Friday, 15 April 2019
By: Isaac Lee Yi De, President

But will it scale?

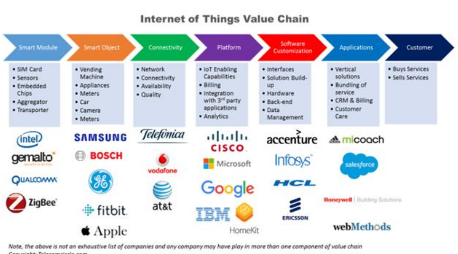
Discussing the constraints of IoT solutions today and implications 5G networks of changing it all

The Promise of a Connected World

According to Statista.com, the number of IoT devices is projected to amount to 75.44 billion worldwide by 2025[1]. Other estimates place it at a more conservative figure of around 21.5 billion[2]. But one can agree that the market for IoT solutions is booming. As of 2018, estimates put it as a USD$151 billion-dollar market[3]. But are these projections based on facts or hype?

As with any technology, there is always a growing fear of whether we're on the brink of a revolution that will cause a massive disruption within the industry we're operating in. IoT solutions today have found use-cases in Smart Homes, Smart City Management, Agriculture, Healthcare, Logistics, Security and the list goes onto 50 over use-cases[4]. These solutions often have the promise of creating the ability to leverage on the data captured by these devices, to optimize, personalize, augment and create a seamless experience for customers, in real time.

While many years ago, barriers to implementing these solutions may have been due to high capital expenditure to manufacture these sensors, cameras, drones or network devices, the current stage of the industry sees many large players providing mass solutions within segments of the value chain for IoT eco-systems.



Source: IoT Valuechain, ACG Research, 2017[5]

Hardware these days has become a commodity, often produced at an extremely price competitive margin by OEM providers in China. While Cloud infrastructure is provided by large players such as Microsoft Azure, AWS and Google Cloud.

Where do new players fit in?

Start-ups largely target a niche within the value chain of providing the SaaS that acts as the aggregator for data inputs from devices and provide some form of intelligence through data analysis or data visualization for easy use. They may also provide consulting and operational services depending on their business model.

The industry today is highly competitive with big city projects taken on by larger names such as Siemens, Intel and Cisco, while start-ups find their niche in specific use-cases such as COE-IoT[6] utilizing drones for Agriculture or Sirqul[7] which provides an IoT Platform for several use cases including Retail, Logistics and Healthcare.

Smart Cities – the Endgame

Perhaps the "biggest" or most well-funded use-case is intertwining all these sectors in providing a Smart City solution. As of 2018, there are around 19 known smart city projects in development[8]. These include "Greenfield projects" which are completely new cities designed to have the infrastructure already in place with smart city solutions. More commonly seen are the projects that target reinventing existing cities to become smart by implementing devices in waste monitoring, foot and road traffic analysis, environmental analysis, smart energy grids, etc.

In Singapore, we have the Smart Nation Initiative which includes developing the infrastructure required to provide common digital and data platforms mandated in the Smart Government Blueprint[9]. In 2018, Singapore was even awarded the Smart City of the year by the Smart City Expo World Congress (SCEWC)[10]. In 2019 alone, Singapore and other top smart cities are estimated to spend around US$1 Billion on Smart City related initiatives[11].

But are we actually there yet?

The truth of the industry is that most companies promising these solutions are operating on a small scale or only running pilots. According to RTinsights 6 in 10 enterprises fail to take IoT projects beyond the pilot stage[12].

The business reason for failure

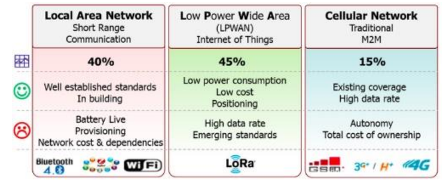
There have been several commonly highlighted issues including the lack of a clear business case, long sales-cycles, privacy concerns and security concerns with previous notable incidences[13]. But perhaps the biggest problem, is a failure of coordination between providers within projects.

Why is it so hard to work together?

Based on the figure shown previously, we can see that providers are already occupying various spaces of the value chain. However, these companies actually have the capabilities to provide an end-to-end solution and being that sort provider is perhaps the holy grail for an IoT company. But the costs of providing such a service is often high, requires a large range of expertise and often you will be out-bided by the competition or it would simply be easier not to. This creates a blur between who provides which part of the value chain and a huge issue when working with multiple companies particularly when developing huge scaled solutions such as smart cities or establishing IoT eco-systems.

