RTT TECHNOLOGY TOPIC
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Ultra Low Cost Smartphones

Introducing this months Hot Topic
Last month's Hot Topic (October 2006) focused on Ultra Low Cost Handsets, handsets with an ex factory cost of 30 dollars or less targeted at emerging markets.

We compared the relative merits of GSM only devices with dual mode GSM/UMTS and single mode UMTS and suggested that a relatively rapid transition to UMTS single mode devices would prove to be spectrally politically and commercially expedient.

This month we review **Ultra Mobile Personal Computers**, computers with a relatively compact form factor and integrated WiFi and WiMax connectivity.

In parallel we study the emerging market for **Ultra Low Cost Personal Computers**, devices with an ex factory cost and end user cost of 100 dollars that include wireless connectivity. Note that when an ex factory cost is the same as an end user cost then hardware and software subsidy is implied.

We suggest some **commonalities between ultra low cost computers and ultra low cost handsets** in terms of their **market and social objectives.** We discuss the relative merits of enabling these devices with WiFi/WiMax transceivers.

The availability of such devices may be an essential requirement for network operators wishing to deploy commercially successful WiMax mobile networks into developed and emerging markets.

However there are significant issues that need to be resolved both in terms of spectral availability, device availability, pricing and market subsidy.

Market success in these markets depends on aggressive cost reduction. This implies access to ultra low cost WiFi and WiMax silicon. Ultra low cost Wi Max silicon requires access to market volumes at least moderately equivalent to mainstream cellular markets. Commonalities between WiFi and WiMax silicon will help in that WiMax can benefit from established WiFi market volume.

However it is not just price but **price and performance** that will determine whether WiMax can achieve its present market and social ambitions.

WiMax performance in the context of the Ultra **Mobile** Personal Computer implies an ability to meet functional user expectations which are significantly increasing over time.

WiMax performance in the context of the Ultra **Low Cost** Personal Computer implies an ability to meet specific social, economic and political objectives.

Both are dependent on WiMax being available across a range of suitable **cost economic frequency allocations.**

Defining the Ultra Mobile Personal Computer
Intel define the Ultra Mobile PC as a device with a hand held form factor, an inch thick, 8 inches across (diagonal) and weighing less than 2 pounds with 20 GB of solid state memory, The screen is WVGA (800 by 480 pixel) and there is an integrated 1 mega pixel camera. Wireless connectivity is assumed to be a mix of WiFi and WiMax (for local and wide area connectivity), Bluetooth (and presumably UWB) for personal area networking, a TV tuner, and GPS.

The WiMax UMPC advantage
From a Wimax wide area radio system perspective, there are two significant advantages to this form factor when compared with a super slim super small cell phone.

Firstly there is space to put in multiple antennas with effective spatial diversity.

Secondly there is a device power budget of 20 watts or so, at least 4 times the power budget available in a cell phone. This makes it easier to implement advanced receiver architectures to help maximise the downlink link budget and to implement a relatively high data rate transmitter.

The two factors together allow coverage and capacity gains to be achieved over other wide area systems using either SIMO (single output, multiple input) or MIMO (multiple output, multiple input) system implementations. Both SIMO and MIMO systems require dual or multiple receivers in the user device and some practical spatial diversity. Both are more practicable in a 'small lap top' form factor than they would be in a small form factor power limited cellular device.

The issue of user expectations
However WiMax 'mobility' implies a user expectation that the device will work almost anywhere in the world and will work when the user is a passenger in a car or a boat or a train or a plane.

This in turn implies access to world wide WiMax spectrum allocations that are suitable for **mobility** applications, hence the term, **Ultra Mobile**. Note that this effectively excludes frequencies above 3 GHz which are line of sight sensitive and imply network densities with unsupportable hand off rates for high mobility users.

Of course WiMax is also being propositioned for deployment in Band VII (the 2.6 GHz 'UMTS' extension band presently being used by Sprint Nextel for a planned WiMax network), Band 1(the present UMTS band), and any other potentially available cellular bandwidth down to and including 700 MHz.

To meet **global roaming** user expectations, WiMax will need to be deployed in certainly one and preferably several of these bands. Ideally this would be a combination of allocations at or above 2 GHz (for maximum capacity) and allocations at 700/800/900 MHz (for coverage).

Link budget gain with WiMax
In common with UTRAN LTE, the WiMax advantage over present cellular systems in terms of link budget gain is based on a combination of smart antenna SIMO/MIMO technology combined with an OFDM multiplex that slows the symbol rate on the radio channel.

