Future Communications

Technology Overview

3.1.1 Future Communications will enable the next generation of computing and services, and generally comprise the following:

(1) Wireless Communications: These include wireless communications for personal area networks (Bluetooth and ZigBee), local area networks (Wi-Fi operating at unlicensed spectrums), and wide area networks (cellular networks at licensed spectrum operated by telecom operators). Traffic from wireless and mobile devices is predicted to exceed traffic from wired devices by 2017.

(2) Optical Communications: Optical fibres carry high volume data and form the backbone of our Internet and telecom infrastructure. Fibres are now entering homes to replace telephone lines and TV cables to provide converged voice, data and video services.

(3) Networks: These include technologies for interconnectivity among networks and systems with different addressing schemes or physical media. Voice, SMS, video, data, and social networks are typical examples of services sitting above the networking layer. Unified Communications and Collaboration (UC&C) bring some of these services together in a unified collaboration experience that helps people share information more efficiently.

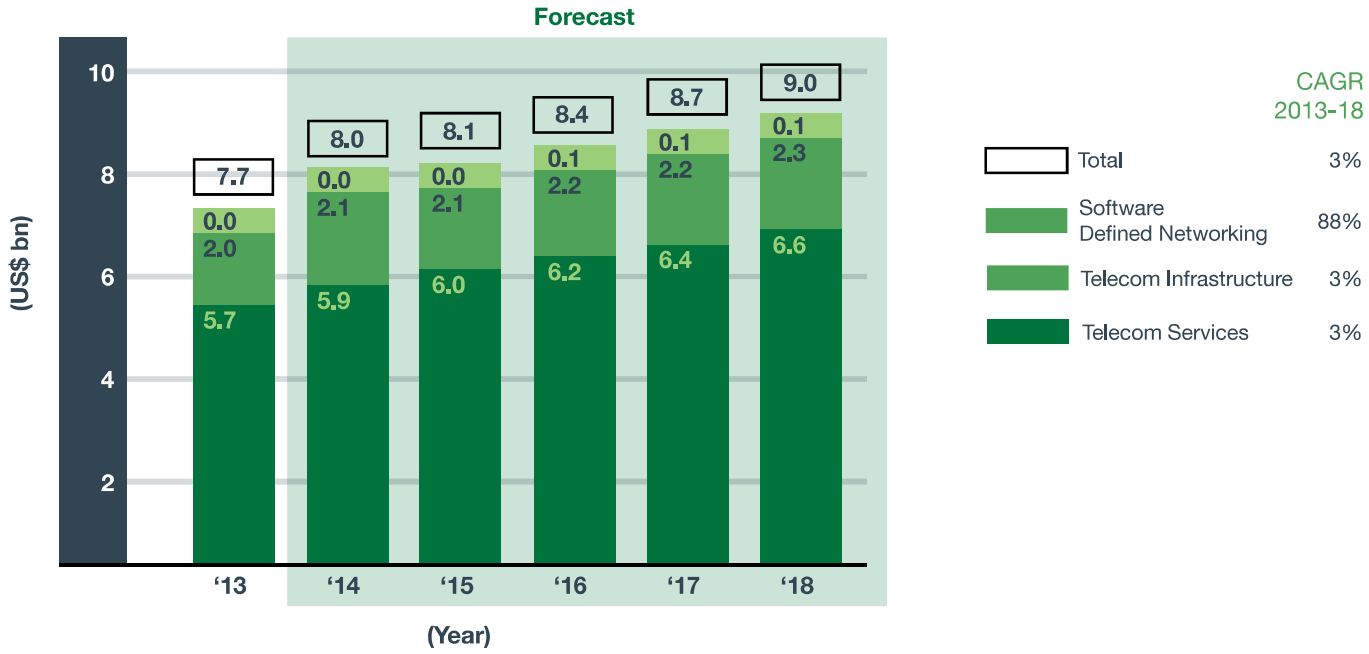
3.1.2 Future communications will enable next generation computing and services like cloud computing, mobile computing or the Internet of Things (IoT). They play pivotal roles in transforming the various key sectors identified in the Infocomm Media 2025 report. Phenomenal traffic growth in wired and wireless data has driven the communications market, with the number of connected devices potentially becoming three times larger than the global population by 2017. Globally, Internet video traffic will be 73 per cent of all Internet traffic by 2017, up from 60 per cent in 2012[10].

