RTT TECHNOLOGY TOPIC
December 2006

Ultra Low Cost Networks

Introducing this months Hot Topic

Over the past two months we have covered Ultra Low Cost Handsets and Ultra Low Cost Smart Phones in the context of initiatives such as the Emerging Markets Handset Programme.

This month we look at **Ultra Low Cost Networks** in the context of present initiatives to specify and describe next generation networks including next generation mobile networks.

We explore the role of network technologies as a function of GDP growth and study the particular role that ultra low cost **mobile** networks may play in **emerging market economies.**

Differentiating communications and connectivity value

Tom Standage in his book, The Victorian Internet, explains how the electric telegraph delivered 'network value' to the rapidly industrialising nations of the 19th Century.

In other work he identifies the role of coffee shops in the 17th and 18th century as centres for information distribution and social and information exchange. Customers were happy to pay for the coffee but expected information for free, free speech and free information as the basis for social, political and economic progress.

In the 20th and 21st century, the same principles apply but the delivery options have, literally, broadened. Present economic growth can be at least partially ascribed to the parallel growth of **connectivity bandwidth.** Connectivity implies **the ability to access, contribute and exchange information.** Connectivity is a combination of voice, audio, text, image, video and data enabled **communication (the internet)** but crucially includes access to **storage bandwidth (the world wide web).**

Defining Next Generation Networks

So non contentiously we can say that next generation networks are likely to be an evolution from present generation networks and present generation networks are or will be based on access to the internet and access via the internet to the World Wide Web.

This is straightforward. The problem is the user's expectation that access to this commodity (the sharing of human knowledge, experience, insight and opinion) is a basic human right analogous to the provision of sanitation and healthcare.

There may of course be a valid argument that governments should provide internet access for free on the basis that the added tax income from the associated additional growth will provide a net economic, social and political gain.

Selective free access is of course already available, for example internet access in schools and internet access in libraries (free to pensioners). The provision of such services is analogous to the right of citizens to have access to free to air broadcast content and the related public service remit to 'inform, educate and entertain'.

Interestingly most of us in the UK are happy to pay a license fee (to the BBC though not perhaps to Mr Murdoch) on the basis that this makes it more likely that the content delivered in return is 'free' from political bias or at least overt political interference.

Of course, governments do not need to invest in communications networks because other people do it for them.

However the contention is that network access, broadly defined to include all forms of present connectivity, directly contributes to an increase in GDP. There are exceptions. Watching the Simpson's or Neighbours does not necessarily add significantly to the economic well being of the nation but the general principle prevails.

Therefore **governments have a duty to ensure connectivity is provided at an affordable cost**.

Most of us are willing, if not necessarily happy, to pay 40 or 50 dollars per month for the right of access to the various forms of communications connectivity available to us. Price perceptions are influenced by what we pay for other forms of connectivity - water, gas, electricity.

Emerging nations are however different. You cannot expect someone on a dollar a day to pay 50 dollars per month for a broadband connection.

What's needed is an ultra low cost network and ultra low cost access to and from that network.

Defining an Ultra Low Cost Network
Ultra Low Cost Storage
We discussed some of the basic cost components of network provision in our January 2006 Hot Topic, 'The Bit Rate Race.'

We pointed out that storage costs are halving each year, a function of solid state, hard disk and optical memory cost reduction and improvements in content compression methodologies.

The low error rates intrinsic to non volatile storage media suggest further improvements in compression techniques are possible provided related standards issues can be addressed. A closer harmonisation of next generation video and audio compression techniques would for example be advantageous.

Other techniques such as load balancing across multiple storage and server resources promise additional scale and cost efficiencies.

Ultra Low Cost Access
We also discussed the relative cost economics of fibre, copper and wireless access. All three of these delivery/access media options have enjoyed incremental but rapid improvements in throughput capability.

Throughput rate increases have been achieved through a mix of frequency multiplexing and time multiplexing techniques.

Fibre and copper are both inherently stable and consistent in terms of their data rates and error rates.

Error rates in wireless are intrinsically higher and more variable as a consequence of the effects of fast and slow fading. These effects are particularly pronounced in wide area mobile wireless systems but are still present in fixed wireless systems particularly when implemented at frequencies above 3 GHz.

Higher error rates and uneven error rate distribution make it harder to realise the full benefits of higher order content compression techniques.

Wide area wireless mobility also implies a significant signalling overhead which adds directly to the overall cost of delivery.

All three access options (fibre, copper and wireless), have a related real estate cost which is a composite of the site or right of access negotiation and acquisition cost and on going site or right of access administration costs.

Present fibre to the home (ftth) deployments for example imply significant street level engineering and financial resource allocation which has to be justified in terms of bi directional data throughput value amortised against relatively ambitious return on investment expectations.

In cellular networks, similar ROI criteria have to be applied to realise a return from spectral investment, site acquisition and on going site management costs.

Cellular networks are, of course, in practice, a composite of radio access, copper and fibre. Our discussion here is to identify some of the specific wireless (RF) cost multipliers.