The technological limitations of scalability

To connect IoT devices together, there are 3 different types of wireless networks and various protocols within them. In the LPWA space there already includes Sigfox, LoRa/LoRaWAN and Ingenu as the most common protocols. Then there are LAN networks which include Bluetooth, Zigbee and WiFi. Lastly in the cellular front there is 3G, 4G-LTE which are NB-IoTs (NarrowBand IoT)[14]. Choosing the right network is critical to the specific use-cases as variations on range and bit rate must fit the requirements of the project.



Source: lora Alliance.org, 2018

Each of these networks have some form of specialization, associated power consumption, coverage and dependencies which limit their implementation within both urban and rural environments. These variations extend to the individual protocols particularly for LPWANs which variations may even be priorietary[15].

Solution	Model	Frequency	Range	Data transfer rate	Packet Size	Stage
Sigfox	Proprietary	868 / 902 MHz	rural: 30-50 km urban: 3-10 km	upload: <300 bps download: 8 bits per day	12 bits	scale
LoRaWAN	Alliance	433 / 868 / 780 / 915 MHz	rural: 15 km urban: 2-5 km	upload: 300 bps – 50 kbps download: 300 bps – 50 kbps	user-defined	scale
Ingenu	Proprietary	2.4 GHz	rural: 5-10 km urban: 1-3 km	upload: 624 kbps download: 156kbps	6 bits – 10 kbits	scale
Weightless-W	Alliance	400-800 MHz	5 km	upload: 1 kbps – 10 Mbps download: 1 kbps – 10 Mbps	>10 bits	introduction
Weightless-N	Alliance	<1 GHz	3 km	upload: 100 bps download: 100 bps	<20 bits	introduction
Weightless-P	Alliance	<1 GHz	2 km	upload: 200 bps – 100 kbps download: 200 bps – 100 kbps	>10 bits	under development
Dash7	Alliance	433 / 868 / 915 MHz	<5 km	upload: 10, 56, or 167 kbps download: 10, 56, or 167 kbps	<256 bits	introduction

Source: A Detailed Breakdown of LPWAN Technologies and Providers, Lux research, 2016

When companies dedicate themselves to a specific network, particularly those which are proprietary, there are migratory constraints of utilizing separate networks. Some firms even dedicate themselves to a networks/alliance and create whole product lines that dedicated those specific networks rather than opt for cross-operatability[16]. Although some companies claim to be network/protocol agnostic, the reality is that there is always a constraint with regards to network migration.

What is so limiting about these networks?

A major technological constraint which firms face in order to create compelling business cases is the fact that the rate in which data is transferred between devices, particularly those of higher-level functionality, is too low utilizing LPWANs which is the most commonly used network for IoT companies. These higher-level functionalities include "Edge Processing" where IoT evolve beyond dumb sensors into smart sensors which are programmable and task-specific analyzers[17].

Let us take computer vision as an IoT capability for example. The available functionality even on the cloud/backend processing requires certain levels of fidelity of images to perform various functionalities.

Category	PAL	1080p	720p	WSVGA	SVGA	VGA	2CIF	CIF	QCIF
Identify	100	38	56	67	67	84	139	139	139
Recognize	50	19	28	34	34	42	70	70	139
Observe	25	10	14	17	17	21	35	35	70
Detect	10	4	6	7	7	9	14	14	28
Monitor	5	2	3	3	3	5	7	7	14

Source: Perfect Pixel Count, Axis Communications, 2014

The table above by Axis Communications[18] places the need for vertical body height representation required for identification functions needed to cover 38% of the total image transmitted for 1080p cameras. (Essentially, this means that the person needs to cover a significant portion of the image to identify them).

Technology	Resolution	30FPS	20FPS	15FPS	10FPS	5FPS	3FPS	1FPS
H.264/MPEG4	640x360	1500	1500	1000	1000	500	500	500
	640x480(VGA)	1500	1500	1000	1000	500	500	500
	720x480(D1)	1500	1500	1000	1000	500	500	500
	800x450	2000	1500	1000	1000	500	500	500
	1280x720(720P)	2000	2000	2000	1000	1000	500	500
	1280x800(WXGA)	3000	3000	2000	2000	1000	500	500
	1280x1024	3000	3000	3000	2000	1000	500	500
	1920x1080(1080P)	**4000**	**4000**	**3000**	**2000**	**1000**	**500**	**500**
	2048x1536(QXGA)	N/A	4000	2500	2500	2000	1500	500
	2592x1944(5M)	N/A	N/A	N/A	3000	3000	2000	1000

