RTT TECHNOLOGY TOPIC
April 2006

Mobile Meta Data

Introducing this month's Hot Topic

In last months Hot Topic, 'Esperanto for Engineers' we discussed the 'language of value'.

We described the five 'value domains' of cellular radio, **radio** system value, **audio** value, **positioning** value, **imaging** value and **data** value.

In this month's Hot Topic, we study how **metadata** can be used in each of these domains to defend and extend the **'mobility premium'** upon which network operators are becoming increasingly dependent.

We review some of the mathematical principles behind metadata management and suggest future differentiation opportunities that will likely assume increasing fiscal importance.

Defining Metadata

Metadata is information about information, data that is used to describe other data. It comes from the Greek, meaning 'among', 'with',' beside' or 'after'. Aristotle's 'Metaphysics' was a follow on to his work on physics - it was consequential to the original information or, in Aristotle's case, body of existing work.

Metadata can be spatial (where), temporal (when) and social (who). It can be manually created or automatically created. Information about information can be more valuable than the information itself.

Semantic metadata is metadata that not only describes the information but explains its significance or meaning. This implies an ability to interpret and infer(Aristotle).

We are going to stretch a point by also talking about 'extended metadata'. 'Extended metadata' is information about an object a place or a situation or a body of work (Aristotle again). The object, the place, the situation, the body of work is 'the data'. An object can be part of a larger object - part of an image for example.

The combination of metadata and extended metadata, particularly in a mobile wireless context, potentially delivers significant value but is in turn dependent on the successful realisation of 'inference algorithms','similarity processing algorithms' and 'sharing algorithms'.

We discuss these algorithms and point to possible future 'algorithmic value' in this space.

This might seem to be ambitiously academic. In practice, metadata and, specifically, mobile meta data is a simple mechanism for increasing 'user engagement' which by implication realises additional user value.

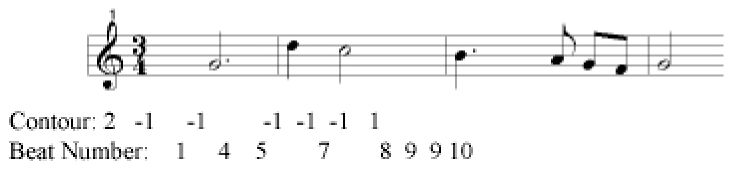
Examples of Metadata

Higher level examples of metadata include electronic programming guides used in audio and video streaming. These can be temporally based (now showing on channel number) or genre based (sport, classical, jazz). The genre based indexing of I Pod music files is an example.

Lower level examples include audio, image and video metadata descriptors that allow users to search for particular characteristics, an extension of present word and image search algorithms now ubiquitous on the World Wide Web. These descriptors also allow automated matching of images or video or voice or audio clips.

Manual metadata depends on our ability to name or describe content. We may of course have forgotten what something is called - a tune, perhaps. If we can hum the tune, it is possible to match the temporal and harmonic patterns of the tune to a data base. This is an automated or at least memory jogging naming process that results in the automated creation of metadata, putting a name to the tune. This may not realise direct application value (the application will probably be free) but provides an opportunity to realise indirect value (sheet music or audio download value).

Figure 1 Tune recognition as an input to a metadata tag
Search by Humming (name this tune)



An example from the [Department of Computer Science, National Chiao Tung University]

The example above will be visually recognisable to some of you because of the pattern combination of the time signature (3/4 waltz time) and the opening interval (a perfect fifth). If you just used the perfect fifth it could be a quite large number of tunes, Twinkle Twinkle Little Star, Theme from 2001, Whisper Not, Moon River etc. However, only one of these examples is a waltz (clue to the tune, think, River and Moon). Congratulations. You have just performed an inference algorithm based on temporal and harmonic pattern recognition.

Examples of MOBILE Metadata

Any of the metadata examples above are potentially accessible in a wide area wireless environment.

However, they are not unique to wireless. **Mobile metadata** combines **metadata value** with **mobility value**

Mobile metadata is based on our ability to acquire and use spatial knowledge of where a user is at any given time combined with other inputs available to us.

Spatial knowledge may be based on cell ID or observed time difference or GPS (macro positioning) possibly combined with heading information (compass heading), possibly combined with micro positioning (low G accelerometers), probably combined with time, possibly combined with temperature or other environmental data (light level or wind speed) .

