

CO-CREATING THE FUTURE

INFOCOMM TECHNOLOGY
ROADMAP 2012

the first 1000 years of the 20th century. The first 1000 years of the 20th century were marked by a period of rapid technological change and innovation, which led to the development of many new technologies and industries. This period was also characterized by a period of rapid population growth and urbanization, which led to the development of many new cities and towns. The first 1000 years of the 20th century were also marked by a period of rapid social and cultural change, which led to the development of many new social and cultural movements and ideas.

The first 1000 years of the 20th century were also marked by a period of rapid economic change and growth, which led to the development of many new economic systems and structures. This period was also characterized by a period of rapid technological change and innovation, which led to the development of many new technologies and industries. The first 1000 years of the 20th century were also marked by a period of rapid social and cultural change, which led to the development of many new social and cultural movements and ideas.

The first 1000 years of the 20th century were also marked by a period of rapid economic change and growth, which led to the development of many new economic systems and structures. This period was also characterized by a period of rapid technological change and innovation, which led to the development of many new technologies and industries. The first 1000 years of the 20th century were also marked by a period of rapid social and cultural change, which led to the development of many new social and cultural movements and ideas.

The first 1000 years of the 20th century were also marked by a period of rapid economic change and growth, which led to the development of many new economic systems and structures. This period was also characterized by a period of rapid technological change and innovation, which led to the development of many new technologies and industries. The first 1000 years of the 20th century were also marked by a period of rapid social and cultural change, which led to the development of many new social and cultural movements and ideas.

The first 1000 years of the 20th century were also marked by a period of rapid economic change and growth, which led to the development of many new economic systems and structures. This period was also characterized by a period of rapid technological change and innovation, which led to the development of many new technologies and industries. The first 1000 years of the 20th century were also marked by a period of rapid social and cultural change, which led to the development of many new social and cultural movements and ideas.

CO-CREATING THE FUTURE

Foreword	02
The Changing World – Global Trends Redefining Our Landscape	03
Overview of ITR – Methodology and Overview of the Nine Themes	05
Executive Summary of Nine Themes	
Big Data	08
Cloud Computing	10
Cyber Security	12
ICT and Sustainability	14
Comms of the Future	16
Social Media	18
New Digital Economy	20
User Interface	22
Internet of Things	24
Conclusion	27
Reference	28
Acknowledgement	29



Foreword

Information Technology has significantly changed how we work, play, live and socialise. Communications has also made the world much smaller, giving us almost real-time updates to information globally, wherever we are and whenever we want it. Since our last Infocomm Technology Roadmap (ITR) in 2005, we have experienced the age of mobility, the social age and the consumerisation of Infocomm. Looking at the rapidly evolving technologies in the next three to five years, we decided that it was an opportune time to embark on our ITR 2012.

The ITR journey is a co-creation process involving many people, including colleagues from the government sector, leaders in the private industry and the broader community. We have identified nine key technology themes – Big Data, Cloud Computing, Cyber Security, Internet of Things, ICT and Sustainability, Communications of the Future, Social Media, New Digital Economy and User Interface – that we foresee will impact the adoption of Infocomm Technology over the next 3-5 years. We believe it is vital for organisations to understand where the technologies are heading, so that we can stay ahead of the infocomm innovation and adoption curve and find ways to harness infocomm technologies for optimal effectiveness and impact.

In line with this, we held the ITR 2012 Symposium in August 2012 to facilitate discussion on the technologies and the innovation opportunities outlined in the roadmap. Through this engagement, we were able to tap on the invaluable industry insights, experiences and feedback from the community to improve the roadmap and develop a shared technology vision.

The report was open for public consultation and we received very good response. The feedback has been integrated into the final version of the ITR 2012 report, available on our website at <http://www.ida.gov.sg/technologyroadmap>.

In this handbook, we are providing an executive summary of the themes captured in the ITR and their respective market trends, adoption enablers and inhibitors. While it is by no means comprehensive, we hope that it can act as a guide to help you and your organisation understand and navigate the infocomm landscape, to create value for your organisation, your customers and your stakeholders.

As we work towards promoting innovation and infocomm adoption across the people, private and public sectors, I would like to take this opportunity to express my heartfelt appreciation to everyone who is part of this co-creation process. Your inputs have helped us set the stage for the development of Singapore's next national infocomm masterplan.

Leong Mun Yuen
Chief Technology Officer & Senior Director
Infocomm Development Authority of Singapore

The Changing World – Global Trends Redefining Our Landscape

INTRODUCTION

Information and Communications Technology (ICT) encompasses all forms of computer and communications equipment and software used to create, design, store, transmit, interpret and manipulate information in its various formats.¹ ICT, particularly the Internet, has been driving innovation, labour productivity, economic growth and the emergence of new business models. It is also rapidly changing our lives and renegotiating the way we work and play.

The development of the ICT landscape has multiple implications on the economy, and the society at large. It is therefore important for us to understand the development of ICT trends, so that we can utilise technology to our advantage and create a strong foundation for economic growth and better living standards.

Developments in the ICT landscape are altering the way we manage and operate our business activities. The early adoption of emerging infocomm technologies is essential for Singapore to sustain its competitive edge to better exploit business and economic opportunities, while a good understanding of these developments leads to the formulation of effective policies to aid business growth and bolster economic competitiveness in the future. Since 2000, IDA has released five editions of the Infocomm Technology Roadmap (ITR), specifically designed to help the industry stay abreast of future trends and developments. Over the years, the ITR has charted the visions, trends and developments of the ICT landscape in Singapore to keep pace with the evolving global landscape. In addition, the series of roadmaps formed a key input to our next national infocomm masterplan

The series of ITRs has been integral to the success of ICT in Singapore. This edition of the ITR will highlight the possible evolution of key infocomm technologies, as well as, enablers for adoption over the following approximate timeframes: less than 3 years, 3 to 5 years, and 5 to 10 years, with an emphasis on the 3 to 5 year timeframe.

While the ITR aims to provide an outlook of the developments in the ICT sector, it is by no means comprehensive. Instead, the roadmap should be used as a guide to envisage the direction of technological trends and evolution, its enablers and inhibitors to adoption, so that effective strategies can be devised to adapt to landscape changes.

Let us first begin the discussion by looking at some key global driving forces. The knowledge of these global trends is essential in plotting an accurate technology roadmap that takes into consideration our rapidly changing environment, and contextualises the technologies to the consumers.

GLOBAL TRENDS

Ageing Population

This issue of ageing population not only impacts developed countries but also the developing ones. Two main factors, namely increased life expectancy and reduced fertility, are driving this trend. In the past five decades, global life expectancy at birth has risen by almost 20 years, from 46.5 years in 1950-1955 to 66.0 years in 2000-2005.² During the same period, the total fertility rate was reduced by almost 50%, from 5.0 to 2.7 children per woman.¹ In the course of the next 50 years, global fertility rate is predicted to drop to the replacement level of 2.1 children per woman.¹ Furthermore, the ageing population is growing at a rate of 1.9%, higher than that of the 1.2% growth rate of the total population. In the near future, the difference between these two rates is likely to become wider.

Managing the challenges of an ageing population presents new opportunities for ICT. Examples include the use of ICT by the elderly for health monitoring and general wellness, and to support integrated healthcare services in elderly homecare. Assistive ICT technologies to help the elderly meet their visual, hearing, dexterity, cognitive and speech needs will be in demand. They can be built into products, specialty hardware and software to aid the elderly's interactions with the computer.

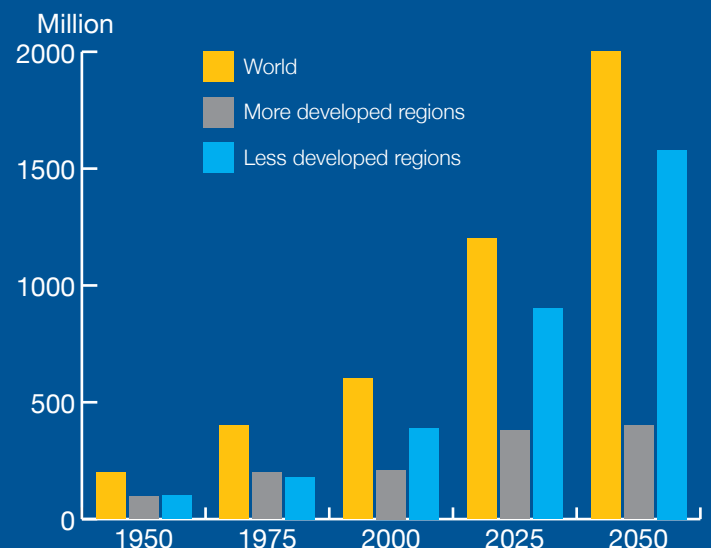


Figure 1: Population aged 60 or over: world and development regions, 1950-2050³

Rapid Urbanisation

With the desire for a better quality of life, rural citizens are moving into cities, thus driving mass urban migration. This puts pressure on the city's limited resources. Cities have to be smarter with integrated infrastructure to optimise resource utility. These networks have to work together seamlessly to automate services and provide greater convenience to citizens. However, the rise of smart cities raises new security and privacy challenges as users implicitly expect systems to be safe. Before smart cities can become a reality, it is important to first put in place transnational authentication systems for citizens and businesses, agreed frameworks for data privacy and the sharing and collection of individual and business data.

“Green” and Sustainability

The rapid urbanisation, increased demand for energy and rapid depletion of resources have resulted in greater awareness of green and sustainable practices. These include alternative energy sources, clean technology, carbon sequestration, carbon credits and recycling programmes. Global companies have also embarked on corporate social responsibility initiatives to improve sustainability. Currently, the ICT sector makes up a significant proportion of total energy consumption worldwide, approximately 5% to 10%.⁴ However, most programs and solutions in sustainability are also supported by ICT infrastructure, which play enabling and integrative roles in reducing power consumption levels. The shift towards electronic delivery of goods and services, for example e-books and video / music streaming, will require less movement of people and objects and thus will result in the consumption of fewer resources and road space.

Social Age

In the Social Age of today, technology users are more connected than before. There exists a class of users, known as Generation C (Gen-C), who have lived their adolescent years after 2000. This is the first generation that has never known a reality detached from the connectivity of the Internet, mobile devices and social networking. By 2020, the Gen-C population is estimated to make up approximately two-fifths of the population in the United States, Europe and the BRIC (Brazil, Russia, India and China) countries, and one-tenth of the rest of the world.⁶ In other words, they will constitute a significant proportion of global consumers.

The new generation's familiarity with technology, their heavy reliance on mobile communications and desire to be constantly connected will re-define inter-personal interactions and the way we work. The increasing connectivity will drive more idea exchanges and accelerate the pace of innovation in the digital world, especially as this generation of users enters the workforce.

Machine-to-machine (M2M) Communications

Internet of Things, the vision of a world where everything and everyone is inter-connected regardless of proximity and location, has garnered much attention in recent years. The main enabler of this vision is aptly known as machine-to-machine (M2M) communications, which is the ability of electronic devices to exchange data with one another. Growth in this sector has been driven by the reduced cost of network and sensors. This lowers the barrier to the installation of sensor networks for real-time monitoring of environmental conditions such as temperature, light intensity and humidity.

Stakes in this new era of hyper-connectivity are enormous. It is estimated that nearly 50 billion devices in the world will benefit from M2M communications by 2020.⁷ This is close to ten times the number of people on Earth. Given the scale and scope of M2M opportunities, organisations are beginning to position themselves for its widespread adoption. In addition, the emergence of faster and more accurate analytics tools adds to the benefits of M2M adoption. By tracking a device through its lifespan, a company can gain a great deal of data and insight not only into the product's performance in different stages, but also into the consumer's needs and behaviours. This intelligence may yield optimised services and solutions for customers and higher profit margins for the companies involved.

Consumerisation of IT

The consumer market has become the main driver of IT innovation, giving rise to the trend of Consumerisation of IT. Unlike the yesteryears where innovations were driven by enterprises, Consumerisation of IT represents a paradigm shift in the ICT landscape. Today, employee-owned technologies are making their way into the workspace. Organisations are beginning to embrace the use of a heterogeneous array of personally-owned devices while recognising and managing the challenges it will bring.

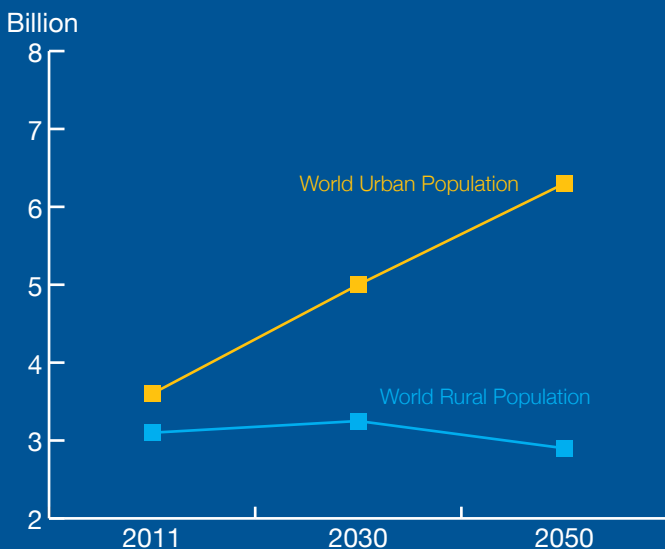


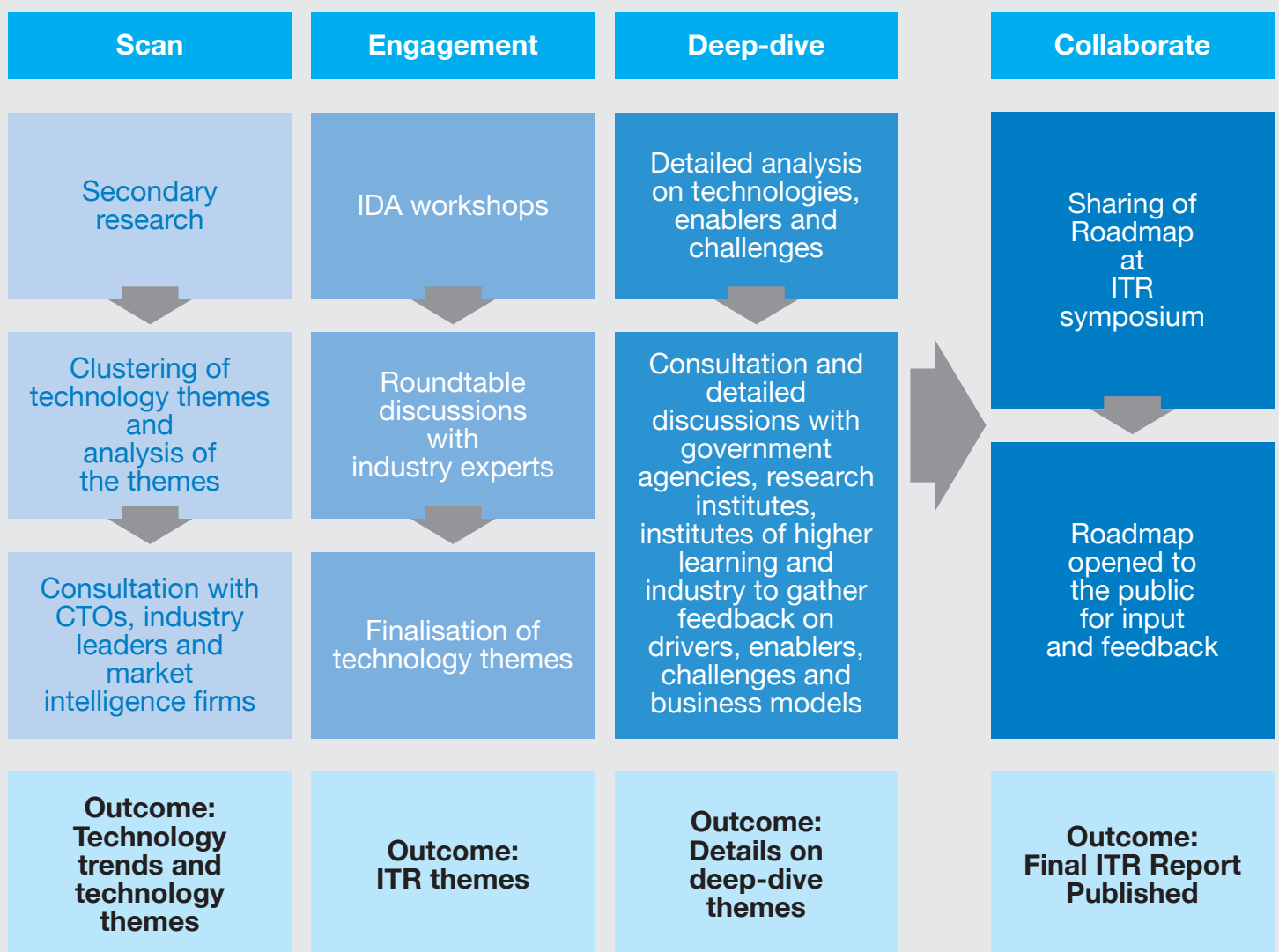
Figure 2: Urban and rural populations, 2011-2050⁵

Overview of ITR – Methodology and Overview of the Nine Themes

This ITR Handbook covers nine key themes that are shaping the ICT landscape. These nine themes are selected due to their importance to the ICT landscape, as well as their potential impact on Singapore’s economy and society.

