RTT TECHNOLOGY TOPIC
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Nervous Networks

Introducing this month's Hot Topic

In this months Hot Topic, we analyse the role of technology and engineering in building business value in cellular mobile networks and study some of the feed back processes required to facilitate the user 'value capture process'.

We draw parallels with the human nervous system and suggest ways in which technology, engineering, and market and fiscal performance metrics can be used to deliver future competitive advantage.

The concept of the 'nervous network 'is introduced and presented as a potentially useful model for auditing present and future business models. We differentiate the role of 'access networks' and 'capture networks' and argue that 'capture value' can be treated as a business asset that will appreciate in value over time.

We propose the case for technology and engineering profit and loss accounts and technology and engineering balance sheets that can be used to audit potential future business value.

We suggest that technology and engineering asset value is often under estimated and as a consequence may lead to outsourcing decisions that are damaging to long term shareholder value. We predict a shift from outsourcing to insourcing as the scale of this underestimation comes to be recognised over the next three to five years.

Network Value Domains

Figure 1 The seven layer model

Layer 1	Technology
Layer 2	Engineering
Layer 3	Administration (finance, human resources, legal and corporate)
Layer 4	Marketing
Layer 5	Sales
Layer 6	Customers
Layer 7	Content

The above shows the seven 'value domains' that make up a typical cellular network business proposition.

Modern business thinking would lead us to believe that business plans should be customer focussed and/or content focussed. Content in this context is bi directional voice, audio, imaging, video and data.

We would not dispute this though we would point out that the cellular industry uses technology and engineering to realise customer and content value.

If the objective is to produce a credible and executable three to five year business plan then there is a case to be made that technology and engineering make a good starting point. The advantage is that both disciplines are amenable to accurate forecasting. For example, we know more or less precisely what semiconductors will be able to do in five years time. We do not know and cannot know what customers might want in five years time but we can accurately define what we can and cannot deliver to them assuming certain cost, bandwidth and power efficiency constraints.

On this basis, each of the above domains has a definable asset value and added value potential which may increase or decrease over time. We have defined administration rather arbitrarily as a composite of finance, human resources, legal and corporate functionality and includes of course other functions such as real estate management which are all more or less essential parts of a cellular network business.

The overall value of the business is a composite of technology, engineering, administration, marketing, sales, customer and content assets. The realisation of asset value is dependent on achieving an optimum balance across all seven of these 'asset domains'. The process of achieving a balanced asset base is dependent on having a developed view of the shape of the business over three to five years. This is only possible if there is a through understanding of how technology and engineering will change inter and intra domain functionality over that period.

Differentiating Technology Value and Engineering Value

A first step is to ensure that there is a clear understanding of the difference between technology and engineering.

Technology comes from the Greek word **'technologia'** which is a composite of 'techne' (craft) and 'logia' (saying) and describes the way in which humans share knowledge about tools, devices and processes to achieve **a practical result.**

Examples of basic enabling technologies in our industry include the RF components used in cellular phones, the optical components and sensor arrays used in camera phones, and the microprocessor logic and memory devices that provide the basic building blocks of a cellular network.

Engineering comes from the Latin word **'Ingeniarus'** and describes the way in which humans apply technology to achieve **a planned result.** Archimedes is an example of an 'engineer' who also happened to be a master mathematician who combined both skills to develop the 'engines of war' using available technology (ropes, pulleys, levers and possibly reflective devices) to achieve a planned result (the defeat of the Romans in their attempted invasion of Syracuse in 212 BC).

Examples of basic enabling engineering in our industry include a developed ability to pour concrete (that well known Roman technology), build masts (civil and mechanical engineering), the application of radio engineering skills and the integration of radio hardware and software engineering.

The role of technology and engineering in 'nervous networks'

A network is simply an interconnected system. A 'nervous network' is an interconnected system that is capable of anticipating and responding to changes taking place internally or externally that demand some form of adaptation process to take place. We have discussed adaptive networks, also known as Competitive Networks in an earlier Hot Topic. Nervous networks, adaptive networks and competitive networks are different ways of describing an entity which is capable of changing itself in response to a changed operational requirement.