Even simple cell ID can add substantial metadata value, for example images can be tagged and or archived and/or searched and/or shared by cell ID location.

This is an area of substantial present research, for example by the Helsinki University of Technology and University of Berkeley under the generic description of **'automatic metadata creation'.**

The research highlights the problems of manual metadata. For example when people take a picture it is boring and usually difficult to manually annotate the image. There will generally be a lack of consistency in manual notation which will make standardised archiving and retrieval more problematic.

In comparison, automated spatial and temporal metadata can be standardised and unambiguous. We know where the user is and what the time is.

Areas of potential additional value are identified .These are based respectively on 'inference algorithms' also known as 'disambiguation algorithms', 'similarity processing algorithms' also known as 'guessing algorithms' and 'sharing algorithms' also known simply as 'group distribution lists'.

The imaging metadata case study referenced above is the Campanile Tower in Berkeley but let's rebase the example to London.

Mobile Metadata and Geospatial Value
If you know a user has just emerged from Westminster Tube Station (macro position), has turned right and then left into Parliament Square and has then turned to face south (compass heading) and up (micro positioning) and then takes a picture, you know that the user is taking a picture of Big Ben. Theoretically this could be double checked against the typical image statistics of Big Ben.

This is the basis of geo tagging and smart tagging familiar to us in present mapping systems. Smart tagging is of course standardised in Windows XP.

Figure 2 Image of Big Ben taken from Parliament Square, facing south.

http://www.sights-and-culture.com

'Big Ben' can then be offered as a metadata annotation for the user to accept or reject.

However, having automatically identified that it is Big Ben that the user is looking at, there is an opportunity to add additional extended metadata information to the image, for example,

Optional extended image metadata for Big Ben

'Big Ben is one of London's best-known landmarks, and looks most spectacular at night when the clock faces are illuminated. You even know when parliament is in session; because a light shines above the clock face (many hands make light work). The four dials of the clock are 23 feet square, the minute hand is 14 feet long and the figures are 2 feet high. Minutely regulated with a stack of coins placed on the huge pendulum, Big Ben is an excellent timekeeper, which has rarely stopped.
The name Big Ben actually refers not to the clock-tower itself, but to the thirteen ton bell hung within. The bell was named after the first commissioner of works, Sir Benjamin Hall.This bell came originally from the old Palace of Westminster; it was given to the Dean of St. Paul's by William III. Before returning to Westminster to hang in its present home, it was refashioned in Whitechapel in 1858. The BBC first broadcast the chimes on the 31st December 1923 - there is a microphone in the turret connected to Broadcasting House'.

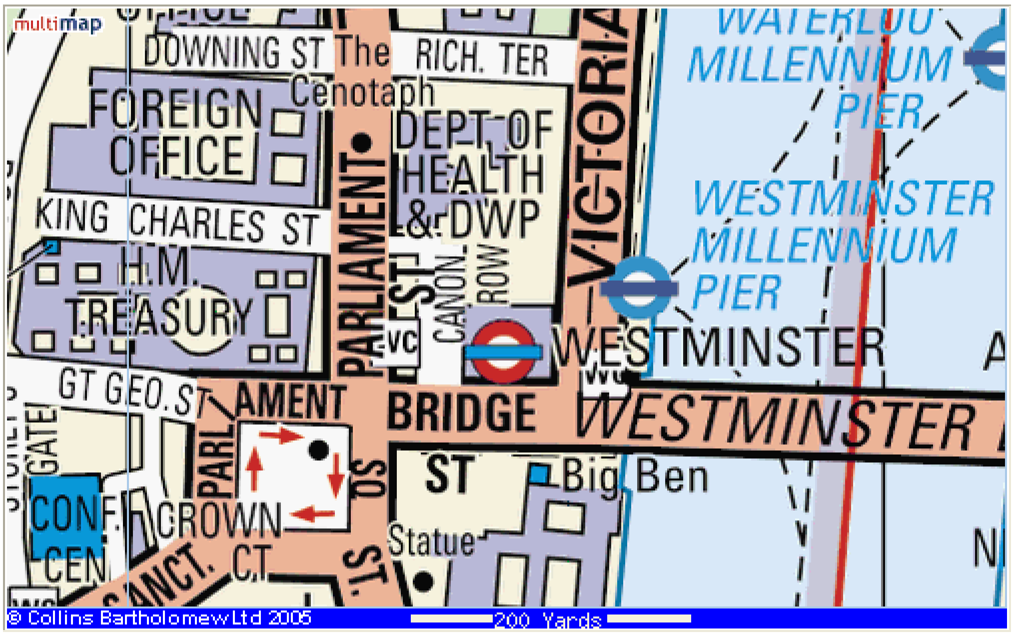
Mobile metadata's contribution to localised offer opportunities, progressive mapping and point and listen applications

