TELECOMS AND EXPONENTIAL GROWTH

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On global telecoms

With more than 40 years in the telecoms business Peter Cochrane has witnessed the arrival of one technology after another with accelerating affect on society and the individual. These exponential waves have been bigger by each arrival with ever shortening arrival times. In the 1950s through to the 1970s it didn't feel exponential, but from the mid-1980s it became very visible and impactful. Logistic curves aplenty!

The logistics of technology change always start slowly, rise rapidly, and then saturate at some peak. By 2012 the developed world's telecoms network connections had saturated. Everyone had, on average, at least one mobile device, 3 and 4G + Wi-Fi is near ubiquitous with network activity and investment overtaken by computing on the periphery. Basic telephony was eclipsed by the Internet and the telecoms focus is now on services. Competition is fierce with customers demanding more and more at the same price, and fixed /mobile operators struggle to cope with increased demands and technology-driven change. The sector is now a commodity market and the real value-add has moved out of networks and into the service periphery of devices, software and apps. The biggest and most profitable companies in the world are now the users and exploiters of networks and not the providers.

"Nothing in the real world is exponential forever."

So what does the future hold for the fixed and mobile network providers in the developed

world? They will see increasingly lean pickings with reducing profit margins that demand increased economies of scale associated with larger customer bases and slicker supply chains. In turn, commoditisation will promote more competition and mergers and acquisition activity with reducing numbers of big players.

"Three dominant players in a commodity market seems to be the norm."

In complete contrast the under-developed world might be viewed as a relative time slippage back as far as 1950. They are still rolling out basic network infrastructures to populations lacking nominal facilities such as universal communication and access to the Internet. Here growth is rapid and demand is outstripping supply. But without exception the provision of telecoms and computing networks always sees great benefit to a society and the growth of their gross domestic product. Health, wealth, education all go hand-in-hand with network and service provision.

The challenges for the under-developed world are legion with a general lack of experience, expertise and funding. The good news is; they don't have to go back in time for their technology. They can avoid the obsolescent technologies of the First World to by-pass copper and go to fibre and wireless provision from the off. Even better, they can immediately gain access to international markets for the export and import of goods and services with access to the facilities on the Internet. 'Boot Strapping' an economy and national capabilities can thus be achieved at near zero expense.

In the fullness of time these countries and populations will see the network and services penetration that the First World enjoys today, and hopefully many of them may well become net contributors to that growing global network. But there is a common enemy. The Internet consumes about 3% of the world's generated power and we are heading to at least triple that with the addition of the Second and Third Worlds, and this will get rapidly worse with the growth of the

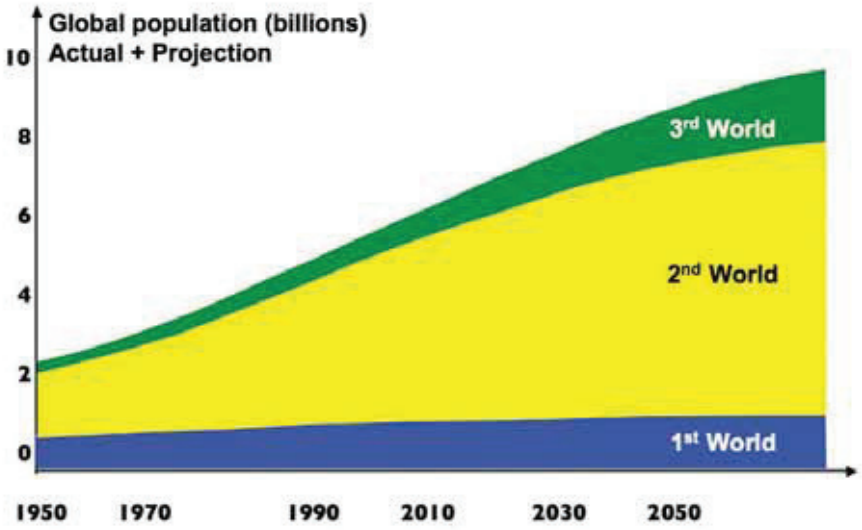

Figure 1: United Nations population growth predictions [1]

Region	2013	2018	Compound annual growth rate
Asia Pacific	1.41	2.24	9.70%
Central and Eastern Europe	2.10	3.39	10.10%
South America	1.75	2.58	8.10%
Middle East	0.92	1.28	6.70%
North America	5.34	9.26	11.70%
Western Europe	3.89	6.52	10.90%
Global	1.73	2.73	9.50%

Table 1: Estimated number of devices and connections/capita [2, 3, 4, 5]

Internet of Things. Add to this our many peripheral devices that are consuming far too much energy and raw materials, and we see a universal 'Green Challenge' that demands a rethink of devices networks and networking.