The slow symbol rate means that high data rate (but low symbol rate) OFDM systems can be deployed into relatively large cells in single frequency networks without suffering inter symbol interference.

Single frequency networks in this context are networks that use the same radio channel for the uplink and downlink and employ time division duplexing to separate the transmit and receive path.

The advantage of using the same channel for the uplink and down link is that the propagation conditions are the same in both directions making it easier to implement SIMO and MIMO antennas. The disadvantage is that you lose the benefit of the duplex frequency spacing used traditionally in cellular networks to achieve receive sensitivity.

There are presently non duplexed spaced bands allocated in the UMTS 1900/2100 band (band1) which could be repurposed for WiMax. Other cellular spectrum would require more reconfiguration to become Wi Max friendly.

This is politically complex rather than technically onerous.

The WiFi WiMax Ultra Mobile PC
Most of us are already users of WiFi enabled lap tops so it seems straight forward to consider adding Wi Max wide area connectivity.

As suggested above however, present spectral allocations are problematic.

Table 1 WiFi and Mobile WiMax Spectrum

Spectrum	**2.3-2.4 GHz** 100 MHz	**2.305-**2.32 2.345-**2.36GHz**	2.4-2.48 GHZ **ISM** 80 MHz	2.498-2.69 GHz	3.5 GHz 3.3-3.4 GHz 3.4-3.8 GHz	5.15-5.35 GHz	5.47-5.725 GHz **ISM**	5.725-5.850 GHz **ISM**
Technology	**WiBro/WiMax**	**Wireless Communication Services**	**WiFi 802.11b and g**	**Mobile WiMax at 2.6 GHZ**	**Mobile WiMax at 3.5 GHz**	**WiFi** 802.11a **Europe Band 1 US Band 1** to 5.24 GHZ	**WiFi 802.11a Europe Band 2**	**WiFi 802.11a US Band 3**
Channel	8.75 MHz	5 or 10 MHz	20 MHz	5 or 10	5 or 10	20 MHz	20 MHz	20 MHz

spacing and OFDM FFT	TDD 512 FFT	TDD 512 or 1024 FFT	TDD 64 FFT	MHz TDD 512 or 1024 FFT	MHz TDD 512 or 1024 FFT	TDD 64 FFT	TDD 64 FFT	TDD 64 FFT

Consider the present allocations;

The 2.3 GHz Korean WiMax band
Known as WiBro, this is a 100 MHz allocation just below the 2.4 GHz ISM WiFi band.

This is a sensible allocation technically but is not deployed outside Korea and therefore unlikely ever to achieve the scale economies needed to meet present price point expectations.

The present challenges of the Korean based operators trying to build subscriber numbers for WiBro underline how difficult it is to champion geographically specific technology standards- standards without market scale.

The 2.3 GHz WCS band
Similar to WiBro in Korea, the 25 MHz gap between the two bands is allocated to Digital Audio Radio Service in the US making this technically difficult for widespread WiMax deployment.

The 2.4 GHz ISM band
The 80 MHz used for present WiFi 802.11 a and g, co existent with Bluetooth.

The band is power limited and therefore unsuitable for WiMax.

The 2.5 GHz WiMax band in the US.
This is the spectrum to be used by Sprint Nextel for their US WiMax network, also proposed for UTRAN LTE networks outside of the US. This is a major win for WiMax but remains a specifically US deployment which implies a lack of global scale.

The 3.5 GHz bands
This spectrum was mostly originally allocated for fixed wireless but is being re purposed where permitted for mobile WiMax, mostly in Europe and Asia. The problem with the 3.5GHz bands is that they are non contiguous and are actually a mix of 3.3-3.4GHz, 3.5 GHz and 3.8 GHz allocations. This makes it hard to achieve economies of scale and will require highly agile expensively intelligent transceivers to deliver country to country roaming capability.

The 5 GHz ISM bands.
These are the 802.11a ISM allocations used for WiFi. Note there are differences between regions in terms of spectral allocation and allowed output power. Band 3 is a possible candidate for WiMax. In common with the 3 GHz allocations, the 5 GHz band is impractical for high mobility users.

If the assumption is that WiMax will become a globally ubiquitous standard, none of the above allocations are particularly useful.

The WiMax Spectrum Owners Alliance is presently working towards establishing roaming agreements across the present operator community, though this group does not include Sprint Nextel.

In parallel, the WiMax forum is lobbying for WiMax to be deployed into other spectral allocations including Band IV in the US (1.7 and 2.1 GHz), Band V (the 850 MHz band in the US), the 700 MHz spectrum to be released through the closing down of analogue TV and the 1900 MHz US band (Band 2).