There are of course various related localised 'offer opportunities' associated with this 'engagement moment', a Macdonald's 24 hour 'Big Ben Burger' or the latest geo specific downloadable Big Ben ring tone, 'Big Ben Bong'. Of course if the superphone has decent solid state microphones, then the user can record his own ring tones and use them and/or upload them with a suitable spatial, temporal and personal meta data tag. More esoteric but still subject specific download opportunities might include Dostoevsky's classic but little known work on badly behaved big clocks 'Chime and Punishment' and/or own own recent best seller, 'Big Clocks of the World and their role in Cellular Phone Design'.

If the user was to focus specifically on the London Eye (lower left hand side of the image), then a similar process could be triggered (a chance to reprise the Picasso in Parliament joke, 'ayes to the right, no's to the left').

Geospatial value is of course closely linked, or could be closely linked, to progressive mapping applications (where only relevant parts of the map are downloaded as you need them) and wide area 'point and listen' applications. Point straight ahead in the Big Ben example, and you could be listening to an audio download of Parliamentary Question time.

Figure 3 A 2D Map of London's Parliament Square showing Big Ben



With thanks to MultiMap www.multimap.co.uk

If you wanted a **3D** overview of the area for **local navigation or local information** reasons or a 'virtual 3D tour' of the inside of Big Ben then this could be downloaded from a server. The Reality Server offering from Mental Images is one example of this type of application.

Mobile metadata and Super phone capabilities
However there are a number of extended opportunities that are specific to the extended audio and image capture and play back/play out capabilities now being included in new generation phones, described as **'Super phones'** in our December 2005 Hot Topic.

This is important because many of our mobile metadata applications do not intuitively require a connection to a network. A Nikon camera with GPS and a compass capability will know where it is and what it is looking at and could have embedded reference data available. A top of the range Nikon SLR camera, for example, has 30,000 reference images stored which are used for auto exposure, auto white balance and auto focus so it's a small step to add another few gigabytes of embedded reference data.

It is therefore important to identify functionality that can be made unique to a phone, particularly a camera phone, connected to a network. The ability to connect to the web to access smart tag or geo tag information is an important differentiator but not the only one.

We suggested that phones could be divided into three functional categories, **standard phones** that help us communicate with one another, **smart phones** that help us to organise our social and business lives and **super phones** that help us to relate to the physical world around us. **Smart super phones combine all three functional domains**

The mobile metadata that you get from network connected smart super phones builds on these functional domains.

We have said that smart super phones by definition will have advanced micro and macro positioning and direction sensing capabilities combined with extended audio (voice and music) and image capture capabilities combined with extended audio and display and text output capabilities plus access to server side storage (the web) plus access to network resident rendering, filtering and processing power.

Returning to our Big Ben example, Big Ben is an object with a unique **audio signature.** Other objects and places have similar but different signatures, the sea side for example, a concert hall, an airport. We mentioned earlier that audio signatures make potentially good ring tones- Big Ben or the Westminster Peal.

If you fancy church bells as ring tones you will be interested in the relevant object meta data tag.

'Consider the effect of bells rung together in a peal rather than singly, in English changes - with each bell striking a fixed interval, usually 200 to 250 mS, after the previous one. Peals of bells can sound very different in character, and the effect is influenced by many factors; the frequency and amplitude of the bells' partials, considered individually and as a group; how they are clappered; and rather critically, the building in which they are being rung' (from a guide to campanology- the harmonic science and mechanics of bell ringing).

Objects and places and spaces similarly have unique **visual signatures**. These can be object specific, The Statue of Liberty for example, or general, the seaside. A sea scape will generally consist of some sky (usually grey in the UK), some sea (usually grey in the UK) and sand (usually grey in the UK). The image statistics will have certain recognisable ratios and certain statistical regional boundaries.