The ITR adopts a systematic process to ensure that the most relevant themes are selected and presented in this report. The process is broken down into four phases in chronological order, namely ‘Scan’, ‘Engagement’, ‘Deep-dive’, and ‘Collaborate’.

Below is an illustration of the process taken to realise the ITR report.



During the ‘Scan’ process, an objective approach was taken to scan for various indicators of bubbling technology trends in the ICT landscape. A list of important trends and technologies was then compiled. Next was the ‘Engagement’ phase, during which opinions on the shortlisted themes were actively sought from IDA staff and industry experts. After a series of discussions, the nine themes were finally selected. The third stage is the ‘Deep-dive’ phase, during which each theme lead performed an in-depth research of his designated theme and collated feedback from government agencies, research institutes, institutes of higher learning and the industry to gain a deeper understanding of each theme’s impact on the global and local landscape.

We are currently in the ‘Collaborate’ phase. At this stage, the ITR symposium is a platform to share and gather valuable feedback and insights from the public, hence the ITR 2012 motto - “Co-creating the Future”.

The Nine ITR themes

Below are short descriptions of each of the nine themes.

Big Data

Driven by the rapid increase in number of people and devices connected to the Internet, data is growing at a phenomenal rate. The amassed data pool contains hidden insights which give governments and enterprises the opportunity to understand the behaviours and opinions of their targeted interest groups. New technologies have to be adopted to manage the data deluge and extract these insights before more effective business models and policies can be formulated.

Cloud Computing

Cloud computing is an orchestration of various technologies enabling, but not limited to, multitenancy, automated provisioning and usage accounting, the Internet and other connectivity technologies like richer Web browsers to realise the vision of computing delivered as a public utility. Cloud elasticity affects an organisation's bottom line by improving efficiency and influences the topline of the business by allowing low-risk experimentation, innovation, and improving turnaround time. In the long term, IT agility enabled by cloud computing will transform the business landscape.

Cyber Security

Cyber Security is increasingly a pertinent part of our lives as we become ever more connected. With cyber attacks becoming better orchestrated and more sophisticated globally, continuous innovation is necessary to provide a secure environment for individuals and enterprises to operate in. To understand the rapidly evolving landscape of Cyber Security, we must understand potential threats and the emergence and evolution of security technologies.

Internet of Things

The boundary between the physical and the digital worlds is blurring with the prevalence of the Internet of Things (IoT) where potentially billions of objects are connected to the Internet. The pervasive connectivity of these physical objects enables multiple interactions that spur the creation of new intelligent services, improvement in information exchange and enhancement of quality of life.

ICT and Sustainability

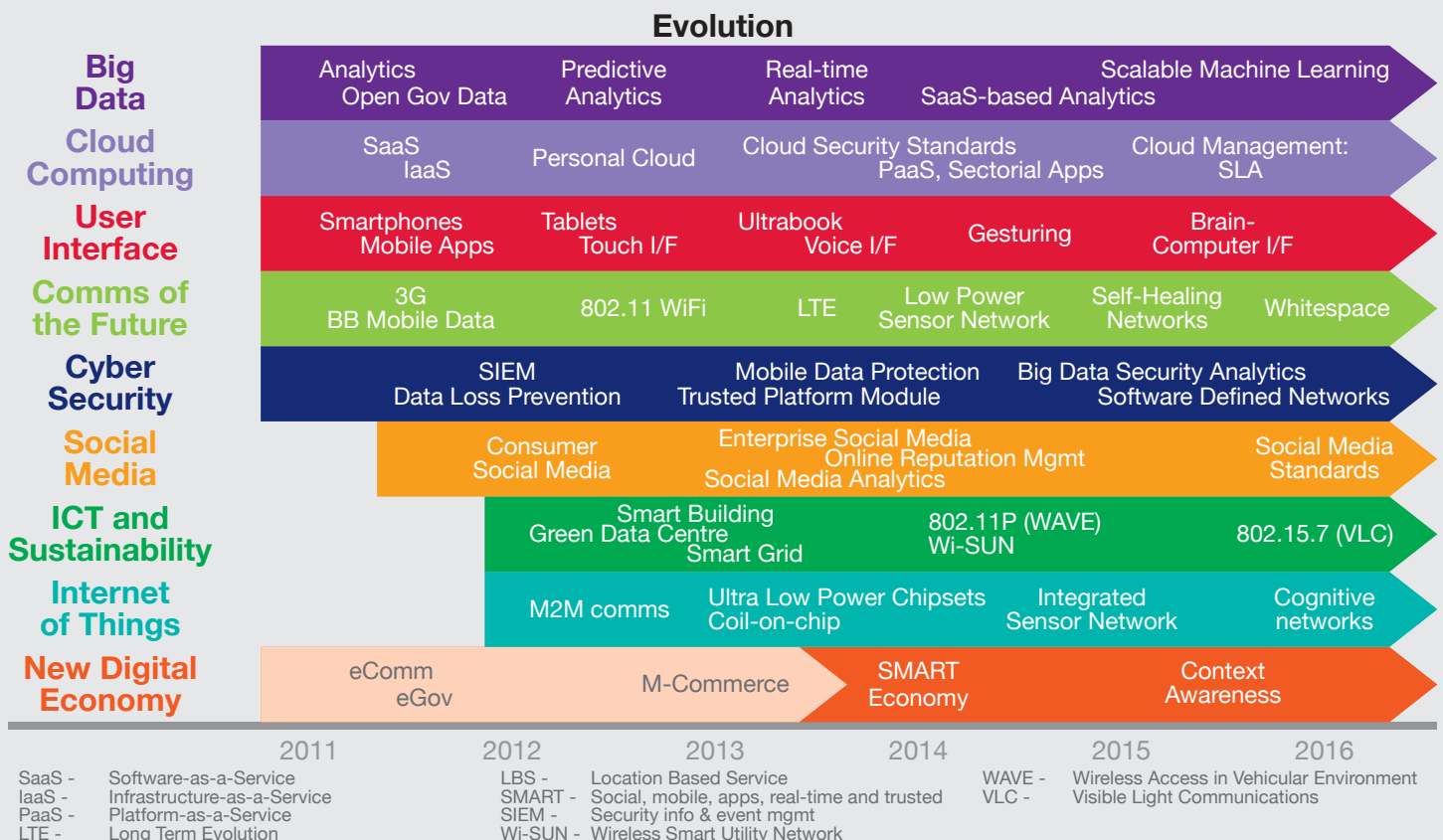
Our actions today will have an impact on the current environment and that of future generations to come. ICT can play an active role in enabling innovations to tackle various sustainability challenges. However, the ICT sector will also need to take actions to minimize its own social and environmental impacts.

Comms of the Future

Convergence is bringing various technologies together, and enabling us to do things beyond our imagination. Communication is no longer confined to traditional voice or data. Mobile devices are empowering individuals to connect anytime, anywhere. The bandwidth of communication networks is also increasing to keep pace with data traffic growth.

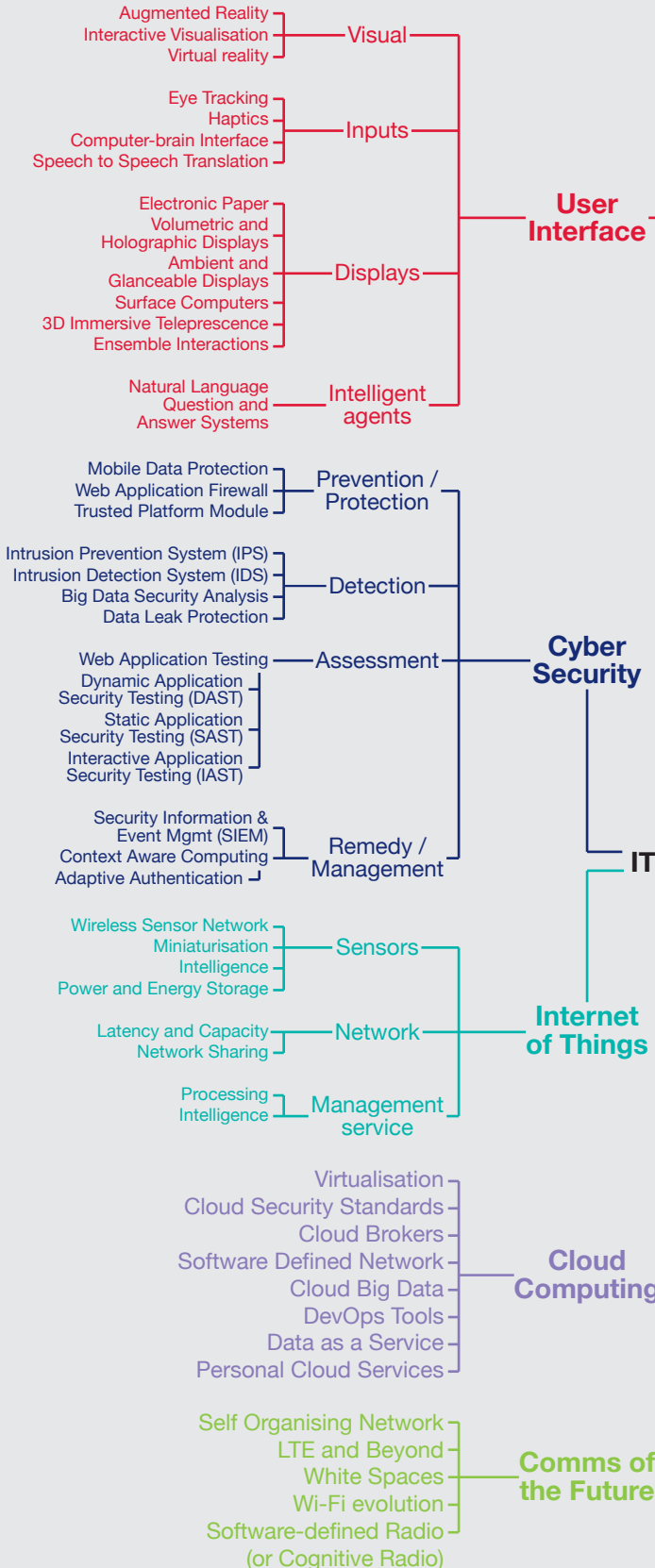
Social Media

A good understanding of the opportunities that arise from the evolution of social media will help organisations to engage the community more effectively and gain useful insights to improve their services or business models. It is thus essential for organisations to learn to tap on and manage interactions on various social media platforms. This will put them in better stead to leverage the power of the masses to extend their influence.



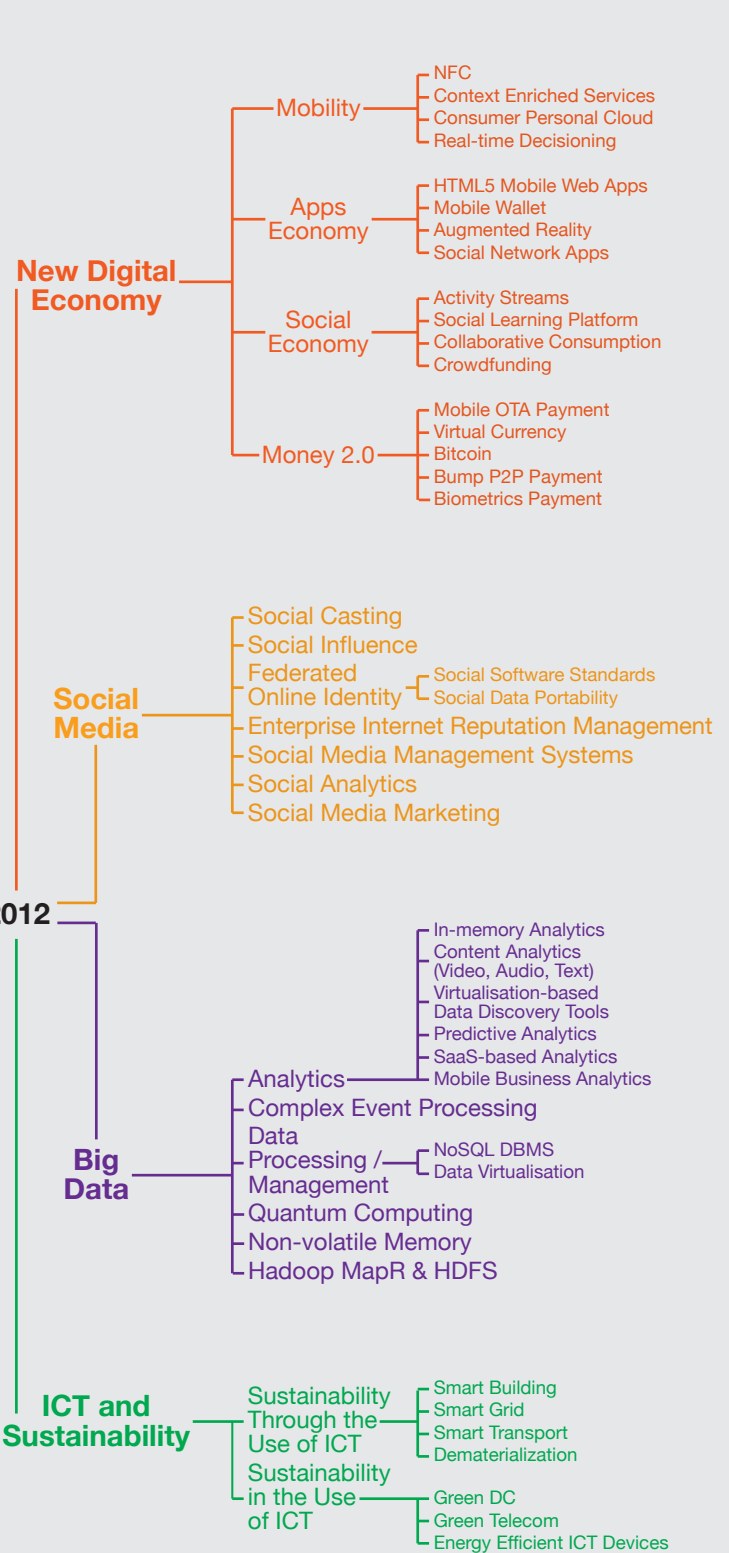
New Digital Economy

With the widespread adoption of social media and mobile technologies, the digital economy has entered a new phase of development, presenting unprecedented opportunities for future growth. These include the provision of direct access to mass consumer markets via mobile devices and the promotion of proactive consumer feedback to improve technology products. It will profoundly transform consumer-enterprise interactions, particularly the conduct of purchases in sectors such as retail and entertainment.



