives businesses a new avenue to differentiate their offering.

EXAMPLE

A solar company embedded sensors in the LED lighting products of its parent company, to create a wireless sensor network that gave insights for energy management. It generated over US$1 billion in revenue in the first year of operation, and secured one of the world's largest LED installations for a multinational customer within the first five months.

4. Unbundle Products and Services
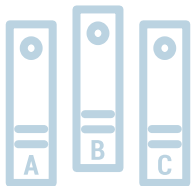
Products like newspapers and pop music albums, once thought to be the smallest viable unit of sale, are now disaggregated into component parts thanks to new technologies that change the economics of production and distribution.

EXAMPLE

A global online education company broke down traditional education into piecemeal offerings of courses, specialisations and degrees, that learners can pick by choice and learn at their own pace. In 2017, it provided over 2,000 courses to more than 25 million learners, and partnered with nearly 150 universities worldwide.

5. Expand Marketplace Reach

By making more products available to a broader audience, technologies such as the Internet make it possible for organisations to fulfil the "long tail" of demand, disrupting incumbents that rely on high volume sales of relatively few items.

EXAMPLE

A leading Asian financial services group connected car sellers and buyers on a single platform, creating a single marketplace that offered a larger product selection for buyers, and better reach for sellers. They successfully created one of the largest used car marketplaces in ASEAN, and gave banks an opportunity to market financial products directly to the used car market.

6. Unlock Adjacent Assets

Today, a business can be a major transportation-for-hire company without owning any vehicles, or offer travellers accommodations worldwide without owning any hotels. Companies like these essentially use adjacent markets to cultivate opportunities on the edge.

EXAMPLE

A Japanese printing company brought together more than 1,400 print providers, and matched them to the printing needs of SMEs and individuals. It developed a customer base of over 300,000 SMEs and individuals, and increased their revenue by fifty-fold in three years.

7. Turn Products into Product Platforms

Rather than focus solely on guarding information, creators of product platforms balance the need to protect intellectual property with the value that could be created. They can achieve this by allowing third-party innovators to build on their core product to meet a wide range of needs.

EXAMPLE

A major US game developer transformed its online gaming technology to create an online game distribution platform that brings together hundreds of game developers and millions of gamers. They established a dominant market share of online PC games purchased through their distribution platform, and have over 150 million registered gamers and a peak of 20 million concurrent users in 2018.

8. Connect Peers

Richer connectivity and new mechanisms for trust and governance have shifted the balance of power from incumbent hubs and hierarchies—which have historically captured value by controlling the flow of information—to peer-to-peer networks characterised by transparency.

EXAMPLE

An online/mobile marketplace matched consumers with skilled labour to handle daily needs such as furniture assembly, moving and packing, home improvements, etc. This allowed a leading furniture retail company to access a new customer segment: people who are not fond of carrying and assembling their own furniture.

9. Distribute Product Development

Using collaboration and information-sharing technologies, organisations today can mobilise a multitude of third parties to help develop products and services, potentially leaving less innovative competitors behind.

EXAMPLE

A Japanese food tech company operated a global user-created recipe-sharing service. The platform connected millions of people who shared cooking ideas. At the same time, it gave food ingredient companies a ready market to promote their products. In 2016, they posted record revenues, having reached nearly two million premium users and 85 million monthly average users.

XaaS and ICM Solution Providers

The XaaS model will be useful to both service and solution providers in the ICM industry, who can explore opportunities by taking similar approaches.

For example, one of the largest cloud infrastructure providers is offering a serverless computer-on-demand service that aligns price with usage. Codes on the application platform are only implemented when triggered by specific events, and developers only need to pay for the resources they consume[34].

The company also servitised their internal intelligent capabilities, turning their products into product platforms by packaging machine learning and advanced analytics capabilities. In doing so, they built a virtual assistant into their offerings[35].
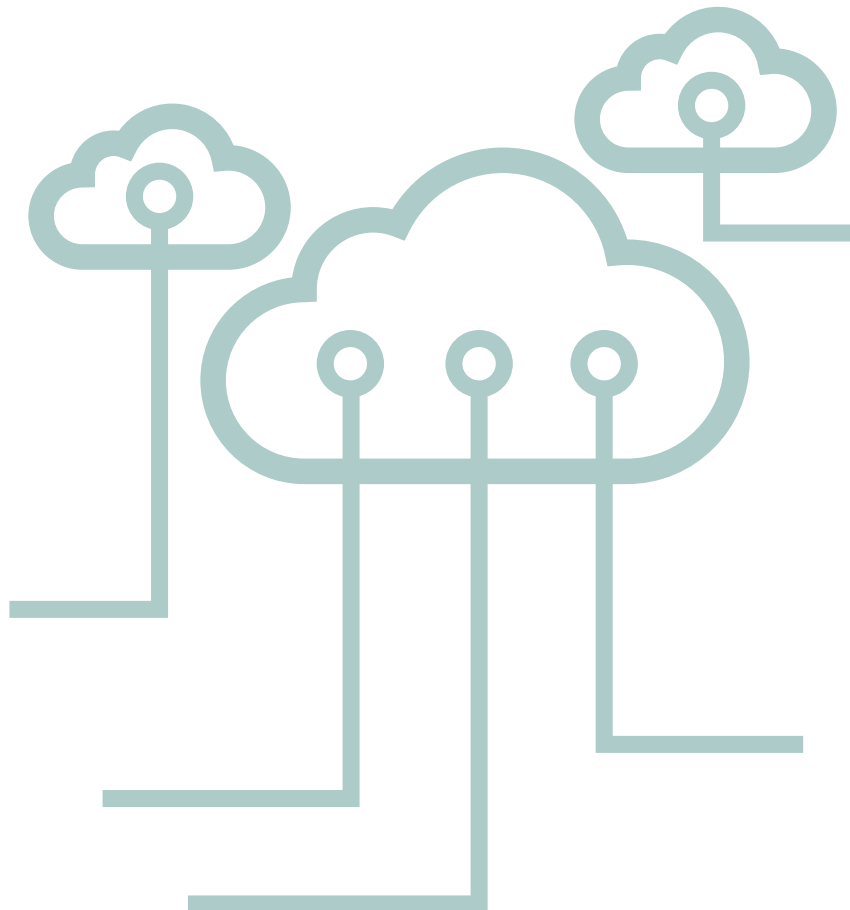
Re-engineering Service Delivery Model to Adopt the XaaS Paradigm

To adopt XaaS, service providers have several options but their choice should be based on customer preferences. These preferences vary across channels in the same business or across businesses in the same channel. To top it all, the preferences will change over time. For this reason, a one-size-fits-all, static-in-time service delivery model will not help service providers move towards the XaaS paradigm. The service providers should be part of a dynamic ecosystem, one that offers choices to develop multiple service offerings for meeting changing customer preferences across channels and over time.
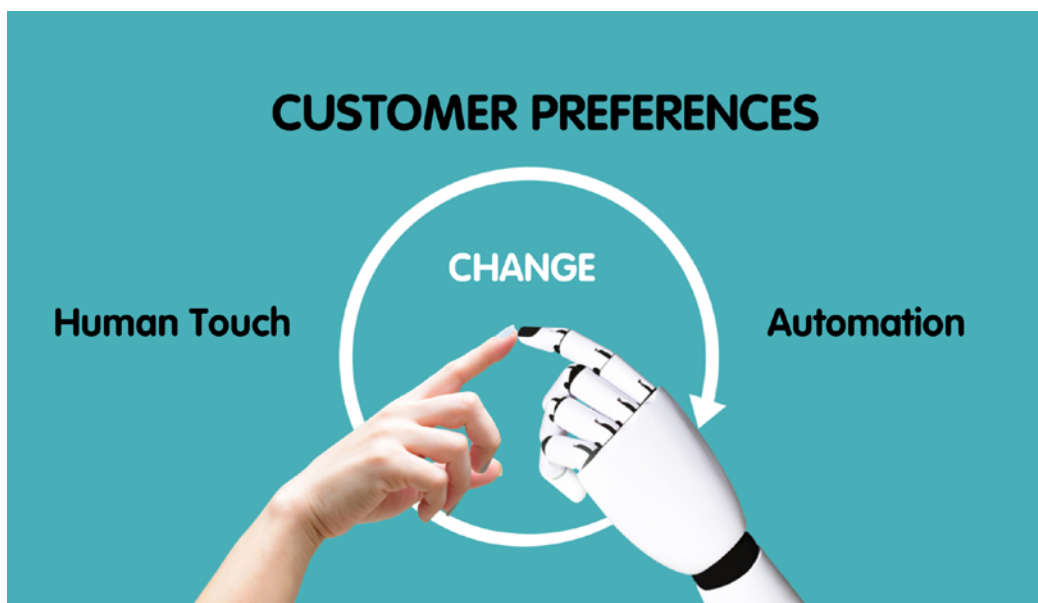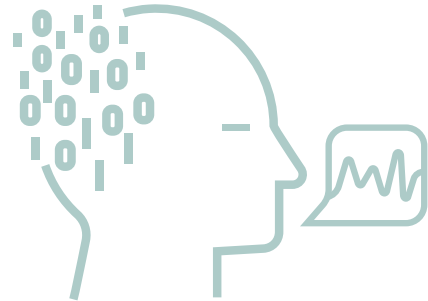

In the XaaS paradigm, service providers will be able to unlock value and enhance productivity by relooking at how workers interact with machines. We believe there are two ways of re-engineering the workplace that can transform their service delivery model for the XaaS paradigm.

① Augmented Workers

As discussed, customer preferences can change across service offerings and over time. But at the heart lies the importance of providing human-centric services. Despite a large part of their lives being integrated with technology, customers still prefer human interactions when dealing with service providers. In a Harvard Business Review article "Your Customers Still Want to Talk to a Human Being" Gregg Johnson[36] highlighted a study where the majority of respondents (57%) wanted to speak to a real person when interacting with a service provider. Another global study by Verint Systems[37] states that despite the rise of digital customer service, 79% of consumers prefer a human interface when engaging with service providers.

To enable human-centric services and unlock greater value, workers will need to be augmented with smart machines and tools to make better decisions, be more creative and be stronger. For example, a US-based start-up used AI to improve their customer service. Their solution included an AI-enhanced customer insights software that provided agents in-call analyses of their speaking behaviour, and automatically measured customer experience to help the agents deliver empathic, personalised and efficient resolution of the issues[38].

57%

of respondents wanted to speak to a real person when interacting with a service provider.

GREGG JOHNSON, HARVARD BUSINESS REVIEW

79%

of consumers prefer a human interface when engaging with service providers.

VERINT SYSTEMS

② Machine Automation

Productivity can be enhanced by delegating highly repetitive, standardised and dangerous tasks to machines. A global study by Deloitte mentioned that 95% of organisations using Robotic Process Automation (RPA) said the technology has improved productivity[39].

However, companies that automate simply to cut costs or improve efficiency will not be taking full advantage of emerging technologies. Knowing what companies want "automation to replace" and where they want "intelligence to augment" will bring far more transformational impact[40].

MAXIMISE AUTOMATION

Humans ▶ Managing Machines ▶ To Serve Customers
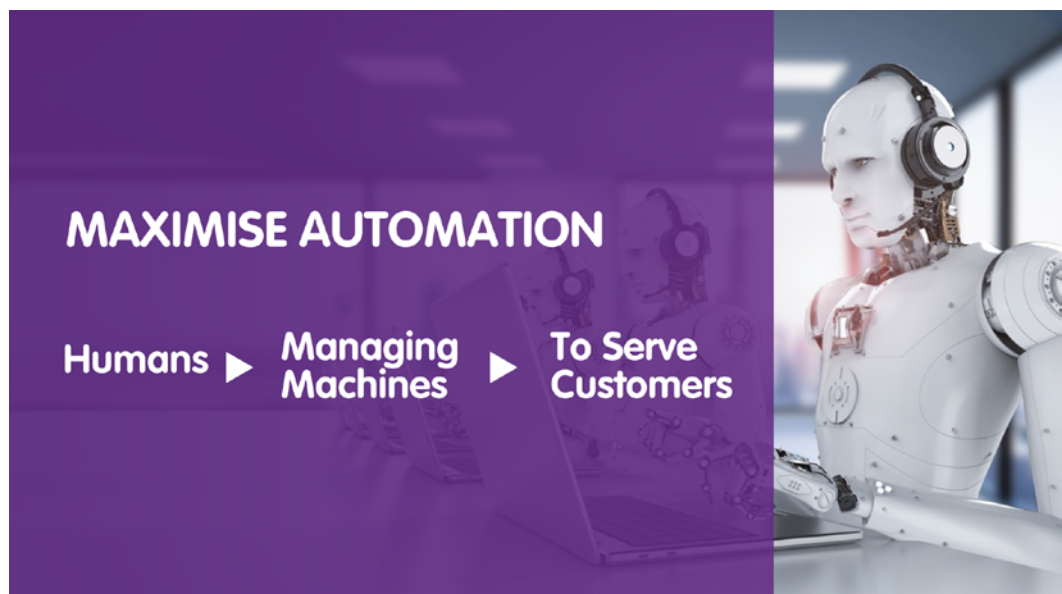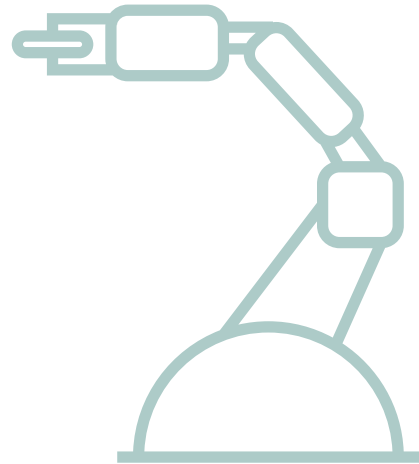
Access to emerging technologies will be critical to offering omni-channel services while maximising automation and augmenting the capabilities of the worker.

The following are some local case studies where companies have been able to bring transformation to their organisations by embracing the XaaS paradigm.

CASE STUDY

Singtel's Robo-colleagues

Singtel leveraged robotics and AI to enhance their customer service delivery as well as augment their employees. By deploying simple bots through RPA, Singtel introduced "robo-colleagues" to help its business units. Teams with functions that range from networks to sales became empowered to create their own "robo-colleagues" to augment their capabilities or increase efficiencies. Similarly, they evolved their digital assistant (Shirley) to not only deal with customers but also to provide assistance to human agents.
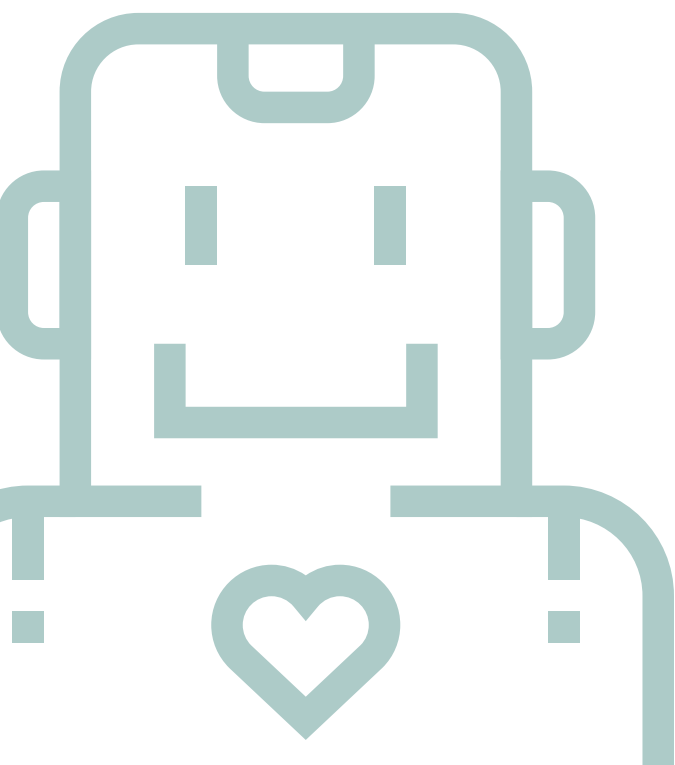(See Appendix 3)

CASE STUDY

UOB's Virtual Employees

UOB used RPA to develop virtual employees, Amy and Eve, two robots assigned to support teams in the Wholesale Banking and Retail businesses. They were able to handle most of the repetitive and time-consuming tasks, freeing up UOB employees to focus on high-value tasks.
(See Appendix 3)

Besides greater productivity, there will be other benefits of a workplace that integrates human and machines.