Object and place and visual signatures come 'for free' from the auto exposure, auto colour balancing and auto focusing functions in higher end camera phones. Auto exposure gives you a clue though not definite proof that it is day or night, auto colour balancing and auto exposure together give you a clue though not definite proof that the image is being taken in daylight outdoors on a sunny or cloudy day or indoors under natural, tungsten or fluorescent lighting. Auto focus gives you a clue though not definite proof of distance and spatial relationships within the image. Two cameras mounted a couple of inches apart and two microphones six inches apart would of course greatly increase the spatial relationship capture capability, but let's not get too carried away at this point.

People have **social signatures**, these are specific (**voice** and **visual**) and **physical** (my lap top has fingerprint recognition which I am impressed by but have never used) and general, for example **behaviour patterns.**

The role of audio, visual and social signatures in developing 'inference value'
Now these are interesting capabilities and necessary for higher end camera phone functionality but do they have a wider application value when combined with network connectivity?

Well yes in that they can add value to 'inference algorithms'.

'Inference algorithms' are algorithms that combine spatial, temporal and social information. Their job is to '**disambiguate'** the **context** in which, for example, a picture has been taken or an observed event is taking place.

So the fact that it is 4.00 am (temporal) on the 21st June (temporal) 2006(temporal)and that you (personal signature) are somewhere on Salisbury Plain (cell ID spatial) looking at the sun (auto exposure and auto white balance) rise over some strangely shaped rocks (image statistics and object recognition) at a certain distance away (auto focus) listening to some chanting (audio signature) tells the network with a very high level of confidence that you are a Druid Priest attending the mid summer solstice at Stonehenge (Non druids are not allowed to attend).

Figure 4 The summer solstice in Stonehenge

With thanks to www.manastro.co.uk

Does this particular example illustrate realisable value? Probably not, but more general applications of inference algorithms will - this is mechanised i.e. automated, mobile metadata inference value.

Revenues from Image and Audio and Memory and Knowledge Sharing - the role of mobile metadata and similarity processing algorithms

Inference algorithms potentially create new application value opportunities and add value to existing applications. Downloadable Druid ring tones spring to mind from the above example - probably a rather specialist market.

'Similarity processing algorithms' are related to but different from inference algorithms.

The job of similarity processing algorithms is to detect and exploit spatial, temporal and social commonalities and similarities or occasionally, useful and relevant dissimilarities (the attraction of opposites).

The relationship with inference algorithms is clear from the example above.

If the network knows I am a Druid (I am not but would not mind if I was) then the **presumption** could be made that I have common and similar social interests to other Druids. I am part of the Druid community which in turn has affiliations with other specialist communities. We may live in similar places, Totnes for example, own a dog on a stick and do similar things at similar times. Before long, an apparently insignificant addressable market has become more significant. Not only does the network know that I am a Druid, it also knows that I attended the 2006 summer solstice and may want to share memories of that moment with other members of my social community. This is the cue moment for the suggested recipients list for any image or video and or audio recording I may have made of the event or for the sharing of particular cosmic thoughts that occurred to me at sunrise. This is sometimes described in the technical literature as **'context to community'** sharing. The suggested recipients sharing list might include other potentially interested and useful parties -for example, the editor of Druid Weekly Magazine ('Reading the Runes').

A parallel and immediately topical example is the solar eclipse just happening (happened) in Africa and Central Asia.

This has spawned a swathe of specialist web sites to service the people viewing and experiencing the event either directly or indirectly

Figure 5 Solar eclipse March 28th 2006 in Africa and Central Asia.

An example web cast format of this event

Tokyo, Mar 25: The national astronomical observatory of Japan and other organisations will hold an event to webcast a total solar eclipse from Africa and Central Asia when it occurs on Wednesday evening Japan time.

The event titled "Eclipse Cafe 2006" is the first of its kind organized by the observatory.

Participants can **view live images of the solar eclipse** webcast at eight astronomical observatories and science museums across Japan, including Rikubetsu astronomical observatory in Hokkaido and Kazuaki Iwasaki space art gallery in Shizuoka prefecture.

Of the eight locations, participants in Hiroshima and Wakayama prefectures have opportunities to ask questions to astronomical researchers in turkey using a **teleconferencing** system.

The webcasting service will be offered with webcast images of solar eclipse in the past. On Wednesday, the images will be transmitted from **Egypt, Turkey and Libya.**

The solar eclipse will be first observed in Libya at around **7:10 pm local time**. It is expected to last about **four minutes**, which is relatively long for a solar eclipse.'