User Interface

User interface and interaction technologies provide users with new ways to interact with data, systems and the environments in which we work, live and play. The paradigm shift in the concept of user interface, of which the user is now the new interface, is fundamentally about multiple user interface technologies and enablers converging to provide a more holistic and immersive user experience.



Big Data

OVERVIEW

Digitization has led to the generation of a massive volume of data over the years. Companies have amassed huge amount of digital information about their businesses and customers while machines have innumerable web log files and sensor data. A study by IDC projects the following growth in data storage up to 2015 (Figure 1).

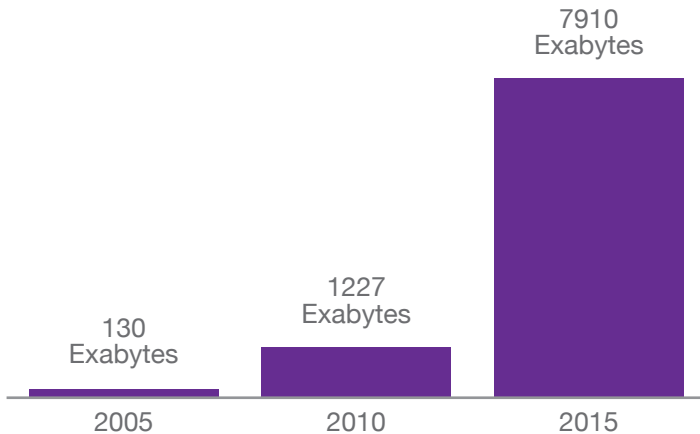


Figure 1: A decade of Digital Universe Growth: Storage in Exabytes¹

This exponential growth of data constitutes to the trend of “Big Data”. Big Data refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage and analyse. It gives rise to an ecosystem of new software and hardware products that enable users to analyse the huge data sets to produce more detail and new insights. Volume tends to be the central issue of Big Data, but it is certainly not the only issue. The velocity of data generation and the variety of data types (structured, semi-structured and unstructured) must also be considered to get the complete spectrum of the Big Data challenge.

The issue of Big Data is an important one. Organisations are moving toward being “data-driven” where business leaders increasingly rely on data to back up their decisions. However, the amount of information to assimilate is beyond human capacity and Big Data technologies have to be in place to manage and process the data to obtain insights. The issue of Big Data affects business users as much as (if not more than) the IT department. While IT can establish the necessary support structure, it is ultimately the business users who need to know how to use the data for analysis and business intelligence.

Data Scientist

A new professional category has emerged with the growing importance and significance of big data – the data scientist. Organisations will need data scientist to take advantage of Big Data. Data scientists² are individuals responsible for modelling complex business problems, discovering business insights and identifying opportunities through the use of statistical, algorithmic, mining and visualization techniques. In addition to advanced analytics skills, data scientists are also proficient at integrating and preparing large, varied datasets, architecting specialized database and computing environments, and communicating results. A data scientist may or may not have specialised industry knowledge to aid in modeling business problems and with understanding and preparing data.

TRENDS

In 2011, the Big Data technology and services market was about US\$4.8 billion. The market is projected to grow at a CAGR of 37.2% between 2011 and 2015, reaching US\$16.9 billion by 2015.

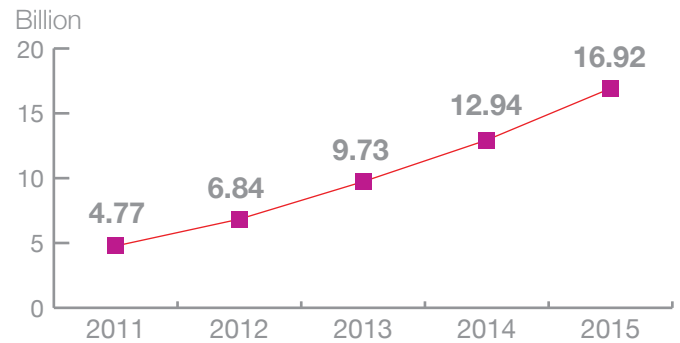


Figure 2: Global Big Data market projection³

Continuous Growth of Digital Content

The communications of the future scenario will see consumers increasingly connected to the mobile Internet, using social media networks as a source of information and actively participating in social network communities. The convergence of mobile device adoption, the mobile Internet and social networking provides an opportunity for organisations to derive competitive advantage through the efficient analysis of unstructured data (e.g., images and audio) from digital content.

Proliferation of Internet of Things

According to Cisco Internet Business Group⁴, there will be about 25 billion devices connected to the Internet by 2015. By 2020, this number will go up to 50 billion. These connected devices which continually send out huge amounts of data include smart meters, sensors and actuators. Companies that deploy sensor networks will have to adopt relevant Big Data technologies to process the data sent by these networks.

Strong Open Source Community

Many of the technologies within the Big Data ecosystem have an open source origin. Some of the technology companies leading in the technology evolution of the Big Data landscape are affiliated to the open source community in different ways. For example, Cloudera is an active contributor to various Big Data open source projects while EMC's Greenplum launched its Chorus social framework as an open source tool to enable collaboration on datasets in a “Facebook-like” way. These market developments indicate that these commercial open source vendors will continue to drive greater adoption of Big Data technologies.

Increasing Investment in Big Data Technologies

Investments in Big Data technologies are expected to continue to increase, as companies seek to become “more data-driven”. A data-driven organisation is one that acquires, processes and leverages data in a timely fashion to create efficiencies, develop new products, and better understand and predict customer preferences and market growth using big data.

TECHNOLOGY OVERVIEW

Big Data Technology Stack

Big Data technologies can be broken down into four layers, namely infrastructure, data organisation and management, data analytics and discovery, and decision support and automation.

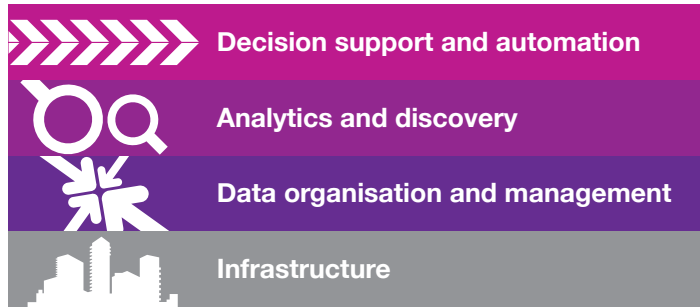


Figure 3: Big Data technology stack⁵

Infrastructure: Storage systems designed in a scale-out fashion to facilitate scaling of system performance and capacity.

Data organisation and management: Software that processes and prepares all types of structured and unstructured data for analysis.

Analytics and discovery: Data analytics software that support data analysis and information discovery.

Decision support and automation: Provides decision making support that can be transactional-based or project-based. Transactional decision management is automated, real-time and rules-based in nature while project-based decision management is typically standalone, ad-hoc and exploratory in nature.

Hadoop & the Ecosystem

Hadoop is almost synonymous with the term “Big Data” in the industry today and is popular as a framework for handling huge volumes of unstructured data. Hadoop is a framework that provides open source libraries for distributed computing with MapReduce software and the Hadoop Distributed File System (HDFS). Hadoop facilitates data processing scalability and takes care of detecting and handling system failures.

Other than MapReduce and HDFS, Hadoop also refers to a collection of other software projects than uses the MapReduce and HDFS framework. They are:

- HBase: A database management system that runs on HDFS
- Hive: Data warehouse system for Hadoop
- Pig: SQL-like language running on top of MapReduce
- Mahout: Machine-learning system implemented on Hadoop
- Sqoop: A tool designed for transferring bulk data between Hadoop and structured data stores such as relational databases

Content Analytics

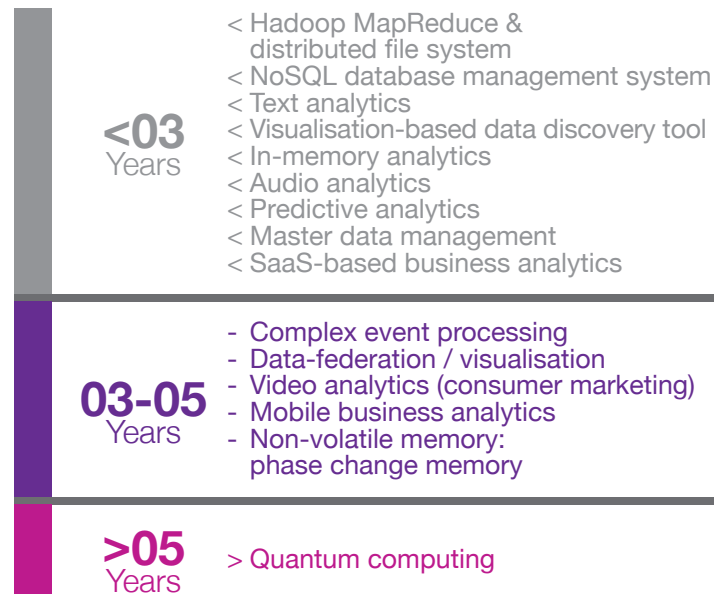
Content analytics is an aggregated term for text, video and audio analytics. Text analytics is the process of deriving information from text sources which can be in the form of

web materials, blogs and social media postings. Video analytics is the analysis of digital video images to interpret, learn and draw inferences from image sequences. Audio analytics uses audio mining techniques to search for specific audio characteristics from large volumes of audio data. When applied in the area of speech recognition, audio analytics identifies spoken words and puts them in a search file.

In-memory Analytics

In-memory analytics is a technology that is designed to run on the core memory of a computer system. Enabled by systems with large core memory, in-memory analytics enables the loading of huge amounts of data for fast query and calculation performance. The use of this technology as a back end resource for analytics improves performance. The speed that is delivered by in-memory analytics makes it possible to power the interactive visualisation of datasets, making data access a more exploratory experience.

RADAR



OPPORTUNITIES

- Analysis of unstructured data such as images and audio on top of text data to unearth insights from a bigger data pool
- Insights from the data analytics outcomes to augment decision making processes
- Analytics (retrospective to predictive) to proactively identify opportunities or tackle problems

CHALLENGES

- Understanding and framing Big Data problems
- Maturity in some of the underlying analytics algorithm
- Shortage of data analytics talent

Cloud Computing

OVERVIEW

Cloud computing is an architecture that orchestrates various technologies enabling, but not limited to, multi-tenancy, automated provisioning and usage accounting, the Internet and other connectivity technologies like richer Web browsers to realise the vision of computing delivered as a public utility.

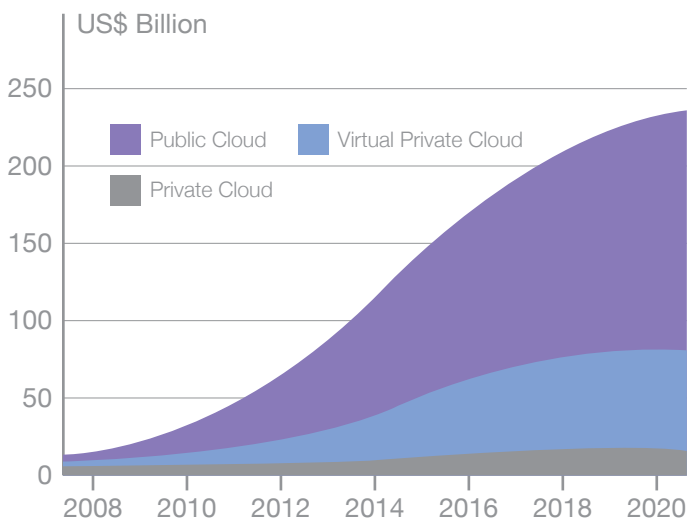
Forrester Research estimated¹ the global cloud market size for cloud computing to reach US\$241 billion by 2020. The public cloud will constitute two-thirds of that market size, or US\$159.3 billion.

On-demand delivery of software, platforms or infrastructure as a service lends itself well to today's challenges of shrinking IT budgets and the metamorphosis of IT from a cost centre to a driver for business growth. Cloud computing can lower the cost of operations by consolidating supply, aggregating demand and improving efficiency through multi-tenancy. IT can leverage on Cloud to improve agility and align itself to create strategic value for business.

Cloud-related technologies are advancing at a lightning pace, moving toward a future cloud that provides a seamless and integrated computing experience. This future cloud will be a cloud of clouds where brokerage services coalesce compute, data and network resources and present services that automatically enforce security and service level requirements.

Cloud computing aligns itself to the growth of its users with the utility model. Cloud elasticity affects an organisation's bottom line by improving efficiency and influences the top line of the business by allowing low-risk experimentation, innovation, and improving turnaround time. In the long term, IT agility enabled by cloud computing will transform the business landscape.

Global Market for Cloud Computing



Source: Sizing the Cloud, Forrester Research Inc, Apr 21, 2011¹

TRENDS

Sheer Volume of Content Transferred

Nokia Siemens Networks predicts² broadband data to increase 1,000 fold by 2020. Cisco also projected³ a CAGR of 90% in global traffic for video and 65% for data through 2016. Both projections outpace Moore's Law so the delivery of content in the long term cannot be fulfilled simply by buying better servers. Content delivery and server utilisation must be optimised to satisfy that demand for information. By 2014, 50% of all data would have been processed in the cloud.³ Cloud computing and the global distribution of public clouds can provide that last mile delivery.

Demand for "Instant Performance"

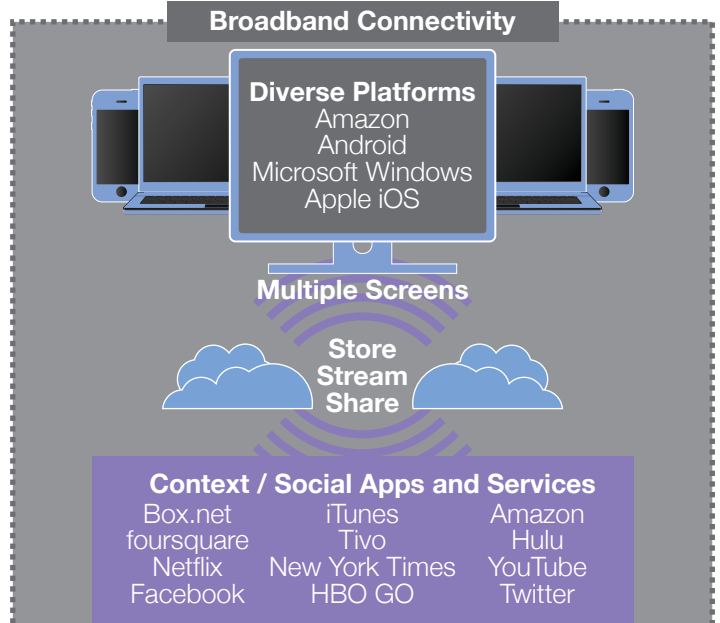
Social analytics is increasingly common as a business strategy to better understand and respond to the customers as individuals. The volume of data adds to the wealth of electronic records waiting to be analysed and combined for intelligence and better insights into the business. Businesses demand such insights with increasing immediacy.

