RTT TECHNOLOGY TOPIC
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Esperanto For Engineers

For this month's Hot Topic we take as inspiration the work of Dr Ludwig Zamenhof, founder of the Esperanto movement.

Esperanto is often dismissed as a marginal curiosity with little relevance to the modern world.

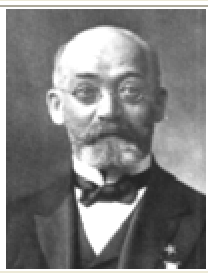
Dr Zamenhof had a minor planet named after him by Yro Vaisala, the Finnish astronomer and physicist, and is considered as a god by the Omoto religion.

Aside from these distractions, his work on a universal language has real relevance to engineers and engineering. For example,The Chinese Academy of Science conducts a biannual international conference on Science and Technology in Esperanto and publishes a quarterly journal, 'Tutmondaj Sciencoj kaj Teknikoj'.

More specifically, Esperanto has practical relevance to our own area of interest, cellular handset and network design.

Dr Ludwig Zamenhof- 1859-1917

Founder of the Esperanto movement



However, we are not on a mission to preach the virtues of Esperanto to engineers.

Rather we are taking Esperanto as an example of a language which is both efficient and precise in the way that it describes the world around us. A language optimised for logical thought and analysis.

For most of us, learning Esperanto is never going to be a high priority, even if it should be.

We can however learn lessons from Esperanto in terms of how we approach decision making in cellular handset and cellular network design.

Decision making is dependent on the accuracy with which a specific problem or set of choices is described.

We suggest a number of **'descriptive domains'** that can be applied which help to clarify some of these choices.

We show how 'descriptive domains' can be used to validate R and D resource allocation and partitioning and integration decisions.

Esperanto for Devices

The principles of Esperanto are applicable for human to human and device to device communication.

New functionality in handsets is often introduced on discrete components. Audio integrated circuits, voice and speech recognition, micro positioning MEMS or GPS integrated circuits are recent examples of new 'real estate' introduced as additional add in components.

This places new demands on packaging and interconnect technology and creates a need for commonality (a common language) both in terms of physical (compatible pin count and connector) and logical (bus architecture) connectivity.

The reason for the discrete approach is usually performance and/or risk related. The new function can initially be made to work more efficiently on a discrete IC and engineers responsible for other functional areas feel safer if the new functionality is ring fenced within its own dedicated physical and logical space.

Standards initiatives such as the Mobile Industry Processor Initiative www.MIPI.org are then needed to ensure at least a basic level of compatibility between different vendor solutions.

This process is neither particularly efficient nor effective and is generally a consequence of inter discipline communication issues.

Esperanto for Engineers

This in turn is a language problem. Partly this has been solved by the use of English as a common language, though English is neither precise nor efficient. The problem is however, not just one of spoken language but the descriptive language used.

Software engineers speak a different 'language' to hardware engineers, DSP engineers speak a different 'language' to RF engineers, imaging system engineers speak a different 'language' to audio engineers who speak a different 'language' to radio system engineers, who speak a different 'language' to micro and macro positioning engineers, who speak a different 'language' to mechanical design engineers.

Silicon design engineers speak a different 'language' to handset design engineers who speak a different 'language' to network design engineers who speak a different 'language' to IT engineers.

Engineers speak a different 'language' to product marketing and sales who speak a different 'language' to business modelling specialists who speak a different 'language' to lawyers and accountants who make the world go round.

This is frustrating as, in reality; all these 'communities of interest and specialist expertise' have more in common than seems initially apparent.

'Descriptive domains' provide a route to resolving these interdisciplinary communication issues.

A Definition of Descriptive Domains
A descriptive domain is simply a mechanism for describing form and function.

The 'analogue domain' and the 'digital domain' provide two examples.

The analogue domain can be widely understood in a modern context as a set of continuously variable values. In a linear system, the output should be directly proportional to the input.

This is the **'form'** of the domain, its defining characteristic.