Growth potential

If you are reading this on paper you are most likely a member of a limited cohort concentrated in the developed world. If you are reading on-line you could be anywhere on the planet with Internet access and a suitable device. In our entire history we have never enjoyed such a facility of distribution and access to information and each other, or indeed, the ability to manufacture and distribute over 1 billion complex computing and communication devices year-on-year. Today 'smart computing and communication devices' (at over 14 billion) outnumber people (7 billion) by over 2:1. However, the distribution and benefit is not equitable. Around 20% of peoples live in the First World consuming about 77% of all resources, whilst 60% or so are in the Second World with around 22% of resources, and the 18% in the Third World see only 1.5% of resources. The potential for the growth in the demand for water, food, sanitation and the basics of life is vast, and so is the opportunity for networks and traffic growth. But by sector and country that growth potential is markedly different, as are the Green solutions.

The enormity of the potential can be glimpsed by considering the UN projections for population out to 2050 (Figure 1) that show near stasis in the developed world and huge expansion in the underdeveloped areas [1]. Compounding this with our best estimates of the number of devices and connections per person (Table 1) makes this even more stark.

And this is before we look at Clouds of Things (Internet of Things) with an expected 50 to 250 billion additional entities demanding connectivity and bandwidth.

Another way of viewing and dimensioning the growth potential is to look at the growth of bits transported per month (Figure 2). There have been numerous attempts to characterise this, and the results published are almost certainly in error, but looking to the past we might reasonably assume that these are pessimistic. That is; the outcome is most probably going to be even greater.

A cloudy future

The looming energy and raw material crisis associated with population growth and things on-line can be offset to a large extent by Clouds. They offer thin clients using fewer chips plus apps and storage on-line, all of which offer considerable power savings. Better still, the reduced transmitter powers are proportional to R^2 (cell diameter = R). So, adopting micro-cell structures for 3, 4, 5G, Wi-Fi and BlueTooth that are 10 to 100 times smaller would see a 100 to 10,000-fold reduction in transmitter power. This in turn dictates far more Fibre-to-the-Premise to provision these cells, which in turn could also see a 10-fold reduction in the number of switching nodes. With no electronics in the street, and no repeaters between major nodes, this might just be as far as telecoms can go.

Necessity is always the mother of invention, and in an interesting turn-about, countries in the developing world with poor, and still evolving infrastructures, are making great advances in networks without infrastructure. Apps providing peer-to-peer working at close range between mobiles are becoming common for file transfers, messaging, and 'across desk' working. These apps are now gaining ground in the developed work and provide the actual bandwidths required by customers at a high level of security.

"When an industry fails to supply, then customers find an alternative."

This same mode is highly applicable for things on-line in the home, office, logistics,

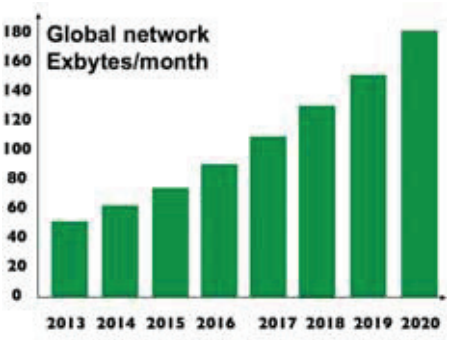

Figure 2: Estimated growth of net traffic by year [2, 3, 4, 5]

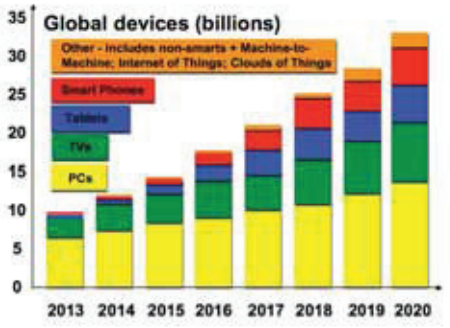

Figure 3: Projected terminal and device growth [2, 3, 4, 5]

Figure 4: Multiple change drivers and related outcomes [6]

manufacturing, food production and supply (Figure 3). In fact it is easy to make a case for the future being dominated by things that communicate at a short range, in closed communities, without ever, or very seldom, connecting to the Internet. Today mobile operators are minority players in the transport of data with some developed countries only seeing around 3% mobile network contribution. It therefore seems axiomatic that mobile networks will be making an ever-smaller contribution to a world dominated by Clouds of Things.