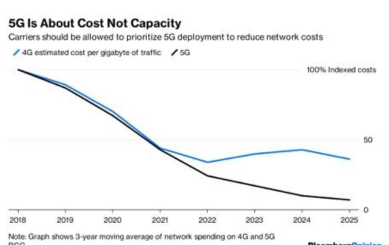
Source: IP Camera bitrate in KBPS by Unifore Security, 2015[19]

By examining the bitrate required for transition of 1080p images at a steady rate. We can see that for a smooth 20-30 FPS for one camera, the required transmission rate per second is around 4mbit/s. These kinds of transmission rates require a continuous 3G/4G-LTE network connection to function which greatly limits the ability to deploy such functions in places without cellular coverage. One must also consider the costs associated with the data transmission, to support an enterprise-wide implementation.

While it is arguable that 1080p is an extreme case and there are work-arounds that can be done to achieve identification without relying on image processing alone, this is still an issue for cameras which need to cover wide areas of deployment. Particularly for smart cities where the ability to access consumer phones to identify persons, such as in retail, are not available.

So what is the deal with 5G?

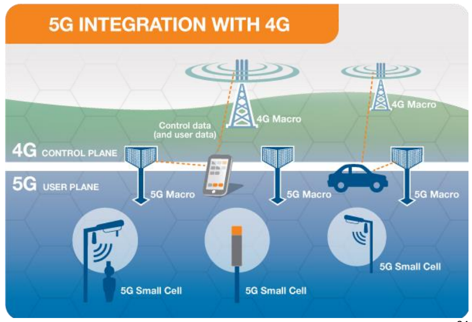
5G is one of the key implementations in the near future which will drastically change the way in which IoT implementations happen. Essentially the promise of 5G is to be able to provide data transmissions at speeds so fast that enables Edge Processing capabilities for higher-level functionality. Additionally, because the rate data transmission will be extremely high, many argue that the cost of data transmission per Gbit/s will drastically decrease[20].



Source: Bloomberg Opinion, 2019

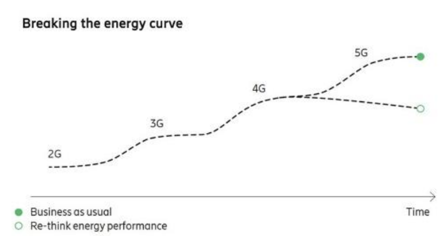
With an estimated initial commercial deployment around 2020[21], 5G would enable functionalities such as Self-driving Cars, Augmented/Virtual Reality projection, Industrial Automation and Machine-to-Machine communication[22]. These would enable IoT providers the ability to build business cases beyond business intelligence/city governance or other forms of data aggregation. Systems enabled by these will be adaptable to the environment of deployment and highly accurate in terms of fidelity of the data transmitted. The number of devices that can connect on 5G networks would also drastically increase by around 10x in network density.

However, the deployment of 5G is debatable in terms of when it will actually arrive at scale. There is still an associated capital expenditure which presents a major financing challenge for telecommunication providers around the world. The way in which 5G functions on a higher frequency also means that it is subjected to foliage and line of sight concerns due to the short range of the signal compared to 4G[23]. This means that deployment will most likely be limited to major cities which are able to support and finance the 5G Macros and Small Cell towers.



Source: EMF Explained, 2018[24]

While some also mention the concern over energy costs, providers like Ericsson predict that they will likely be able to at least manage them with hardware and software modernization.



Source: Ericsson Blog, 2019[25]

What does say about the future of IoT?

The dream of smart cities is likely to be realized but at significant initial costs. The current players in this field will likely have to spend a significant portion of capital and time developing solutions with Edge Processing capabilities within the major cities to stay competitive. Alternatively, they may have to focus on peripheral cities/rural areas in which 5G implementation is not likely to disrupt the current state of functionalities available to corporate clients and governments. To fulfill ambitions of having the best smart systems, governments and corporate client are likely to start investing in companies which are able to deliver on these Edge Processing capabilities in the near future, working closely with telecommunication providers and other necessary players in the IoT Eco-system.

On the manufacturing front, the devices in the market which are heavily commoditized today will likely grow redundant to products which offer greater functionality. These will likely be in more demand as customization for complex functions will be required to cater to specific requirements of businesses and governments looking to stay competitive.

We will likely see fewer devices in the market than originally predicted. However, the value driven per device is likely going to be much higher than anticipated, making the IoT industry still a huge market for players to engage in. A large portion of value add for businesses currently will be developing networks that are able to manage and integrate both Edge Processing and dumb devices/sensors under the same platform in a meaningful way. This will likely carry companies through the transition phase before tehe prevalence of more creative applications for Edge Processing take over the market.