The **'function'** of the domain is to provide a generic method for describing the physical world around us. Light sound and gravity and of course radio waves are all in the analogue domain.

The 'form' of the digital domain is defined as the process of describing data sets as a series of distinct and discrete values.

The 'function' of the digital domain is to provide a generic method for describing analogue signals as discrete and distinct values.

Most people are comfortable with these descriptions but do not necessarily understand some of the practical implications of working in either domain.

For example, an engineer might need to describe the fiscal merits of digital processing in terms that are accessible to an accounting discipline.

This suggests the need to add in 'cost' and 'value' to the descriptive domain.

Let's test the validity of this on some practical examples

Cost, value and descriptive domains -a description of silicon value.

As with many technology based industries, the cellular industry is built on a foundation of sand, also known as silicon.

Silicon based devices provide us with the capability to capture, process, filter, amplify, transmit, receive and reproduce complex analogue real world signals.

Silicon based devices allow us to speak, send (data, audio, image and video), spend and store.

Silicon value translates into software value which translates into system value which translates into spectral value.

Decreasing device geometry delivers a bandwidth gain both in terms of volume and value.

'Bandwidth value' at device level determines bandwidth value at system and network level which, for cellular networks, implies a return on spectral investment.

By studying silicon value we determine how future software, system and spectral value will be realised.

RAPID - The Five Domains of Silicon Value -
In the context of cellular phone design, there are five value domains **- R**adio systems, **A**udio systems, **P**ositioning systems, **I**maging Systems and **D**ata Systems.

Silicon vendors and silicon design teams who successfully integrate these five domains over the next five years will be at a competitive advantage.

In last month's Hot Topic, 'Competitive Networks', we discussed 'blended bandwidth' and 'balanced bandwidth' as inter related concepts that could be used to qualify radio access and network transport functionality and radio access and network transport value. Integration is the process of blending and balancing.

The same principle applies at silicon level. First define the domains and then qualify how these domains add individual and/or overall value. Use this to qualify partitioning and integration decisions and R and D resource decisions.

R			**A**		**P**		**I**		**D**	
Radio			Audio		Positioning		Imaging		Data	
Wide area	Local area	Personal area	Voice	Audio	Micro	Macro	Image	Video	PIM	CIM

'Blended bandwidth' (the horizontal axis) implies a need to integrate each of the five domains, and within each of the five domains, to integrate individual sub system functions. The amount of cross integration determines the **'breadth'** of the blended bandwidth proposition.

For example, 'blended bandwidth' in the **'radio system domain'** means getting wide area systems (for example HSPA or 1XEVDO) to work with broadcast wide area, local area WiFi and personal area Bluetooth and/or UWB.

In the **'audio system domain'**, 'blended bandwidth' involves a successful integration of **voice** encoder/decoder functionality with **audio** encoder/decoder functionality (AAC AAC Plus, MP3Pro, and Windows Audio). This includes functions such as voice and speech recognition.

In the **'positioning system domain'**, 'blended bandwidth' requires the integration of micro positioning systems (for example MEMS based low G accelerometer devices) with macro positioning (GPS, A GPS or observed time difference systems). Micro and macro positioning systems have the capability of adding value to all other domains and should be considered as critical to the overall silicon value proposition.

In the **'imaging system domain'**, 'blended bandwidth' means the integration of image and video, and the integration of imaging systems with all other system domains. Imaging systems include sensor arrays, image processing and display sub systems. MMS is an imaging domain function.

In the **'data system domain'**, 'blended bandwidth' involves making personal and corporate information systems transparent to all other domains. SMS Text is inherently a data domain function.

'Balanced bandwidth' is how much functionality you support in any one domain and in any one function within each domain - the **'depth'** of the domain.

For example, in the **radio system domain**, the choice for **wide area** system functionality might be whether to support a Class 1 five code (1.2 Mbps) or Class 5 ten code (3.2 Mbps) or class 9 fifteen code (10 Mbps) HSPA handset.