The 700 MHz spectrum would allow WiMax to be deployed more economically into developing countries. Deployment into Band IV or Band II would also significantly improve the roll out economics including WiMax overlays on existing cellular systems.

WiMax silicon vendors point to commonalities between the WiFi and WiMax PHY and MAC implementations. Both use an OFDM multiplex, both have similar contention based MACS, both use IP protocols. Dual mode WiFi/Wimax chip sets can therefore share common baseband functionality and, significantly, some common intellectual property rights. Additonally these IP rights may be less aggressively contested than present UMTS handset IPR.

WiFI scale economies can therefore be transferred to WiMax. The inclusion of WiFi chip sets in cellular phones for example will add significant volume.

Even so, it is difficult to see how WiMax silicon even when coupled with WiFi can ever hope to approach the price points of cellular silicon unless a broader segment of spectrum is made available for future wide area implementation.

Similarly it is hard to see either how sufficient global roaming functionality can be delivered on present spectral allocations to meet ultra mobile user expectations.

Similarly it is hard to see how sufficient mobility functionality (the ability to use these devices in trains, boats, cars and aeroplanes) can be delivered on present spectral allocations.

Commonalities between the Ultra Mobile Personal Computer and the Ultra Low Cost Personal Computer.

On casual examination, there would seem to be little commonality between the Ultra Mobile Personal Computer and the Ultra Low Cost Personal Computer.

The Ultra Mobile PC is aimed at power users, international jet setters with advanced functionality expectations. These users are more likely to be in or from developed or developing countries.

The Ultra Low Cost PC is aimed, as we shall see below, at specific educational markets in emerging countries.

However the Ultra Low Cost PC does have a commonality with the market and social objectives of the Ultra Low Cost Cellular Handset.

It is presently assumed that Ultra Low Cost cellular handsets will be voice centric

devices. However there is an alternative possibility that ultra low cost handsets could be data centric, or rather, information centric devices. Let's call these devices **Ultra Low Cost Smart Phones.**

Depending on how you categorise them, smart phones already outsell lap tops by volume. Additionally there are potential **software cross subsidies** (open source versus closed source) and **hardware cross subsidies** (cellular network and related political subsidies) that could make **ultra low cost smart phones** a reality.These devices would meet many of the stated requirements for ultra mobile personal computers. These devices would also meet many of the stated requirements for ultra low cost personal computers.

Defining the Ultra Low Cost Personal Computer
Similar to the Ultra Low Cost Handset, the Ultra Low Cost PC is promoted as a device that can bridge the digital divide between developed and developing nations.

Championed by Nicholas Negroponte, co founder of the MIT Media Lab and originally presented at the World Economic Forum in Davos in January 2005, ultra low cost personal computers are targeted specifically at educating children. The promotional campaign is known as OLTPC, One Lap Top Per Child.

Ultra Low Cost PC's are intended for direct distribution to schools and would not be available on the open market. The cost and end user price would be less than 100 dollars. Although not stated explicitly, it is unlikely that this delivered cost could be achievable without some hardware and software subsidy.

The geographic focus of the campaign is similar to the Ultra Low Cost Handset initiative with initial rollouts in the less developed parts of Latin America, Africa and Asia.

Arguably the devices might stand a better chance of achieving the required price point if they could be made suitable to a broader more generic user base. For 'ageing markets', the developed world where pensioners will be numerically dominant, there could for example be social, economic and political justification for a One Lap Top Per Pensioner (OLTPP) campaign - but we digress.

Altruism - the need for a political and economic pay back
The One Lap Top Per Child campaign is based on evidence that **educational investment** in under developed countries **delivers a net gain in GDP**.

Bridging the digital divide with an **Ultra Low Cost Computer** yields a **dollar plus dividend.**

Every dollar spent yields x dollars plus in terms of future economic activity. This growth in economic activity creates the conditions for greater political stability. The combination of economic growth and political stability delivers social gain and economic gain in terms of new market opportunities.

The Ultra Low Cost Handset campaign is based on evidence that **telecommunications investment** (wireless and wireline, though wireless tends to be

faster and more cost effective) in emerging countries **delivers a net gain in GDP.**

Bridging the digital divide with an **Ultra Low Cost Handset** yields a **dollar plus dividend.**

Every dollar spent yields x dollars plus in terms of future economic activity. This growth in economic activity creates the conditions for greater political stability. The combination of economic growth and political stability delivers social gain and economic gain in terms of new market opportunities.