1. Perform Better through Augmentation

Workers augmented with smart machines and tools will have superior insights to make decisions. Enhanced design processes[41] will also help them be more creative and physically stronger to deal with manually challenging tasks.

3. Protect

Workers will be able to stay safe and protect themselves with the assistance of smart tools such as Smart Glasses[h]. They can also delegate dangerous tasks in hazardous situations to machines.

To realise all the benefits, workplaces must undergo significant changes. Human-machine relationships will need to be re-engineered, and more crucially, jobs to be re-designed.

2. Improve Productivity by Saving Time

With repetitive tasks delegated to machines[42], workers will be more productive, and can focus on more complex, high-value tasks. Automation will also ensure workers can complete a higher volume of work in a given time.

h   ABI Research - US$18 billion market for AR in energy and utilities as it augments worker safety and reduces asset damage.
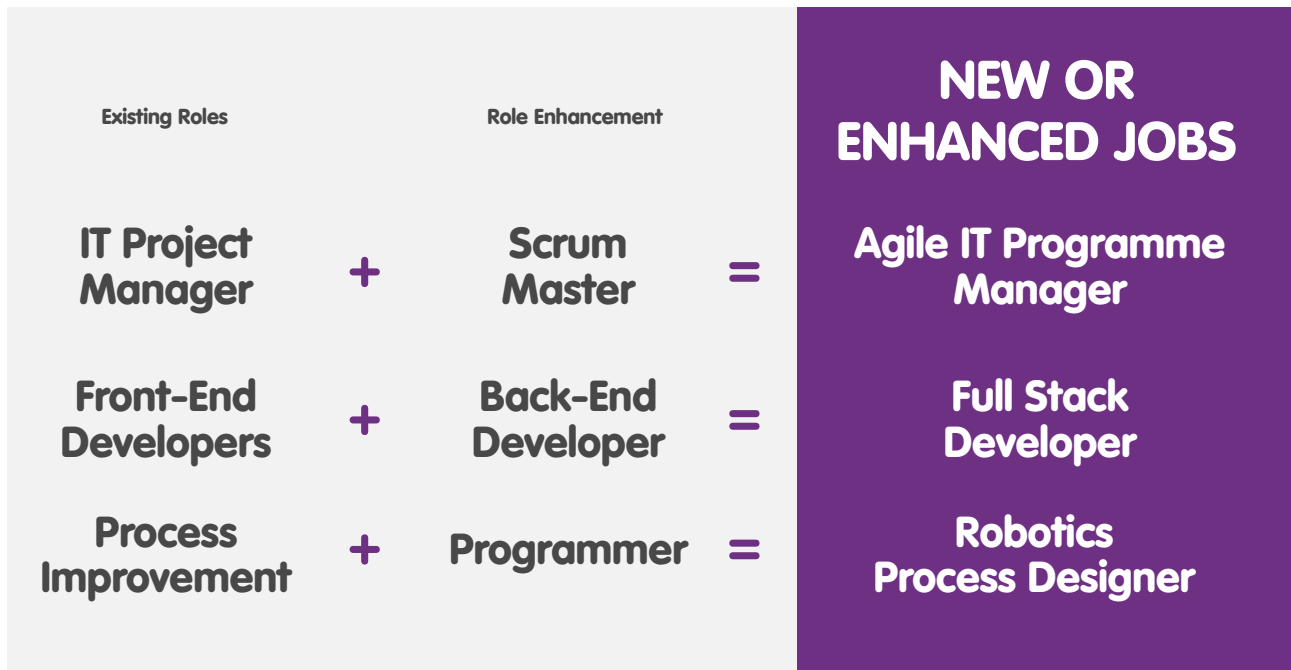
OBJECTIVE 3

CREATE AND ENHANCE JOBS

It is important that we understand this reality: In the future, almost all jobs will be digital jobs.

As service providers re-engineer human-machine relationships to generate greater value and enhance productivity, majority of the jobs will be transformed.

Jobs will no longer be the way they are today.

Job titles and descriptions will have to be upgraded, to embrace the new, more potent human-machine workforce.

Existing Roles		Role Enhancement		**NEW OR ENHANCED JOBS**
IT Project Manager	+	**Scrum Master**	=	**Agile IT Programme Manager**
Front-End Developers	+	**Back-End Developer**	=	**Full Stack Developer**
Process Improvement	+	**Programmer**	=	**Robotics Process Designer**

Sources: IMDA. (1) https://www.forbes.com/sites/jeannemeister/2018/09/24/the-future-of-work-three-new-hr-roles-in-the-age-of-artificial-intelligence/#618b92224cd9 (2) https://www.newenglandcollegeonline.com/resources/accounting/how-technology-is-changing-the-accounting-profession/ (3) https://www.supplychaindigital.com/procurement/four-key-areas-digital-transformation-procurement

Many occupations will experience transformations, and new job categories will be created. Most industries will thus face a pressing need to upgrade their workers' skill sets.

Human skills such as creativity and emotional intelligence will still be relevant. However, technical skills like technology design, programming, systems analysis and evaluations will become increasingly critical as technology becomes more integrated into workers' roles.

**CASE STUDY**

INLAND REVENUE
AUTHORITY
OF SINGAPORE

IRAS LEA:D

In order to perform their roles effectively, IRAS service officers had to retrain and equip themselves with the relevant digital capabilities. Thanks to the LEA:D programme, their skills were enhanced and they could now support digital channels, as well as use design thinking and data effectively. (See Appendix 3)
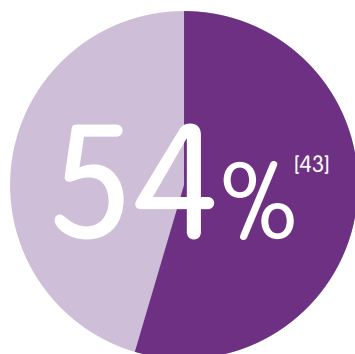
For workers, future-proofing their skills through continuous reskilling and upskilling will become a priority. As a matter of fact, a global survey revealed that:
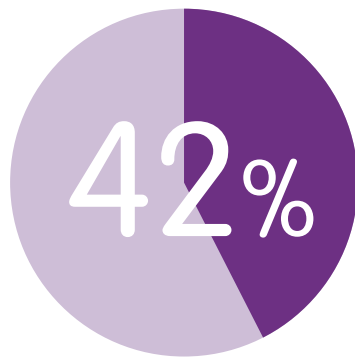
42% of core skills will require changes,

and

54%[43] of employees will need significant skill upgrades from 2018–2022.

OBJECTIVE 4

MAKE EMERGING TECHNOLOGIES ACCESSIBLE

40% of the businesses surveyed globally[44] cited that access to the newest technologies is one of their key drivers to adopt the XaaS model[45].

It is clear to them that innovation should not be restricted to the innovative few, but instead be democratised and accessible by all business functions and workers.

This will apply to businesses in Singapore as we move towards Services 4.0.
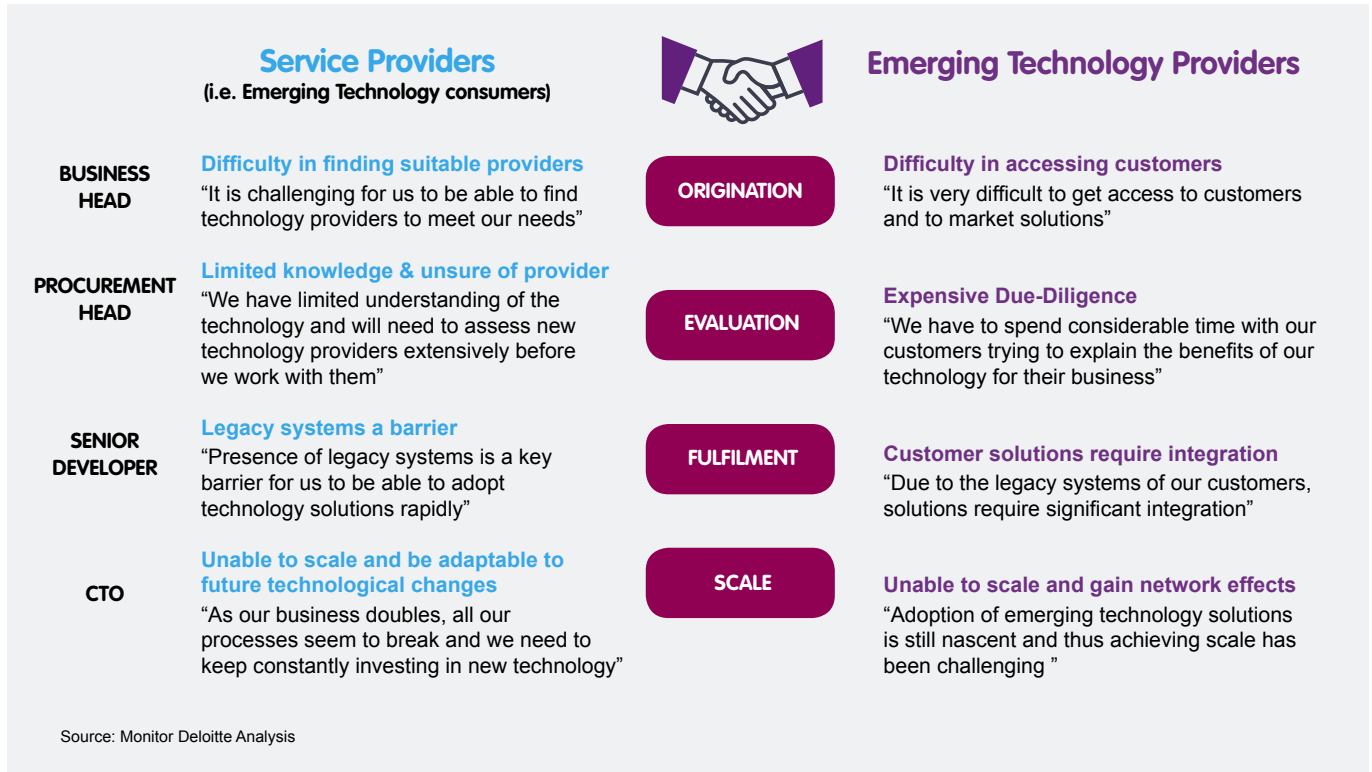
In fact, respondents in the global survey revealed that grassroot experimentation is the most important catalyst for adopting the XaaS model, underscoring the importance of making emerging technologies more accessible.

To harness the operational efficiency and business agility that Services 4.0 can bring through XaaS, businesses will require ecosystems that ensure emerging technologies are readily accessible.

The challenge is, current technology ecosystems are typically not suited to accelerate emerging technologies. Such systems, in reality, impede the implementation of Services 4.0.

Barriers Facing XaaS

In current technology ecosystems, there are often barriers between suppliers (emerging technology providers) and adopters (service providers). The barriers centre around four areas: origination, evaluation, fulfilment and scale.

Service Providers
(i.e. Emerging Technology consumers)

Emerging Technology Providers

ORIGINATION

BUSINESS HEAD

Difficulty in finding suitable providers
"It is challenging for us to be able to find technology providers to meet our needs"

Difficulty in accessing customers
"It is very difficult to get access to customers and to market solutions"

EVALUATION

PROCUREMENT HEAD

Limited knowledge & unsure of provider
"We have limited understanding of the technology and will need to assess new technology providers extensively before we work with them"

Expensive Due-Diligence
"We have to spend considerable time with our customers trying to explain the benefits of our technology for their business"

FULFILMENT

SENIOR DEVELOPER

Legacy systems a barrier
"Presence of legacy systems is a key barrier for us to be able to adopt technology solutions rapidly"

Customer solutions require integration
"Due to the legacy systems of our customers, solutions require significant integration"

SCALE

CTO

Unable to scale and be adaptable to future technological changes
"As our business doubles, all our processes seem to break and we need to keep constantly investing in new technology"

Unable to scale and gain network effects
"Adoption of emerging technology solutions is still nascent and thus achieving scale has been challenging "

Source: Monitor Deloitte Analysis

Origination

Service providers find it challenging to access suitable suppliers to meet their needs for emerging technologies. At the same time, providers of emerging technologies struggle with limited market opportunities.

Evaluation

Limited understanding of the technologies and the suppliers' credibility result in service providers conducting long, expensive due diligence processes. This makes it challenging for vendors to put their solutions in the market quickly, and for service providers to adopt the solutions fast.

Fulfilment

Prevalence of legacy systems is a major barrier for adopting emerging technologies. Service providers would need to perform significant customisations and integrations to ensure the new solutions work on the legacy systems.
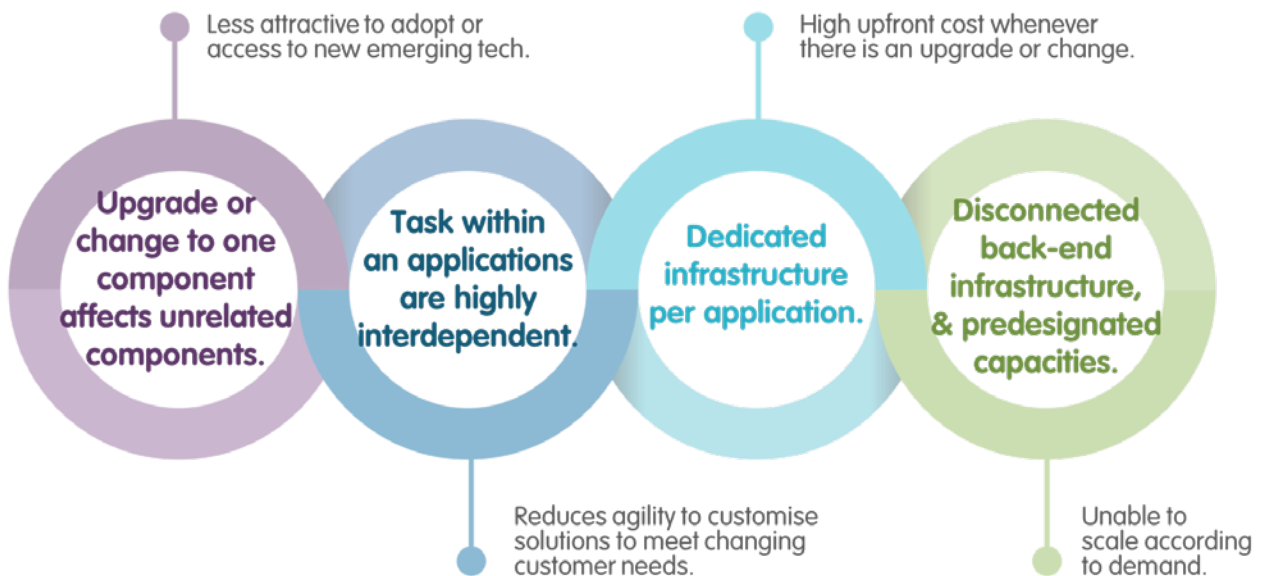
Scale

Legacy systems become obsolete quickly, causing service providers to struggle to adapt to changes in their business. Some emerging technologies, on the other hand, are still nascent. Solution providers struggle to grow and achieve network effects that can come from combining their solutions with other providers.

Many current technology ecosystems are also monolithic in nature, with IT systems that require continuation of legacy systems.

In such ecosystems, each basic application has its own dedicated back-end support infrastructure. The interdependent applications and disconnected back-end infrastructure will result in the following four barriers to change and their implications:

EXISTING IT INFRASTRUCTURE

Less attractive to adopt or access to new emerging tech.

High upfront cost whenever there is an upgrade or change.

Upgrade or change to one component affects unrelated components.

Task within an applications are highly interdependent.

Dedicated infrastructure per application.

Disconnected back-end infrastructure, & predesignated capacities.

Reduces agility to customise solutions to meet changing customer needs.

Unable to scale according to demand.

In summary, businesses face a pressing need to adopt a new technology ecosystem, one that will help them evolve from monolithic, legacy systems to more flexible and scalable microservices architectures. Only by doing so can they accelerate the adoption of emerging technologies, and democratise access for all stakeholders.

An Evolving Technology Ecosystem enabled by the Cloud Native Architecture
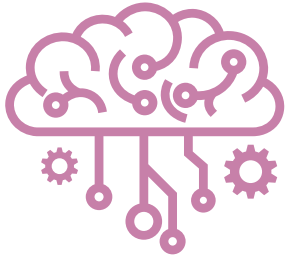
We have envisioned a new technology ecosystem to overcome the challenges posed by current ecosystems.

This ecosystem will transform the way companies develop and adopt emerging technologies. It will enable both service providers and ICM solution companies to modernise their legacy systems, and respond to the changing demands of customers, workers and business partners.