The elastic nature of cloud computing lends itself naturally to the business need for intelligence and is increasingly relevant as IT is faced with the demands of ever expanding data, more instant turnaround and more dynamic workloads. Analytics may expand beyond the confines of business data, eg, the inclusion of social mining, paving the way for analytics software as a service.

Seamless Experience from Personal Cloud / BYOD

According to CSC's cloud usage index⁴, device pervasiveness is the key driver for 30% of organisations implementing cloud solutions in Singapore. The ubiquity of an untethered Internet and affordability of powerful, easy-to-use devices have driven productivity as executives stay connected to the company anytime, anywhere and using any device.

Frictionless Sync Defines the Consumer Cloud Experience



Gartner expects personal clouds to replace personal computers by 2014.⁵ The seamless experience and integration of data, social and communication services into a smart device will be the new benchmark for corporate IT offerings. IT can leverage cloud services to fulfil this demand.

TECHNOLOGY OVERVIEW

Virtualisation

Server virtualisation technologies started maturing as far back as 2005 when Intel and later AMD released processors with hardware assisted virtualisation.

Features like automatic failover of virtual machines (VM), live-migration of VMs, automatic provisioning and installation, automated backup and cloning of VM, and hands-free maintenance rollout are widely deployed in today's virtualised data centres. Virtualisation providers have partnered both hardware and software providers to provide an integrated provisioning experience. Virtual Desktop Infrastructure is another growing trend that will benefit from Singapore's extensive fibre coverage.

Cloud Big Data

Hadoop, or its MapReduce equivalent, is prevalent for big data processing and is readily available from various cloud providers including Amazon, Microsoft and Google. Cloud computing is a natural choice for the provisioning of such services because of the cloud's elastic nature and the availability of data on the cloud platform.

Other advances that leverages cloud computing to push the boundaries of real time business analytics includes improvements in casual super computer provisioning, standardisation of data-as-a-service, proliferation of analytics software-as-a-service and advances in extreme transaction processing.

Security, Compliance and Standards

The rogue culture of cloud computing is not accidental. After all, the market that embraced it is characterised by agile

businesses that favour rapid test cycles over the traditional IT preference for comprehensive planning.

Security, data locality and confidentiality, and the lack of service level agreements (SLA) control measures have always been the Achilles heel in cloud adoption. Cloud computing changes usage behaviour. Today risk management controls, policies, processes and procedures and security products are trailing the newfound flexibility and agility.

The Information Technology Standards Committee has published two technical references on virtualisation security, and security and service level guidelines for public cloud services. Additional standards are currently being developed in other areas of cloud computing including data exchange formats, security practices, workload management, and service level management.

Semantics capabilities are being developed to track the movement of data within a cloud provider that may span continents. Walls can be erected to prevent data emigration while the eradication of data from cloud will be possible.

Standardised cloud architecture lays the foundation for cloud interoperability that in turn enables cloud bursting.

OPPORTUNITIES

- Improved collaboration with a common data platform
- Standardisation of IT practice, processes, security & architecture to improve operational efficiency
- Achieve business agility with low cost experimentation

CHALLENGES

- Security, data governance and identity management
- Lack of skilled developers who can design for the cloud

RADAR

	<03 Years	03-05 Years	>05 Years
Services	< Community Clouds < Personal Cloud Services	- DevOps Tools - Cloud Optimised Applications	> Cloud Standards - Interoperability
Data	< Data aaS < Cloud Big Data	- Public Cloud Storage	
Compute	< Virtualisation	- Hybrid Cloud	> Cloud Bursting
Network		- Internet 2.0 - Software Defined Networking	
Security	< Security aaS < Identity & Access Management aaS	- Cloud Security Standards - Data Tracking	
SLA	< Cloud Brokerage aaS	- SLA based Charging - Federated Clouds	

Cyber Security

OVERVIEW

Cyber security is such a critical concern that it is projected to be among the fastest growing segments of the infocomm technology in the next three to five years. In cyberspace, everything and everyone are interconnected digitally.

A proactive and coordinated cyber security system is necessary to minimise the adverse effects caused by cyber attacks from people or organisations with malicious intent. Today, these attacks are systematically orchestrated and commercialised to achieve greater impact and damage, with less effort and sophistication.

Singapore's Cyber Security Strategy

Under the guidance of the National Infocomm Security Committee, Master Plan 2 (MP2), IDA is bringing the public, private and people sectors together to secure Singapore's cyberspace. The framework for MP2, shown in the figure below, depicts the vision, coverage, strategic outcome and four supporting strategic thrusts to maintain the high resilience and availability of Singapore's infocomm infrastructure and services:



Figure 1: Infocomm Security Masterplan 2 (MP2), Singapore, 2008
Source: IDA

Strategic Thrust 1: Harden national infocomm infrastructure and services.

This strategic thrust aims to enhance the resilience of our underlying foundation to combat cyber threats with Singapore's "hardened" national infocomm infrastructure and services.

Strategic Thrust 2: Enhance infocomm security competencies. This thrust looks at enhancing the security competencies of infocomm users and infocomm security practitioners in managing infocomm security risks.

Strategic Thrust 3: Cultivate a vibrant infocomm security ecosystem. A vibrant infocomm security ecosystem strengthens Singapore's capability to protect our national infocomm infrastructure and services. An active infocomm security research and development (R&D) scene would ensure that a variety of up-to-date infocomm security solutions is available to counter evolving infocomm security threats.

Strategic Thrust 4: Increase international collaboration. As cyber threats are borderless, it is important to continue to work closely with our international counterparts. MP2 also focuses on exchanging best practices in infocomm security and exploring collaboration in this area.

TRENDS

Cyber Espionage and Weapon: Stuxnet and Flame

In June 2010, the Stuxnet¹ attacks demonstrated that specific cyber activities could be used to create direct damage on the physical world and into critical infrastructure that provide essential services. Around mid-2012, Flame (also known as Flamer or Skywiper²) was discovered, more potent and complex than Stuxnet.

These events led to the realisation of a new threat called **Advanced Persistent Threats (APTs)**. APTs are:

- Highly customised intrusion techniques with very specific detail and capability;
- Stealthy and persistent, giving them the ability to extract valuable intelligence; and
- Targeted at high-value objectives such as military, political or economic intelligence, organisations of strategic importance, government agencies and their support chain operators.

Hackers and Cyber Conflicts

Hackers are using cyberspace, in near real time, as a means to promote their political agenda, freedom of speech and human rights, as well as, for re-grouping and re-configuration of their activities. Irrespective of their motivations, hackers are a force to contend with.

When given state support, hackers can move into or join forces with cyber armies, causing new threats or cyber events escalation that may result in physical conflict. Depending on their classification, some of these activities can be considered as cyber-terrorism or cyber-espionage.

Cybercrime

Unlike traditional crime, cybercrime creates impacts that are closer (in space), wider (in reach) and faster (in time) while recognising no boundaries. In September 2011, a Norton study on cybercrime noted that in 2010, cybercrime damages, based on financial and time losses amounted to US\$388 billion³ globally. To combat cybercrime, the appropriate level of security awareness needs to be inculcated as well as communication and collaboration improved.

Mobile Device Computing Risk

At the end of 2012, an estimated 659.8 million⁴ units of smartphones will be shipped. By 2016, there will be around 5 billion mobile device users. Mobile computing risks take the top spot on the list of new emerging risks.

Embedded Devices Exploitation

With the increasing use of sensory devices and the maturing of anti-malware applications, malware writers are seeking new ground for their exploitations. Sophisticated attackers know that controlling hardware is the new key to their success as it will gain greater control and maintain longer access to the system and its data.

TECHNOLOGY OVERVIEW

Traditional IT security technologies such as risk assessment and assurance, detection and protection will continue to evolve to respond to the new trends and challenges.

Web Ecosystem Protection

The use of World Wide Web has taken over the rest of the applications as the key application in the use of cyberspace, introducing risks such as Denial Of Service attacks. Special focus would be on web application testing techniques such as Dynamic Application Security Testing (DAST) and protection of the web ecosystem as in Domain Name System Security Extensions (DNSSEC).

Operational Technology (OT) Security

A wide spectrum of products, solutions and services would need to be aligned, created and developed to ensure operational protection and continuity, such as in critical infrastructure protection for energy and power distributions. Securing the whole support chain would drive new development of specialised security technology.

Big Data Security Analysis

Using analytics from large amounts of data, together with multi-intelligence feeds for correlation, Big Data security analysis could be used for detection of simple malware to counter APTs.

Mobile Device Protection

As awareness grows, there will be improvements in mobile device security for use in enterprises e.g. the use of Address Space Layout Randomisation (ASLR) in the new Android phones to counter malware attacks. Next, mobile device management (MDM) would provide the required security control and management of applications and mobile devices.

Software Defined Networking (SDN) Security

At the same time, SDN, despite its infancy, is making changes in the networking space. Granular security control will provide improvements to network security. However, the implementation of SDN would introduce new unexpected risks and require new mitigating measures.

Security is gradually embedded in design, even at the chip level, and it is no longer an afterthought.

OPPORTUNITIES

- Security need from new trends eg. Internet of Things, Bring-Your-Own-Device (BYOD), Big Data and mobility
- Concern and requirement arising to provide confidentiality, integrity, availability and protection across all levels and layers
- National security programmes and technology innovation to strengthen cyber ecosystem

CHALLENGES

- Dimension of the issues is huge as it extends to both the physical and cyber worlds
- Technology cannot solve all issues eg. cyberbullying, an emerging problem in social networks
- Require policy and education to build greater awareness, even behavioural change

RADAR

	<03 Years	03-05 Years	>05 Years
Prevention / Protection	< Firewall < Unified Threat Management	- Mobile Data Protection - Web Application Firewall - Next Generation - Firewall - Trusted Platform Module	> Security in silicon
Detection	< IDS / IPS	- Big Data Security Analysis - Data Leak Protection - Security as a Service	> Self healing system
Assessment	< P-testing tools		> Web Application testing
Remedies / Management	< Security information and event management	- Adaptive authentication - Context aware computing	> Operational technology security > Software Defined Networking security

ICT and Sustainability

OVERVIEW

Sustainability is “development which meets the needs of the present without compromising the ability of future generations to meet their own needs.”¹ Sustainability has emerged as a result of concerns about the unintended social, economic and environmental consequences of rapid urbanisation and economic growth, as well as growing resource constraints.

The 2009 Singapore Sustainable Blueprint outlines strategies and initiatives to guide Singapore to achieve a higher level of environmental sustainability with clear goals to measure our performance. It is a big challenge that calls for social, technological and behavioural changes such as:

- Reshaping our cities for sustainable urban living and enhancing our quality of life;
- Driving the efficient use of energy and integration of renewable sources;
- Improving transportation systems that allow us to travel more seamlessly without causing too much congestion and pollution.

ICT can play quantifying, enabling and integrative roles in addressing these sustainability challenges. A ubiquitous sensing capability for quantitative and predictive analytics, and using smart ICT applications to improve energy efficiency and reduce the carbon footprint are some ways in which ICT can make a difference. In addition, the ICT sector itself will also need to be sustainable by optimising the energy and resource efficiency of its systems, products and services while minimising the environmental impact.

TRENDS

Increasing Cost and Scarcity of Energy

The persistent increase in oil prices (Figure 1), fuelled by rapid economic growth, especially in developing economies such as China and India, has prompted many countries to reduce oil dependence. Singapore established an Energy National Innovation Challenge in February 2011 to seek out innovations that could help increase energy efficiency, reduce carbon emissions, and expand energy options for the country. One area of focus is in Green Data Centres where standards and benchmarking initiatives to drive energy efficiency have been introduced.



Figure 1: OPEC Basket Price from 2003-2012⁶
Source: OPEC

Population Growth and Urbanisation

World population reached 7 billion in Oct 2011. More than half live in urban areas, and 60% will do so by year 2030. Singapore population grew from 4 to 5.1 million in less than a decade, and is one of the most urbanized and densely populated countries in the world. With the global population growth and urbanisation trend as a driver, cities worldwide are looking at optimizing resources, such as land, food, water and energy as well as adequately providing and maintaining public infrastructure and services.

Global Warming and Greenhouse Gases (GHG)

Earth has warmed by 0.8 °C since the last century. This has significant impact in our ecosystems, economics and human health. Many scientists and government organizations have agreed that the global warming is due to the increase in greenhouse gas emissions from human activities. Hence, much of the efforts in addressing sustainability focus on activities to reduce the emission of GHG in our environment.

Proliferation of ICT Usage

The use of ICT has profound effects on society and its production capacity. In Singapore, the use of ICT is pervasive in all sectors of the economy and the ICT sector alone was worth S\$83 billion² in 2011. The government pro-actively promotes the use of ICT to improve efficiency and has invested in building ICT infrastructure that will hopefully meet the needs of future generations without compromising on quality of service and ecological sustainability.

According to the World Summit on the Information Society, the ICT sector accounts for 5-10% of the world total energy demand. With the proliferation of ICT usage, electricity demand is expected to double to 10-20% by 2020.³ Such demand comes from the extensive utilisation of ICT end-user devices, telecommunication networks and the data centre facilities to host the servers and data storage devices (Figure 2).

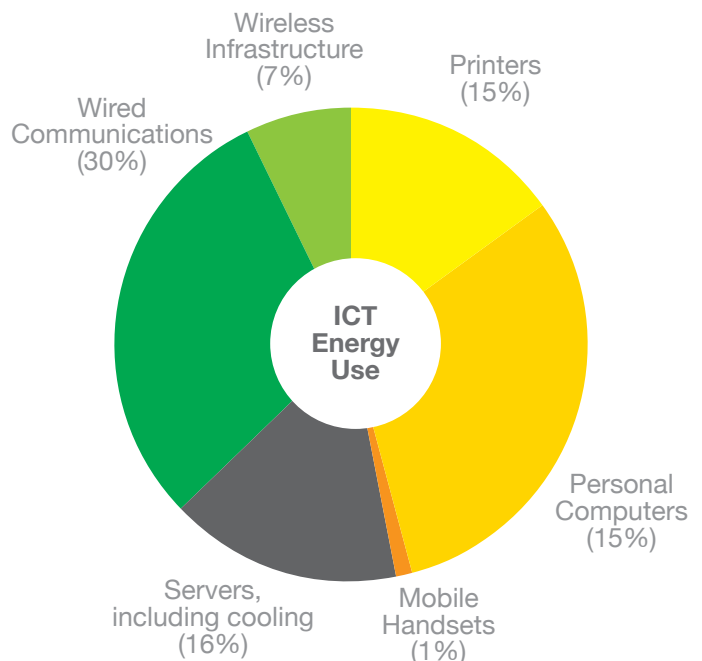


Figure 2: Energy Consumption by the ICT Sector⁷
Source: Gartner 2008

TECHNOLOGY OVERVIEW

Sustainability Through the Use of ICT

Smart Grid – The world's electricity systems face a number of challenges, such as ageing infrastructure, growth in energy demand, integration of renewable energy sources and electric vehicles, and the need to lower carbon emissions. Smart grid technologies offer ways not just to meet these challenges but also to develop a cleaner energy supply that is more energy efficient, more affordable and more sustainable.

Smart Transport – The transport sector accounts for nearly 25% of global energy-related carbon emissions. The use of intelligent transport systems ranging from traffic control and automatic number plate recognition to more advanced applications that integrate live data and feedback from a number of other sources can provide important information that can facilitate predictive modelling and more efficient traffic management.