The inter relationship of RF Access Efficiency and Network Cost
The escalation of spectral and site values has highlighted a perceived need for cellular technologies to provide incremental but rapid improvements in capacity, the number of users per MHz of allocated or auctioned spectrum multiplied by typical user per data throughput requirements, and coverage (range).

New technologies are therefore justified on the basis of their 'efficiency' in terms of user/data throughput per MHz, which we will call, for lack of a better term, **'RF Access Efficiency.'**

In practice, new technologies need to offer useful performance gains, lower real costs and increased margins for vendors.

The engineering effort needed to realise efficiency gains
However new technologies, particularly new radio technologies, generally deliver initially disappointing performance gains.

This is because the potential gains implicit in the technology can only be realised through the application of significant engineering effort.

Mobile WiMax presents a present example of this effect.

WiMax can be deployed into licensed or unlicensed spectrum and into duplex spaced or non paired (TDD) allocations.

Deployment into non paired bands is attractive because it is easier to make adaptive mechanisms such as MIMO (multiple input multiple output antennas) and adaptive modulation, coding and power control work in a reciprocal channel (where the uplink is at the same frequency as the downlink).

Traditionally the disadvantage with non paired band deployments is that they suffer from uplink to downlink inter symbol interference at higher data rates and/or in larger cells.

Adding an OFDM multiplex however slows down the symbol rate which deals with the ISI issue.

The potential throughput and/or range gains claimed for Mobile WiMax are based on the combination of MIMO together with adaptive modulation and coding together with the OFDM multiplex together with the simpler (less bandwidth and power hungry) channel measurement implicit in non paired simplex channels.

Mobile WiMax could also be deployed in to licensed non paired bands, for example the TDD1 and TDD2 allocations in UMTS Band I and into existing cellular paired bands though this would require a different approach to channel measurement (separate measurement of the uplink and downlink paths).

The OFDM multiplex, while resolving the uplink/downlink issue in non paired band deployments and providing generally improved resilience to multi path fading, requires more linearity in the handset and base station transceiver than present UMTS systems and requires a tighter time and frequency reference to maintain the orthogonality of the complex composite modulated waveform.

So although **WiMax** ,**and** for that matter proposed OFDM based **UTRAN LTE** radio systems, **promise** potentially **significant efficiency gains over present cellular systems**, **these gains can only be realised as a result of significant engineering effort both in terms of handset and base station engineering and network engineering.**

The impact of standards and spectral policy on RF network economics

At this point it is worth considering the impact that standards and spectral policy have on RF network economics.

Standards policy has an impact on **technology costs. Spectral policy** has an impact on **engineering costs.**

The computer scientist Bran Ferren defined technology as 'Stuff that doesn't work yet'. Generally technologies will have been specified and standardised to take effective advantage of available and anticipated device capabilities.

Engineering is the necessary process whereby those capabilities are turned into a cash and/or competitive advantage.

Technology design and development has to be amortised over a sufficient market volume and value to achieve an acceptable return on investment.

Engineering effort has to be amortised over a sufficient market volume and value to achieve an acceptable return on investment.

A poorly executed standards policy results in the duplication and dissipation of technology design and development effort. The lack of a mandated technology policy increases technology risk. This requires vendors to adopt more aggressive ROI policies. As a result, technology costs increase.

A poorly executed spectral allocation policy results in the duplication and dissipation of engineering effort. The lack of a globally harmonised spectral allocation policy increases engineering risk. This requires vendors to adopt more aggressive ROI policies. As a result, engineering costs increase.

Standards policy, spectral policy and RF economies of scale
Cellular handsets benefit from substantial economies of scale.

Cellular base stations and related network components have much lower scale economies. There are (several orders of magnitude) fewer base stations in the world than handsets.

This makes it harder to recover non recurring technology and engineering costs.

The result is that base stations and network components are necessarily expensive.

As network density has increased over time, the number of base stations has increased providing the basis for more effective cost amortisation.

Successive generations of radio access technologies options compete with each other on the promise of offering efficiency gains and a cost/performance advantage.

So for example, GSM was justified on the basis of capacity and coverage benefits when compared to ETACS. CDMA and UMTS were justified on a similar basis and more recently, WiMax has been promoted on the basis of data rate gains.

In practice, progress in terms of radio efficiency tends to be more incremental than market statement or sentiment would imply. Step function gains in efficiency just don't happen in practice. Performance gain is achieved as the result of technology maturation based on engineered optimisation combined with market volume.

Similarly, technology can deliver useful gains in terms of reduced component count and component cost but again these gains are incremental and need to be coupled with engineering effort and market volume to be significant.

So **component cost reductions** are **a product of technology, engineering effort and market volume. Improvements in access efficiency** are **a product of technology, engineering effort and market volume.**

The requirement for market volume implies that economies of scale are dependent on the ability of vendors to ship common products to multiple markets.

Barriers to achieving economies of scale in base station products
Which brings us to consider some of the barriers that presently exist to achieving economies of scale in cellular base station products.