Humans are one example of an evolved form of competitive network capable of anticipating and responding to threat and opportunity based on a nervous system that can anticipate and respond by increasing heart rate and blood pressure and mental awareness.

Adaptation is the process used to improve efficiency. Our calorie consumption increases as our heart rate increases, efficiency is achieved by matching energy use to the required task.

Displays that adapt to changing lighting conditions and **microprocessors** that change frequency and voltage depending on the application load are examples of **functionally adaptive device technologies**. The present challenge is to improve the power efficiency of these devices by making them more **predictive**.

Load management and **admission control** algorithms are examples of **functionally adaptive engineering**. The objective is to improve radio and network bandwidth efficiency which in a radio context also implies power efficiency. Allocating higher data rates to users close to a cell site will generally improve user duty cycles. Again the present challenge is to improve the efficiency of these processes by making them more **predictive**.

Measurement Metrics

Network operators have worked towards capturing at least some of the performance metrics that impact directly on the end user experience and/or content value and expressing these metrics in Key Performance Indice (KPI) agreements with vendors.

These include traditional metrics such as blocked call rates, handover success rates, call success rates, voice quality, and more recently, audio, image and video quality (content quality).This is an area that still has substantial development potential particularly in the context of power efficiency where present measurement metrics are arguably over simplistic.

Access Networks and Capture Networks

Power efficiency from a user perspective will depend on the ratio of uploading and downloading, session length and session complexity. Present engineering work tends to be focussed on optimising the efficiency metrics of **the downlink** - **the access network model.** Our argument is that a substantial percentage of future revenues will be dependent on **uplink value** - **the capture network model.** For example finding a way in which users can **upload** images from a handset **rather than store** images in a handset. (Snap and send rather than snap and store). This suggests that uplink power efficiency will become progressively more important as imaging and audio capture bandwidth in handsets increases over time. Uplink power efficiency is directly dependent on the device technology used in the handset combined with admission control algorithms. Delivering uplink power efficiency is therefore directly dependent on an intimate integration of handset device technology and admission control engineering.

Nervous Networks and Fiscal Efficiency

You can probably tell by now that we are working towards the thesis that technology and engineering have definable (and usually understated) asset values which are directly related to average revenues per user and average margin per user over a typical user and/or product life cycle.

This brings us to the concept of fiscal efficiency.

We are saying that there are essentially seven network value domains into which we can pour money, time and effort - technology, engineering, administration (including finance, HR, legal and corporate management), marketing, sales, customers and content.

If we underspend or overspend in any one of these seven functional domains we will compromise the overall fiscal efficiency of the business. We are defining fiscal efficiency as the ability to realise a given return from a certain level of investment. This is an issue of getting the business in balance.

However in all seven domains, we can improve fiscal efficiency by improving the process of **adaptation**. This includes the adaptation process **within each domain** and the adaptation process **between domains.**

There are three related functions

Adaptation - the ability of a system or part of a system to respond to a changed requirement or changed condition

Scale - the order of magnitude over which the adaptation takes place (the range) and the rate and resolution of the response

Context - the amount of observable information available in order for the system itself or some external function to take a decision on the adaptation process. The accuracy of the observation process and the ability of the system to interpret and act on the observed information will have a direct impact on fiscal efficiency. An ability to anticipate a changed requirement or condition based on the observable context is particularly important. This is in turn dependent on having an effective cross domain signalling system.

An Increase in Network Value Domain Interdependency - the relevance of the OSI seven layer model

The need for efficient effective cross domain signalling increases as network value domain interdependency increases. We know that network value domain interdependency will increase because we already see it happening in the OSI seven layer model.