Similarity processing algorithms would automatically capture these **spatial** (where), **temporal** (when and for how long) and **social** (who) relationships and create future potential engagement and revenue opportunities from a discrete but significant special interest group

In the case of Big Ben, it is self evident that there are potentially millions of spatial, temporal and socially linked images, memories and 'advice tags' available to share which can be automatically identified.

Sharing Algorithms
So automated sharing algorithms can be built on automated inference algorithms and automated similarity algorithms. Sharing algorithms are based on an assumed common interest which may include a spatial common interest (same place), temporal common interest (previous, present or possible future common interest) and a social common interest. Most of us are offered the opportunity to 'benefit' from sharing algorithms at various times through the working day. **Plaxo** is one example. This is **algorithmic value in the corporate data domain**. **Friends Reunited** is an example of **algorithmic value** applied **in the personal data domain**. Both are examples of extended social Meta data tagging where **the tagged object is……us.** This is generally only acceptable if we have elected to accept the process. It also suggests a need to establish that we are who we say we are. There is an implicit need for **social disambiguation.**

Disambiguating social mobile metadata-
Voice recognition and the contribution of wide band codecs and improved background noise cancellation
We have said that spatial and temporal metadata are implicitly unambiguous. Social metadata is potentially more ambiguous. How can we be sure the user of the phone/camera phone is the owner of the camera phone? Voice recognition helps in that it can uniquely identify the user. Wide band codecs and improved background noise cancellation will significantly improve present voice recognition performance. Note that these capabilities inherently depend on a user's willingness to be identified which in turn is dependent on the user's perception of value from the function. Higher quality codecs and better background noise control will also improve general audio capture quality, making voice tags and audio tag additions to images (manual metadata input) and user captured ring tones (a form of mobile metadata) more functionally attractive.

Text tagging functionality
Speech recognition and the contribution of wide band codecs and improved background noise cancellation
The same principal applies to speech recognition in that accuracy should steadily improve over time making speech driven text tagging more functionally effective. (manual metadata input).

The requirement for standardised metadata descriptors
A combination of factors are therefore improving the functionality of automatic metadata capture and manual metadata input over time.

Automatic spatial metadata capture improves as positioning accuracy and object recognition/image recognition/image resolution improves; **automatic social metadata capture** improves as voice recognition improves.

Manual metadata input (text tagging) improves as speech recognition improves.

However the benefits of these improvements can only be realised provided that standardised descriptors have been agreed to provide the basis for interoperability. Interoperability in this context means the ability to capture, process and share metadata from multiple sources.

The role of MPEG 7 in mobile metadata standardisation
Even with improved speech recognition, text based metadata input is problematic in that it is non standardised. Each user will tend to use a different vocabulary and syntax. This makes it difficult to implement inference and similarity algorithms other than slightly haphazard word and phrase matching.

It is easier to standardise automatically generated meta data. For example to mandate prescriptive methods for describing the harmonic and temporal structures of a voice file or audio file or the colour, texture, shape and gradient of an image file or the structure and semantics(who is doing what to whom) of a video file.

Images, video and audio files can usually use Fourier descriptors given that the majority of image, video and audio content will have been compressed using Fourier based JPEG or MPEG compression algorithms.

The purpose of MPEG7 is to standardise these audio and visual descriptors to allow the development of standardised search, match and retrieval techniques, including metadata based inference and similarity algorithms.

Taking imaging as an example, descriptors can be region specific or macroblock specific. For example, it is possible to search for a man in a red woolly hat in a particular area of an image in multiple images by looking for the frequency descriptor for the colour red and the 'closest match' texture descriptor.

Generically, all images are converted into a common unified format in which image features are identified based on the wavelength of the colours making up the scene, expressed as a standardised 63 bit descriptor.

Some of the more complex algorithms, for example automated face recognition algorithms, require more accuracy and resolution and use a 253 bit descriptor.

Video descriptions are based on a differentiation of simple scenes and complex scenes together with motion estimation using vectors (direction and magnitude).

In a perfect world, this all works with present and proposed MPEG 4 based object coding though in practice it is still problematic to extract meaningful video objects out of a high frame rate high resolution video. These are non trivial processing tasks not to be attempted seriously in embedded software and are presently better performed as a server side function (potentially good news for network operator and server added value).