Market Size

3.2.1 The global market size of Future Communications is projected to hit US$2088 billion in 2018 and the global market size is expected to grow relatively slowly, with CAGR (2014 – 2018) at three per cent[11]. Singapore's addressable market globally for Future Communications is expected to be around US$9 billion by 2018, as shown below. Both the addressable telecom infrastructure and telecom services are estimated to register five-year CAGR (2013 – 2018) at three per cent. Software defined networking will exhibit five-year CAGR (2013 – 2018) at around 88 per cent. However, the market size of software defined networking is much smaller compared to telecom infrastructure and telecom services.

3.2.2 In investment[12], global public funding mainly focuses on nation-scale infrastructure development while large technology corporations and venture capitalists (VCs) focus more on end-user services and applications. For example, public funding in cellular networks are estimated to be around US$169 million by 2018, while VCs can potentially invest US$3.5 billion on consumer-centric 4G cellular terminals, cellular infrastructure and base stations. The private sector mergers and acquisitions are expected to reach US$6.3 billion in 2018.

Singapore's Future Communications Addressable Global Market, 2013 - 18 (US$ bn)
CAGR = Compound Annual Growth Rate



Trends

3.3.1 Mobility: Smart phones and tablets are increasingly becoming part of business because of strong growth in enterprise mobility and the bring-your-own-device (BYOD) phenomenon. International Data Corporation (IDC) forecasts that by 2017, smartphone shipments will grow an average of 30 per cent. In 2014, 80 per cent of enterprise app users have used mobile versions of traditional software applications, and Singaporeans own more than one handphone each. Seamless mobility will be more pervasive, where switching from one radio access technology to another radio access technology does not cause QoS degradation or service interruption.

3.3.2 Over-The-Top Content (OTT): OTT is the new norm for telecommunications[13]. For instance, Netflix traffic accounted for 34 per cent of North America's downloads during the busiest hours of the day in 2014[14], with YouTube coming in second with around 13 per cent. But because most OTT services are based on best-effort network service, telecom networks and OTT services should be well integrated to maximise quality OTT service and experience.

3.3.3 4K Video: 4K Ultra HD technology is the next evolution of HD (High Definition) and High Efficiency Video Coding (HEVC) is a video compression standard suitable for 4K video that can make shooting video in 4K resolution standard in all cameras[15]. This is because HEVC is twice as efficient as the current MPEG-4/H.264 standard. Nevertheless, interactive communications in 4K will require much higher network bandwidth with much lower latency.

3.3.4 IoT, M2M and Wearables: The explosive growth of IoT challenges us to rethink traditional networks that have been mainly designed for human-to-human communications. Wearables and M2M devices have their own traffic patterns that are very different from human-to-human communications. Real-time IoT applications need stringent quality of service guarantees on communication data rate and latency. Low power is also a key consideration for sensors and wearables.

3.3.5 Efficient Network Management and Multi-tenant Networks: Today's network infrastructure is highly complex as the control and data planes are tightly integrated in the network equipment. To improve network efficiency, network architecture will evolve towards decoupling of data plane and control plane. This will enable networks to become more and more software defined and efficient in the management of network resource. As a result, network will evolve to be programmable and open. Multi-tenant network in the form of network slicing is another trend for network evolution. Such networks can be virtualised to support multiple operators and vertical owners can own and run its own networks without the need of a dedicated physical network.

3.3.6 Demands of Smart Cities: Smart Cities comprise many sub-systems that communicate together seamlessly. The sheer increase in the number of connected devices and the ever-increasing size of these data packets can put heavy strains on the communications infrastructure. For example, Smart Transportation initiatives tapping on seamless mobility that keep commuters informed about bus or train arrival timings and real-time seats availability mean that many devices need to communicate simultaneously.

Technology Roadmap

3.4.1 The following table reflects the industry's view of the likely evolution and mainstream adoption of Future Communications technologies.

Demand Drivers	1-2 Years	3-5 Years	>5 Years
Higher Speed (Wireless)	**Higher Speed due to Higher Spectrum Efficiency**	**Higher Speed due to Advances of Communication and Networking Technologies**	**100x Typical Data Rate of 1–2 Years**
	• 802.11ac[T] • Femtocells[T] • LTE-Advanced (Carrier Aggregation)[T]	• Heterogeneous Network (HetNet)[T] • Small Cell[T] • 4.5G[T] • LTE-U (Unlicensed LTE)[T] • 802.11ad[T]	• 5G Standardisation (>1Gbps)[T] • Massive MIMO[T] • >6GHZ Radio Access[T]
Higher Speed Transmis-sion	**100Gbps per Wavelength**	**1Tbps per Wavelength**	**100x Typical Data Rate of 1–2 Years**
	• 100G Optical[T]	• 400G/ Multi-Terabit[T]	• Optical OFDM (OFDM for optical)[T] • Quantum Communications[T]
Higher Speed (Optical Access)	**Maximum 2.5Gbps**	**Maximum 10Gbps**	**100Gbps and Beyond**
	• GPON • FiberLAN[T]	• 10G-PON/XG-PON (ITU's 10G to Home)[T]	• WDM PON[T]
Lower Latency	**Tens of Milliseconds**	**Around 1 ms – 5 ms**	**Target at <1 ms**
	• LTE-A (Carrier Aggregation)[T]	• Cloud-Based RAN[T] • Dedicated Short-Range Communications[T]	• 5G RAT (<1 ms)[T]