Figure 2 The OSI (Open Systems Interconnection) Seven Layer Model

Layer 7	Application	Windows/Symbian O/S
Layer 6	Presentation	HTML/XML
Layer 5	Session	SIP/RSVP/RTP
Layer 4	Transport	TCP
Layer 3	Network	IP
Layer 2	Data link	ATM or ethernet
Layer 1	Physical	Wireless or copper or optical

Within the OSI model, there is increasing recognition that layer to layer visibility has to improve in order to make each individual layer more responsive. Each individual layer has to become more dynamically adaptive to changes occuring in other higher or lower layers in the protocol stack. An example would be a network proscribed change in content quality managed at layers 5, 6 and 7 made in response to a bandwidth constraint that could be detected at layers 4, 3 or 2 or a bandwidth and power constraint at the physical layer (layer 1).

The research and standards work ongoing in this area is generically described as **'cross layer coding'**. Cross layer coding will be particularly important in HSPA for example. The modulation and coding scheme can be changed on a per user stream basis at 10 millisecond or 2 millisecond and, eventually, .5 millisecond intervals on the basis of the measured 'context' which is captured using a scale of 30 channel quality indicator values (a composite of signal quality, application requirement and buffer occupancy. **HSPA** is therefore a good example of an **adaptation** process with a certain **scale** determined by a measured **context.**

How do we relate changes in the OSI model to changes in network domain value?

HSPA provides a useful case study showing how changes in the OSI physical and MAC layer change higher layer functionality. For example, HSPA changes the way in which content is delivered which in turn potentially changes the way in which users are billed for content or rewarded for content that they have provided (the capture network proposition). HSPA should theoretically deliver a benefit in terms of bandwidth and power efficiency and therefore produce a delivery cost advantage. However it may introduce additional complexities into the customer, product and service management process. This has associated human resource allocation and cost implications.

Adaptation rate- micro adaptive processes

This brings us to consider issues of adaptation rate. At technology/device level, frequency and voltage scaling can potentially be implemented at a rate /frequency/interval of a few tens of microseconds. At engineering level, bandwidth allocation can be changed on a per user basis every few milliseconds. These are processes that can be described as micro adaptive and directly effect both the user experience and the way that content is delivered.

Adaptation rate - macro adaptation processes

Administrative functions generally change at a more leisurely pace (minutes, hours, days, months, years) but the same principles of adaptation apply and reactive decisions taken in the administrative domain will directly effect the user experience and the way that content is delivered.

The integration of Micro Adaptation and Macro Adaptation Processes

As a consequence it is worthwhile considering how these two response processes can be more closely integrated. The answer has been partly given in our March Hot Topic 'Esperanto For Engineers' which argued the case for describing technology and engineering issues in a language that could be more readily absorbed by a broader management audience. We suggested as an example a language or methodology for describing silicon value.

In a wider context, we need to find a way in which technology and engineering can be made more obviously relevant to the overall business decision process. In practice this suggests a need to explain how the 'little decisions' being taken every few microseconds and milliseconds in the network affect the 'big decisions' being taken at managerial level.

The shift from Outsourcing to Insourcing

This brings us to our final point. The general thrust of innovation within the dual domains of cellular technology and cellular engineering is to produce systems and subsystems that respond relatively instantaneously to changing user needs. Ideally these systems develop **an ability to anticipate** those needs. The **systems become more sentient over time**. In the process, the **subsystems deliver bandwidth and power efficiency benefits.**

This level of intelligence is derived from **an intimate knowledge of customer behaviour**. As we said in our February Hot Topic, **cellular phones** are **the eyes and ears of the network.**

While there may be a persuasive short term risk management/cost management rationale for outsourcing technology and engineering functions to vendors or other third parties, the long term rationale is less clear.

Technology and engineering together have **the ability to deliver market and fiscal**

efficiency benefits that have to date been inadequately expressed.

To be effective and efficient and responsive, a nervous network requires all parts of the 'body' to be connected. The risk of outsourcing technology planning and engineering integration is that a network operator loses visibility to a level of customer and content knowledge that will become more important over time. It's a bit like trying to crop a field with someone else in charge of the tractor.

Risk is a 'poison chalice' that tends to move up and down the value chain depending on whether an industry is expanding or contracting. At times of contraction, it makes complete sense to try and move risk to other third parties. Handset manufacturers try to move risk to their semiconductor suppliers; network operators try to move risk to their vendors. When a market is expanding, this may be a less than optimum strategy.

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

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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.

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