For **local area** radio system functionality, the choice would be between 802.11 a, b and g and related functional extensions (802.11n and MIMO).

In **personal area**, the decision would be whether to support Bluetooth EDR and/or the more extreme variants of UWB.

In the **audio system domain**, the choice for voice would be which of the higher rate voice codecs to support, the choice for audio would be which audio codec to support, other choices would be functional such as voice or speech recognition support, advanced noise cancellation, extended audio capture or advanced search and playback capabilities.

In the **positioning domain,** the choice is essentially rate, resolution and accuracy both in micro and macro positioning. An improvement in any one of these metrics will imply additional processor loading.

In the **imaging domain**, the decision would be whether to support newer coding schemes such as JPEG2000 (imaging) or H264/ MPEG Part 10 AVC/SVC or, in general, any of the emerging wavelet based progressive rendering schemes.

In the **data domain**, decisions revolve around the amount of local and remote storage dedicated to personal and corporate data management systems and related data set management capabilities.

Testing the model on specific applications

To be valid, we now need to show that the model has relevance when applied to specific applications.

For example, a **gaming** application may be a composite of radio layer functionality, audio functionality, micro and macro positioning functionality, imaging functionality and personal profiling (personal data set management).

A **camera phone** application will already have wide area radio access, may have enhanced audio, should probably have integrated positioning, will certainly have imaging and should have data functionality.

The concept of a 'dominant domain'

This leads us towards defining future handsets in terms of their **'dominant domain'.**

The 'dominant domain' of an audio phone is the audio system domain with potentially all other domains adding complementary domain value.

The dominant domain of a location device is the positioning domain with potentially all other domains adding domain value.

The 'dominant domain' of a camera phone is the imaging system domain, with potentially all other domains adding complementary domain value. Within the imaging domain, the dominant functionality is image capture (the optical sub system and sensor array).

The 'dominant domain' of a games phone is also the imaging domain but the dominant functionality within the domain is, arguably, the display sub system and associated 2D and 3D rendering engines.

The 'dominant domain' of a 'business phone' is the data domain, with the emphasis within the data domain on corporate information management. All other domains are however potential value added contributors to the overall system value of the dominant domain.

Dual Dominant Domain Phones
The above examples are reasonably clear cut but let's take for example an ultra low cost (ULC) phone.

The dominant domain of an Ultra Low Cost Phone is the wide area part of the radio system domain and the voice part of the audio domain plus some parts of other domains (text from the data domain function, possibly basic camera functionality from the imaging domain). Being pragmatic, it is sensible to describe a ULC phone as a 'dual dominant domain device'.

Domain Value
Each individual domain has a value and cost. The cost is functional and physical and is a composite of processing load and occupied silicon real estate. Value is a composite of the realised price of the product plus incremental through life revenue contribution as functionality is increased in any one domain.

Domain value is independent of partitioning or integration. Presently, individual domains may be on separate interconnected devices. For example, in the radio domain, Bluetooth has been historically separate from the GSM RF and baseband and/or from embedded WiFi functionality. In the audio domain, speech codecs and audio codecs may be and often are, separate entities. Micro positioning is separate from macro positioning. Imaging is separate from video. For example, most camera phones have two cameras, one for still image capture, one for lower resolution video. The data domain may be distributed across several devices, for example, the application processor, the SIM card etc.

This does not mean that domain value is not a valid approach for qualifying partitioning or integration decisions. Adding functionality to phones has increased the complexity of the decision process and implies a need for a level of inter domain understanding that is hard to achieve. Radio system specialists have not historically needed to know much about audio systems or positioning systems or imaging systems or data systems.

So the domain value approach can be useful at engineering level either to work through the mechanics of partitioning or integration or to decide how much functionality to support in any one domain and/or to decide how to allocate R and D effort to achieve a maximum return.