These trends are not occurring in isolation. The causality might not be immediately clear, and indeed it is complex, but Clouds go hand-in-hand with mobile working, Bring Your Own Device, Be My Own Boss, apps, Big Data, Social Everything, et al [6] as depicted in Figure 4. Human need and those of the planet are key elements to the whole equation with speed of change and adaptability the elements we have to master. For sure this cannot be achieved on the back of old telecoms network thinking. To survive, fixed and mobile operators will have to adopt new models. At the forefront we see Fibre-to-the-Premise augmented with open 3, 4G and Wi-Fi at the end of every fibre meeting the needs of operator, user, and the future.

One of the biggest expenses confronting developed world operators will be writing down the cost and replacement of technologies that cannot support customer demands. A failure to grasp the real needs of customers, industry and society sees most local networks unable to support Cloud Working for example. How come? A focus on the exploration of existing copper cables and asymmetric video distribution are prime culprits, but today's demand, not to mention the future, is for symmetric services of greater bandwidth.

For the developing world none of this is bad news. They have time to recognise the trends and move on, skipping by the old, and moving to the new. And the fastest way to realise this is to ape the world of computing. DIY software and apps mutate to DIY broadband, mobile and Cloud networks. This is not rocket science and can be realised by a combination of 'black box-plug-and-play' technologies augmented by basic people training.

Is this a reasonable assertion? Well, we have already seen the impact of a few dedicated people on a mission for their community when there has been no broadband or mobile coverage. DIY networks are not beyond the average man given a little help. In this regard open network design, installer guides, support, software and hardware are key and already available. We might therefore reasonably expect that Clouds will follow.

"Tell a community that net connectivity is uneconomic in their case, and just see what happens - peoples are no longer willing to take 'No' for an answer."

One size does not fit all

There was a time when 'Silver Bullets' (singular solutions) dominated and everyone rallied to a one standard with recognised solutions and practices. That time has gone. Getting the job done fast and effectively to meet rapidly changing demands is now the credo. And this applies to all worlds – developed and developing, and not something the old lumbering giants of network provision feel comfortable with. Their scale, technology choices and operating modes precludes their participation in much of this future.

So what can be done? There are many models and modes and not just one. Telcos are best placed to get bandwidth to communities and properties to then stand back and watch the people complete that costly last mile. Telcos don't have to do it all, and in any case they do not have the resources to engineer at speed, and their continued focus on 'the easy' (towns and cities) is neither good enough or indeed what is required. So let individuals, communities and companies dig the trenches, install the fibre cables and terminal equipments – and let them manage their own networks.

In a world dominated by mobile it makes no economic sense for fixed and mobile operators to do every install as if it were precious and difficult. They are neither. So install the core connectivity and charge a flat fee, make it easy to use and, provide support when requested. This is happening in pockets world-wide and is set to become the model for Clouds.

"Bandwidth is free, distance is irrelevant and you can't charge for time."

Energy - no free lunch

Much of the developing world enjoys the natural resource of light, wind, heat and wide open spaces. Solar cells, wind power and heat pumps can supply the energy for a

Power source	Power density (W/m^2) Low	High
Natural gas	200	2000
Coal	100	1000
Solar (PV)	4	9
Solar (CSP)	4	10
Wind	0.5	1.5
Biomass	0.5	0.6

Table 2: Land area used for common energy generation solutions [7]

Storage type	Specific energy (MJ/kg)
Uranium reactor	1,539,842,000
Hydrogen, liquid	141.86
Gasoline	46.4
Polypropylene	46.4
Diesel fuel	45.6
Coal	32.5
Aluminium, molten	31.0
Magnesium	24.7
Wood	18.0
Peat	17.7
Glucose	15.55
Cow / camel dung	15.5
Sodium	13.3
Battery, lithium-air rechargable	9.0
Household waste	8.0
Battery, lithium	4.3
Battery,alkaline	1.8
Battery, zinc-air	1.59
Battery, lead-acid	0.56
Compressed air at 300 bar	0.5
Water at 100m dam height	0.001

Table 3: Energy density for generation and storage [8]

villages or towns, but this is only reliable if there is a means of storage. In fact humanity does not face an energy famine, it faces a dire shortage of storage.