At the heart of this technology ecosystem is the Cloud Native Architecture. It is designed with the following principles in mind:

1. Enable access and provision of emerging technologies at a lower cost to both ICM solution companies and service providers and their workers.

2. Democratise access to technology to enable ease of development and adoption by all service providers and employees.

3. Offer the flexibility and scalability to respond to changing customer and market demands.

4. Enable and promote convergence of different emerging technologies to allow the development of innovative solutions and service offerings.

5. Provide a wide network of solution providers to help service providers identify suitable technology providers.

CLOUD NATIVE ARCHITECTURE

is the heart of the evolving ICM ecosystem that makes emerging technologies more accessible to Service Providers and Augmented Workers.
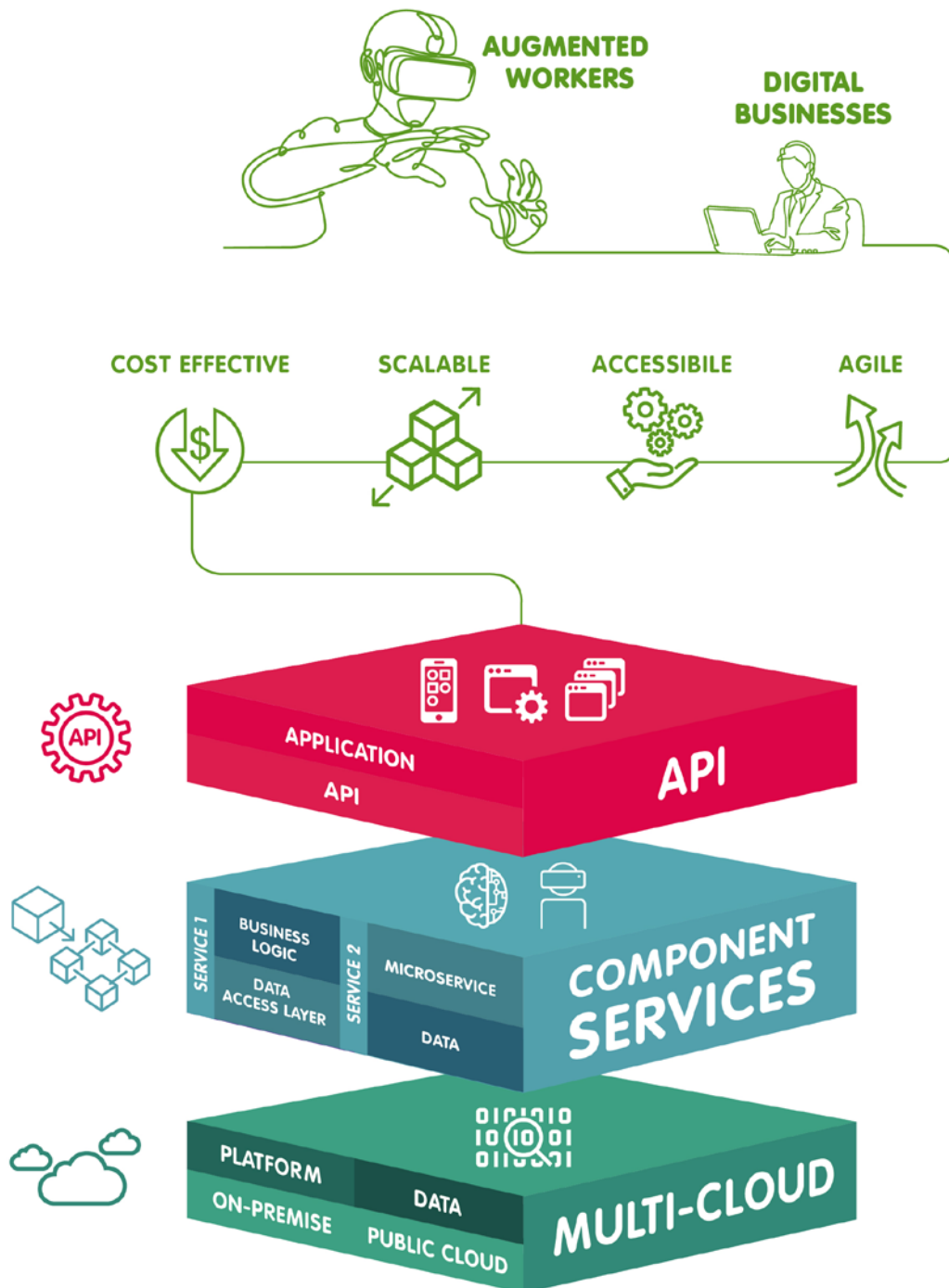
OBJECTIVE 5

CREATE AN INCLUSIVE ECOSYSTEM

Cloud Native Architecture brings together components of emerging technologies, and makes them accessible to all.

This way everyone can be empowered by innovation, not only those with specialised training, or those with deep pockets to buy or create monolithic systems.

Companies big and small, and workers from any department and function, will have access to the benefits of technology as they work towards Services 4.0.

An inclusive ecosystem enabled by the Cloud Native Architecture will give technological access to all workers and businesses, whether they belong to MNCs (~7,000 in Singapore[i]), SMEs (~200,000) or Large Local Enterprises (LLEs) (~2,000 including GLCs).

i   Approximate number of enterprises in Singapore.
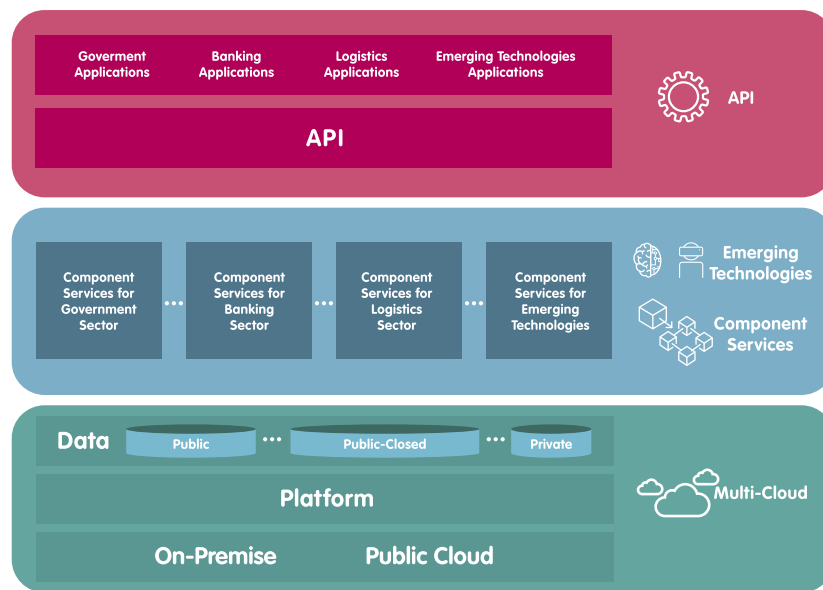
Cloud Native Architecture is not new. In fact, its impact is already felt in countries where cloud-based technology adoption is widespread.

The United States, most notably, is one of the top adopters with over 50% of enterprises deploying cloud in some form. Many major integrated cloud service providers such as Microsoft, AWS, Google and IBM, all of which are based there, are good examples of businesses who understand the inclusive nature of Cloud Native Architecture and are creating new possibilities with it.

For example, Azure, the cloud platform by Microsoft, offers a wide range of intelligent services such as LUIS (Language Understanding) and Computer Vision. It comes with a variety of deployment options that help developers create impactful solutions and applications[46] using AI technology. Additionally, nearly 40,000 developers have tapped on Microsoft's Bot Framework platform to build, deploy and manage Future-Ready Bots[35].

The software giant also makes their intelligent capabilities available to developers via APIs, giving them access to the same building blocks that the company uses. On top of that, understanding the taxing computing needs of AI, Microsoft has begun creating an AI supercomputer that would be available to anyone on the cloud.

Similarly, AWS offers their Activate Programme to service providers, especially start-ups, that gives them a cheaper and easier way to adopt and scale infrastructure. It also provides support resources including credit, training and expert support[47]. Airbnb and Lyft are examples of start-ups that have leveraged AWS to develop their solutions.

AWS Activate also has packages to provide targeted services. Their Builders package for start-ups and entrepreneurs is just getting started, while the Portfolio package for start-ups can be seen at selected accelerators, incubators and other enabling organisations.

The following are local examples of companies providing services using Cloud Native Architecture to create an inclusive ecosystem for large and small companies alike.

CASE STUDY

osome

Osome is a company in Singapore offering online incorporation, secretarial and accounting services. What differentiates them from others is that they combine artificial and human intelligence to serve their customers more efficiently and seamlessly. For instance, robots are used to automate form-filling tasks, thereby allowing their certified secretaries and accountants to focus on customer queries, provide guidance and tailor solutions. With arduous business processes streamlined, customers can incorporate a company in just 38 minutes. What's more, their 24/7 online chatbots make their services far more accessible to customers when compared to similar service providers. Customers can process invoices and ask questions during weekends or even late at night. (See Appendix 3)

EXAMPLE

Inclusive Ecosystems – Marketplace for Healthcare & Financial Services

Through the collaboration between healthcare and financial service stakeholders, a unique digital ecosystem is created to provide superior insurance services to patients in Singapore.

Health and insurance products are generally fragmented across multiple providers. Underwriting processes are manual, often requiring patients to provide the same information repeatedly to different insurance providers. On the providers' end, they face difficulty in pricing premiums accurately.

To solve these problems, a marketplace is formed to help insurers work with third-party component services. It enables data sharing across firms and sectors, building smart contracts that trigger auto-payouts after incidents, and using AI to underwrite more targeted premiums.

It is an inclusive ecosystem where parties big or small can join to provide data and component services, and create solutions and services for patients. Stakeholders include the government, large and small players in banking, insurers, and third-party providers of apps and wearables.
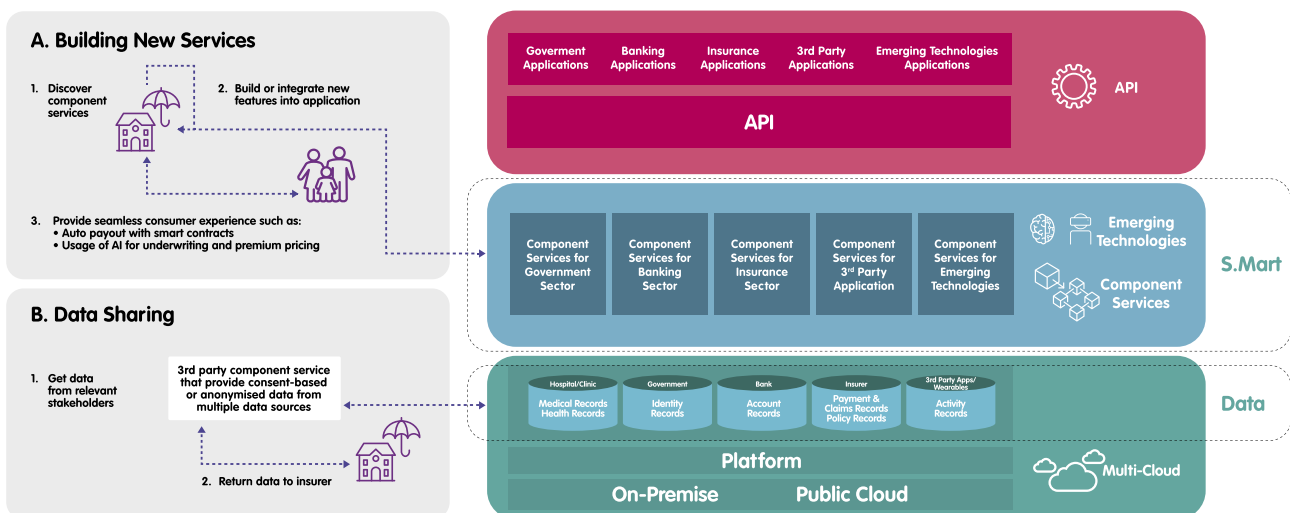
Source: IMDA

03 | THE CLOUD NATIVE ARCHITECTURE

> **❝** From Gmail to YouTube to Search, everything at Google runs in containers. Containerisation allows our development teams to move fast, deploy software efficiently, and operate at an unprecedented scale. **❞**
>
> - Containers at Google: A better way to develop and deploy applications

Cloud Native[48] is broadly defined as an approach to build and run applications that inherently enable users to take advantage of the cloud computing delivery model.

This is achieved by having loosely coupled applications (the code is not hard-wired to any of the infrastructure components) and is increasingly based on the microservices architecture.

Cloud Native is more than just being Cloud-Ready. Cloud-Ready[49] applications are predominantly local-only programmes, either for use on a single machine or an on-site server. They are typically based on monolithic architectures with features built for static environments. On the other hand, Cloud Native is a major step forward. Compared to Cloud-Ready applications, they significantly enhance the scalability, flexibility, agility and cost of operations. Three tenets that define Cloud Native are Multi-Cloud, emerging technologies as component services and made accessible by application programming interface (API).

3 Tenets of Cloud Native Architecture

To realise Services 4.0 and meet changing customer demands, it is increasingly critical for businesses to be agile, flexible and adaptable. Cloud Native Architecture enables companies to easily scale up or scale down their IT capabilities as and when the needs arise on a per consumption basis, without the hassle of purchasing new hardware and/or hiring more IT staff.

New tools, functions and services can also be deployed quickly to respond to dynamic market and customer needs, thereby facilitating innovation. Furthermore, Cloud Native solutions require limited upfront capital investment. They are affordable, and within the reach of SMEs.

In the long run, embracing the Cloud Native Architecture can lower IT costs significantly. Businesses can save on building and maintaining in-house computing infrastructure, IT human resource, expensive licences and constant software and hardware upgrades.

Lastly, cloud solutions provide a high degree of abstraction, which makes it easy to use without needing to understand the underlying technology.

In general, the Cloud Native Architecture is defined by these three tenets:

1. Multi-Cloud

Cloud Native Architecture is based on Multi-Cloud, which involves the distribution of cloud assets, software, applications, etc. across several cloud environments.

Multi-Cloud enables the on-boarding and use of multiple vendors, and thus increases the number of solutions available to users. This allows for rapid deployment and adoption of services on the Cloud Native Architecture.

Multi-Cloud is a cloud deployment model involving the use of cloud services from multiple cloud service providers, often in combination with on-premise and public cloud infrastructure. Multi-Cloud enables several additional benefits[50]:

a. In a Multi-Cloud environment, the decoupling between the infrastructure layer and the other layers (not present in a single cloud environment) offers higher flexibility. Companies can also mix and match services from different cloud providers.

b. Public cloud hostings can be chosen such that they are located in different countries. This gives service providers greater geo-presence and quicker recovery during natural disasters. It also enables the Cloud Native Architecture to serve international markets more efficiently.

c. With more vendors competing for customers with their products, service providers have more negotiation power to achieve better price to performance ratio.

d. Better redundancy and reliability can be achieved due to reduced dependency on a single vendor, enabling service providers to easily access a pool of reliable vendors.

2. Emerging Technologies Offered as Component Services

Component services are assets that can be widely reused in a variety of applications. It is defined as a model for creating, assembling, and deploying service components using heterogeneous technologies.

This approach ensures agility as business processes do not have to be re-created from scratch, and existing functionality can be leveraged from multiple sources. Other[51] benefits include lower maintenance costs and easier debugging of applications.

Adopting component services, thus, will be crucial to ensure the Cloud Native Architecture can scale services quickly. It will be a key factor for building ecosystems that are adaptable to technological changes and enable democratisation of technology.

A **component** is a well-defined piece of business functionality that is typically offered as a **service**. It is self-contained, reusable and encapsulated in code, thus enabling reuse.

Component services are considered a transformative way to develop IT architecture. They leverage existing functionalities, and hence facilitate faster innovation cycles and greater efficiency.

Component services can either be based on a monolithic or a microservices[52-55] architecture. A microservices-focused architecture breaks up interdependent applications into their tasks, and develops a suite of small services—each running its own process—that are reusable, independent and rapidly deployable. Such an architecture ultimately increases scalability and adoptability[56].

What's more, microservices do not have dedicated back-end infrastructure. Instead, it efficiently shares computing resources based on demand. For developers, the autonomous microservice modules can be rapidly iterated, avoiding the need to re-deploy the entire application with each update.

As microservices are organised around business capabilities, i.e. each service is built around a specific capability, they allow companies to build independent, cross-functional DevOps teams that are focused on a particular service or business function.