Domain value as a market forecast tool

Similarly, the domain value approach can help in developing future market models. Forecasting the future sales volume and value of voice phones, audio phones, location devices, camera phones and business phones and/or personal organisers can become muddled by a lack of descriptive clarity.

Given that function determines form factor, domain based functional descriptions provide a valid alternative approach allowing product families to be developed at silicon and handset level with clearly differentiated functionally based cost and value metrics.

Domain value as a market research tool

The same applies in market research. The telecoms industry, in our case, the wireless telecoms industry, is a classic example of a technology driven rather than customer driven industry.

This is altogether a good thing.

However, in a technology driven industry, 'listening to your customer' is probably the worst thing you can possibly do. **Understanding your customer** is however **completely crucial.**

'Understanding' in this context implies a quantitative understanding of the economic and emotional value of each of the domains and the perceived quality metrics of each domain.

Quantifying domain specific economic and emotional value

Such an approach is not particularly difficult and can be objectively based.

For example, it is possible to quantify the economic and emotional value of wide area radio system mobility and ubiquity and build models of how the value/cost metric changes as bandwidth and perceived quality increases over time.

It is possible to quantify audio system value on the basis of voice and audio value using well defined and calibrated mean opinion score methodologies and to model how the value/cost metric changes as bandwidth and perceived quality increases over time.

It is possible to quantify micro and macro positioning value and to model how the value/cost metric changes as accuracy and fix speed increases over time.

It is possible to quantify imaging system value and to model how the value/cost metric changes as resolution and colour depth and perceived quality increase over time using well defined and calibrated mean opinion score methodologies.

It is possible to quantify data system value both in terms of personal efficiency and corporate efficiency metrics.

It might be argued that emotional value is hard to quantify. However emotional value is part of the 'engagement cycle' that determines the 'soft value' (or 'fondness') that users feel towards particular service offerings.

Intuitively, as emotional value increases, session length increases; a directly measurable metric.

Is domain value relevant to handset design?
Yes. We have chosen silicon value as an example but it is equally applicable to handset research and design. It is a valid approach to developing handset technology policy over a forward three to five year time scale.

Is domain value relevant to infrastructure and network design?
Certainly, all five value domains can be used to quantify cost metrics and value metrics in a radio network proposition. For example, radio system costs and radio system value, audio system costs and audio system value, positioning system costs and positioning system value, imaging system costs and imaging system value and data system costs and data system value can be and should be separately identified.

Is domain value relevant to content management?
Absolutely. Content has a direct impact on radio system cost and radio system value, audio value is an integral part of the content proposition but benefits from being separately identified as a cost and value component, positioning adds value to content, imaging is an integral part of the content proposition but benefits from being separately identified as a cost and value component, data systems are an integral part of the content cost and value proposition.

Note that audio, image and data costs are a composite of delivery and storage cost and delivery and storage value, both are usefully described in their individual domains.

Is domain value relevant to other application sectors?

Yes probably. Superficially it appears to work in an automotive context where radio system value, audio system value, positioning system value, imaging system value and data system value are all separately identifiable components.

Is it a universal model?
Yes within the relatively limited context of wireless mobility. It is certainly universally useful as a mechanism or framework for getting engineering and marketing teams to work together on product definition projects. It provides an objective basis upon which R and D resource allocation can be judged and an objective basis for deciding on 'hard to call' partitioning and integration decisions.

Summary
The definition and development of multi media handsets with integrated radio system, audio system, positioning system, imaging and data system functionality demands particular inter discipline design skills.

Convergence increases rather than decreases the need for inter process communication.

Making multimedia handsets work with multi-service networks introduces additional descriptive complexity and requires a closer coupling between traditionally separate engineering and marketing and business modelling disciplines.

Developing consistent descriptive methodologies that capture engineering and business value metrics helps the inter discipline communication process.

The challenge is to combine the language of engineering with the language of fiscal risk and opportunity.

Descriptive domains provide a mechanism for promoting a more efficient and effective cross discipline dialogue- engineering Esperanto.

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.

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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