As such, these projects become candidates for **'political subsidy',** subsidy delivered via entities such as the World Bank or United Nations, **charity with a political and economic purpose.**

It is certainly not our role to doubt the altruistic motives of the people and organisations behind the OLTPC campaign and ULCH handset campaign but pragmatically these projects become more deliverable if they can benefit from existing economies of scale and attract industry subsidy to complement political subsidy.

Economies of scale
The Ultra Low Cost Computer concept product presented at Davos had a small memory footprint of 1 GB but included wide area GSM connectivity. Note this implies that economies of scale have to apply both to the computer functionality and radio functionality in the device. You could argue of course that these devices do not need to be mobile. Children will be sitting in the classroom. This however is an assumption. If the inclusion of mobility actually reduces the end cost then the assumption is invalid.

It is the established GSM and/or UMTS economies of scale that make this product a plausible possibility.

Industry subsidy
The inclusion of GSM connectivity crucially means that the product can be subsidised from connection revenues. Ah, I hear you argue, children in emerging nations cannot afford connection charges. Neither can they afford a 100 dollar cost price. Connection charges at least provide the opportunity to amortise the initial cost price over a given time scale. It is also perfectly reasonable for governments to make extension and expansion spectrum available at preferential terms to operators who can demonstrate that they have a social and economic dividend component in their business model.

The Techno Political Dimension
The cellular industry has always been highly politicised. In common with the broadcasting industry, it is dependent on national entities (governments) allocating and auctioning spectrum with constraints placed on how that spectrum is used.

In common with the broadcasting industry, the cellular industry is also **a delivery medium that can be used to achieve particular political objectives.** This is increasingly true as the industry has moved away from a voice dominant business model to a model more focussed on information collection and distribution.

As with all relationships, the coupling is bi directional. Governments dictate what the cellular industry can and cannot do. Reciprocally, the cellular industry uses its spending power (spectral investment and tax revenues) to influence government policy.

For the relationship to work there has to be mutual reciprocal benefit.

The cellular industry has a self interest in developing new markets. Children in emerging markets represent a long term economic investment but deliver short term political gain.

This is the basis for a potential hardware subsidy model for a **GSM or UMTS enabled Ultra Low Cost personal computer.**

Low income adults in emerging markets represent a long term economic investment but also deliver short term political gain.

This is the basis for a potential hardware subsidy model for **a GSM enabled or UMTS enabled ultra mobile PC.**

Similar subsidy justifications may exist for proprietary software vendors who wish to consolidate their influence over future generations of users and software consumers. Closed source software may arguably on this basis be more cost economic than open source software for these emerging market applications.

The combination of a **hardware subsidy** model combined with a **software subsidy** model provides the basis for a **GSM enabled or UMTS enabled Ultra Low Cost Smartphone**.

The Ultra Low Cost Smartphone is an Ultra Low Cost Ultra Mobile PC, a product with potentially the ability to be globally dominant.

The Implications for WiMax
Hardware subsidies and software subsidies are a by product of established market dominance. You could regard them as a pay back but it's a pay back with a long term purpose, to deliver long term economic gain to the giver. Provided the recipient also benefits in terms of short term and long term gains then everyone wins.

The PC industry arguably has sufficient volume and value both in terms of hardware and software revenues to support subsidy initiatives for emerging markets. This could provide the basis for a **WiFi and WiMax enabled Ultra Low Cost PC** which would be more or less **functionally equivalent to an Ultra Low Cost Smart Phone.**

The PC industry however does not have the luxury of the service revenue streams enjoyed by GSM operators, nor the political influence that has accrued from three decades of cellular spectral investment.

This political influence is an important component in the spectral allocation process.

WiMax needs more spectrum to be economically viable.

WiMax, even assuming support from the PC industry, probably does not have sufficient political power to change present spectral policy.

The conundrum of 'technology neutral' spectral allocation
But perhaps it doesn't need to. The present trend amongst regulators and spectral policy makers is to make spectrum 'technology neutral', the policy of 'let the market decide'.

Wi Max can therefore compete on the basis of its technical rather than political merit.

This however assumes that this present policy shift is sustainable.

Technology neutrality undermines volume efficiency and frustrates user functionality.

Technology neutrality castrates the industry's ability to deliver 'mutually beneficial' hardware and software subsidies.

If governments around the world want and need ultra low cost personal computers and ultra low cost handsets (also known as Ultra Low Cost Smart Phones) to achieve specific social, economic and political objectives, **they must accept that mandated technology** rather than technology neutrality **is a required economic precondition**.

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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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