Smart Building – Buildings account for approximately 40% of the world's energy consumption and 20% of total CO₂ emissions. Smart building technology can support the ongoing process of monitoring and optimising energy consumption, using installed building systems to improve energy efficiency without negatively affecting the comfort of occupants.

Dematerialization – The shift toward electronic delivery of services, eg, e-books and streaming video / music, offers the prospect of both people and things moving less. Such activities and transactions conducted by "moving bits rather than molecules" take up less road space and consume fewer resources.

RADAR

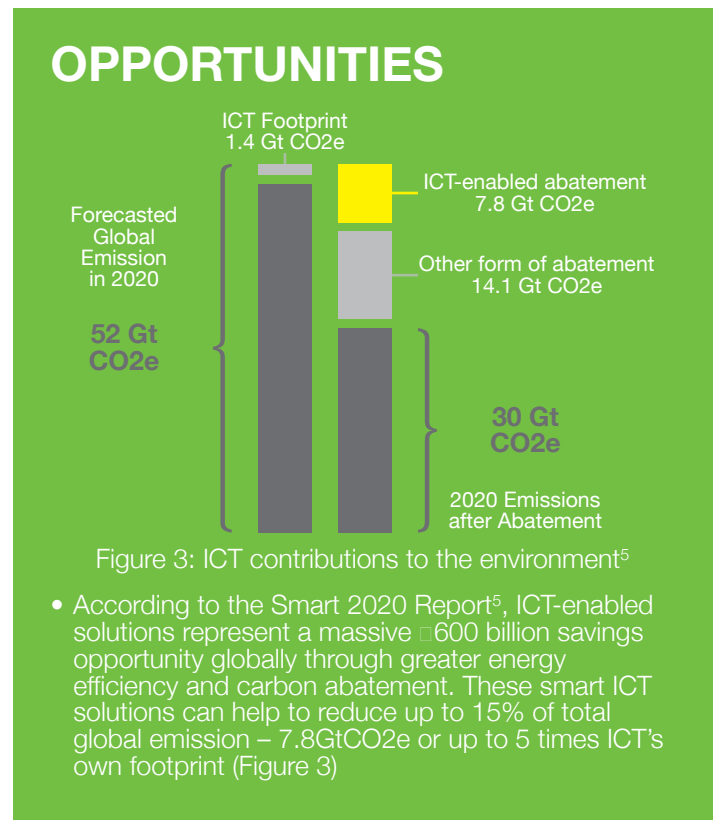
	Sustainability Through the Use of ICT	Sustainability in the Use of ICT
<03 Years	<ul style="list-style-type: none"> < Smart Grid < Smart Transport < Smart Building 	<ul style="list-style-type: none"> < Energy-Efficient Ethernet (IEEE 802.3az) < Modular Data Centres < Energy Efficient CPU / Storage / Display
03-05 Years	<ul style="list-style-type: none"> - Wireless Access in Vehicular Environment (WAVE) - Wi-SUN (Smart Utility Network) - Zigbee Smart Energy 2.0 	<ul style="list-style-type: none"> - Bit-Interleave Passive Optical Network - Direct Current (DC) distribution in Data Centre - Colour E-paper
>05 Years	<ul style="list-style-type: none"> > Grid to Vehicle (G2V) / Vehicle to Grid (V2G) Communication > Visible Light Communication (IEEE 802.15.7) > Home Energy Management System (HEMS) 	<ul style="list-style-type: none"> > Large Scale Antenna System > Energy Harvesting ICT Devices > Liquid Immersion Cooling for Servers

Sustainability in the Use of ICT

Green Data Centre – Data centres are significant contributors to the carbon footprint, given their heavy usage of energy. It is estimated that data centres and network equipment account for almost 18% of the entire ICT sector's carbon footprint. The use of virtualization technology and facility enhancement technology (such as better airflow and cooling management) can help to better manage data centre resources and improve their energy efficiency.

Green Network – Many of today's communication networks are optimised for performance but not energy efficiency. A network optimised for both performance and energy requires very different designs and architecture. Network researchers believe that it may be possible to improve our network efficiency by a factor of 1,000 times⁴ by 2015.

Energy Efficient ICT devices – With R&D investments, many ICT components such as power supply units, processors, storage and displays, now consume less energy than older devices. ICT devices are also getting smaller. The change in size indirectly means that energy consumption can be made more efficient.



Comms of the Future

OVERVIEW

Today, the movement from basic fixed telephony to wireless mobile connectivity is changing the way we communicate, work and entertain ourselves. Singapore has one of world's highest mobile penetration rates, indicating a trend that has implications for future development of applications and services.

The popularity of smartphones, tablets and other Web-enabled, connected devices further fuels social media and networking activities. This "always on" connectivity has given rise to a world where the Internet of Things (IoT) influences business and public services as well as our digital lifestyle. We can expect more new machine-to-machine (M2M) / IoT applications to crowd the landscape. To cope with the scale and elastic demand, cloud-based infrastructure that offers more flexibility will become an attractive proposition.

The confluence of these three domains – mobile, social, and cloud technologies – has created something the industry describes as the "perfect storm," an unusual convergence of forces that creates some exciting impact. We can expect new waves of applications enabling even more info-gratification on the go in the near future. The Internet and the underlying infrastructures that power our communication networks (fixed and mobile) will experience dramatic changes to support and adapt to ever increasing demand.

TRENDS

Mobility-enabled Applications

Globally mobile broadband subscriptions have grown 45% annually over the past four years. Today there are twice as many mobile broadband as fixed broadband subscriptions. Singapore has a mobile penetration rate of 150.4% while mobile broadband penetration currently stands at 69.7%. The explosion of mobile applications is driving high data traffic and infrastructures will need to evolve to manage the demand. Context-aware services are emerging as the next big wave of applications enabled by mobility.

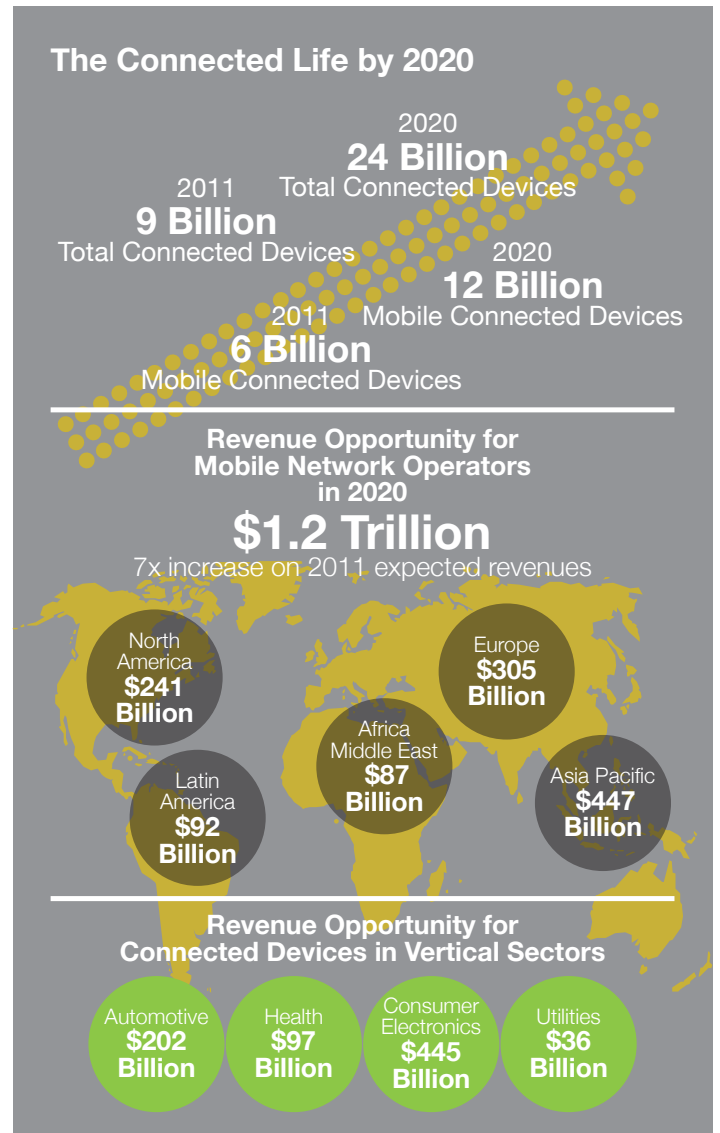
Variety of Devices and Connections

There was a surge in the sale of smartphones, tablets and other Web-enabled devices in 2011, a pivotal year for the mobile industry. We are also witnessing a cultural shift toward cross-platform digital media consumption, anytime, anywhere.

The future ICT landscape will see more pervasive use of M2M / IoT. Greater convergence and multi-channel delivery of content over different platforms will lead to a more seamless, customised and interactive user experience.

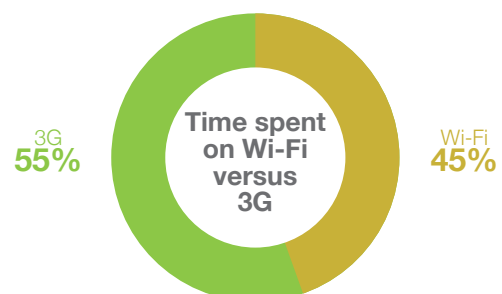
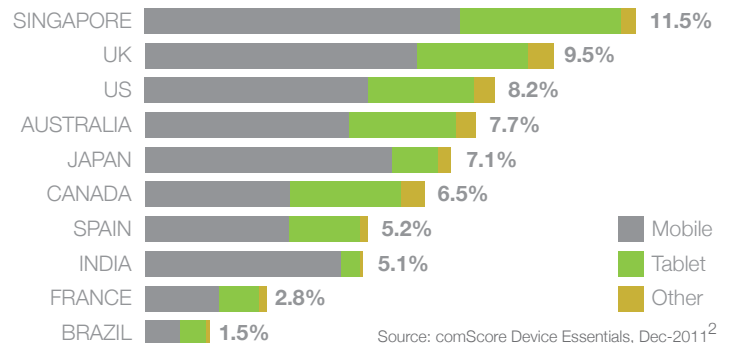
Variety of Services and Content Types

Networks experience data deluge resulting from higher consumption of over-the-top (OTT) services, HD media contents, social networking and mobile applications. Increasingly, the use of personal clouds and Bring-Your-Own-Device (BYOD) will define the consumer space, giving rise to a diversity of mobile services and business applications.



Source: Source: GSMA (<http://www.connectedlife.gsma.com>)¹

Non-Computer Traffic for Selected Markets



Source: Blackbox Research Pte Ltd (<http://www.blackbox.com.sg>)³

TECHNOLOGY OVERVIEW

New Mobile Networks Capabilities

Increase in mobile data usage is transforming mobile network designs. To relieve the network load and increase network capacity, smaller cells and better spectral efficiency technologies will need to be developed.

Currently, Femtocell offers the smallest footprint of a mobile radio access network. However, the business motivation for its deployment varies across the market. Femtocell can be positioned to complement access to improve wireless coverage, offload traffic from the macro-cell network or even creative cross product bundling.

LTE (Long Term Evolution), fully deployed, will offer a number of distinct advantages over other wireless technologies. These advantages include high peak data rates and low latency, and greater efficiencies in using the wireless spectrum.

TV Whitespaces (TVWS) and Related Technologies

TVWS relates to parts of the television broadcast radio spectrum which, in a given location or any given time, remains unused for broadcast television. This creates opportunities for the alternative use of such pockets of spectrum.

An example is the use of Wi-Fi technology within the TVWS. This is covered under IEEE 802.11af which defines two basic classes of implementation:

- Cognitive Radio utilises radio technology that is able to sense the environment and configure itself. The technology is heavily dependent upon Software Defined Radio (SDR) technology.
- Geographic sensing technology is another method that is favoured by many. It consists of a geographic database and knowledge of available channels to avoid crowding saturated channels.

Wi-Fi and Hotspot 2.0

Operators are exploring a more seamless offloading mechanism onto Wi-Fi to give a better user experience. Together with the new IEEE 802.11u standard, the SIM-based EAP-SIM / AKA authentication has become the foundation of the next generation hotspot – Hotspot 2.0.

Wi-Fi is also expected to take centre stage in the enterprise space due to the prevalence of Bring-Your-Own-Device (BYOD) and mobility.

Faster, high-performance Wi-Fi technologies for 60 GHz (802.11ad) and Very High Throughput in 5 GHz (802.11ac) are in development. These technologies will provide high-performance connectivity for a range of home applications, allowing users to network data-demanding digital home devices without sacrificing performance.

IPV6

With the depletion of IP version 4 (IPv4) addresses, the Regional Internet Registrar (RIR) has identified a need for IPv6 addresses. IPv6 offers a much larger address space to cater to the rising demand for Internet connectivity.

With improved routing capabilities and enhanced mobility features for wireless use, enterprises can look forward to using IPv6 to generate new opportunities for innovation and deliver new services for their operations or businesses.

Optical Transport Network (OTN)

Using the OTN technology network based on wavelength division multiplexing (WDM), 40G Ethernet and 100G Ethernet were standardised in June 2010. Systems based upon these standards will power the backbone infrastructure of our future networks.

RADAR

	Enablers	Infrastructure
<03 Years	<ul style="list-style-type: none"> < Low power comms modules < Resource sharing 	<ul style="list-style-type: none"> < LTE < WiFi - 802.11n < Femtocells
03-05 Years	<ul style="list-style-type: none"> - Self Organising Network - IPv6 - Virtualisation - Software defined radio - Cooperative / collaborative comms 	<ul style="list-style-type: none"> - Mesh network sensor - Wireless 802.11ac: 5 GHz - Wireless 802.11ad: 60 GHz - 40G / 100G WDM optical
>05 Years	> TV Whitespace	> LTE-A

OPPORTUNITIES

- Low latency, HD multimedia applications and user-generated content
- Richer communication (presence, messaging, sharing, etc)
- Pervasive M2M / IoT applications

CHALLENGES

- Good QoS and resource management in a converged multi-service network environment
- User profile management

Social Media

OVERVIEW

The term “social media” refers to online sites which exhibit the characteristics of participation, openness, conversation, community and connectedness.¹

Essentially social media comprises networks that democratise the landscape of engagement. The public is increasingly self-organising events and campaigns, and coordinating them through social media. The effectiveness of this kind of engagement was most evident during the major earthquakes in Haiti and Japan.

Social media has permeated many facets of life and has become an essential channel for the transmission, distribution and sharing of information, the formation of consensus-seeking groups and the growth of support networks for decision making. Understandably, organisations in the public and private sectors, as well as non-profits, must learn to create appropriate strategies to leverage the power of social media to support their activities and mission objectives.

Some have already embarked on the adoption of social media networks and metrics to facilitate R&D efforts, improve productivity and creativity, and monitor or track social media activity to analyse how best to deliver products and services. In the process, social media tactics such as gamification (“playing” together online to gain recognition and status) have been used to increase employee engagement by including a “fun” element into work processes.

TRENDS

Social Networking and Mobility

Today, 82% of the world’s online population (or 1.2 billion people) visit social networking sites.² Besides the high adoption rate, the time spent on social networking activities has more than tripled since 2007. In Singapore, more than 90% of our nearly 3 million Internet users visit social networking sites such as Facebook, Twitter and LinkedIn.