Vendors are keen to promote the software configurability of their base station product offerings.

In reality however there are a substantial number of frequency conscious functions in a base station including the antenna, front end duplexing and diplexing.

Active devices such as the PA and LNA may be capable of working across relatively wide frequency bands, and may be capable of handling different channel spacings and modulation techniques and power outputs. This does not necessarily mean they are **efficient** across all bands or modes or operational conditions.

Spectral allocation policy and technology standards making policy therefore has a direct impact on base station hardware and software cost.

The present trend towards technology neutrality in spectral allocation is particularly dangerous in terms of its effect on the amortisation of NRE costs.

Barriers to achieving economies of scale for other network components
The same principle applies to other network components where cost is directly linked to complexity.

The opportunity exists for example to share economies of scale between present WiFi products and cellular products. There are justifiable differences in terms of physical layer implementation but unjustifiable differences in terms of MAC and higher layer protocol implementation which cause unnecessary duplication of design resource.

In an ideal world, the following radio access common denominator network standards would be agreed

1) A standard common denominator wide area radio access interface.
2) A standard common denominator local area radio access interface.
3) A standard common denominator personal area radio access interface.
4) A standardized approach to the co existence of all three interfaces.
5) An agreed standardized approach to handover, access management and load balancing algorithms (a system level mechanism for achieving gains in uplink sensitivity and selectivity).
6) A standardised approach to session management.
7) A standardised approach to content and context management
8) A standardised approach to billing.

These standards would be or should be agreed globally.

The need for global spectral and technology harmonisation
The need for spectral harmonisation is now reasonably well acknowledged.

Having common spectrum available from country to country directly reduces handset and network costs.

The parallel need for technology harmonisation is less well appreciated.

The Emerging Market Handset Programme has been created with the laudable aim of bringing low cost handsets to markets that could not previously afford basic voice communication.

In last month's Hot Topic we suggested that actually what emerging markets needed was information connectivity rather than basic voice connectivity and we argued the case for an 'Emerging Market Smart Phone Programme'.

But actually we are arguing that there is not much point in having Ultra Low Cost Handsets or Ultra Low Cost Smart Phones unless you can also deliver **Ultra Low Cost Networks.**

This requires governments to provide the necessary framework to allow vendors to develop and ship cost economic products. Cost economic in this context implies the need to exploit global economies of scale. **Global economies of scale can only be exploited on the basis of agreed global spectral and technology standards.**

The impact of IPR on RF component and sub system costs
Similarly there is a need to have equitable intellectual property agreements in place that provide an economic return on company specific organisationally specific technology specific research and development investment.

This is a troubled area made more troublesome by regional differences in IPR law and accepted good practice. The recent success by CSIRO in Australia in pursuing OFDM patent rights is relevant.

Overall it would seem to make economic sense to develop effective patent pooling arrangements as part of an integrated international standards making activity though such a suggestion might be considered over sanguine

The Cost of 'Design Dissipation'
Resolving intellectual property rights through an adversarial and fragmented international IPR regime is just another example of how potential gains from technology and engineering innovation may fail to deliver their full cost efficiency and economic benefits due to poorly executed governmental and intergovernmental policy.

To summarise:

Technologies when first introduced have a **potential** 'efficiency gain'.

The potential gain is only realised after considerable engineering effort is invested to ensure the technology actually works as originally intended.

Having to support multiple technologies deployed into multiple bands that are different from country to country results in an unnecessary dissipation of design effort and engineering resource. A lack of international clarity on IPR issues creates additional aggravation.

This implies a need for an **Emerging Market Network Programme** which includes internationally mandated spectral allocation, internationally mandated technology standards and an internationally mandated IPR regime based on well established and demonstrably successful patent pooling principles. **Such a requirement is largely at odds with present 'light touch' regulatory policy.**

The adoption of **technology neutrality** as a policy is an abrogation of international governmental responsibility - **a policy to not have a policy.**

Regulators have a duty to ensure efficiencies of scale can be applied in the supply chain and to avoid the negative impact that design dissipation has on product efficiency, product pricing and product availability.

This is particularly true if we are serious about addressing cost sensitive markets and, incidentally, serious about wireless competing with, or working effectively with, continuously improving fibre and copper access technologies.

Bridging the 'digital divide' in emerging nations requires cooperation not exhortation.

This in turn implies a return to prescriptive globally harmonised spectral allocation combined with prescriptive and closely integrated mandated technology standards and a globally harmonised approach to IPR management.

About RTT Technology Topics

RTT Technology Topics reflect areas of research that we are presently working on.

We aim to introduce new terminology and new ideas to clarify present and future technology and business issues.

Do pass these Technology Topics on to your colleagues, encourage them to join our Push List and respond with comments.

Contact RTT

RTT, the Shosteck Group and The Mobile World are presently working on a number of research and forecasting projects in the cellular, two way radio, satellite and broadcasting industry.

If you would like more information on this work then please contact

geoff@rttonline.com

00 44 208 744 3163