Cameras equipped with depth sensors and/ or twin camera stereoptic capture makes it easier to capture 3D video and segmented objects which in turn make object based coding more useful but these at present represent a specialised application sector.

Thus MPEG 7 marks a useful start in terms of a standards process but there is much practical work still to be done.

Mobile Metadata and the Five Domains of User Value
Anyway, the fact that we have not arrived at an end destination (assuming there is one) does not mean we cannot enjoy the journey and mobile metadata already has much to offer in terms of **'interconnected user domain value'.**

To summarise
In the **radio system domain**, mobile metadata can extract value from cell ID, direction and speed of movement and all of the other (many) user specific behaviour metrics that are potentially available from the radio air interface. This value can be realised by integration with parallel mobile metadata inputs including:

Audio domain mobile metadata associated with voice capture and voice recognition, speech capture and speech recognition and wide band audio capture and audio listening.

Micro (low G accelerometer) and macro (GPS or equivalent based) **positioning** system value.

Imaging value - mobile metadata as an integral part of the image and video sharing value proposition.

Data domain value - the integration of mobile meta data into the personal and corporate information management proposition.

Mathematical (algorithmic value) as an integral part of the mobile metadata proposition

Realisation of mobile meta data value in all five user value domains is however dependent on an effective implementation of standardised **'descriptive maths'** (MPEG7 descriptors or other standardised equivalents) and **comparative algorithms** - inference and similarity algorithms.

Some though not all of the **algorithmic decisional techniques** used in this space can be traced back to the three 'mathematicians of the month' featured in our December 2005' Smart Super Phone' Hot Topic - the Reverend **Thomas Beyes,**(1702-1761), **George Boole** (1815 -1864) and **Augustus De Morgan** (1806-1871).

Similarly **some though not all** of the **descriptor techniques** can be traced back to **Joseph Fourier** (1768-1830) and **Carl Friedrich Gauss** (1777-1855) profiled in our September 2005 Hot Topic 'Maths in Mobile Phones'.

Contemporary mathematical makers and shakers in the mobile metadata space

But life moves on and it is important to realise that mathematical techniques and algorithmic techniques continue to evolve.

In the telecoms industry, we have tended historically to focus on **engineering capability (infrastructure deployment)** and **technology capability (product R and D)** to provide **competitive differentiation.**

This is less relevant over time.

Modern mobile phones and modern mobility networks including **mobility networks based on mobile metadata constructs are strategically dependent on mathematical and algorithmic value.**

This includes the **'descriptive maths'** used to describe signals and systems and the '**decisional maths'** used to respond to changing needs and conditions. An example of descriptive maths used in the signal space is the Fourier transform and present work on wavelet transforms. Descriptive maths helps us to capture and process the analogue world around us. One example of decisional maths applied at system level would be an admission control algorithm,

Some of the mathematical value both in pure and applied maths is **'heritage value',** the legacy of several thousand years of mathematical study and inspiration.. Some of the mathematical value is 'contemporary value', the contributions presently being made by practising mathematicians.

So it is relevant to consider the areas in contemporary mathematics that are most likely to prove useful in terms of differentiating the future **'user experience proposition'.**

Mathematicians of the Month April 2006
One way to do this is to find out what work, or more accurately, whose work is winning awards.

For years there was no mathematical equivalent to the Nobel Prize. Rumour has it that the Swedish mathematician Gosta Mittag Leffler had an affair with Alfred Nobel's wife. This effectively shut out all future mathematicians from the Nobel award and recognition process.

There is a Field award for mathematicians but this is only awarded every 4 years and is restricted to mathematicians under 40.

In 2002, the Norwegian government decided to fund a yearly award known as the **Abel Prize** to mark the double centenary of the birth of **Niels Henrik Abel.**

Niels Henrik Abel died in 1829 at the age of 27 after contracting TB following an ill advised sleigh ride.

Figure 6

Niels Henrik Abel
1802-1829


In his short life he had however developed the foundations for **group theory**, also worked on in parallel by **Galois.**

Group theory is essentially an integration of **geometry, number theory and algebra**. Abel worked specifically on the commutative properties of group operations, arithmetical processes like addition where it does not matter in which order sums are performed. These came to be known as **abelian groups.**

Strangely but perhaps not surprisingly, group theory is increasingly relevant in many areas of telecommunications including mobile telecommunications and mobile metadata management.