Given their inherent advantages, microservices are fast becoming the choice for companies to deploy component services.

Offering emerging technologies as separate component services on the Cloud Native Architecture will facilitate the democratisation of technological capabilities to everyone in an ecosystem.

Additionally, technology solution providers and developers will be able to combine multiple emerging technology component services, and accelerate the creation of highly innovative solutions.

3. Application Programming Interface (API)

APIs expose component services to users, and promote innovation by enabling new business processes, products and services, and facilitating communication between services.

APIs provide access to component services, facilitating functionality reuse across systems that will result in higher efficiency and rapid innovation.

The promise of the Cloud Native Architecture is the ability to scale services quickly and enable abstraction of technology. This can be realised by the use of APIs together with component services.

> **API** is a programming-based software interface that acts as a bridge between two or more applications and/or systems, enabling them to seamlessly communicate with each other without making any change to the original applications or systems.

The growth of APIs stems from a fundamental need to encapsulate and share information. They enable transaction processing between elements in the solution stack, and allow access to component services.

The trend towards integration has been steadily accelerating over the years, driven by increasingly sophisticated ecosystems, and business processes that are supported by complex interactions across multiple endpoints in custom software, in-house packaged applications and third-party services.

APIs used along with component services can reduce the time to market for various products and services, and lower the cost of the build by "plugging in" with open API. Deploying APIs can also help extend the reach of existing services, and potentially create new revenue streams.

Companies are likely to build internal component services for functions that are unique, and expose them internally through APIs. For instance, APIs enable a customer service application that supports external customers to be leveraged by other departments, such as IT for help-desk queries, HR for internal customers, and logistics for vendor support.

On the other hand, companies are likely to consume external APIs to leverage existing component services that are not core to their business, thus enabling them to access best-in-class services to accelerate innovation.

For many companies, using APIs is expected to be a gradual and incremental process. A good starting point would be to layer APIs on top of legacy systems, making it possible to reuse and share core assets and data across the organisation.

APIs are key accelerators of innovation and new business models. For this reason, component services accessed through APIs will form a core part of the Cloud Native Architecture, and is instrumental in realising Services 4.0.

Benefits to Service Providers

Today there is a growing trend of people moving towards consumption models that enable access without ownership. On-demand transportation services are good examples of how people can avoid the operational and maintenance expenses that come with owning cars.

Service providers face a similar trend. Their employees, business partners, vendors and customers are looking for consumption models that are agile, accessible and offer scalable access to services at lower costs. They also wish to reduce the complexity of their IT infrastructures to focus on digital transformation.

Through the Cloud Native Architecture, service providers will be able to create greater efficiencies, and engage customers, employees and business partners in new ways. They will enjoy cost effectiveness, greater scalability, streamlining of business processes, better access to new technologies and the ability to provide new services.

# From Monolithic to Microservices

Cloud Native Architecture will guide the change in technology ecosystems, enabling them to be more conducive for adopting emerging technologies.

The shift from a monolithic architecture to a microservices architecture is expected to ease access to emerging technologies, and as a consequence, potentially lower the cost of maintaining infrastructures, and become more scalable and responsive to needs.

71% of organisations surveyed had considered adopting microservices, but only 9% had been able to achieve it[2]. The high cost of change due to the presence of legacy systems is a major reason.

45% of the companies also cited organisational challenges such as the lack of specific IT skills for developing and managing microservices. Evidently, there is a pressing need to address the lack of talent with microservices and DevOps IT skills.

Overcoming such challenges will be essential in an evolving technology ecosystem.
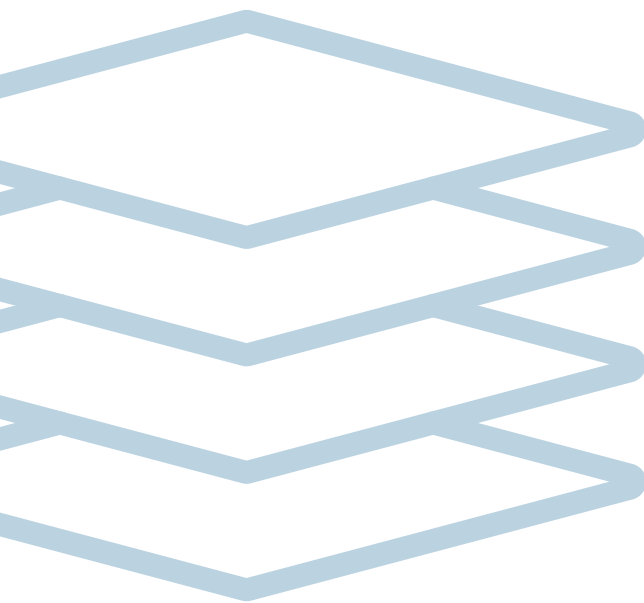
Multiple Tech Stack Ecosystem

We envision the Cloud Native Architecture to be an open ecosystem that will allow companies to incorporate and grow multiple technology stacks (tech stacks).

The Cloud Native Architecture does not prioritise any particular tech stack, from a specific company, and hence, multinational companies, governments and local companies can all participate and promote their tech stacks and related ecosystems.

Digital businesses, large and small, will be able to gain access to a wide range of tech stacks and the associated ecosystems to innovate further and accelerate component services development.

Cloud Native Architecture
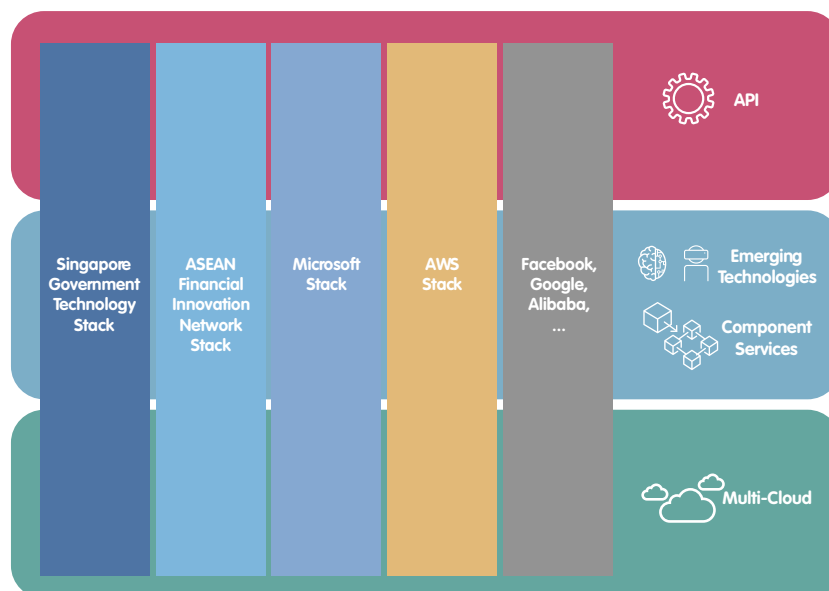
EXAMPLE

Microservices building Bots on Cloud – Social Robot from MIT Labs

The world's first "social robot" was developed by MIT labs in 2013, and was recognised by TIME magazine as the best invention of 2017.

This has been positioned as a social companion offering a whole new way for humans to interact with technology. It expresses emotions, analyses and learns human behaviour, and actually behaves like a human, demonstrating some very human character traits—a breakthrough achievement in the sphere of robotics.

The robot's back-end and mobile infrastructure are based on microservices[1] developed on AWS. Thus, this back-end infrastructure was highly flexible to support the handling of further growth while keeping expenses under control. It also ensured high system reliability and disaster recovery potential (load balancing, cloud formation, etc.). All services were fully autonomous so each could be scaled independently from the others. It used security solutions enabled through the AWS platform to address data privacy and other security concerns.

[1] Source: Waverley Case Studies - Jibo Robot

CASE STUDY

✖DBS

DBS Cloud

DBS's decision to adopt a cloud-based solution was spurred by many factors. Customers were fast becoming digitally savvy, and they wanted access to digital services across multiple channels and devices. Computing requirements were rising too. Driven by significant growth and investments in digitalisation, they doubled in three years and were expected to grow further. Moreover, the rise of Fintech start-ups—as well as global and local tech giants looking to disrupt the bank's business—further fuelled the need for digital transformation.

After migrating to a Cloud Native solution, the benefits quickly became evident. Scalable hardware enabled up to 7.1x cost savings.

For software, the bank enjoyed 7.8x savings as it could tap into open source APIs and use as-a-service solutions instead of enterprise software. The lower need for configuration and system set-up also cut labour costs by 5.3x.

The advantages didn't end there. There were financial savings from the reduced need for space to house backup servers and branches could be closed. The transformation also enabled DBS to be more agile and efficient, changing processes to respond to evolving customer demands. Digital channels such as online services and web applications could now be created more easily, enabling DBS to serve global customers at all times. (See Appendix 3)

The Need for Cloud

- DBS customers are changing; with growing business volumes and digitalisation, compute workloads at DBS have doubled in the last 3 years, and will continue to see significant growth.
- Customers are also becoming more digitally savvy and are demanding for digital services.
- Rising threats from non-banks, e.g. Alibaba, which are moving into payment spaces.

BEFORE	Principles of Cloud Native Architecture	AFTER
• Traditional servers with physical hardware required space, made scaling up a challenge • Required standby servers for peak load	**Flexibility and scalability**	**DBS has become more agile and can easily scale with demand:** • Cloud allows DBS to scale up easily, without being dependent on available space • DBS also no longer need to have on standby extra servers to cater for peak demand
• High upfront investments in enterprise software and hardware	**Lower upfront and operational cost**	**Up to 7.1x cost savings for hardware, 7.8x cost savings for software** • With cloud, DBS reduced their computing and storage hardware needs; they can also tap on open source software and buy on a per need basis • Cost savings from reduced dependency on physical space and the need for brick & mortar outlets
• Legacy systems were complicated and required extensive expertise to set-up	**Ease of adoption**	**5.3x cost savings for man-effort required** • The virtualisation of hardware and tapping on open source software saves man-effort towards setting up a system

• Traditional/offline service delivery models unable to provide end-to-end frictionless services
• Worker productivity was hindered by manual and inefficient internal processes
	Deliver seamless services	**Improved B2C and intra-B service delivery**
		• Online services and web applications allows 24/7 worldwide service delivery to customers
		• Business processes realigned to customers' need to become more efficient and improve end-to-end service delivery
		• Database-as-a-Service is also available internally:
		  • Staff is able to submit their application via a web portal
		  • Approvals are automated, and this avoids bottleneck in the application process
		  • Realignment of business processes not based on job roles, but by what is needed

Source: IMDA

CASE STUDY

Janio was formed in Singapore in early 2018 when a group of young logisticians spotted a gap in the Southeast Asian ecosystem for simple, seamless logistics solutions. It set out to become Asia's leading logistics network by providing an integrated cross-border delivery solution for merchants across the globe.

Recognising the many advantages of the cloud, the team built its business on cloud services. Chief Marketing Officer, Nathaniel Yim, summed up the benefits when he said, "Cloud services allowed Janio to launch in just three months, scaling from just ten to thousands of orders per day!" (See Appendix 3)

Integrating ICM Ecosystem Players

Cloud Native Architecture will significantly change the way players participate in the ecosystem in future:

Service Providers

Cloud Native Architecture will enhance their access to emerging technology solutions, enabling them to provide seamless new technology-based services. The architecture will also fuel the development of more customised solutions to meet specific business needs.

Workers

Workers will no longer need to depend on IT departments for solutions. The Cloud Native Architecture will foster an ecosystem where they can leverage component services to augment their work. Components services will be easy to understand, easy to use, and easily customisable to suit their different needs. The power of choice will be in the hands of workers.

System Integrators

Cloud Native Architecture will enable system integrators to accelerate innovation, and build new customised solutions by mixing and matching component services from multiple vendors on the Multi-Cloud platform.

Technology and Solution Providers

Cloud Native Architecture will help technology and solution providers to become more competitive by giving them access to other parties looking to adopt their solutions. Greater competitiveness will also stem from lower costs of development and greater scalability. What's more, agile cross-functional teams can work independently on a single function component service, using languages and tools best suited for the job. This will play a big part in accelerating solutions to market.

Developers

Through APIs, the Cloud Native Architecture will offer better access to emerging technology solutions and component services. Developers can tap on them to convert ideas into solutions, then enhance and test the solutions in an accelerated manner. They can also leverage existing functionality to achieve rapid innovation and scalability. The architecture will also make it easier to debug applications.

Platform Providers

Platform providers are typically tied to a restrictive, rigid infrastructure provided by a single vendor. By migrating to a Multi-Cloud platform that the Cloud Native Architecture will enable, they will no longer be tied down, and will have better ability to launch component services.

Infrastructure Providers

Currently, most cloud deployments are based on single cloud vendors, thus limiting opportunities for infrastructure providers. However, with the Cloud Native Architecture, infrastructure providers will be able to participate in a Multi-Cloud environment, thus giving them an opportunity to access a large number of customers.

Cloud Native Architecture Integrates ICM Ecosystem Players

	Current State	Roles of Players in the Future
SERVICE PROVIDERS	• Point services • Limited delivery channels	• Provide new seamless services • Access emerging technology solutions & offer new technology-based services
SYSTEM INTEGRATORS	• Full stack solutions by integrating monolithic applications	• Build new solutions based on mixing and matching a variety of new component services on Multi-Cloud platform
TECHNOLOGY & SOLUTION PROVDERS	• Monolithic architecture	• Increase competitiveness by migrating services to the cloud. E.g. Component services will be built by technology & solution providers
DEVELOPERS	• Stand-alone applications	• Increased access to emerging technology solutions & microservices • Rapid launch of solutions
PLATFORM PROVIDERS	• Restrictive, rigid platform	• Increased ability to launch component services and Multi-Cloud based platforms. E.g. Cloud providers will contribute to Cloud Native Architecture
INFRASTRUCTURE PROVIDERS	• Large, capital infrastructure	• Increased participation in and enable a Multi-Cloud environment

Enabling Emerging Technology Recommendations

Cloud Native Architecture is the technology ecosystem we envisioned to realise Singapore's goal of becoming a Services 4.0 Hub.

In the Services and Digital Economy Technology Roadmap, we have determined five emerging technology areas that Singapore should focus on and develop further capabilities. Our recommendations for each of these areas can be realised through the Cloud Native Architecture.
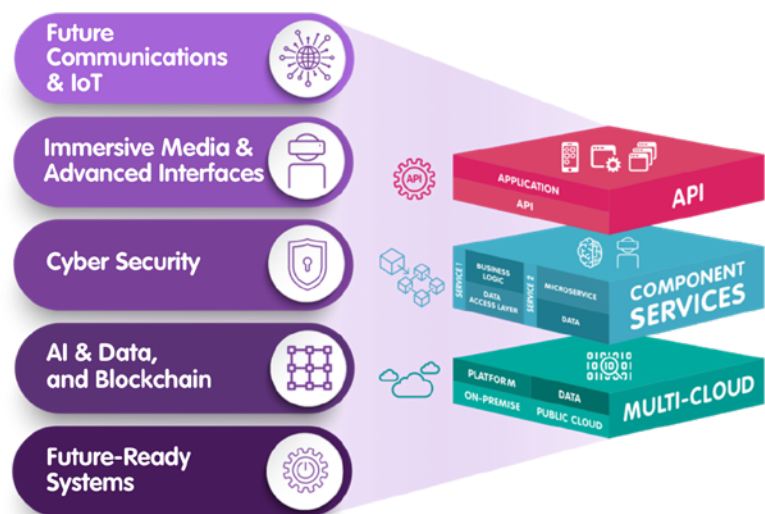
5 Emerging Technology Areas

1. Future Communications & IoT

Future Communications deals with wired and wireless technologies that provide the critical physical and digital supporting infrastructure necessary for the Cloud Native Architecture ecosystem that we envisioned.

IoT includes technologies that help us capture information in new ways, and create value from data obtained from connected devices and objects.

2. Immersive Media & Advanced Interfaces

This technology area refers to the game-changing technologies that let both consumers and enterprises experience highly intuitive interactions. They include the removal of tangible interfaces to let users communicate naturally such as using gaze, gestures, voice and eventually context.

Such technologies can help businesses in Singapore be more effective by simplifying and enhancing interactions with their customers.

3. Cyber Security

Cyber Security refers to the foundational security technologies that will be critical to addressing security and data privacy concerns of both consumers and businesses.

The Cloud Native Architecture ecosystem will further fuel the trends, which are reshaping the cyber security landscape globally and within Singapore, such as erosion of the perimeter, the proliferation of velocity and data, and exponential development and adoption of emerging technologies.