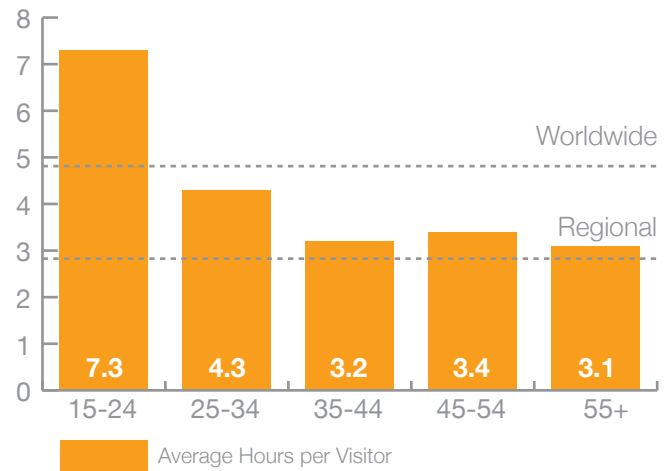
Social Networking Country Snapshot

SINGAPORE

Total Audience (Age 15+)	2.9 Million		
Total Social Network Audience	2.7 Million		
Online Population Visiting Social Networks	94.3%	Index to Worldwide 115	Index to Region 143
Share of Time Spent on Social Networking	18.0%	94	160
Average Time Spent on Social Networking	4.4 Hrs	76	148

Top 5 Social Networks	Total Unique Visitors ('000)	% Reach	Average Minutes Per Visitor
Facebook	2,235	77.0	278.4
Twitter	528	18.2	32.2
LinkedIn	385	13.3	19.4
Tumblr	319	11.0	85.4
Windows Live Profile	202	7.0	2.7

Average Engagement with Social Networking



Social Networking Demographic Reach

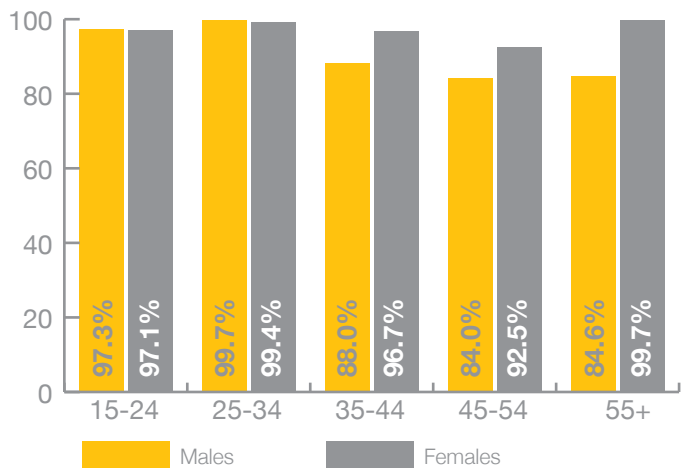


Figure 1: Social Network Use in Singapore 2011²

Source: Comscore: “It’s a Social World: Top 10 Need-to-Knows About Social Networking and Where It’s Headed”

Increasingly, social media access will mostly be accessed through devices such as tablets and mobile phones, highlighting the trend of instant access to information and personal networks for the mobile user. This is reflected in Nielsen’s 2011 “State of the Media: The Social Media Report”³ which states that close to 40% of social media users access social media content from their mobile phones and iPads.

TECHNOLOGY OVERVIEW

Social Media Management Systems

As social media usage grows, a “fire hose” of information, becomes available on the Internet, with or without the brand or organisation’s participation or permission. This makes it a challenge to monitor and engage individual participants, sift through the large datasets, and derive insights and corporate intelligence.

Social media management systems emerge as a result of the need to monitor chatter across different social media channels, and coordinate the engagements on these platforms. It is important though to note that there is no single solution that meets all the needs of users. Organisations ultimately need to have a clear engagement strategy so as to select the appropriate tools to maximise the benefits of their social media participation.

Social Influence

One key outcome of social media management is the ability to identify the influencers in the community and actively engage them. Influence is “the ability to cause an effect, change behaviour and drive measurable outcomes online”.⁴ With social media, social influence has become a social currency which marketers can leverage for marketing and advertising, and individuals can exploit for their own purposes. Social influence ranking services such as Klout, Kred and PeerIndex offer a range of tools to measure social capital.

Companies that want to use digital influence to build their brands online and manage their corporate reputation should be clear about their objectives, audience, benchmarks and milestones before they initiate social engagement campaigns to produce strategic and meaningful outcomes.

Social Media Analytics

To determine the Return on Investment (ROI), as well as to derive insights on the social behaviour of stakeholders, social analytics plays an increasingly important role in understanding the social media landscape. From analysing social networks to gauging sentiments, social analytics covers a broad spectrum of topics but just like social influence, it is still in the infancy stage. Issues such as the lack of a definitive set of metrics and inconsistent data sources (due to new social media platforms emerging and old ones closing) need to be resolved before definitive analysis can take place.

Navigating the Social Media Landscape

The ability to capture, interpret, and act in real time, based on signals from social media in the context of other enterprise data will become a tremendous competitive advantage for businesses and government agencies. Organisations that want a social media presence must be clear about their measurement frameworks so that they are strategic in their approach, measure the right things, interpret social data effectively, extract relevant insights and take timely and appropriate actions to meet stakeholder expectations.

RADAR

<03
Years

- < Social media monetisation
- < Social media management systems
- < Location-based services (LBS)
- < Social mobile applications
- < Social gaming
- < Social media marketing
- < Social music
- < Social media influence / ranking algorithms
- < Reputation management
- < Open Application Programming Interfaces (APIs) to access social network data
- < Text language translation
- < Government to citizen / industry consultancy

03-05
Years

- Context-aware computing
- Social commerce
- Emotive technology to sense moods
- Open social graph
- Text language translation (accurate and real time)
- Framework to manage privacy of online personal data
- Common platform to access various social networks

>05
Years

- > Virtual concierge
- > Social media standards
- > Social mapping
- > User profiling and grouping
- > Text language translation (localised)

OPPORTUNITIES

- Build an influential online presence to gain social capital and engage influencers to help build brand awareness
- Enhance engagement with stakeholders through the various social media channels
- Develop a better understanding of stakeholders through their activities on the social media channels

CHALLENGES

- Build in-house social media expertise to fully utilise the social media channels for enhanced stakeholder engagement
- Derive consistent feedback on social media interactions
- Change the paradigm from a business-centric to customer-centric focus

New Digital Economy

OVERVIEW

The widespread adoption of consumer infocomm technologies such as social media and mobile telephony, coupled with the increased acceptance of online activities like online shopping, e-banking and content sharing, has enabled a new digital economy to emerge. These trends are powered by the Internet and driven by the consumers. The New Digital Economy will transform businesses and governments in their processes and operations, and will in turn lead to extraordinary wealth creation around the world.

There is no authoritative definition for the Digital Economy although the term has been in use since the 1990s. Most definitions of the Digital Economy will include more than just the Internet Economy (economic value derived from the Internet) to incorporate economic and social activities resulting from other infocomm technologies. For example, the Australian government defines the Digital Economy as "the global network of economic and social activities that are enabled by platforms such as the Internet, mobile and sensor networks."¹

Mobile is fast becoming the primary window to the Internet for most consumers. The adoption of smart mobile devices has empowered a new era of infocomm-enabled business models that can potentially either disrupt traditional businesses or be leveraged for unprecedented growth and opportunities. Apps on handheld devices are gaining more consumer "face time" and social networking sites are becoming consumers' first site of visit on the Web, replacing "Search." Even in emerging markets, because of the millions of new mobile customers, new business models are emerging continuously and may even be applied back in reverse to developed markets.

TRENDS

Mobility

With the Internet Economy migrating to the mobile-centric platform, businesses and governments need to be ready to provide their information and services effectively through the mobile channel. The mobile Internet gives added dimensions to information about users, enabling the creation of new services. For example, information about the user's current location is a key enabler for context aware services.

Apps Economy

The Apps ecosystem began with the launch of the Apple App Store in July 2008. This was quickly followed by the launch of other competing stores. The apps stores have since seen more than 50 billion app downloads over the last four years. App downloads is expected to continue to grow in the coming years. The Apps ecosystem has opened a direct access to the mass consumer market for the first time to the whole spectrum of software developers from hobbyist to large enterprises. Consumers are also spending heavily in this new consumption category.

Social Economy

Social media has enabled a greater level of trust as compared to the default anonymous nature of the Internet. Popular social networking platforms have large population size and diverse reach. This trust and reach allow innovative community-driven solutions and business models known

collectively as collaborative consumption and crowdsourcing to flourish. This is challenging traditional business models in many sectors including publishing, finance, retail, research and even government.

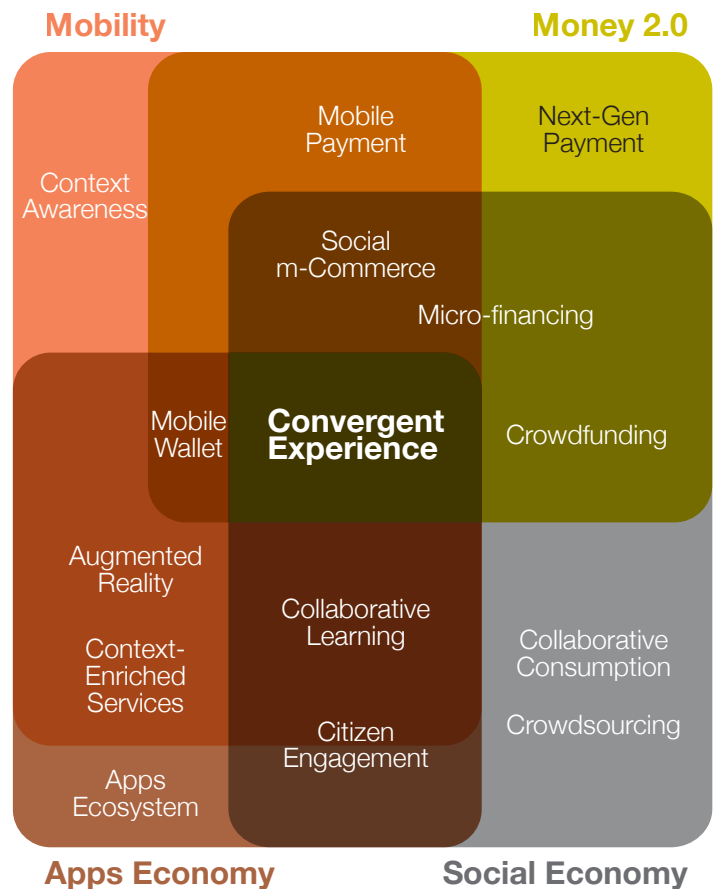
Money 2.0

Both incumbent financial institutions and new entrants such as telecommunications operators, Web and IT companies as well as start-ups are introducing next-generation digital payment solutions. They are aiming to establish strategic cash and physical credit card replacement solutions which will be used by the masses in this fast growing digital age.

Convergent Experience

Consumers expect their experiences to be seamless in both the digital and real worlds. The real world will see increased influence and integration from the digital world while the digital world will see more real world objects digitised and represented within it. Other than the convergence of the digital and real worlds, the combination of mobile Internet and social media, together with the seamless integration of digital payments, will define a new consumer landscape. A positive convergent experience for consumers is immersive, interactive and contextualised such that there is instant gratification in highly mobile, networked social communities.

Convergent of Trends Brings New Services



TECHNOLOGY OVERVIEW

Context-enriched Services

Context-enriched services use context (eg, location, presence, social attributes and other information) to form compelling, situation-aware and intuitive functions that anticipate and react to end users' immediate needs. The effectiveness of context-enriched services lies in the ability to use empirical data to anticipate customer needs.

Context-enriched service providers will be better able to create an enhanced demographic profile of market segments with the additional user data. These service providers can capture behavioural data from customer habits, usage patterns and preferences. Advances in networks, mobile hardware capabilities, social computing, cloud computing and unified communication will make it easier to build and use context-enriched services, presenting significant business opportunities for service providers, mobile device manufacturers and suppliers of communication infrastructure.

Mobile Wallet

Mobile wallets are smartphones or tablet apps that store a consumer's payment details to finance online and in-store purchases on his devices.² A mobile wallet solution could incorporate a variety of functionalities and services including fund transfer, commerce - the buying and selling of goods, ticketing and micro-payments (fast transactions of small amounts of cash). Mobile wallets can also be leveraged for targeted marketing by integrating loyalty programmes, push notifications and usage pattern analysis. Paying with smartphones is expected to overtake cash and credit card payments by 2020.³

Consumer Personal Cloud

The personal cloud refers to the storing, accessing and sharing of consumer content over the Internet across multiple devices. The emergence of consumer personal clouds reflects consumer desire to access content on any device anytime, anywhere, without complications or restrictions.

As consumers become more comfortable and versatile with new services on new devices, they will come to expect more of service providers and cloud computing. This will lead to a migration of content and services, as well as applications, to the cloud and will increase the demand for cross-platform personalised cloud services, a transition that will re-define production and distribution channels, as well as business models.

HTML5 Mobile Web Apps

HTML5, the latest generation of the Hyper Text Markup Language, will significantly evolve the Web browsing standard. For example, the inclusion of multimedia in the specification of HTML5 negates browsers' need for third party plug-ins like Flash and Silverlight to view multimedia content, thus enabling better interoperability across platforms and eliminating external dependencies.

HTML5 Mobile Web Apps can offer rich native-app-like features directly in the mobile browsers. This could potentially offer an alternative to wall-gardened app ecosystems on some mobile platforms. Although the HTML5 standard is still in development, it is already functional in many popular Internet browsers for both desktops and mobile devices.

OPPORTUNITIES

- Innovative suggestions from consumers and other external contributors can be tapped upon to co-create better products and services
- Small businesses will be empowered with direct access to the mass consumer market, enabling the development of more intimate and personalised customer relationships
- Better value-for-money purchases made possible through demand aggregation, excess reduction and community-driven decision making will make the digital economy a dynamic and interactive experience

CHALLENGES

- Organisations need to meet higher expectations of citizens and customers, which go beyond traditional forms of citizen engagement and customer support
- Industry incumbents need to quickly adapt and improve their business models to keep pace with the rate of entry of new innovative businesses

RADAR



User Interface

OVERVIEW

User interface and interaction technologies provide users with new ways to interact with data, systems and the environments in which we work, live and play. Today there is a paradigm shift in the concept of user interface in which the user is now the new interface and multiple user interface technologies and enablers could converge to provide a more holistic and immersive user experience.

In Singapore, projected figures of smartphone and tablet shipments suggest that we could see a smartphone penetration of nearly 100% and a tablet adoption of about 30% by 2013.¹ The economic opportunities that could be derived from user interface and interaction technologies would not be trivial, with the size of the global user interface market predicted to grow from US\$10 billion in 2011 to US\$25 billion by 2016.²

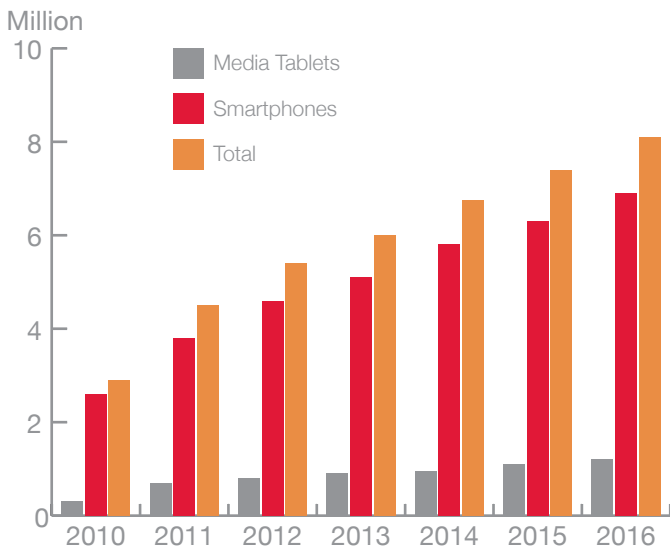


Figure 1: Projected Shipments of Smartphones and Tablets to Singapore from 2010 to 2016¹
Sources: IDC

MARKET TRENDS

Several market trends provide the main drivers of change for user interface and interaction technologies. Visual info-gratification refers to consumers accessing information about real world objects, naturally and on-the-go, simply by pointing their smart devices at anything interesting. There are already existing consumer apps such as WhereToGet.It and Google's Skymap that provide value-added services through visual info-gratification.³

The concept of natural user interface has also shattered the existing paradigm of user interfaces by positioning users as the new user interface. Microsoft Kinect was developed, based on this concept. Kinect is able to decipher images, gestures and speech commands from users, and has brought gesture recognition technology into the mainstream. Today, the term "the Kinect effect" is used to refer to the impact this technology is having on different environments beyond the way people play games or are entertained.

