RTT TECHNOLOGY TOPIC
July 2004

Five PHYS named FLO

THE FIVE FLEXIBLE PHYS

RTT's May and June Hot Topics covered the differences between Series 40, Series 60, Series 80 and Series 90 phones- four different hardware and software form factors- entry level camera phone (Series 40), camera phone with enhanced memory and /or gaming capabilities (Series 60), enterprise phone (Series 80) and Media Phone (Series 90) and four different network form factors - a Series 40 network, a Series 60 network, a Series 80 network, a Series 90 network.

Over the next four Hot Topics, we will be looking at the multiple physical layer options now available to us - how **adding phys to a phone increases** the phone's **value** both at point of sale and through life (**operator revenue and margin**).

THE EDGE/UMTS FLEXIBLE PHY

Release 6 of the 3GPP standard describes the functionality needed from the EDGE and UMTS physical layer (PHY). In addition to higher headline data rates (achieved by using higher level modulation and/or wider channel bandwidths) the physical layer has to be capable of supporting multiple data streams per user and each stream has to be capable of supporting variable data rates. **Each individual data stream can of course be considered as a revenue stream.**

Upper and lower user data rates are set at the start of a session (static matching) and can then change every frame (dynamic rate matching). For EDGE, the multiple per user multiplex is known as dual transfer mode, enabling circuit switched and packet switched traffic to share a time slot.

Data rates can change by increasing or decreasing the number of time slots and/or changing the channel coding and modulation (MCS1-9) In UMTS, multiple data streams can be matched to individual channel codes, either SF4 to SF256 OVSF codes or (in HSDPA) increments of 5,10 or 15 SF16 code channels.

The functionality is described in the standard as uplink and downlink temporary block flow (TBF) flexibility, with data rates and formats set by the Transport Format Combination Indicator (TFCI), a similar concept to the resource management cell used in ATM. The physical layer is described in general as **Flexible Layer One (FLO**).

UMTS is configured to support up to 6 simultaneous uplink and downlink streams per user. To put this into a user perspective, the radio layer is or will be capable of supporting simultaneous voice and video, simultaneous and synchronised subtitling (3Gtxt), image, audio and data exchange.

OTHER FLEXIBLE PHYS

UMTS and EDGE are not however unique in having a flexible PHY. The latest Bluetooth specification takes advantage of a higher headline data rate (3M/bit/s using Pi4 DQPSK) to support three **simultaneous** traffic streams, any of which could be **variable rate.**

A typical configuration could be **voice, data and device control.** Translating this into a user perspective, the radio layer could support a voice call (on a wireless headset), manage a wireless mouse and wireless keyboard and a simultaneous file exchange.

Similarly with **Wifi** and **WiMax**, the data rates can be anything from 1 M/bit/s to 108 M/bit/s (802.11 a or g in bonded channel mode) with time sliced time bounded voice and audio co-sharing with best effort data (ie three simultaneous variable rate data streams).

It is the same story with DAB which can support an audio feed at (say) 384 k/bit/s and two DMB channels (local news and information) and DVB-H (simultaneous **datacasting**, **infocasting, audio and TV**.)

SIMULTANEOUS FLEXIBLE PHYS

It would of course be feasible to have all these devices working simultaneously in a handset. Nokia already have devices that have EDGE, Bluetooth and wireless LAN (80 Series 9500 Communicator) and with wireless LAN at 2.4 GHz and 5 GHz (802.11) it would be possible to have all three devices actively transmitting and receiving at the same time.

Near field antenna technologies open up the possibility of these multiple PHY phones being implemented in a relatively compact form factor. Target power requirements for DAB (at 220 MHz) and DVB-H (at 750 MHz) are in the order of between 100 and 200 milliWatts so adding these capabilities in is not unthinkable within the next 2 to 3 years making a grand total of 5 flexible radio bearers (plus an optional GPS receiver).

Figure 1
THE FIVE (FLEXIBLE) PHYS

	UMTS	**BLUETOOTH**	**WIFI/WIMAX**	**DAB/DMB**	**DVB-H**
Flexible Phy	Up to 6 simultaneous **bi-directional** traffic streams e.g. voice, image, 3Gtxt audio, data.	Up to 3 simultaneous **bi-directional** traffic streams e.g. voice, data and device control.	Up to 3 simultaneous **bi-directional** traffic streams e.g. voice (VowLAN), video and best effort	Up to 3 simultaneous **uni-directional** traffic streams e.g. DAB plus two separate stream decodes.	Up to 4 simultaneous **uni-directional** traffic streams e.g. IP data casting, IP infocasting, IP audio, IP TV.

Flexible MAC Layer	Multiple users per channel, multiple channels per user.	Voice, data and device profiles.	Contention **or** connection based MAC	Unidirectional MAC	Unidirectional MAC
Flexible Network Layer	IP voice, IP audio, IP video, IP data, multiple QOS data streams per IP address (Ipv4/IPv6)				
Flexible Transport layer	TCP/IP and UDP fixed length packets, virtual paths and virtual circuits using tunnelling and fixed routing trajectories				
Flexible Session Layer	Session initiation and session management protocols(SIP) and bandwidth reservation techniques(RSVP, Diffserv, MPLS,SMIL)				
Flexible Presentation Layer	XML and multimedia presentation and management protocols.				
Flexible Application Layer	Multitasking, flexible O/S and flexible GUI implementation				

AND THEN TWO OR THREE MORE

And of course we probably need to add in Ultra Wide Band (UWB) and Near Field Communication (NFC) as two additional PHYS, though at present, the final choice of technology for UWB still has to be resolved and NFC has not yet reached a final standard so neither has been included in the list above. Also technically we have omitted to include infrared - a sensible if rather light sensitive option for wide band personal area connectivity with an updated ETSI/ARIB AIR standard (**A**rea **I**nfra**R**ed) supporting a 120 degree beam width and 4M/bit/4 meter rate and range.