This will be a critical enabler, without which, trust in the digital economy cannot be established and connected players—ICM solution companies, service providers and end consumer—will find it difficult to participate in the Cloud Native Architecture ecosystem.

4. AI & Data, and Blockchain

This area centres around creating value through the use of intelligent systems, and will be a focus area across the entire Cloud Native Architecture ecosystem.

AI and Blockchain are the foundational drivers of innovations, providing superior insights, improving effectiveness and efficiency, and enhancing value for businesses and workers alike.

5. Future-Ready Systems

These technologies deal with advanced human-machine interactions such as cobots and Future-Ready Bots that are not widely available yet commercially.

Developing this area further, and making it a part of the Cloud Native Architecture ecosystem will enable Singapore to become a global leader in future-ready systems.

Refer to the link here for the SDE Technology Roadmap Annexes which include detailed technology reports in the five emerging technology areas.

04 SERVICES 4.0: IMPACT ON SINGAPORE

Services 4.0 will naturally transform the services economy, but it will also send waves of change throughout our nation.

The impact will be felt at every level, from the economy, to businesses, and ultimately the workers' community.

Impact on the Economy

Services 4.0 will bring benefits to the services economy in Singapore by creating new economic value and new jobs.

New Value Creation in Services Economy

The new service paradigm is expected to accelerate new value creation, with the two main drivers being:

1. An increase in the share of services economy as a percentage of total GDP due to the economy servitising its products and re-engineering its services.

2. An increase in the value from existing services on the back of accelerated adoption of emerging technologies.

Currently, our economy generates 66% of its value from external demand. This share will continue to grow as Singapore becomes the hub for Services 4.0, and we are able to capture a larger share of the opportunities emanating from Services 4.0.

New Job Creation in Services Economy

Services 4.0 will also generate additional jobs that will boost employment[j] in the services economy. Similarly, the impact stems from two key drivers:

1. Companies will hire more skilled talent to support their value generation goals.

2. An increase in productivity growth rate due to the adoption of emerging technologies.

While the latter might lead to some job displacements, it will enhance existing jobs, and foster innovation, creativity, critical and analytical thinking and emotional intelligence.

According to The Future of Jobs Report 2018 by World Economic Forum, talent availability is by far the most important factor for companies deciding to locate in Singapore. It's more pressing than labour and production cost. Services 4.0 will help to bridge Singapore's talent gap comprehensively, and will provide the impetus to equip more workers with much needed emerging skills[k].

Impact on Companies
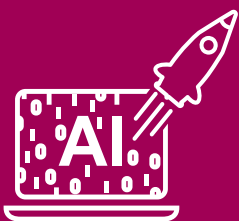
In Services 4.0, both service providers and ICM solution companies will enjoy benefits, primarily across these three areas:

1. Creating new value and improving productivity.

2. Creating new and enhance traditional jobs.

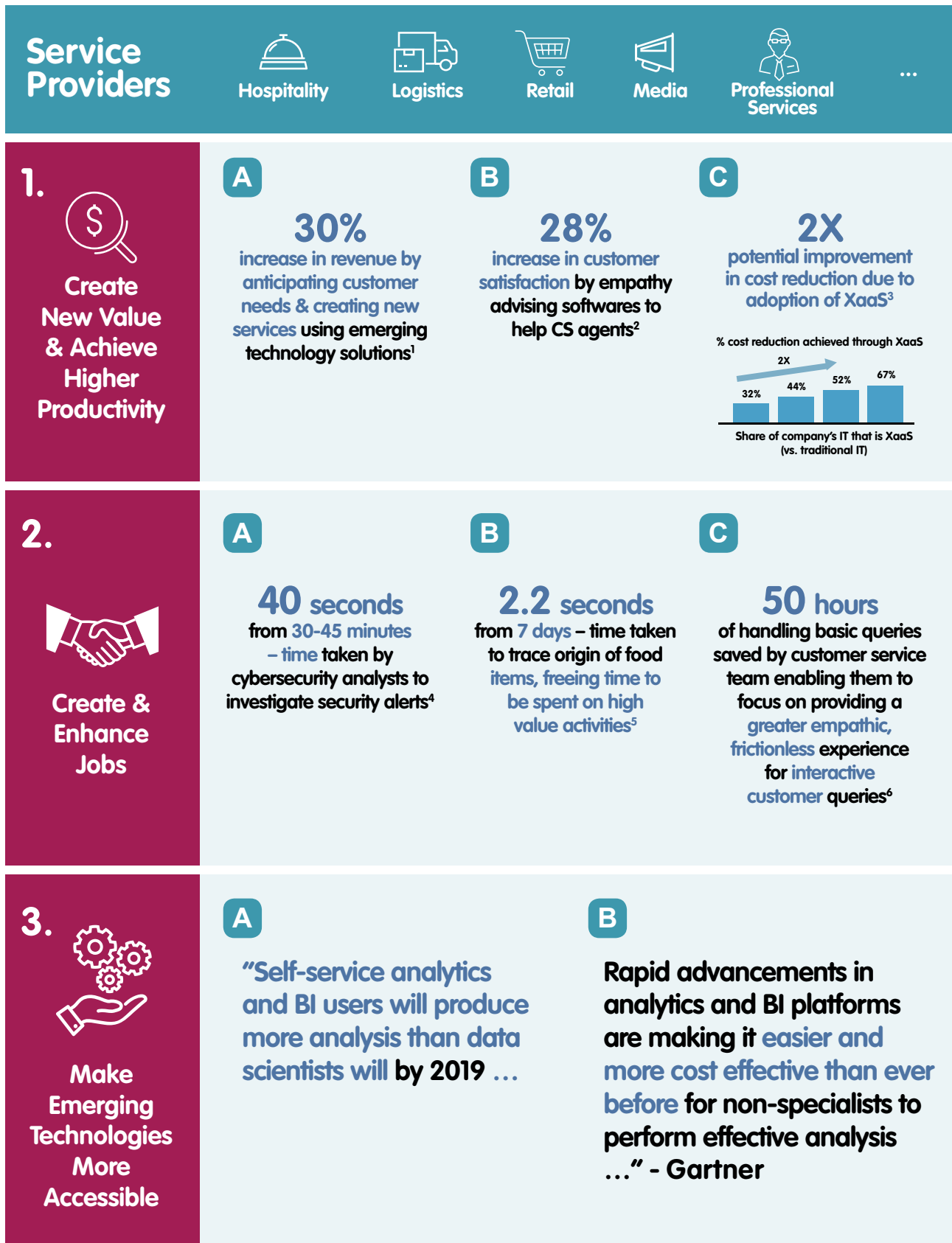3. Making emerging technologies more accessible to all companies—big or small.

In fact, Singapore companies can look forward to similar experiences as their global counterparts, where Services 4.0 has helped adopters generate significant value and productivity.

In one case, emerging technologies have helped a company improve their service delivery by anticipating customer needs and create new services, resulting in an improvement in service delivery. This brought about a 30% rise in revenue for the company.

These global adopters of Services 4.0 have also created new and enhanced jobs to embrace the new workforce dynamics. As a result, their workers could reduce the time needed to execute routine tasks, and shift their focus to higher value activities. With easier access to emerging technologies, service providers were also able to leverage these technologies for their operations and service offerings.
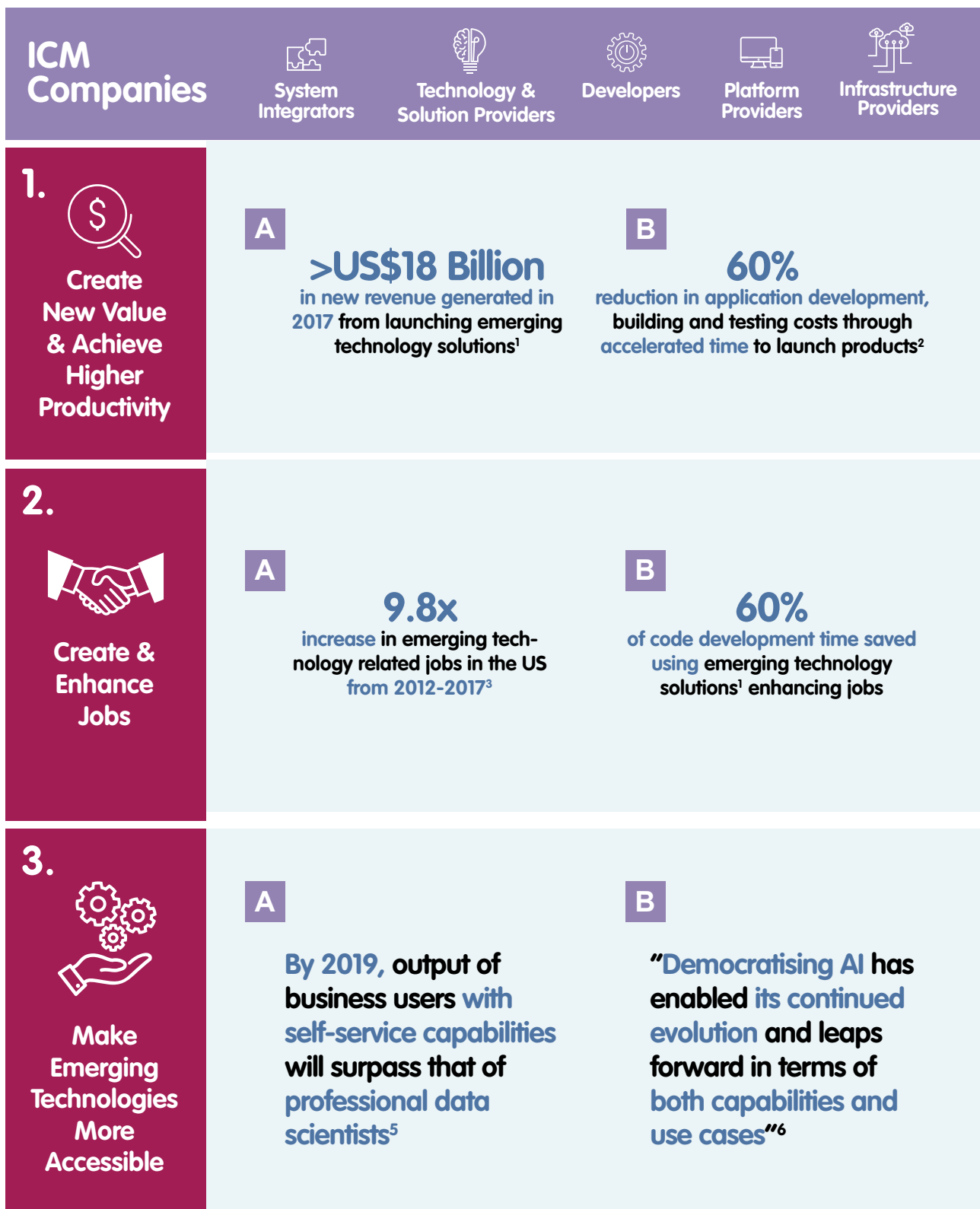
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[j]   Currently approximately 74% of total employment belong to the services economy.
[k]   10 emerging skills have been identified for Singapore in the WEF: Future of Jobs Report 2018.

Service Providers	Hospitality	Logistics	Retail	Media	Professional Services	...

1. Create New Value & Achieve Higher Productivity

A

30%

increase in revenue by anticipating customer needs & creating new services using emerging technology solutions[1]

B

28%

increase in customer satisfaction by empathy advising softwares to help CS agents[2]

C

2X

potential improvement in cost reduction due to adoption of XaaS[3]

% cost reduction achieved through XaaS

2X

32%   44%   52%   67%

Share of company's IT that is XaaS (vs. traditional IT)

2. Create & Enhance Jobs

A

40 seconds

from 30-45 minutes – time taken by cybersecurity analysts to investigate security alerts[4]

B

2.2 seconds

from 7 days – time taken to trace origin of food items, freeing time to be spent on high value activities[5]

C

50 hours

of handling basic queries saved by customer service team enabling them to focus on providing a greater empathic, frictionless experience for interactive customer queries[6]

3. Make Emerging Technologies More Accessible

A

"Self-service analytics and BI users will produce more analysis than data scientists will by 2019 …

B

Rapid advancements in analytics and BI platforms are making it easier and more cost effective than ever before for non-specialists to perform effective analysis …" - Gartner

Note: 1. InsideSales's AI solutions, 2. Humana using Cogito AI solutions, 3. Source: Deloitte Flexible Consumption study, 4. Source: Deloitte "AI-augmented Cybersecurity", 5. Walmart & IBM blockchain, 6. National Park Depot used AI solutions.

Source: Marketing Institute, Medium, CRM Exchange, Deloitte Flexible Consumption study, Monitor Deloitte Analysis

ICM Companies	System Integrators	Technology & Solution Providers	Developers	Platform Providers	Infrastructure Providers

1. Create New Value & Achieve Higher Productivity

A **>US$18 Billion** in new revenue generated in 2017 from launching emerging technology solutions[1]

B **60%** reduction in application development, building and testing costs through accelerated time to launch products[2]

2. Create & Enhance Jobs

A **9.8x** increase in emerging technology related jobs in the US from 2012-2017[3]

B **60%** of code development time saved using emerging technology solutions[1] enhancing jobs

3. Make Emerging Technologies More Accessible

A **By 2019,** output of business users with self-service capabilities will surpass that of professional data scientists[5]

B "**Democratising AI** has enabled its continued evolution and leaps forward in terms of both capabilities and use cases"[6]

Note: 1. IBM Cognitive Solutions revenue in 2017, 2. Benefits for Developers from Micro services & Cloud, 3. LinkedIn Survey, 4. Medium, 5. Gartner survey on Data Analytics & AI, 6. Singularity Hub
Source: Forrester, IBM website, Monitor Deloitte Analysis

Similarly, ICM solution companies worldwide who adopted Services 4.0 were also able to generate more value, improve productivity, and at the same time, enhance their workers and job roles. Better access to emerging technologies also helped them evolve their capabilities to improve their service delivery by anticipating customer needs and create new services.
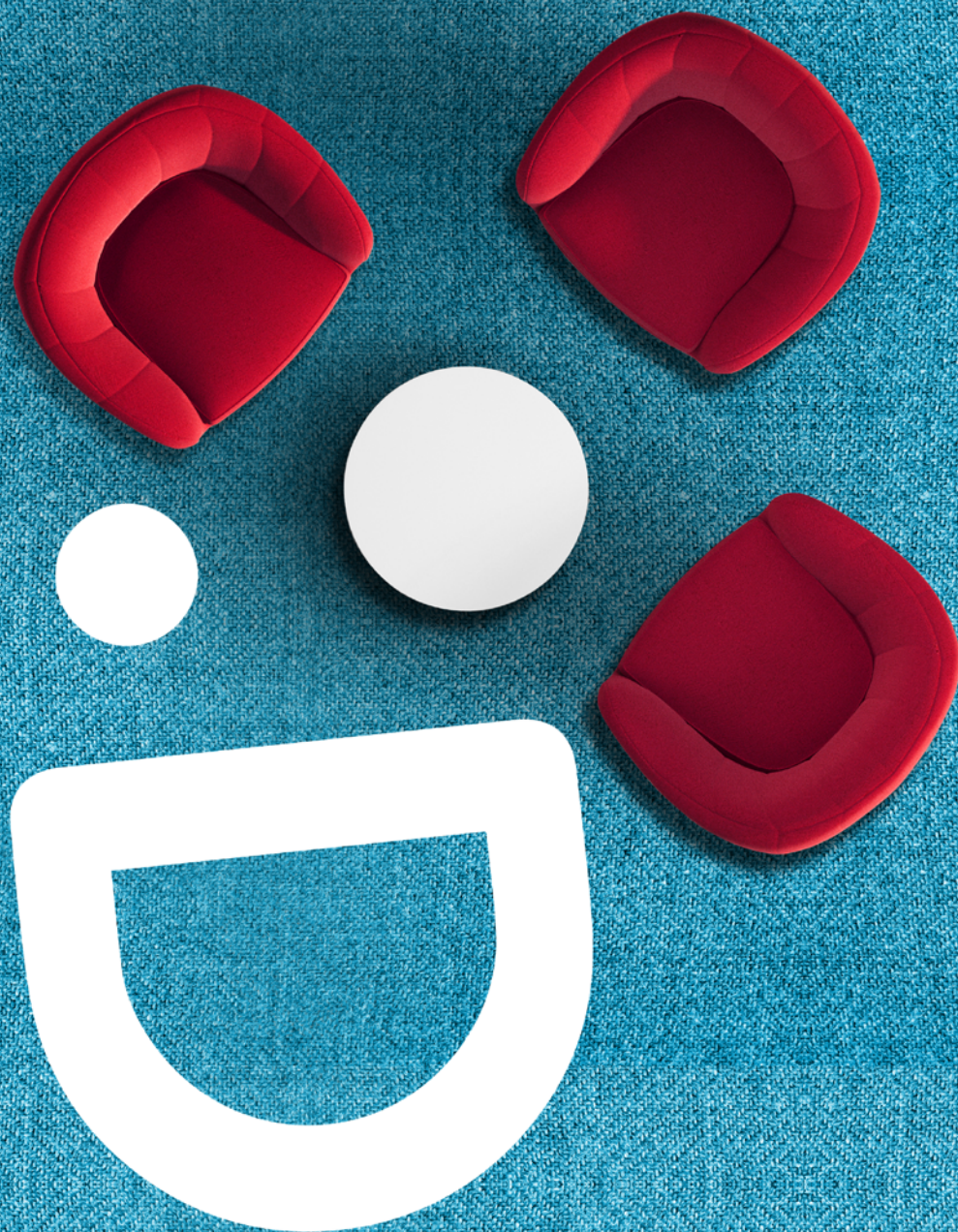
05 RECOMMENDATIONS