The third market trend is the convergence of multiple user interface technologies that could lead to more enhanced user experiences. Although this convergence was developed in specific industrial contexts (eg, maintenance training and familiarisation) and is by itself not new, the application of user

interface technologies for immersive environments could be extended to the consumer context. For example, in March 2012, the Bloomingdales store in Los Angeles showcased the BodyMetrics Pod which used eight Kinect sensors to bodyscan ladies in five seconds to find the right and most flattering fit in denim jeans.⁴

Smarter devices are also emerging to increase the richness of the user experience. Apple has filed a patent to incorporate Kinect-like gesture recognition in future iPhones and Microsoft has launched the second generation surface computer this year. Beyond such developments, future smart devices could feature other user interface enablers such as facial recognition, eye tracking (which monitors facial expressions and eye gazes) and speech-to-speech translation.

STAKEHOLDER BENEFITS

User interface and interaction technologies could improve the quality of life of Singaporeans. Singaporean consumers' mobile access to information about real world objects presents them with a greater range of choices and increases exposure to diverse influences and sources of information, including historical and sociological perspectives. In addition, Kinect could help in the rehabilitation experience of stroke patients⁵ and in making the learning environment in schools more dynamic, interactive and engaging.

Emerging interaction technologies and the convergence with existing ones increase the options of how consumers could interact with data and systems. For enterprises, the convergence of multiple user interaction technologies brings about richer data and contextualised information about the consumer and the operating environment. With increased contact points and channels with consumers, the market reach of enterprises can be extended. A seamless perspective of the consumer could be pieced together to generate insights for more focused, value-added services.

For governments, user interface and interaction technologies could surface details of emerging phenomena on the ground which would otherwise not be apparent. This could be useful in providing a common operating view of the physical environment for collaborative command and control (eg, events of infrastructure breakdown and homeland security incidents).⁶ It could also enable adaptive policy planning through the simulation of the effects of policy and interventions on the environment.

ENABLING TECHNOLOGIES

In terms of enabling technologies, there are already existing capabilities in the market, such as surface computers, interactive visualisation, voice and speech analytics, elementary eye tracking and facial recognition, which will continue to see increased adoption in less than three years.

The enabling technologies in the three to five year timeframe would position the user more strongly as the new user interface and make sense of complex and large interconnected datasets for natural language question and answering systems. By monitoring such capabilities in this timeframe, more advanced applications and services could be developed in sectors beyond the gaming sector. In addition, inference capabilities on big data could enable intelligent question and answering systems which could be applied in a wide range of sectors.

Enabling technologies in the more than five year timeframe could be areas for Research and Development (R&D) as these areas (eg, emotion detection and voice biometrics) are not mature and could take at least five years to reach consumers or enterprises' expectations in terms of either price or quality or both. Figure 2 shows the enabling technologies along the different timelines.



Figure 2: Timeline of the enabling technologies

Education, healthcare, government, market intelligence and retail are examples of sectors that can use user interface and interaction technologies for sector transformation. Figure 3 highlights some of the opportunities to transform these sectors. Some opportunities such as high precision information environments for command and control and adaptive policy planning, and seamless indoor and outdoor services require coordination across sectors.

It is necessary to understand the underlying business processes, the data required and the relationships between stakeholders so as to better use technology to generate innovative and relevant solutions. In the journey of understanding the current state and envisioning the future state, ontologies (known as shared representation of knowledge showing entities and their relations) could be created to visualise the entities in the data and how they are related to one another.

IMPLICATIONS

For user interface and future interaction technologies to overcome challenges and sustain adoption, stronger collaboration to determine how their ontologies and business processes are related to one another is needed. Ontologies would need to be aligned and synchronised so as to form cross-sectoral ontologies that can be used across sectors. The development and usage of cross-sectoral ontologies would widen the perspective of sectoral transformation to also include understanding the cross-sectoral linkages and how sectors impact one another in terms of operations and strategic economic impact.

On data use, policies on trusted data management and data governance would provide assurance that consumer data would not be used for purposes than otherwise intended. Technologies such as data anonymisation to support downstream analysis, data fusion and value-added services (eg, 3D location-based services) could support trusted data management and data governance. Furthermore, a secure, trusted and robust infocomm infrastructure has to be continually leveraged and improved.

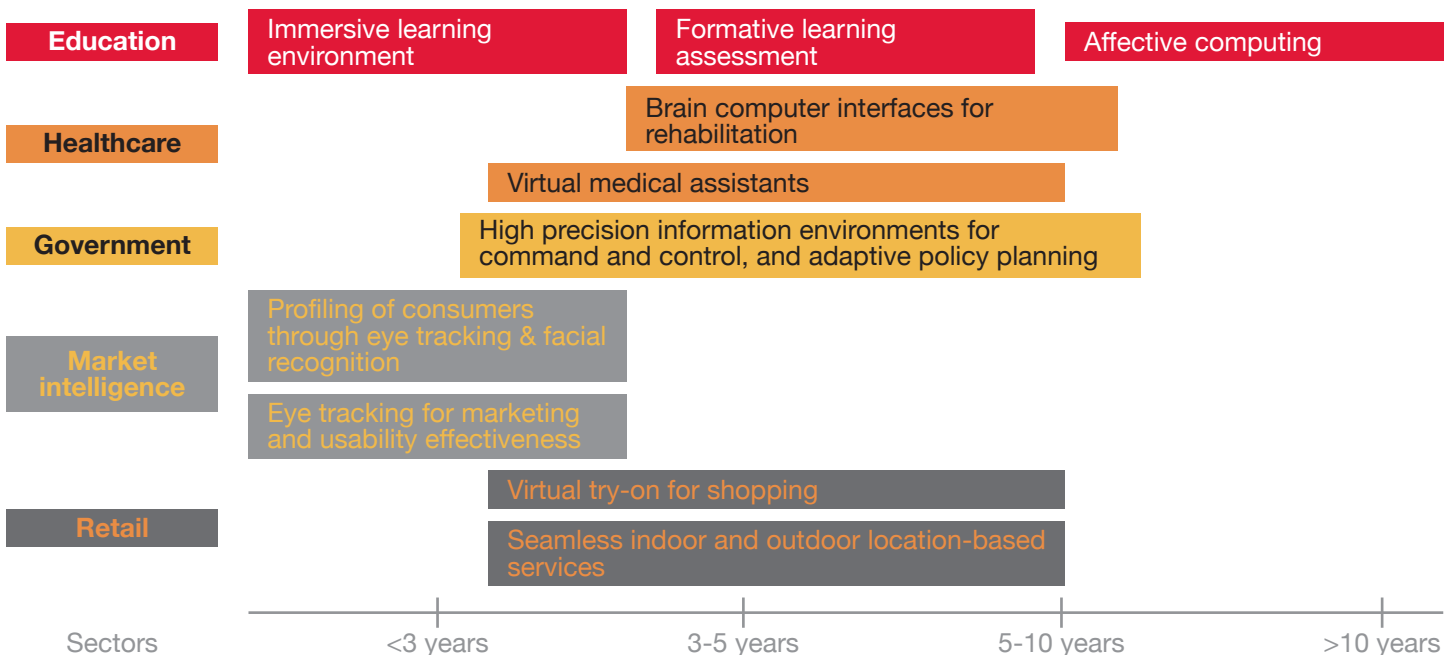


Figure 3: Timeline of market opportunities

Internet of Things

OVERVIEW

The boundary between the physical and the digital worlds is blurring with the prevalence of the Internet of Things (IoT) where the physical, digital and virtual worlds converge in a networked environment. IoT refers to the pervasive connectivity of physical objects, often using the same Internet Protocol (IP) that connects the Internet, to enable communication, interactions and controls. The concept was first mentioned in 1999 by the Radio Frequency Identification (RFID) community, and its deployment has gained momentum lately because of the growth of mobile devices, ubiquitous communication, cloud computing and data analytics.

Today many definitions of IoT have surfaced from CASGRAS, CERP-IoT, ITU, IEEE and the term is still evolving as technologies and ideas develop. Earlier IoT solutions took the form of machine-to-machine (M2M) communication. IoT makes it possible for virtually any object to be connected and working in synergy across various platforms, improving information exchange and enhancing the quality of life.

Global ICT trends are shifting from optimisation to innovation (some might even say disruptions). Sensors are getting smaller and more intelligent, networks are virtualised, bandwidth is increasing, innovations are occurring in cloud applications and analytics are shifting from static to real-time. These trends contribute to the transformational development of IoT.

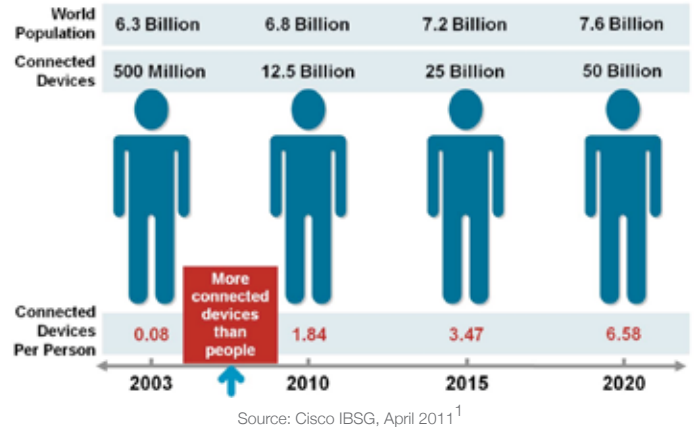
IoT is poised to bring tremendous value and impact - helping people decide the best route to work and choose a favourite restaurant, and ensuring that our health is constantly being monitored. For enterprises, IoT will create tangible business benefits ranging from improved management and tracking of assets to new business models and cost savings achieved through optimization of equipment and resources.

TRENDS

More “Things or Objects” than People

In 2010, the estimated number of devices connected to the Internet was 12.5 billion. This massive figure exceeded the world's human population of 6.8 billion, making it the first time in history that there were more connected devices than human beings.

This phenomenon was caused by the explosive growth of smartphones and tablet PCs. Looking to the future, the number of devices connected to the Internet could grow to 25 billion by 2015 and 50 billion by 2020.



Convergence of Data to Provide New Services

In today's ICT sector, industries are adopting new technologies and streamlining business processes to stay competitive. The integration of multiple sources of data from sensing devices can lead to the creation and improvement of new services across the industry.

In the logistics and supply chain, goods tagged with active RFID chips are integrated with location-based sensors on delivery trucks to facilitate tracking as they traverse the supply chain. In healthcare, medical providers are shifting from on-premise treatment to remote health monitoring to create greater flexibility and accountability of personal health for their patients. Moving ahead, modern cars can be equipped with vehicle-to-vehicle (V2V) communications to improve vehicle safety and contribute to traffic monitoring, complemented by road cameras and sensors.

OPPORTUNITIES

- Transportation – Improve transport utilisation and safety with convergence of real-time traffic data
- Smart Grid – Manage energy efficiencies, reduction of CO2 emission and low carbon footprint
- Supply Chain – Reduce cost of operation and improve automation & efficiency with real-time information
- Government – Improve public services and enhance urban planning and homeland security
- Retail – Improve sales with targeted marketing and new business / revenue models using context-aware services
- Healthcare – Promote personal health management with medical body area network

CHALLENGES

- Standardisation, Network Latency, Security and Privacy, Cost vs Usability

Security and Privacy Technologies

IoT needs to be built in such a way that it ensures a safe environment for user control. Today, there exist various encryption and authentication technologies such as Rivest Shamir Adleman (RSA) and message authentication code (MAC) to protect the confidentiality and authenticity of transaction data as they “transit” between networks. Encryptions such as full disk encryption (FDE) are also performed for user data “at rest” to prevent unauthorised access and data tampering.

With potentially billions of smart objects communicating and exchanging data in real time, new standards and technologies should address security and privacy features for users, network, data and applications. IP-based security solutions such as Internet Key Exchange (IKEv2), Host Identity Protocol (HIP) and IPsec are explored to perform authenticated key exchanges over IPsec protocol for secure payload delivery. Encryption algorithms need to be made faster to respond to the volume and complexity of information collected and exchanged. New technologies are needed to support data management, providing privacy yet allowing the sharing of real-time information through data abstraction, data anonymisation, data integration and data synchronisation.

Analytics

It is clear that in decision making process, the availability of real-time, accurate information is crucial. With the growing volume and variety of data, good decision making relies heavily on advances in analytic capability technologies to process data within a reasonable time frame to produce the best outcomes.

Streaming analytics is gaining popularity due to the ability to process data real-time as data is being captured by IoT applications. In-memory analytics is an approach to shorten query response times to support faster decision making, as querying data resides in computer’s random access memory (RAM), as opposed to on physical disks.

Other emerging trends such as context-aware computing services are able to propose the most relevant choices based on current situations and activities and predictive analytics are able to uncover relationships and patterns within data that can be used to predict future behaviour or events.

With IoT bringing vast amounts of information via billions of smart objects and sensors, new areas of data processing and analytics have to be explored at the different layers within the IoT, ie, sensors, communication, data, applications, in order to achieve optimum real-time decision making.

Wearable Computers

Wearable computers that combine the advances of integrated circuits, radio electronics and augmented reality are emerging as applications in IoT. Command line interface (CLI) that we are all accustomed to in the desktop world is not suitable in the mobile environment; hence the idea of wearable computing to go beyond the limitations of physical location, time, activity, etc becomes more prevalent.

Many types of technologies will be needed for wearable computers such as human interfaces, gesture recognition and motion sensing techniques. The use of wearable computers will most likely be an extension of personal computing which today is represented by the smartphone or tablet. IoT functionality will be integrated into these wearable devices to create a more realistic user interactions and experience.

RADAR

		<03 Years	03-05 Years	>05 Years
Management Service	Processing	< In-memory analytics	- Streaming analytics	
	Intelligence	< Context-aware computing < Predictive analysis	- Complex event processing	> Behavioural analytics
Gateway and Network	Network Capacity and Latency	< LTE		> LTE-A
	Network Sharing		- Software-defined radios	> Cognitive networks
Sensors Connectivity and Network	Wireless Sensor Network	< ZigBee	- 6LowPAN	
	Miniaturisation	< Coil-on-chip < Monolithic / single chip device		> Nanotechnology
	Intelligence		- Adaptive learning analytics	
	Power and Energy Storage	< Ultra-low power chip sets	- New batteries	> Energy harvesting

Conclusion

The nine themes identified by ITR 2012 highlight the key technological developments that will play a significant role in steering the ICT sector in the next 3-5 years. Not only will each theme evolve along its own course, the inter-dependence of the themes will also create exciting opportunities in the form of convergence and innovation. These developments will pave the way for innovation and create new opportunities for the various sectors.