Geometry is important in vector maths (mathematical calculations that have direction and magnitude), number theory is important in statistical processing (for example the processing of image signal statistics) and algebra crops up all over the place.

A popular description of group theory is that it helps discover and describe what happens when one does something to something and then compares the results with the result of doing the same thing to something else, or something else to the same thing.

Group theory has been and is used in a wide cross section of physical problem solving including the modelling of turbulence and weather forecasting.

Our interest in a wireless telecoms context is to study the role of group theory in the management and manipulation of complex and interrelated data sets which change over time and space at varying rates.

That's why it is useful to keep track of whose winning the Abel prize each year. They are all mature contemporary working mathematicians and as such provide an insight into evolving areas of mathematics that are potentially strategically intellectually important.

This of course assumes that the Norwegian Academy of Science and Letters knows more than we do about the work of contemporary mathematicians which for the majority of us is probably a valid assumption.

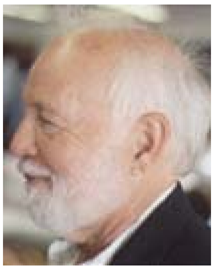
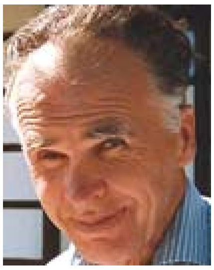
In **2003**, the Abel prize was awarded to **Jean-Pierre Serre** for his work on **topology**

(place and space) and group theory.

In **2004**, the Abel prize was awarded jointly to **Sir Michael Francis Atiyah** and **Isadore M Singer** for their work on the eponymous Atiyah-Singer index theorem, a construct for measuring and modelling **how quantities and forces vary over time and space taking into account their rate of change**.

In **2005,** the Abel prize was awarded to **Peter Lax** for his work on non linear differential equations and singularities, the modelling of odd things that happen at odd moments, breaking the sound barrier for example. Dedicated readers of RTT Hot Topics might remember our venture on to this territory in our March 2003 Hot Topic 'Turbulent Networks'. One reader hurtfully assumed the Hot Topic was an early April fool which was of course untrue. System stability is going to be a major focus in multi media multi service network provision including multi media multi service networks with integrated mobile metadata functionality .Peter Lax wittingly or unwittingly is building on work done by Benoit Mandelbrot in the 1980's that in turn was based on the work of Lewis Fry Richardson (uncle of the late Sir Ralph Richardson) on aeronautical turbulence prior to the first world war.

In **2006**, the Abel prize was awarded to Lennart Carleson for his work on **harmonic analysis** and his theory of **smooth dynamical systems.**

Figure 7 Mathematicians of the month April 2006				
Abel Prize Winners 2003-2006				
Jean Pierre Serre	Michael F Atiyah	Isadore M Singer	Peter Lax	Lennert Carleson
2003	2004	2004	2005	2006
				

Lennart Carleson conveniently brings together two story lines that we have explored.

His work on **harmonic analysis** developed Fourier's work but specifically applied to **acoustic waveform synthesis.** The popular press describes Lennart as the 'mathematician who paved the way for the iPOd' This is perhaps a rather journalistic interpretation. In practice his work in this area in the 1960's marked an important advance in musical set theory, the categorizing of musical objects and their harmonic relationships. These have subsequently proved useful in audio system simulation and design and automated audio meta data tagging. Robert Moog was developing his Moog synthesizer at the same time.

Lennart's real genius is that he has done this work together with his work on dynamic systems, the branch of modern mathematics now dedicated to the modeling of large systems like financial markets and the weather - systems that change over time.

Multi media multi service network provision including multi media multi service networks with integrated mobile metadata functionality increasingly exhibit large system behaviour.

This is not surprising given that they are large systems with multiple inputs, many of which are hard to predict.

As with the weather, it sometimes seems hard to predict human behaviour, particularly long term behaviour. This is however a scaling issue. We do not have enough visibility to the spatial, temporal and social data sets or the vector behavior (direction and magnitude) of the data sets over a sufficiently wide range of time scales.

The mechanics of mobile metadata potentially allow us to capture and manage this information and ultimately, provided user elective issues can be addressed, to realize value from the process. At this point, data on data (metadata) becomes more valuable than the data itself.

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