VISION:
SINGAPORE AS A SERVICES 4.0 HUB FOR KEY SECTORS
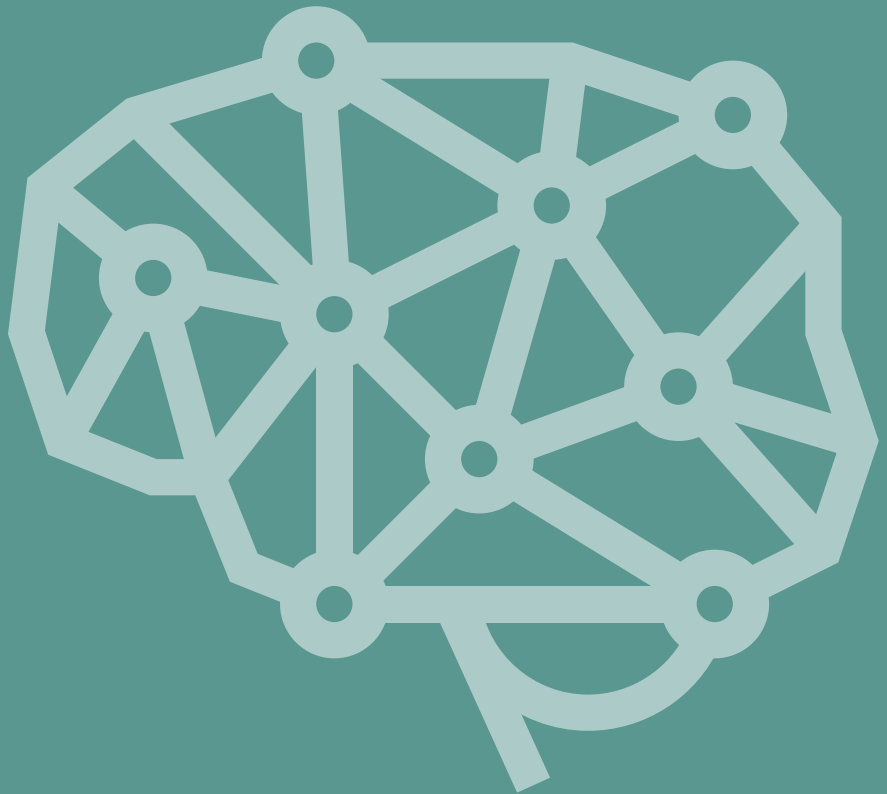
To become a Services 4.0 Hub for key sectors, Singapore should build on its competitive advantages as illustrated in the following:

1. Trusted brand for data governance.

2. Skilled service workforce that uses technology to augment work and deliver better results.

3. Strong design thinking culture necessary for the creation of new Services 4.0 experience.

4. A diverse multicultural society that is well placed to create empathic services for the global audience.

5. Strong ICM integration capabilities backed by strong R&D investments and drive to innovate.

6. World-class connectivity infrastructure that supports reliable interoperating Multi-Cloud platforms and cloud access.
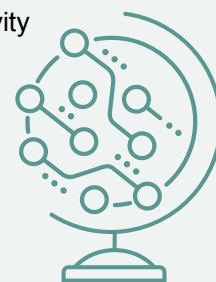
With this in mind, our vision would be to transform Singapore into a Services 4.0 hub for key sectors.
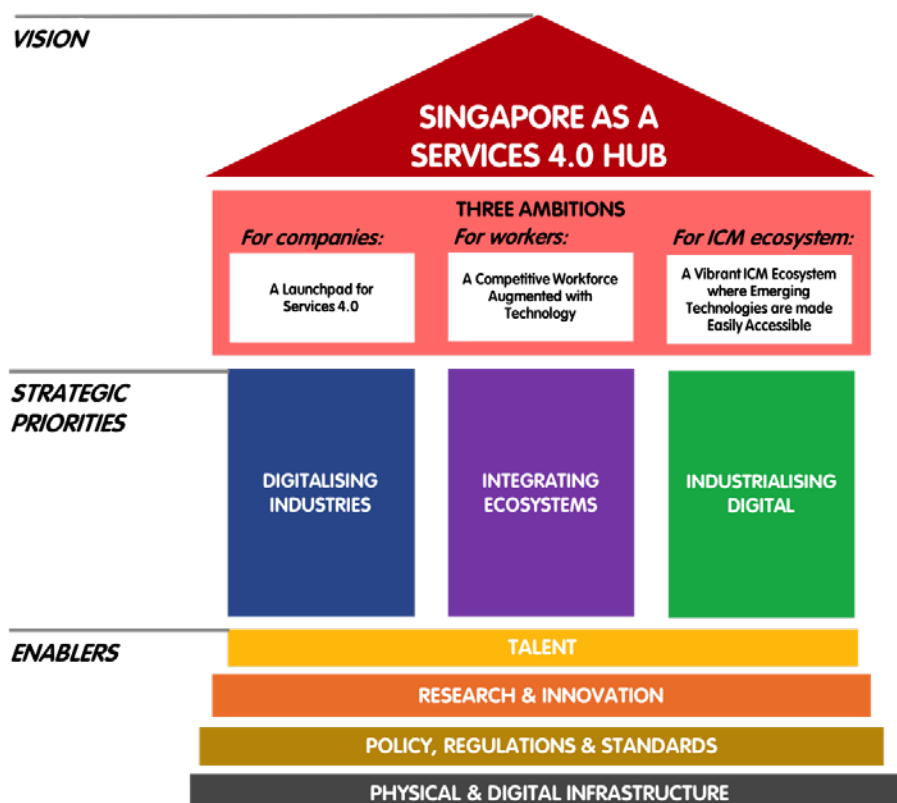
3 Ambitions for Singapore becoming a Services 4.0 Hub for Key Sectors

Singapore should consider three ambitions, centering around companies, workers and ICM solution companies, to realise its vision of a Services 4.0 hub for key sectors.

Companies – A Launchpad for Services 4.0

A #Services40Hub where #EveryBusinessADigitalBusiness and #EmpoweringPossibilities for Businesses

As a #Services40Hub, Singapore aspires to become a launchpad for service providers who wish to design, launch and deliver seamless services aligned with the Services 4.0 vision.

They will find Singapore a conducive environment with eager ecosystem partners looking to embark on the XaaS paradigm (#EveryBusinessADigitalBusiness). Thus, service providers can offer seamless services which are end-to-end, frictionless, anticipatory and empathic.

Singapore also hopes provide a supportive ICM ecosystem that removes barriers to the adoption of emerging technologies, thus empowering businesses to imagine possibilities. More importantly, allowing concepts to be turned into services in a more cost effective way and speed up time to market (#EmpoweringPossibilities).

1

Workers – A Competitive Workforce Augmented with Technology

A #DigitalTalentHub where there is a #BotForEveryWorker, and #EmpoweringPossibilities for Workers

In order to prepare the Singapore workforce for the Services 4.0 paradigm, it is imperative that workers are augmented with technology.

In the current landscape, the workplace is already undergoing a shift where workers increasingly collaborate, communicate and connect on online platforms. In the Services 4.0 paradigm, workers are envisioned to work collaboratively with different kinds of bots.

#BotforEveryWorker captures the ambition where every organisation invests in bots to augment their workers. It is worth noting that workers remain central to all organisations, bots are deployed to augment and not replace humans. Workers will be able to customise the way bots interact with them to make their jobs innovative, creative and efficient while minimising repetitive chores. Hence, workers can accomplish a greater variety of tasks more efficiently working alongside bots (#EmpoweringPossibilities).

With an augmented workforce, Singapore would hope to transform into a #DigitalTalentHub, providing a case study for a human-machine integrated workforce and a destination of choice for companies looking for a competitive workforce and digital talent.

2

ICM Ecosystem – A Vibrant ICM Ecosystem where Emerging Technologies are made Easily Accessible

#EmpoweringPossibilities with #GoCloudNative

To address the increasing need to adopt emerging technologies and democratise innovation, Singapore will need to evolve its ICM ecosystem towards the Cloud Native Architecture to provide easy access to emerging technologies.

Within the evolved ecosystem, API-driven component services can make technology development and deployment more agile, scalable, accessible and cost effective.

#GoCloudNative is core to realising our vision. It would catalyse the development of Cloud Native Architecture, and build an inclusive ecosystem that makes emerging technologies more accessible.

Cloud Native Architecture would reinforce #EmpoweringPossibilities as it would allow ecosystem providers and service providers to imagine new possibilities and realise them through the application of emerging technologies.

3

Role of Government

The government of Singapore would play an important role in the nation's journey towards becoming a Services 4.0 Hub for key sectors. The foremost being the Vision Setter, followed thereafter by these three roles:
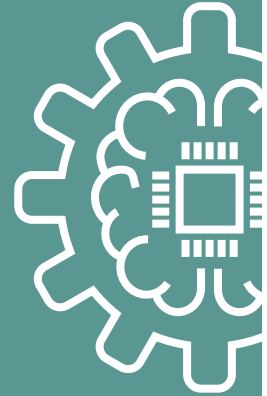
Government Leads by Example

The government should continue to lead by example in applying and scaling new emerging technologies and new service models.

It should, for example, transform its own service delivery and adopt the principles of Services 4.0 and XaaS.

The Singapore government is leading by example through the following programmes that support and enrich the Cloud Native Architecture:

- "Moments of Life", a series of seamless end-to-end government services catering to the lives of citizens and residents.
- GovTech Stack (announced on 2 Oct 2018), a part of GovTech's transformation.
- API Exchange (APEX) under GovTech, a gateway solution to government data exchange services such as National Digital Identity comprising of SingPass and CorpPass and other component services.
- Data.gov.sg, the rich repository of government data.

Government as the Researcher and Developer

The government should continue to foster technological innovation by encouraging emerging technology research projects and supporting talent development.

Singapore should continue to establish itself as a R&D hub. Singapore has been actively supporting universities and research institutions to strengthen Singapore's research influence both locally and globally. Examples include the Research, Innovation and Enterprise 2020 plan that is Singapore's national strategy to develop a knowledge-based, innovation-driven economy and society.

Government as the Environment Builder

The government should establish a favourable and safe environment to help companies adopt emerging technologies more readily. This can be achieved through establishing targeted policies, regulations and standards as well as physical and digital infrastructures.

This role is especially important for emerging technologies that have high uncertainty and steep hype cycles. To be effective, government agencies should continue to collaborate to fulfil this role.

To realise Services 4.0, IMDA will need to become the key orchestrator to build a conducive environment with support from government agencies and industry partners.

Key Recommendations

To realise Singapore's three ambitions, the government should embark on strategic programmes corresponding to the three strategic priorities in the Digital Economy Framework.
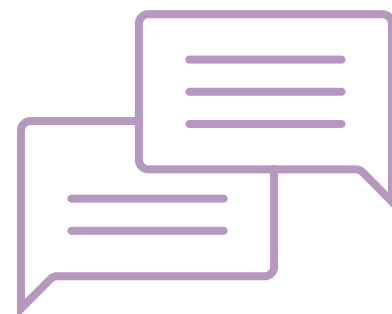
① Digitalising Industries

1A. Identify Priority Sectors for Sector-wide Transformation

While Services 4.0 will impact multiple sectors in the long term, some will take priority. Services 4.0 will complement Singapore's Industry Transformation Maps (ITMs) agenda across 6 clusters and 23 sectors.

The government should conduct a study to identify priority sectors for Services 4.0 transformation. Sectors with high service orientation, high digital adoption capability and greater international market focus could be prioritised for Services 4.0 transformation. This may include sectors in the trade and connectivity, modern services and lifestyle.

1B. Service Providers to Servitise Their Business, Organisation and Workforce

Services 4.0 will require service providers to adopt emerging technologies and adapt their business processes and offerings. A targeted programme should be rolled out to provide a suite of support services to help service providers move to Cloud Native Architecture. These support services can include but are not limited to providing technology expertise, organisational transformation support and workforce transformation support. The purpose of these support services should be to help

service providers transition into the XaaS paradigm. It should also help augment the capabilities of workers while maximising the automation of repetitive tasks using emerging technologies.

1C. Service Providers to Adopt More Cloud Native Solutions and Ensure Compliance with Cloud Native Security Framework

To raise awareness of Services 4.0, initiatives should be designed to empower service providers who are motivated to adopt Cloud Native solutions.
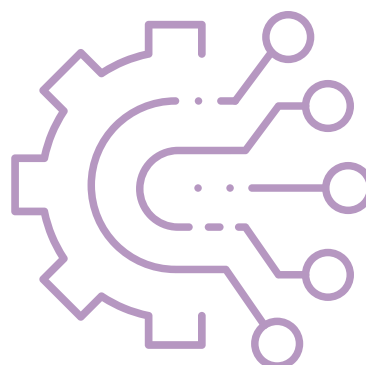
The initiatives would help them share information, resources and/or infrastructure. They will also kick-start pilot experiments, and generate iconic use cases to lead the industry by example, and in turn, catalyse demand for Services 4.0.

In addition, Cloud Native Security Framework should be established to address the cyber security concerns that were amongst the biggest barriers for enterprises to adopt a Cloud Native approach.

② Integrating Ecosystems

2A. Develop Seamless Services Across Sectors and Enterprises by Taking an Ecosystem Approach

Service providers should be encouraged to adopt an ecosystem approach for Services 4.0. Through this approach, they could leverage digital platforms to provide omni-channel, end-to-end and seamless experience to the customers. The focus will be more on how to meet the changing customer needs rather than just providing one-channel, one product or service experience. Establishing cross sector platforms could be explored to help reduce friction for both B2B and B2C service providers when providing Services 4.0 via digital ecosystems.

③ Industrialising Digital

3A. Government to Catalyse Build-up of the Cloud Native Architecture

Government should roll out initiatives to build the supply capacity of Cloud Native Architecture. For example, Singapore currently has API Exchange (APEX) under GovTech as an API gateway for data sharing across the government. Data.gov.sg as Singapore's one stop data portal has also enhanced the government's open data efforts. These platforms can be made part of the Cloud Native Architecture for ICM solution companies to build innovative emerging technology solutions for government or non-government usage.

It is important that appropriate awareness be put in place to increase adoption of these tools amongst the ICM solution companies.

3B. ICM Solution Companies will Need to Adopt and Deliver Cloud Native Solutions, and Comply with Cloud Native Security Framework

Adoption of the Cloud Native Architecture can be increased provided Singapore's ICM solution companies can design, develop and deploy Cloud Native solutions effectively for their clients.

A targeted programme with support services should be provided to both LLEs and SMEs in Singapore. Being early adopters of emerging technologies and Services 4.0-ready will empower them to expand their market reach internationally.

ICM solution companies should deliver Cloud Native solutions while ensuring that their solutions address cyber security concerns. The general cyber security awareness of the local population is still relatively low in Singapore. This is especially true for general citizens and SMEs who may not take a proactive approach to ensure protection from cyberattacks. Therefore, ICM solution companies should be motivated to comply with Cloud Native Security Framework where they can proactively think about addressing cyber security issues in their product development, service delivery, and maintenance and operations of their solutions to their clients.

Across the four enablers of the Digital Economy Framework for Action, the following recommendations should be considered:

1. Talent

1A. Train Developers to Create Solutions Based on the Cloud Native Architecture and DevOps/Agile Methodologies

To build awareness and capability in adopting the Cloud Native Architecture, developers would benefit from training in related topics such as development methodologies as well as, DevOps practices and tools. The training could be oriented towards both technical and business aspects, and done in partnership with global and local technology leaders to build on their expertise.