While functionality will likely increase, so will the need for greater cyber-security and device management in the future. As devices get more complex, so do the complexities of their vulnerability to tampering and mis-use. Particularly with regards to Machine-to-Machine communication, the resultant backlash of major system compromise or service shutdowns may cause catastrophic losses for businesses in terms of both revenues and trust. This may draw back relevance to technologies such as Blockchain which were perceived to be impractical in the pre-5G age.

Telecommunication providers likely to lead

Given these factors, telecom providers who already specialize in the fields of IoT networking and cyber-security are likely to take lead in implementing smart IoT technologies and packaging the deployment of 5G Macro and Small Cell towers together with additional IoT solutions, to build the business case for deployment in certain regions. These regions may even extend outside of urban environments if there is a clear business case of them. However, it is also worth noting that Big Tech players such as Amazon, Microsoft and Alibaba may also start horizontally integrating across the value chain due to their critical position as a public cloud provider becoming increasingly paramount.

What can we learn?

For many IoT start-ups in major cities today, we will likely see them getting acquired by larger IoT firms, shifting business models or becoming lower-cost solutions providers to areas in which 5G may not be applicable. There are already forces which suggest consolidation within, not just IoT, but telecommunications as well. These will likely lead to certain champions within the parts of the value chain which will monopolize their respective vertical to a certain extent. While we don't know if this outcome is for certain, we can strongly see that the advent of 5G will likely disrupt the IoT industry which is still consider today to be innovative and new.

This shows the need for prudence when developing strategies and business models in the emerging technology sector in order to future proof against these macro-industry forces. Companies and governments also need to examine the nuances in terms of technological capabilities, dependencies and development of current devices to determine if these will be relevant in the future.

Contact: Isaac Lee Yi De, President
Yide.lee.2016@business.smu.edu.sg

Sources:

1. https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/
2. https://iot-analytics.com/state-of-the-iot-update-q1-q2-2018-number-of-iot-devices-now-7b/
3. https://www.forbes.com/sites/louiscolumbus/2018/12/13/2018-roundup-of-internet-of-things-forecasts-and-market-estimates/#5ae0e9357d83
4. http://www.libelium.com/resources/top_50_iot_sensor_applications_ranking/
5. https://www.acgcc.com/lantronix-mach10-an-important-solution-in-an-iot-value-chain/
6. http://www.coe-iot.com/agritech/
7. https://corp.sirqul.com/
8. https://en.wikipedia.org/wiki/Smart_city (Various)
9. https://www.smartnation.sg/why-Smart-Nation/pillars-of-smart-nation
10. https://www.tech.gov.sg/media/technews/singapore-named-smart-city-of-2018
11. https://www.cio.com/article/3339543/singapore-to-spend-us1-billion-in-smart-city-initiative-during-2019.html
12. https://www.rtinsights.com/six-in-10-enterprises-fail-to-take-iot-beyond-the-pilot-stage/
13. https://www.iotforall.com/5-worst-iot-hacking-vulnerabilities/
14. https://medium.com/coinmonks/lpwan-lora-lorawan-and-the-internet-of-things-aed7d5975d5d
15. http://web.luxresearchinc.com/hubfs/Insight_Breakdown_of_LPWAN_Technologies.pdf?t=1461874447328
16. https://www.unabiz.com/
17. https://www.computerworld.com/article/3131422/gaining-an-edge-in-iot.html
18. https://www.axis.com/files/feature_articles/ar_perfect_pixel_count_55971_en_1402_lo.pdf
19. https://www.unifore.net/ip-video-surveillance/simple-guide-of-ip-camera-bitrate-setting.html
20. https://www.washingtonpost.com/business/germany-wants-more-5g-faster-that-may-not-be-better/2019/01/02/60d8e0b2-0e85-11e9-8f0c-6f878a26288a_story.html?utm_term=.cd88bba66ec6
21. https://www.businesstimes.com.sg/government-economy/singapore-to-start-5g-roll-out-by-2020-iswaran
22. https://www.zdnet.com/article/what-is-5g-everything-you-need-to-know/
23. https://www.lightreading.com/mobile/5g/high-band-5g-lets-address-the-range-question-shall-we/a/d-id/731293
24. http://www.emfexplained.info/?ID=25916
25. https://www.ericsson.com/en/blog/2019/2/breaking-the-energy-curve-5g-energy-efficiency