THE IMPACT ON HIGHER LAYER PROTOCOLS

But there is not much point in having five (or seven or eight) flexible phys unless the rest of the protocol stack can take advantage of the properties of each and all of the bearers. The changes implied and complexities introduced are subtle but significant. The changes include (for example) the introduction of a connection oriented MAC into 802.11 to support voice, audio and video time bounded services (Layer 2 flexibility), the introduction of multiple QoS streams per IP address (Layer 3 flexibility), the introduction of fixed length packets and tunnelling to create virtual paths and circuits (IP ATM Layer 4 flexibility), the integration of existing session management and bandwidth reservation protocols at the session layer (Layer 5 flexibility), XML based multi-media 'declarative content' presentation protocols at the presentation layer (Layer 6 flexibility) and multitasking and flexible O/S and GUI implementation at the application layer(Layer 7 flexibility). Incidentally, each of these adds significantly to the address and signalling overheads loaded on to the original user data stream- **flexibility does not come for free**. Arguably this does not matter in wireline access where bandwidth and power are in abundant supply. It does matter in bandwidth and power limited i.e.-wireless applications. In fact, the innocent looking list above probably takes about 4 dB out of a typical end to end link budget. Given that 1 dB equates to a 10% increase in network density then this implies a direct cost multiplication **- power equals cost in wireless.**

THE APPLICATION LAYER POWER PROBLEM

It also creates a power problem at the application layer. Consider what's needed to manage the five flexible phys. Two users establish a simultaneous full duplex voice and video call using two UMTS camera phones. The camera phones each have a 1.3 Megapixel camera capable of taking pictures at 30 frames per second at 24-bit colour depth down to less than a lux. On the wireless keyboard (connected to the camera phone by a Bluetooth transceiver), each of the users annotate the video stream with SMS based simultaneous subtitles (3GTXT). The annotation includes a time stamp, positioning co-ordinates and digital authentication. Using the wireless mouse, either or both users can be simultaneously downloading data files using the in built dual band (2.4/5GHz) wireless LAN transceiver and receiving a DAB/DMB or DVB-H download. Such an application would draw several watts from the power supply.

THE MULTITASKING MULTIPLEX

So in practice, the ability to use all five phys **together simultaneously** in a compact form factor product is probably still **three to five years away**. In the meantime, however, we can begin to see how application layer and lower layer functionality will evolve to manage what is effectively a 'complex multiplex'. The complex multiplex consists of text, voice, audio, image, video and data. As the multiplex is bi-directional this implies six multiple inputs and six multiple outputs. This in turn dictates the multitasking needed in the (multi-threaded) application processor (or multi-processor). The multiplex has to be supported by the MAC and radio layer. In UMTS, this is done on multiple OVSF code streams or (in HSDPA) multiple SF16 code carriers. The multiplex then needs to be supported across the network using multiple per user rate matched virtual paths or circuits. The traffic is implicitly bi-directional, symmetric and asynchronous and the end to end channel is implicitly conversational ie has a fixed end to end delay and **no** delay variability.
For a more detailed treatment of multitasking, see the January 04 Hot Topic on Media Processor Design.

CONCLUSION

There are products available today that support simultaneous operation of two physical layers (for instance EDGE and Bluetooth or EDGE and wireless LAN). Adding additional physical layers is feasible provided cost, size and power constraints can be addressed.

Near field antenna technologies will help realise these multiple PHY radios in a (relatively) compact form factor. All of the 5 physical layers discussed each individually support multiple simultaneous variable rate channels per user. The upper layers of the protocol stack have to mirror this functionality. Flexibility in the upper layers introduces address, signalling and control overheads and processor overheads. The address, signalling and control overheads have to be subtracted from the link budget and can be significant (in the order of 3 or 4 dB). The processor overheads introduced by the requirement to multitask across multiple per user data streams and multiple radio bearers will also be significant and explains the current preoccupation with new (more power efficient) parallel processing architectures.

In practice, cost constraints and application segmentation ultimately determine what is included or not included in a phone. A low cost entry level Series 40 phone might typically be a two PHY phone, a Series 60 could be a 3 or 4 PHY phone, a Series 80 could be a 5 or 6 PHY phone and a Series 90 could be a 7 or 8 PHY phone.

Adding Phys adds cost but also adds user value. A Series 90 phone should realise a higher price at point of sale and higher through life revenues for an operator (and could therefore be more heavily subsidised). The increased value comes from longer session lengths (billable bandwidth) rather than premium tariffing but this is a typical 'beneficial circle'- higher value products adding more value provided the value exceeds the additional incremental cost - a metric best described from an operator's perspective not as **ARPU** (average revenue per user) or **AMPU** (average margin per user) but as **AMPP (average margin per phone).**

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