1B. Continue to Develop Emerging Technology Programmes for Students

To nurture talent in the field of emerging technologies, Singapore should develop targeted talent development programmes in science, technology, engineering and mathematics.

First and foremost, Singapore could develop a cloud platform that provides students with the tools to develop component services, making emerging technologies accessible for young talent.

Secondly, Singapore could develop dedicated training programmes and competitions that encourage students to develop emerging technology solutions.

1C. Provide Support Programmes to Workers to be Confident and Capable of Using Augmentation Technologies

In the era of the augmented workers, workers should understand that they would not be replaced by technology, but rather they would be augmented by technology. Their roles, in fact, will be enhanced, not diminished.

Targeted adoption programmes could be designed to train workers in order to effectively incorporate augmentation technologies into their work.

Singapore should continue to invest in the development of competency centres by partnering with technology leaders from across the globe, as well as local technology firms.

These centres provide an environment where workers can gain access to emerging technology tools and solutions, enabling them to learn and institutionalise the augmentation technologies into their work.

The centres could also connect workers with technology firms through an external internship programme where workers are placed in a technology company for a period of time. The training would allow them to gain hands-on experience in using emerging technologies which increases their ability to apply these tools at work. In addition, the competency centres could also provide micro-degrees and certification programmes to standardise skill sets and build a competitive workforce.

2. Research and Innovation

2A. Invest in Human-Machine Augmentation Technologies

Significant improvements in productivity can be achieved by encouraging the usage of human-machine augmentation technologies. Furthermore, these technologies will also help in creating new and innovative services, and build a competitive workforce. As such, Singapore should continue to invest in building local capabilities in such technologies by investing in R&D efforts, and attracting investments from local and international private sector entities.

As Singapore is a regional data hub with large volumes of data passing through, privacy engineering is another area that would enable collaboration between industry and the research community. This will require support from research institutes and the collaboration of industry to find commercially viable solutions to address today's data privacy challenges.

In addition, there should be initiatives to encourage multi-disciplinary research capabilities to realise the benefits of technology convergence. Multi-disciplinary research will also enable an infusion of technology in the creative realm of services (e.g. technology in design, arts and literature) as well as strengthen the social and ethical boundaries of emerging technologies such as ethical AI.

2B. Develop Iconic Projects around Application of Emerging Technologies

As Singapore envisions itself to become a Services 4.0 hub, the nation should develop iconic projects that apply emerging technologies to solve challenges relevant to both Singapore and the global economy. For example, applying emerging technologies to solve challenges such as developing sustainable cities, affordable and clean energy, as well as public health and well-being. Successful development of these iconic projects will generate momentum among stakeholders to adopt emerging technologies and will attract global investments into Singapore.

2C. Provide Virtual Innovation Labs to Spur Innovation

The virtual innovation lab would provide a sandbox environment for experimentation by service providers and developers. The developers would be able to co-develop and peer-review emerging technology projects across multiple applications and use cases in an online or virtual context. This collective approach allows companies to combine resources, transfer knowledge, develop products and solutions and nurture capabilities in applying emerging technologies.

The platform could:
- Be a showcase of local R&D and intellectual property
- Be a venue for ideation and innovation
- Be a provider of consultancy and experimentation services
- Offer commercialisation opportunities for R&D projects
- Be a platform for networking and business matchmaking

3. Policies, Regulations and Standards

3A. Continue to Review Regulations to Facilitate Frictionless Data Flow

The success of Services 4.0 and the Cloud Native Architecture hinges on the willingness and ability of players to share data in the ecosystem. Both multilateral (where multiple providers and users of data come together through a common platform) and bilateral (where two willing players share data for mutual benefits) data would need to be considered.

More importantly, the issue of trust would need to be addressed. This is especially true in the private sector space where data is considered a competitive advantage, and hence Singapore would need to continually review policies that would impact the exchange of data.

Data sharing across sectors should be fostered. Initiatives could include developing common data sharing frameworks, instituting standard guidelines and agreement principles that stakeholders can refer to, formulating support programmes to push organisations to become more data-driven both internally and with their stakeholders, and developing data exchange platforms aligned to the Cloud Native Architecture.

3B. Continue to Establish Singapore as a Trusted Hub for Cross-border Data Flow and Collaboration

Singapore announced a new council in June 2018 to advise on the ethical use of emerging technologies such as AI and data. Similar programmes should continue to be rolled out to bolster Singapore's image as the trusted hub for cross-border data flow. Singapore should also continue to actively collaborate with regional and international councils, to develop common data sharing standards and platforms to allow cross-border data flow.

3C. Establish Standards to Support the Cloud Native Architecture

There are several standards available globally for developing the Cloud Native Architecture. It might be daunting for players to decide which standard best suits their needs. The choice becomes even more difficult because of the very dynamic nature of emerging technologies housed within the Cloud Native Architecture. To overcome this, Singapore should continue exploring ways to improve awareness of the various international standards for Cloud Native. Areas where standards can be explored include: application definition, orchestration, composite definition application, resource scheduling, distributed systems and infrastructure provisioning. More importantly, understanding of API standards should be provided to the stakeholders as API is one of the tenets of the Cloud Native Architecture.
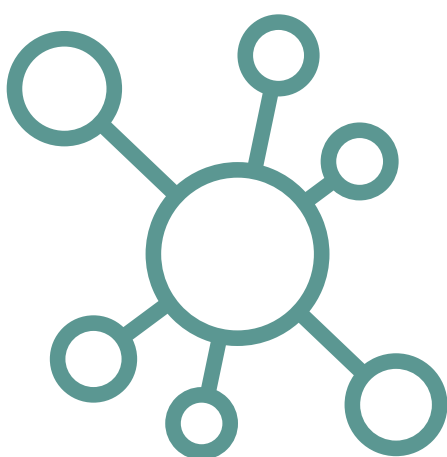
3D. Continue to Review Policies to include New Areas in Development of Emerging Technologies

As regulatory uncertainty is becoming a key barrier to the adoption of emerging technologies, the role of government as an ecosystem builder, especially in terms of regulations and standards, becomes increasingly important. The government should continue to review relevant policies to establish a favourable ecosystem for development, as well as adoption of emerging technologies. For example, in blockchain technology, the formation of a multi-stakeholder blockchain governance think tank with multidisciplinary skill sets (e.g. technical, legal and regulatory expertise) could be considered to examine the legal and regulatory challenges for blockchain adoption and implementation in Singapore.

4. Physical and Digital Infrastructures

4A. Build Physical Infrastructure to Facilitate Adoption of Emerging Technologies

Communication infrastructure will remain the foundation for emerging technologies. 10G and other high-speed fibre infrastructure will thus be central to support the vision of a Services 4.0 Hub.

Currently, adoption of emerging communications technologies like 10G is not widespread among enterprises. Intervention programmes should be formulated to make 10G affordable to catalyse digital transformation in enterprises.

As use cases for ultra low latency mobile networks, such as "intelligent edge", "intelligent cloud" and "tactile internet", emerge and become increasingly relevant, 5G technologies are expected to experience more testing and greater adoption.

4B. Invest to Increase Capacity and Capability of Data Centres and Hyperscale Computing

Cloud Native Architecture will demand increased capacity and computing power. This, in turn, will create a pressing need for more sophisticated data centres.

Initiatives such as high rise and floating data centres could mitigate Singapore's land scarcity and hot climate. Data centres built on hyperscale computing architecture would be another area of focus to meet the surge in demand.

Additionally, Multi-Cloud environment will require greater interconnectivity between cloud platforms, thus fuelling a demand for both high bandwidth and low latency communications between data centres.

4C. Catalyse the Development of As-a-service Platforms

Core to the Cloud Native Architecture will be the proliferation of as-a-service platforms to improve access to emerging technologies. For example, AI-as-a-service will servitise AI solutions, so that they are made easily accessible to enterprises and consumers for augmenting their on-premise deployments. Similarly, Immersive Media and Advanced Interface-as-a-Service could democratise access to IMAI technologies. Future-Ready Systems-as-a-service, comprising advanced computing architecture, would enable component services to be made available for further development of Intelligent-Machine, Machine-Machine and Human-Machine systems.

4D. Enable a Services 4.0 Marketplace

To promote the adoption of Cloud Native Architecture, a marketplace could be established.

Serving as an API directory to discover relevant component services, the marketplace will make emerging technology solutions easily accessible by those who need it.

As the usage of component services become commonplace, the cost of deploying emerging technologies in new products and solutions may reduce. This would catalyse the adoption of Cloud Native Architecture and spur innovation.

4E. Comply with Cloud Native Security Framework

Security is a key barrier to the adoption of the Cloud Native Architecture. To mitigate this barrier, players in the ICM ecosystem will need to work together to develop and adopt cyber security solutions suited for the Cloud Native Architecture.

A robust framework would need to be established to guide the industry towards this goal. The framework should let the stakeholders assess the key problems that need to be solved for Cloud Native-related cyber security issues, inform them about the various Cloud Native security standards and direct them to competent cyber security providers. The framework could also be a playbook for the best practices in developing and deploying cyber security components services.

Some of the technology aspects that could be considered in this framework are:

• Promote the availability of cloud-delivered application security

• Promote the provision of Identity, Authentication and Access services via the Cloud Native Architecture

• Promote cloud security orchestration

• Provide a common marketplace that will make it easy and intuitive for companies to develop and adopt cyber security solutions

APPENDIX 1:

Brief Description of Selected Big Shifts

1. *Technology will develop rapidly* – The technologies that are in focus have a unique characteristic. They are exponential in nature. The power and/or speed of these technologies can double every year and/or the costs drop by half. The nine technology trends highlight the impact of a few of these exponential technology trends.

2. *Empowerment* – In today's society, it's about the individual over the collective. Fuelled by individual empowerment and access to information and communication technologies the world is seeing a rise of empowerment driven ideology as people and communities seek dramatic change from the status quo. As individuals engage increasingly over social networks due to the proliferation of ICT, networks of ideological thinkers are no longer constrained by proximity and are able to grow exponentially with new followers who seek sources of insight online.

3. *Hyperconnectivity* – The ability to constantly connect and communicate, whether it be by text, video, or email, has become so routine, and this is not limited to human interactions. As the world gets more integrated, collaborative, and connected, hyperconnectivity is the new way of life. Everything is communicating with each other: humans to humans, humans to machines, and machines to machines.

4. *Disengagement* – The advent of digital has created incredible impacts in connecting people across the globe, but often at the expense of face-to-face interpersonal interaction. On the one hand, new friendships and relationships are explored through the rise of networking and social platforms. Connections are made where previously serendipity was the medium of choice. On the other hand, interpersonal disintegration seems to prevail. Instead of discourse at a dinner table, the glow of smartphones illuminates diners' faces. Furthermore, the reliance on platform-based technology has generated interesting implications on development psychology. Attention spans are shorter, retention has diminished and customer loyalty is becoming increasingly difficult.

5. *Dematerialisation*[57] – The phrase coined by Robert Tercek describes the shifting consumer preference for physical products (e.g. consumer electronics and fixed media) to software-enabled services like streaming audio. Access is becoming more important than ownership of materials. Dematerialisation is not restricted to consumer goods but moving up the value chain to transform the corporate environment.

6. *Growing Migration* – Urbanisation is a leading factor affecting the mass migration of particular socio-economic groups, leading to the movement of people, ideas, and challenges across the globe. Immigration, border migration, demographic changes, and increases in refugees are causing massive demographic shifts, affecting cultural assimilation, integration, and economic development. Regulatory and societal structures, and politics are challenges by growing mass migrations, but this also brings about the benefits of cultural diversity and thought exchange.

7. *Blurring Boundaries*[58] – Long-standing boundaries and constraints that have traditionally determined the evolution of business are dissolving, allowing new ecosystem possibilities to flourish. Few would dispute the central importance of digital technology as the key source of change. Industries and sectors have been converging, boundaries between and within firms have been weakening, the old distinction between products and services are breaking down, and the gaps between capabilities and influence of large and small organisations are declining.

8. *Sharing Economy* – In the last few years, companies in the sharing economy have been transforming 'traditional' business sectors, most notably hotels and transport. Worldwide investments in sharing economy startups are increasing each year, with US$12 billion being invested so far[59]. The concept of the sharing economy is impressively simple: anything that is not being used can be rented out. Direct contact between the supplier and the customer is established via an online platform.

9. *Knowledge Worker*[60] – Online talent marketplaces and emerging technologies are changing how companies find and engage talent. To stay competitive, firms need to embrace the future of knowledge work. The emergence of new ways of reaching and engaging workers, and the automation of knowledge work by means of AI and other technologies, are changing the way knowledge work gets done in organisations.

APPENDIX 2:

Acronyms

AI	Artificial Intelligence
AR	Augmented Reality
API	Application Programming Interface
B2B	Business-to-Business
B2C	Business-to-Consumer
CAGR	Compound Annual Growth Rate
GDP	Gross Domestic Product
IDP	Industry Digital Plan
IT	Information Technology
ITM	Industry Transformation Map
ICM	Infocomm and Media
ICT	Information and Communications Technology
IoT	Internet-of-Things
IMDA	Info-communications Media Development Authority
IMAI	Immersive Media and Advanced Interfaces
Intra-B	Intra-Business
LLE	Local Large Enterprise
SDE	Services and Digital Economy
SME	Small and Medium-sized Enterprise
VR	Virtual Reality
XaaS	Everything-as-a-Service

APPENDIX 3:

Singapore Case Studies on Services 4.0

DBS – Enhancing Customer Experience by Evolving the Call Centres

DBS customer call centres handle several million calls each year, and the bank decided to look into using technology to improve customer experience and operational efficiency.

As a first step, DBS used call predictions to pre-empt the nature of customers' calls to their customer service officers (CSOs). By analysing patterns of recent incidents faced by the customers, DBS was able to predict the nature of the calls and quickly identify all relevant information without requiring the customers to provide any information. The CSOs were thus able to reduce call handling time, and offer quicker resolutions to the customer's problems.

To further enhance customer experience, DBS also looked at achieving 'Zero Contact Resolution' by using call prediction to reach out to customers even before they contact DBS call centres. To achieve this, the bank analysed customers' behaviours and key events to redesign processes and measures for reaching out to customers proactively. For example, in the event a customer encountered a failed transaction because their new credit card was not activated, DBS' call engine would pick up the incident, pre-emptively send an SMS to inform the customer of the reason of failure, and propose steps to resolve the issue. The customer could then follow the steps and retry the transaction without needing to call the CSOs.

Moving forward, DBS will be looking at using call prediction to intercept customers and direct them towards digital solutions. Through the use of analytics, guided conversations and chatbots, DBS will be able to customise their digital service to each customer. Customers who choose to adopt DBS' digital services will find that they can easily access a whole array of services and any issues they face can be resolved effortlessly and quickly.

The journey towards digitalisation for DBS' call centres helps the bank meet increasing demand for better customer experience. By employing analytics, DBS can create a more effective and targeted customer service, and the use of chatbots and guided conversation help automate and streamline real-time interactions with customers, as well as keep service delivery seamless and available 24/7.

Source: IMDA

DBS – Journey to Cloud

With growing business volumes and digitalisation, DBS' computing workloads have doubled in the last three years and will continue to see significant growth. Customers were also becoming more digitally savvy and demanded digital services. The growth of new digital platforms were also a rising threat to DBS as more players moved into payment spaces.

By adopting cloud technology, DBS was able to make the leap forward in terms of mobility, efficiency and productivity. The benefits of cloud were achieved at three levels—hardware, software and people.

While traditional servers required physical hardware that took up space, adopting cloud technology allowed DBS to scale up easily without being dependent on available space. DBS also no longer needed to have on hand physical spare servers to cater to periods of peak demands. For software, DBS was able to tap on open-source software instead of enterprise software. As such, the bank was able to buy on a per-need basis. Finally, moving to cloud had reduced the human resource required to set up servers. Submission of server requirements could be done via a web application, and approvals were automated.

With the move to cloud, DBS was able to enjoy up to 7.1x cost savings on hardware, 7.8x on software and 5.8x on labour. It allowed DBS to be more agile and to scale easily with demand. It also reduced the bank's dependency on physical space as well as brick and mortar outlets. Its services, such as DBS PayLah!, had since been cloud-hosted and are now available to customers for use 24/7, while other apps like digibank allowed DBS to extend its reach overseas. Business processes were realigned as the cloud became part of the workflow, improving the end-to-end service delivery to meet customers' needs quickly.