Everywhere we see the rise of DIY computing, communication and networking; might power supplies be next? Perhaps. But only if we develop far more effective energy storage systems. Beyond current battery technology we see nothing that matches the energy density of oil. However, hydrogen, liquid metals and pneumatics are showing promise. For the First World these may turn out to be highly sophisticated, but for the second and third they need to be simple and robust, and in that regard we have a ways to go.

For the immediate future, energy generation and supply might be the primary limiter to progress towards a fully networked future.

"We cannot continue to eat the planet – we have to find symbiotic solutions."

Just how far we have to go, or alternatively how big the opportunity might be, can be gauged from Tables 2 and 3. The specific citations detail the energy and power density per unit volume and land area used.

Of course, the generation and storage of energy for powering a community needing heat/cooling light and power is on a different scale to that for networks and devices, but we have to become smarter at energy management. For example some electric vehicular systems are now being engineered with a dual role for general network/ domestic/office storage as well as transport. So that car in the garage can store energy at peak production and return it to the network during peaks of demand. Power 'smoothing' i.e. flattening 'peaks and troughs' is hugely beneficial to electricity producers and distributors, not to mention end users. So, it might just be that some of our network elements, switches and server farms, hubs and devices might move in that general direction in future.

"In the Third World, laptops and tablets are popular with parents because they are the brightest light in their home."

Borrowing cultures

Throughout the developed world, social networking, open source, freedom to connect and communicate rapidly took off to become the norm. People share Wi-Fi, mobiles and

computing devices, information, expertise and solutions. Open Wi-Fi services, free Cloud storage and open apps, plus designs and knowledge sharing are now features of modern society. The arrival of 3D and 4D printing with open distribution of design and build appears to be the next phase. Security will most likely follow as the global blight of continual and growing threats demand a greater and more expansive effort than ineffective firewalls and malware.

"The need to share now trumps the need to control."

In the underdeveloped world we see many different and diverse cultures where 'borrowing' takes on a whole new meaning. A length of copper cable might be 'borrowed' to make jewellery or repair a cooking utensil, or a battery from a cell site might be removed to bring an old vehicle or machine back to life. All without a thought to disabling of a network and services. Until education programs are in place and/or there is a recognised societal dependence on networks, design and engineering has to take into account these unusual failure mechanisms. Nevertheless, experience to date sees the spread of networks giving farmers direct access markets, whilst connected villages benefit from education and health care services on-line, and life is gradually improved.

As we move up that scale toward and into the Second World there is generally an almost enviable level of ingenuity in evidence with energy supplies and network elements provided by the most meagre means – but it works. There is also a deal of device and facility sharing in an effort for societies to enjoy the greatest benefit.

"The need to share has overtaken the need to own."

Prognosis

The end game has to be the engineering of equitable and sustainable lifestyles for all human kind. But this isn't going to be realised in a hurry, and without ubiquitous networks it will not be realised at all. Sustainable energy, food, water and products are key, and they in turn rely on Clouds of Things. The tagging, tracking and monitoring of manufactured products based on new materials and processes; their reuse, re-purposing and near 100% efficient recycling is essential to the future, and not an option.

Today we have many of the technologies to achieve such a vision, but we do not have the networks. In the developed world the numbers of new communications and computing connections is almost asymptotic, but the lack of bandwidth stands to cripple a migration into Clouds. However, the numbers of new communications and computing units is growing exponentially in the under-developed world, and will continue to do so for decades to come.

The biggest growth factor of all will be the introduction of 50 to 250 billion things needing to connect and communicate. But they are unlikely to significantly boost mobile and fixed line traffic flows as networks without infrastructure increasingly appear to be the likely dominant mode. Low cost and low power car-to-car, container-to-container, mobile-to-mobile, people-to-people connections look to be the biggest growth sectors.

All developed societies share the same economic models with an assumed Infinite Resource and Finite Consumption Limits. Clearly that is wrong and cannot work in the long term. The same was true of the telecoms industry, but it has now inverted. Customers have an infinite appetite to consume bits, and optical fibre and wireless technologies enjoy an ability to supply and deliver a near infinity of capacity. The overall logistics curve of demand and delivery is nowhere near saturation. And so companies and governments have only to look to the future for operating models, rather than the past, because that is where their populations are headed.

"The exponential growth of bits and bytes demand and delivery sees no sign of stasis – yet."

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