The accumulation of structured and unstructured data in institutional databases and social networks lends credence to the concept of **Big Data**. The challenge with this is that datasets become so vast that only with the emergence of new technologies can management of these data be possible. The huge datasets of information present considerable opportunities for valuable knowledge to be extracted using various data analytics tools. Enterprises and governments will be able to proactively manage people's needs by using these tools to offer new business models and capabilities that provide improved products and services to suit each individual's needs. Coupled with the escalation of consumption demand, the provision of on-demand software, services and infrastructure will gain traction as enterprises adopt **Cloud Computing** on a bigger scale. The elasticity and scalability of Cloud Computing will help organisations reduce costs and increase efficiencies through multi-tenancy. Individuals will also draw on personal clouds to store, share and manage their multimedia content and information.

The **Internet of Things (IoT)**, driven by the decreased price point of sensors, increased availability of low-cost network connections and new consumer demands will gain prevalence in the next 3-5 years. In IoT, a multitude of mobile devices, sensor networks and even household appliances are envisaged to be connected to an IP network which will enable data exchange between disparate devices to perform specific tasks. This will generate a significant amount of data, thus driving the need for data analytics techniques to make sense of these data. In **ICT and Sustainability**, the collective development of sensor network technologies and data analytics to monitor energy consumption and resource allocation through smart grids, smart transport systems and smart buildings aims to achieve ecological sustainability. At the same time, with devices communicating with one another across disparate platforms and networks, the capacity and resilience of communications networks become even more important. **Comms of the Future** will include a myriad of faster and higher-performance technologies like Long Term Evolution (LTE) and the potential use of TV spectrum whitespace or unlicensed spectrum.

Social Media has carved out a new space in the cyber landscape in recent years, especially with the accessibility and reach through mobile channels. Sharing information at a rate faster than that of traditional mainstream media, social media encourages participation and engagement, and promotes transparency and accountability. It is increasingly used as the platform for community building, and businesses and governments are seeking to understand how to leverage social media to drive the **New Digital Economy (NDE)**. Also, coupled with the proliferation of mobile devices and e-commerce, the NDE provides a range of innovative business opportunities and models. For the government, the NDE enables a digitally connected citizenry where innovative ideas from the ground can be tapped to co-create a shared vision for the country. For small businesses, they are empowered with direct access to mass consumer markets and are able to forge more intimate relationships with the customer. For individuals, collaborative consumption drives value-for-money purchases through demand aggregation and excess reduction.

Advances in manufacturing, design and nanotechnology are creating smaller and more powerful chips that can be embedded in handheld devices and sensors, spawning a new era of intelligence computing. Improvements in technologies related to **User Interface** of the Future will lead to a more seamless, interactive and immersive ICT user experience. Context-aware computing and artificial intelligence technology will continue to evolve, giving rise to a more ubiquitous ICT environment.

Finally, **Cyber Security** will remain a concern throughout the themes and will be an inhibitor to adoption for some of the technologies. However, the need to provide confidentiality, integrity, availability and protection will encourage innovation and provide opportunities for the development of new technologies and standards.

ICT will be critical in addressing challenges posed by an ageing population, rapid urbanisation and sustainability for the future. Understanding this ICT landscape allows us to remain agile and prepare for a future where technology touches our everyday lives. The ITR serves as a guide to build new capabilities, sustain our competitive edge and **co-create a future** for everyone.

Reference

The Changing World - Global Trends Redefining Our Landscape

1. The University of Queensland, Australia. What is ICT? [Online] Available from: <http://www.uq.edu.au/ict/what-is-ict> [Accessed 30th July 2012].
2. Population Division, DESA, United Nations. Demographic Determinants of Population Ageing. [Online] Available from: <http://www.un.org/esa/population/publications/worldageing19502050/pdf/8chapteri.pdf> [Accessed 30th July 2012].
3. Population Division, DESA, United Nations. Magnitude and Speed of Population Ageing. [Online] Available from: <http://www.un.org/esa/population/publications/worldageing19502050/pdf/80chapterii.pdf> [Accessed 30th July 2012].
4. United Nations (UN) and International Telecommunications Union (ITU). Why and How the Environment has to be taken into Account at the World Summit on the Information Society. [Online] Available from: http://www.itu.int/dms_pub/itu-s/md/03/wsispc2/c/S03-WSISPC2-C-0043!!PDF-E.pdf [Accessed 30th July 2012].
5. Population Division, DESA, United Nations. World Urbanization Prospects. [Online] Available from: http://esa.un.org/unpd/wup/pdf/WUP2011_Highlights.pdf [Accessed 30th July 2012].
6. Booz & Company. The Rise of Generation C: Implications for the World of 2020. [Online] Available from: http://www.booz.com/media/uploads/Rise_Of_Generation_C.pdf [Accessed 30th July 2012].
7. Qualcomm. M2M White Paper: The Growth of Device Connectivity. [Online] Available from: <http://www.qualcomm.com/media/documents/files/m2m-white-paper-growth-device-connectivity.pdf&sa=U&ei=O3ofUJ1Rh-WsB8TlgdGL&ved=0CBEQFJAA&usq=AFQjCNEqA7LRR058xyEb8fL2P-YLp4e7A> [Accessed 30th July 2012].

Big Data

1. IDC. The 2011 Digital Universe Study: Extracting Value from Chaos. [Online] Available from: <http://www.emc.com/collateral/analyst-reports/dc-extracting-value-from-chaos-ar.pdf> [Accessed 30th July 2012].
2. Douglas Laney, Lisa Kart. Emerging Role of the Data Scientist and the Art of Data Science. [Online] Available from: <http://www.gartner.com/id=1955615> [Accessed 30th July 2012].
3. IDC. Worldwide Big Data Technology and Services 2012-2015 Forecast. [Online] Available from: <http://www.idc.com/getdoc.jsp?containerId=233485> [Accessed 30th July 2012].
4. Cisco. The Internet of Things: How the Next Evolution of the Internet is Changing Everything. [Online] Available from: http://www.cisco.com/web/about/ac79/docs/inov/loT_IBSG_0411FINAL.pdf [Accessed 9th July 2012].
5. IDC. IDC's Worldwide Big Data Taxonomy, 2011. [Online] Available from: <http://www.idc.com/getdoc.jsp?containerId=231099> [Accessed 9th July 2012].

Cloud Computing

1. Ried, S; Kisker, H. Sizing The Cloud. [Online] Available from: <http://www.forrester.com/Sizing+The+Cloud/fulltext/-/E-RES58161?objectId=RES58161> [Accessed 30th July 2012].
2. Nokia Siemens. 2020: Beyond 4G. [Online] Available from: <http://4g-portal.com/nokia-siemens-networks-beyond-4g-white-paper> [Accessed 30th July 2012].
3. Cisco. Cisco Global Cloud Index: Forecast and Methodology, 2010-2015. [Online] Available from: http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns1175/Cloud_Index_White_Paper.html [Accessed 30th July 2012].
4. CSC. CSC Cloud Usage Index. [Online] Available from: http://assets1.csc.com/newsroom/downloads/CSC_Cloud_Usage_Index_Report.pdf [Accessed 30th July 2012].
5. Gartner. Gartner says the Personal Cloud Will Replace the Personal Computer as the Center

of Users' Digital Lives by 2014. [Online] Available from: <http://www.gartner.com/it/page.jsp?id=1947315> [Accessed 30th July 2012].

Cyber Security

1. Microsoft. Win32/Stuxnet. [Online] Available from: <http://www.microsoft.com/security/portal/Threat/Encyclopedia/Entry.aspx?Name=Win32/Stuxnet> [Accessed 30th July 2012].
2. Laboratory of Cryptography and System Security (CrySys Lab), Budapest University of Technology and Economics. sKyWlper (a.k.a. Flame a.k.a. Flamer): A complex malware for targeted attacks. [Online] Available from: <http://www.crysys.hu/skywiper/skywiper.pdf> [Accessed 30th July 2012].
3. Zetter, K. Meet 'Flame', The Massive Spy Malware Infiltrating Iranian Computers. [Online] Available from: <http://www.wired.com/threatlevel/2012/05/flame/all/1> [Accessed 30th July 2012].

ICT & Sustainability

1. United Nations (UN). Our Common Future, From One Earth to One World. [Online] Available from: <http://www.un-documents.net/oct-ov.htm#1.2> [Accessed 30th July 2012].
2. Infocomm Development Authority of Singapore (IDA). Infocomm Statistics. [Online] Available from: http://www.ida.gov.sg/Annual%20Report/2010/subpages/infocomm_stats/infocomm_industry.html [Accessed 30th July 2012].
3. United Nations (UN) and International Telecommunications Union (ITU). Why and How the Environment has to be taken into Account at the World Summit on the Information Society. [Online] Available from: http://www.itu.int/dms_pub/itu-s/md/03/wsispc2/c/S03-WSISPC2-C-0043!!PDF-E.pdf [Accessed 30th July 2012].
4. GreenTouch. GreenTouch Fast Facts. [Online] Available from: <http://www.greentouch.org/index.php?page=facts-facts> [Accessed 30th July 2012].
5. The Climate Group and Global e-Sustainability Initiative. The Smart2020 Report. [Online] Available from: <http://www.smart2020.org/> [Accessed 30th July 2012].
6. Organisation of the Petroleum Exporting Countries (OPEC). OPEC Basket Price. [Online] Available from: http://www.opec.org/opec_web/en/data_graphs/40.htm [Accessed 30th July 2012].
7. Gartner. Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions. [Online] Available from: <http://www.gartner.com/it/page.jsp?id=503867> [Accessed 30th July 2012].

Comms of the Future

1. GSMA. Connected Life. [Online] Available from: <http://www.connectedlife.gsma.com> [Accessed 30th July 2012].
2. ComScore. 2012 Mobile Future in Focus. [Online] Available from: http://www.comscore.com/Press_Events/Press_Releases/Whitepapers/2012/2012_Mobile_Future_in_Focus [Accessed 30th July 2012].
3. Blackbox. Smartphones in Singapore. [Online] Available from: <http://www.blackbox.com.sg/wp/wp-content/uploads/2012/05/Blackbox-YKA-Whitepaper-Smartphones.pdf> [Accessed 30th July 2012].

Social Media

1. Mayfield, A. What is Social Media? [Online] Available from: http://www.icrossing.co.uk/fileadmin/uploads/eBooks/What_is_Social_Media_iCrossing_ebook.pdf [Accessed 30th July 2012].
2. ComScore. It's a Social World: Social Networking Leads as Top Online Activity Globally, Accounting for 1 in Every 5 Online Minutes. [Online] Available from: http://www.comscore.com/Press_Events/Press_Releases/2011/12/Social_Networking_Leads_as_Top_Online_Activity_Globally [Accessed 30th July 2012].
3. Nielsen Wire. Social Media Report: Sending Time, Money and Going Mobile. [Online]

Available from: http://blog.nielsen.com/nielsenwire/online_mobile/social-media-report-spending-time-money-and-going-mobile/ [Accessed 30th July 2012].

4. Brian Solis. Report: The Rise of Digital Influence and How to Measure It. [Online] Available from: <http://www.briansolis.com/2012/03/report-the-rise-of-digital-influence/> [Accessed 30th July 2012].

New Digital Economy

1. Australian Government, Department of Broadband, Communications and the Digital Economy. [Online] Available from: http://www.dbcde.gov.au/digital_economy/what_is_the_digital_economy [Accessed 30th July 2012].
2. Mashable Tech. Big Banks Fear Losing Consumers to Mobile Wallets. [Online] Available from: <http://mashable.com/2012/06/05/big-banks-fear-mobile-wallets/> [Accessed 30th July 2012].
3. Computerworld. Paying with smartphones to outpace credit cards by 2020, experts say. [Online] Available from: <http://news.idg.no/cw/art.cfm?id=867E1CAE-F636-8341-110455AB457C6016> [Accessed 30th July 2012].

User Interface

1. IDC Asia. Pacific Quarterly Mobile Phone Tracker Data (May 2012)
2. IDC. Quarterly Tablet Tracker Data (May 2012)
3. Visiongain. Mobile User Interface 2011 to 2016: Designing Compelling UI in iPhone and Android Era. [Online] Available from: <http://www.reportlinker.com/p0629374-summary/Mobile-User-Interface-Designing-Compelling-UI-in-iPhone-and-Android-Era.html> [Accessed 30th July 2012].
4. Trendwatching.com. Point-Know-Buy: Why infotul, spontaneity-loving consumers will embrace instant visual information gratification. [Online] Available from: <http://www.trendwatching.com/trends/pointknowbuy/> [Accessed 30th July 2012].
5. Chen, Y. Bloomingdale's Kinect Change Room Helps You Find the Perfect Pair of Jeans. [Online] Available from: <http://www.psfk.com/2012/03/bloomingdales-kinect-change-room.html> [Accessed 30th July 2012].
6. Malta Industrial Innovation for SMEs. Creation of a Post Stroke Rehabilitation Programme for the Xbox Kinect – Designated for In Hospital and At Home Scenarios. [Online] Available from: https://cordis.europa.eu/partners/c/document_library/get_file?uuid=32a37558-2ccb-4c84-acb9-992a83e93b21&groupId=1538278 [Accessed 30th July 2012].

Internet of Things

1. Cisco International Business Solutions Group (IBSG). The Internet of Things: How the Next Evolution of the Internet is Changing Everything. [Online] Available from: http://www.cisco.com/web/about/ac79/docs/inov/loT_IBSG_0411FINAL.pdf [Accessed 30th July 2012].
2. Beecham Research. M2M Sector Map. [Online] Available from: <http://www.beechamresearch.com/download.aspx?id=18> [Accessed 30th July 2012].

Acknowledgement

The Infocomm Technology Roadmap (ITR) 2012 handbook would not be possible without the support and assistance rendered by many experts across the Information Communications Technologies (ICT) industry, as well as colleagues from other government agencies. Many of them had given numerous hours of their time to provide information and feedback, during and after the ITR roundtable and workshops.

In addition, we would also like to thank all colleagues at IDA, who have contributed to this handbook and for their support through the journey.

For those we have failed to mention here, we are in no way less grateful for your assistance to the success of the ITR 2012. We could not have done so much without everyone's contributions.

Thank you.



The Infocomm Development Authority of Singapore (IDA) is committed to growing Singapore into a dynamic global infocomm hub. IDA uses an integrated approach to developing info-communications in Singapore. This involves nurturing a competitive telecoms market as well as a conducive business environment with programmes and schemes for both local and international companies.

Head Office

10 Pasir Panjang Road #10-01
Mapletree Business City
Singapore 117438
Tel: +65 6211 0888
Fax: +65 6211 2222
Email: info@ida.gov.sg
Website: www.ida.gov.sg

Singapore • China • India • Qatar • USA

Notice: This document is protected by copyright, trademark and other forms of proprietary rights. Save as permitted by law, no part of this document may be reproduced, distributed or adapted without the express permission of IDA.

This document is provided "AS IS" without any express or implied warranty of any kind. Whilst IDA has made every reasonable effort to ensure that the information contained herein are obtained from reliable sources and that any opinion and/or conclusions drawn therefrom are made in good faith. To the extent not prohibited by law, IDA, its employees, agents and/or assigns shall not be responsible or liable for reliance by any person on the information, opinion and/or conclusion contained herein. IDA, its employees, agents, and/or assigns shall not be liable for any direct, indirect, incidental or consequential losses arising out of the use of this document.