Source: IMDA

IRAS

In a bid to redefine the experiences for taxpayers, IRAS embarked on a new transformation movement in early 2016 that leveraged Analytics, Design and Digitalisation (LEA:D). The transformation movement helped IRAS stay relevant in the current environment where rapid technological progress had changed lifestyles, disrupted businesses and transformed business models. The four strategic properties under the LEA:D movement included:

A. Anticipating Needs, Co-Creating and Customising Solutions

With an 'Outside-In' approach, IRAS intensified its efforts to understand taxpayers' needs in 2017. Service design projects were completed for three taxpayer segments covering individuals, property owners and businesses, from which insights were harnessed to develop taxpayer-centric services and solutions that integrated tax into their lifecycles or business operations.

To facilitate co-creation with the software development community for digital tax solutions, IRAS launched the first public API marketplace in March 2017. This was a community platform for software developers to access IRAS' services or data for the creation of tax-related services. IRAS believed that collaborating with developers would enable rapid adoption of APIs and lead to the development of meaningful, effective and taxpayer-centric digital solutions.

API allowed seamless integration of tax into the natural systems of taxpayers. For instance, employers under the Auto-Inclusion Scheme could submit their employees' salary details directly to IRAS via the API service with just the click of a button. Another example was the direct transmission of Goods and Services Tax (GST) returns and transactions listings and seamless ACRA and IRAS filing for small businesses using XBRL.

B. Connecting Digitally

IRAS adopted User Experience Design (UXD) and revamped myTax Portal with Responsive Web Design (RWD) to ensure digital services were kept mobile-friendly. Compared to 30% before the revamp, about 90% of surveyed taxpayers no longer had difficulty accessing IRAS' eServices. In addition to the positive feedback received from taxpayers, the project was also awarded the "GovInsider Innovation Award 2017 for Best Use of UI/UX Design".

Taxpayers could access Virtual Assistant "Ask Jamie" on IRAS website as well as chat with IRAS officers on matters relating to individual income tax, property tax and GST. Since Aug 2018, Ask Jamie had been enhanced via integration with SingPass API to provide case-specific tax advice on assessment status and outstanding tax balance.

C. Using Data Intelligently

IRAS used analytics to sift through collected data to identify meaningful patterns to support decision-making and prioritise its resources. For example, IRAS invested in building Social Network Analysis (SNA) capabilities, which had enhanced its ability to uncover wilful tax fraudsters that seek to conceal their identities behind complex layers of structures and networks.

D. Building an Adaptable and High-Performing Workforce

IRAS took steps to ensure its workforce was future-ready through the use of digital and analytics tools in a highly digital workplace. For instance, IRAS was the first in the public sector to drive the adoption of RPA at an enterprise-level.

Today it has about 50 non-IT users certified as RPA developers who are able to automate manual processes for compliance checks, business processing, procurement services and customer management services in IRAS.

IRAS service officers have also developed new digital capabilities to be able to support digital channels such as live chat, design thinking, developing bot services with intelligent automation, use of data and conversational design skills.

No Need for Service is the Best Service

The service mantra of IRAS "No Need for Service is the Best Service" defined the ultimate goal of enabling taxpayers to meet their tax obligations without requiring their involvement. This ambition reflected the need to go beyond merely converting manual processes to digital services, and to focus on reducing processes that required inputs from taxpayers. The goal was to provide taxpayers with a taxpaying environment that would be fuss-free and low in compliance cost.

With IRAS' continuous efforts in simplifying tax filing, tax season in 2018 was a breeze for taxpayers. The No-Filing Service (NFS), for instance, had rendered annual tax filing a non-event for most personal income taxpayers with 2 in 3 taxpayers not required to file their individual income taxes.

96.5% of taxpayers filed their tax returns on time by 18 Apr 2018, up from 96% the previous year. 780,000 taxpayers, or more than 97% of those who filed their tax returns, did so electronically. About 23% of taxpayers used their mobile devices to access myTax Portal to file or view their tax returns on the go.

80,000 taxpayers received an early or immediate tax bill. This was an ongoing initiative for early finalisation of assessments so that taxpayers could plan ahead for greater certainty of their tax payments. Around 6,000 partnerships filed their Form P early by the end of February 2018. This has enabled more than 12,000 partners to enjoy the convenience of having their partnership income pre-filled by IRAS in their individual income tax returns.

Looking ahead, IRAS will seek ways to provide more customised digital services to bring greater convenience to taxpayers.

Source: IMDA

Janio

Janio was formed in Singapore in early 2018 when a group of young logisticians spotted a gap in the Southeast Asian ecosystem for simple, seamless logistics solutions. It set out to build Asia's leading logistics network by providing an integrated cross-border delivery solution for merchants across the globe. At its core, Janio operates as a technology platform serving some of the biggest e-commerce marketplaces, business owners and logistics partners alike, connecting these key players across Southeast Asia's e-commerce ecosystem. Janio's goal was to create an integrated network that would shrink Asia's supply chain onto a single platform, and become the backbone that would support the region's growing e-commerce environment.

Janio built its business on cloud services. This approach has given it speed and flexibility in its operations. In particular, there were three benefits: The first was the ease of use that was enabled by cloud-based web service that greatly simplified set up and cut down set-up time. The second was rapid development that was brought about by cloud development tool that enabled auto-deployment without disrupting operation. The last—but certainly not the least—was the ability to scale that was enabled by cloud resources that could be sized easily according to order and query loads. Cloud services from Google, AWS, Heroku and Semaphore—just to name a few—supported important functions in Janio's operation pipeline and gave Janio its business cutting edge. As Nathaniel Yim, Chief Marketing Officer of Janio, put it: "Cloud services allowed Janio to launch in just three months, scaling from just ten to thousands of orders per day!"

Source: IMDA

Singtel – Building a digital workforce

As a leading provider of communications solutions and digital services, Singtel continually invests in new technology and deploying them across the business to increase productivity, cultivate innovation and give customers an optimal interaction experience.

Singtel has long been a proponent of automation to drive internal efficiencies and deeper customer engagement. Using RPA, simple and repetitive tasks are carried out by bots or "robo-colleagues".

Since the introduction of its first bot, ATOM, a year ago, Singtel has upskilled its employees and empowered business units to create their own "robo-colleagues". For example, staff developed a telesales bot to help in digital sales, built a digital field assistant to help resolve common technical issues encountered on site, and created a vendors' claim bot to automate claims processing. All of which helped reduce dedicated working hours. This is done by applying strict governance of the bots and proper data security compliance.

To further automate their operations, Singtel created a chatbot, Shirley, with AI cognitive capabilities to handle customers' queries using contextual understanding. While Shirley was initially deployed for relatively uncomplicated interaction with customers, Singtel now plans to use a more advanced version of Shirley to assist its agents in their responses to customers. Programmed with a higher level of cognition, Shirley is able to recommend appropriate responses for the agent to read back to the customer. Shirley has the capacity to keep learning and improving to handle complex queries to provide a faster and better customer service experience.

Digitalising the customers' journey necessarily means that Singtel employees have also embarked on a parallel digital journey where they get reskilled in tandem with the introduction of services deploying emerging and advanced technologies. This has seen a concerted capability training drive in cyber security and data analytics. On the consumer services front, due to the specificity of customer services, employees are often retrained on the job, with those at the forefront of transforming the business taking on the mantle of training their workforce as well to deliver across new customer care channels. Over time, digital has become a new way of working in Singtel, whether improving processes or solving problems. In the case of Singtel's new flagship store which was named the best retail store concept by the Singapore Retailers' Association last September, the benefits of creating an omni-channel experience for customers through live bots, intelligent WiFi queues and crowd analytics have proven tangible. Customer engagement has improved significantly as evidenced by increased customer footfall as well as increased customer experience scores. Automation and digitalisation have also freed up retail staff to upsell and cross-sell services.

These results have helped persuade and motivate Singtel employees to keep on digitalising. At the end of the day, however, they are also well aware of the company's belief that the success of automation and digitalisation will always rest squarely on the workforce. Algorithms and technology are important, but it is people who ultimately create and manage the business processes that will determine how quickly companies can transform themselves to stay relevant to customers.

Source: IMDA

Amy and Eve – UOB's Two New Virtual Employees

With the onset of the digital revolution, global banks began to seek ways to create new products and services for digitally savvy customers, as well as to achieve greater productivity, efficiencies and cost savings.

To achieve this, UOB developed two new virtual employees, Amy and Eve, through the use of RPA. Amy and Eve were the bank's first robots, and were assigned to support teams in the Wholesale Banking and Retail businesses.

Attached to the Trade Finance Operations function, Amy helped to process requests for Letters of Credit by extracting a wide range of data and entering it into the Finance of International Trade Automated System. This was then passed on to another colleague for approval. With Amy, the bank had managed to reduce a task that used to take 240 seconds, 12 screens, and multiple cross-checking to only 40 seconds to complete.

Eve, on the other hand, helped in the Unsecured Loans Processing function for processing requests for credit card applications. Her responsibilities included looking through information on a customer's Central Provident Fund statement to compute their annual income. This was then provided to her colleagues to approve the application. Eve was able to manage up to 1,800 applications a day, and could process it 3.5 times faster than others previously assigned to this repetitive task.

By integrating technology into the workforce, UOB was able to increase the speed and accuracy of such transactions while maintaining a human touch when providing services to customers. Moreover, with Amy and Eve handling repetitive and time-consuming tasks, UOB employees could focus on more challenging and fulfilling roles. With such benefits, the bank plans to continue introducing more robots to manage other processes relating to card operations, cash management, and trade and remittance in the future.

Source: IMDA

Osome

Osome is a business in Singapore that provides online incorporation, secretarial, accounting and other services. Helmed by serial entrepreneurs who are well versed in launching new businesses, the company aimed to serve businesses that wanted to outsource processes to a convenient, reliable counterpart. As of January 2018, Osome had over 600 customers.

By combining AI and human intelligence to work in the most efficient and seamless manner, Osome streamlined the process of incorporating a company, reducing the usual time taken to as little as 38 minutes. A chatbot acted as the first line of contact while other robots filled forms, sent requests to ACRA and tracked deadlines. This allowed the firm's certified secretaries and accountants to focus on customer queries, provide guidance and tailor solutions.

Osome's key selling point was that they could help save customers' time. Osome's services were available 24/7 online, which allowed customers to process invoices and make enquiries on weekends or even late at night, and receive answers within 15 minutes. Osome could be assessed on desktops and mobile devices, which made it easy to manage company administration on the go. Furthermore, there was no need for meetings or paperwork as everything was signed, processed and paid electronically.

There were two sides to Osome that fuelled its rapid growth: the front-end which consisted of a great user experience driven by product design and its agents' passion, and the back-end comprising of a carefully thought-out architecture. Osome had built cloud-native applications exclusively using Amazon AWS that enabled a scalable, reliable and secure infrastructure straight out of the box. And external APIs (from Google, IBM, Xero, etc.) allowed Osome to quickly deliver some very complex features, powered by cutting-edge technologies such as AI and OCR.

Osome's passion lay in creating solid products that offers great user experience, products that customers would recommend to friends. To achieve that, they anticipated the customer needs and provided simple, easy-to-use solutions. But harnessing the best technologies alone would not have been enough. It needed the right people to make it work. The agents' passion for delivering the best services to customers was what completed the whole Osome experience.

Osome relies on partners like accounting systems, government services from ACRA to MOM—which it connected through APIs—to offer Services 4.0 to their customers. Osome focused mostly on the 'last mile' services, which meant that to sustain the high level of automation and quality, Osome needed to rely on a strong ecosystem of services that had been developed with a Services 4.0 framework in mind.

Source: IMDA

APPENDIX 4:
Steering Committee and Technical Committee Members

Steering Committee Members

Mr. Tan Kiat How (Co-Chair)	Chief Executive, Infocomm Media Development Authority
Ms. Wu Choy Peng (Co-Chair)	Chief Technology Officer, GIC Pte Ltd
Mr. Lim Tuang Liang	Executive Director, National Research Foundation Singapore (NRF)
Dr. Lim Keng Hui	Executive Director, Institute of High Performance Computing (IHPC), Agency for Science, Technology and Research (A*STAR)
Mr. Chan Cheow Hoe	Government Chief Digital Technology Officer/Deputy Chief Executive, Government Technology Agency
Mr. Cheong Chee Hoo	Chief Executive Officer, DSO National Laboratories
Mr. Leong Keng Thai	Deputy Chief Executive, Infocomm Media Development Authority
Mr. Teo Chin Hock	Deputy Chief Executive, Cyber Security Agency
Mr. Ravinder Singh	President, S T Engineering Electronics Ltd
Ms. Teo Lay Lim	Senior Managing Director, Accenture Pte Ltd

Steering Committee Members

Mr. Chua Joo Hock	Managing Partner, Vertex Ventures SEA
Ms. Janet Young	Managing Director, United Overseas Bank Limited
Mr. Caesar Sengupta	Vice President, Google Singapore
Mr. Paul Cobban	Chief Data & Transformation Officer, DBS Bank
Mr. David Morrison	Director, Chief Technology Officer, Huawei Technologies (Singapore) Pte Ltd
Mr. Yap Chee Yuen (Co-Chair of Technical Committee)	Chairman, IT Standards Committee, c/o Infocomm Media Development Authority of Singapore
Mr. Philip Heah (Co-Chair of Technical Committee)	Assistant Chief Executive, Technology and Infrastructure Group, Infocomm Media Development Authority

Technical Committee Members

Mr. Yap Chee Yuen (Co-Chair)	Chairman, IT Standards Committee, c/o Infocomm Media Development Authority of Singapore
Mr. Philip Heah (Co-Chair)	Assistant Chief Executive, Technology and Infrastructure Group, Infocomm Media Development Authority
Mr. Paul Cobban	Chief Data & Transformation Officer, DBS Bank Ltd
Mr. Ni De En	Director, National Research Foundation Singapore
Mr. Ling Keok Tong	Director, Infocomms & FoM, Agency for Science, Technology and Research (A*STAR), Science & Engineering Research Council (SERC)
Mr. Foong Sew Bun	Deputy Chief Executive, Government Technology Agency
Mr. Joshua Koh	Chief Executive Officer, Commune Lifestyle Pte Ltd
Mr. Lee Fook Chiew	Chief Executive Officer, The Institute of Singapore Chartered Accountants (ISCA)
Ms. Pang Mei Yee	Vice President, DHL Supply Chain Singapore Pte Ltd
Mr. Dexter Teo	Executive Director, IPOS International Pte Ltd
Dr. Sun Sumei (Co-Chair of Workgroup 1)	Head of Communications & Networks Cluster, Institute for Infocomm Research, Agency for Science, Technology and Research (A*STAR)

Technical Committee Members

Mr. Mark Chong (Co-Chair of Workgroup 1)	Group Chief Technology Officer, Singapore Telecommunications Ltd (Singtel)
Professor Wolfgang Müller-Wittig (Co-Chair of Workgroup 2)	Executive Director, Fraunhofer Singapore
Mr. Glen Francis (Co-Chair of Workgroup 2)	Chief Technology Officer, Singapore Press Holdings
Professor Lam Kwok Yan (Co-Chair of Workgroup 3)	Programme Chair (Secure Community), Graduate College Professor of Computer Science, School of Computer Science and Engineering, Nanyang Technological University (NTU)
Mr. Lin Yih (Co-Chair of Workgroup 3)	Director, Digital Applied Research & Technology Pte Ltd (DART)
Professor Steven Miller (Co-Chair of Workgroup 4)	Vice Provost, Singapore Management University
Dr. Tan Geok Leng (Co-Chair of Workgroup 4)	Chief Executive Officer, AIDA Technologies Pte Ltd
Professor Lawrence Wong (Co-Chair of Workgroup 5)	Deputy Director, Smart Systems Institute, National University of Singapore (NUS)
Mr. Leong Mun Yuen (Co-Chair of Workgroup 5)	Senior Advisor & SVP, ETPL

APPENDIX 5:
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#SGDIGITAL

Singapore Digital (SG:D) gives Singapore's digitalisation efforts a face, identifying our digital programmes and initiatives with one set of visuals, and speaking to our local and international audiences in the same language.

The SG:D logo is made up of rounded fonts that evolve from the expressive dot that is red. SG stands for Singapore and :D refers to our digital economy. The :D smiley face icon also signifies the optimism of Singaporeans moving into a digital economy. As we progress into the digital economy, it's all about the people - empathy and assurance will be at the heart of all that we do.

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