[T] is classified as Technology, otherwise as Capability.
Industry has differing views on the timeframe for mainstream adoption for some technologies.

Seamless Handover	**Seamless Authentication**	**Seamless Handover**	**Seamless Session Continuity and QoS**
	• 802.11u (Hotspot 2.0)[T] • Cellular/Wi-Fi Integration[T]	• Heterogeneous Network (HetNet)[T] • 802.11ax[T] • TV Whitespace[T]	• Mobile Satellite Services[T] • DASH7 (Open Source RFID-std for Sensor Networking)[T] • IEEE 802.22 (Regional Area Network in TVWS)[T] • Fixed/Mobile Convergence[T]
Efficient Network Manage-ment	**Automation and Simplification**	**Hardware Abstraction and Network Function Virtualisation**	**Software Defined and Open Source**
	• Green Network Infrastructure[T] • Self-Organising Network (SON) [T] • OpenFlow[T] • SDN for DC[T]	• NFV (Network Function Virtualisation)[T] • SDN for Core Networks[T] • Embedded SIM[T] • IPv6[T]	• White-Box Switching[T] • Dynamic Spectrum Management[T] • Cognitive Radio[T] • 5G Standardisation[T]
Efficient Network	**Standalone Solutions**	**Open and Flexible**	**Intelligent at Edge**
	• Location-Based Services (LBS)[T]	• Data Driven Efficiency[T] • LTE Broadcast[T]	• Edge/Fog Computing[T]
Adaptive and Low Power	**Low Power for Small Scale Networks**	**Low Power for Large Scale Networks**	**Low Power for Pervasive Networks**
	• Zigbee[T] • Z-Wave[T]	• LTE M2M[T] • D2D (Device-to-Device)[T]	• Cognitive Radio[T] • IEEE 802.11ah[T] • 5G Standardisation[T]
Service Innovation	**Service Integration**	**Seamless Service**	**Immersive Experience**
	• Cloud UC[T] • UCC[T] • IMS[T]	• Hybrid UCC[T] • Web Real-Time Communications[T]	• Holographic Telepresence[T] • 4K/16K Telepresence[T]
Network Security	**Security at Individual Communication Technology Level**	**Security at Network Architecture Level**	**Comprehensive Network Security**
	• IMS Security	• SDN Security • NFV Security • Security for Embedded SIM	• 5G Security

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R&D Opportunities

3.5.1 We need to align our national R&D efforts with the industry and sector development directions in the Infocomm Media 2025 report. This table highlights some examples of technology capabilities in Future Communications that we need to build to support the appropriate sector transformations described in Chapter One.

Targeted Capabilities	Sector	Next Practices (3-5 years)	Transformational Practices (>5 years)
Heterogeneous Networks	Education	**Personalised Learning via Analytics**	**Ubiquitous Connectedness in Learning via Wearables and Sensors**
		High-density communications and seamless handover of real-time low bit-rate data from online devices across indoor and outdoor for learning query	High-density communications and seamless handover of high bit-rate real-time video streams from online devices across indoor and outdoor for immersive learning experience
	ICM (HetNet Infrastructure)	**Seamless Mobility Among Different Radio Access Technologies and Size of Cells**	**Pervasive Seamless Wireless Connectivity for Various Networks and Devices**
		• Spectrum sharing policies • Context-aware network selection • Self-Organising Network (SON) for HetNet	• New radio access technologies such as massive MIMO and 3D beamforming to achieve high throughput • Cognitive radio with predictive capability and self configurable radio for various MAC and physical layers of radio access networks • Network slicing and dynamic service orchestrations of network resources in the mobile networks
Vehicle-to-Everything (V2X)	Transport	**Context-Aware & Data-Driven Intelligence**	**Smart Integrated Transportation System**
		• Low power, scalable and long distance sensor-to-sensor communications via cellular networks • Reliable Dedicated Short-Range Communications (DSRC) for V2V and V2I	Network embedded computing for edge analytics