HSDPA/EV-DO for Rural India

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ABSTRACT

Telecom penetration into rural India needs networks and devices that support richer media and higher data rates, but these have to be available at very affordable prices. In this paper, we examine whether the evolution of GSM into HSDPA and CDMA into EV-DO could enable this transformation, since they promise seven times higher peak data rates and four-fold improvement in capacity, with reduced round-trip time and better resource allocation providing WLAN like connections at costs that are 1/15th of GPRS. We examine if this is achievable in practice, and its impact on the cost of rural services.

INTRODUCTION AND CONTEXT

India has seen a rapid increase in wireless coverage. GSM and CDMA are the competing technologies. As of July 2005, the wireless penetration at 59.83 million is significantly higher than landline penetration, which is at 47.17 million. The overall tele-density is around 9.86% [1]. The monthly cellular additions are getting closer to 3 million/month, with GSM technology base having a higher subscriber base accounting for about 80%. The bad news is that the gap between rural tele-density (1.74%) and urban tele-density (26.2%) has been widening, perhaps because per capita rural GDP of 352$ is a fourth of urban GDP [2]. This is unacceptable since 72% of India is rural. However, there is a strong push to increase cellular coverage with targets as shown below [3]:

	BY AREA		**BY POPULATION**	
	2004	**2006**	**2004**	**2006**
TOWNS	~1700 of ~5200	~4900 of ~5200	~200 Million	~300 Million
RURAL AREAS	Negligible	~350,000 of ~607,000	Negligible	~450 Million

The assumptions we make are as follows:

- Subscribers are dispersed. GSM coverage enables quick and easy HSDPA access.
- Bandwidth usage per session is high, owing to rich media access (lower literacy levels imply richer and more descriptive media, as against text-oriented media). However, number of sessions per subscriber per day is low. Many more subscribers thus share the higher network capacity.
- Peak and average bandwidth requirements are the same - there are no "busy hour" traffic profiles.

Currently, India is clubbed with countries like Russia and China as forming an emerging market for low-cost feature phones. The low-cost phone is primarily a voice communication device, with SMS. The display is monochrome LCD with no graphics capability. This limits the usage of the phone in the rural areas to voice conversations alone. On the other hand, the rapid spread of television content in rural India shows us that visual content annotated by voice is important to communicate to the rural masses. The requirements to grow mobile subscription in rural India are thus:

- Enable Rich Media content availability to the rural masses.
- Rich media requires bandwidth that is clearly not supported by existing 2/2.5G cellular services or even by early 3G services. This can be supported only in evolved 3G services, which enable a fat data pipe, like HSDPA/EV-DO. However, HSDPA is viewed as a high revenue/MB opportunity in the western world.
- Services need to be rolled out on the fat data pipe (either "in-network" or "out-of network"). Services should include innovative wrappers on traditional "download" and "streaming" services.
- Traditional Mass Media communication is typically uni-directional. This obviously limits interactivity. Rich media with interactivity is a highly desirable requirement.
- "Untethered", rather than truly mobile could be a key requirement. Services could be delivered in innovative ways like mobile-vans, which encompass several other services.

FAT DATA PIPE TO THE RURAL MASSES – VIA THE CELLULAR NETWORK

To enable availability of innovative services with rich visual content, operators must deploy a fat data pipe, which can be realised by evolved 3G technologies like HSDPA (High Speed Downlink Packet Access) for the GSM family evolution path and EV-DO for the CDMA family. HSDPA has several advantages:

- **Increased bandwidth**: HSDPA offers over 7X peak data rates, up to a theoretical max of 14Mbps.
- **Increased network capacity**: Over 4 times existing capacity, through better spectral efficiency and advanced modulation schemes (16 QAM). It is also reuse efficient, with a reuse factor of 1.
- **Reduced Round-Trip-Time**: Incremental redundancy and Hybrid ARQ at the Layer 1-Layer 2 level reduces RTT, as against convention ARQ, implemented in the IP Layer.
- **Favourable allocation of resources**: The network schedules grants, based on the mobiles that are active in the cell.

The net effect is to increase the average capacity of the system and to improve the service performance experienced by individual users. Using HSDPA, the expectation is that the cost to deliver a 10Mbyte file can be brought down to one-fifteenth the amount that it would take via GPRS and one-fifth via UMTS Release 99 [4].

HSDPA is realised by a downlink channel (HS-DSCH) shared between terminals by allocation of individual codes, from a common pool of codes assigned for the channel. The HS-DSCH is associated with one downlink DPCH, and one or several Shared Control Channels (HS-SCCH). The HS-DSCH is transmitted over the entire cell or over only part of the cell using e.g. beam-forming antennas. The HS-SCCH is a fixed rate (60 kbps, SF=128) downlink physical channel used to carry downlink signaling related to HS-DSCH transmission. The High Speed Physical Downlink Shared Channel (HS- PDSCH) is used to carry the High Speed Downlink Shared Channel (HS-DSCH). A HS-PDSCH corresponds to one channelisation code of fixed spreading factor SF=16 from the set of channelization codes reserved for HS-DSCH transmission. Multi-code transmission is allowed, which translates to the terminal being assigned multiple channelisation codes in the same HS-PDSCH sub-frame, depending on the terminal capability. An HS-PDSCH may use QPSK or 16QAM modulation.

The following table captures the key parameters of HSDPA, compared with GSM/GPRS:

Feature	GSM/GPRS	HSDPA
Multiple Access Scheme	TDMA	CDMA
Modulation Schemes	GMSK, 8-PSK(EDGE)	QPSK, 16-QAM
Signal Bandwidth	200 kHz	3.84 MHz
Channel Symbol Rate	270.833 ks/s	3.84 Ms/s
Maximum output Power [dBm]	30 to 33	24 to 33
Minimum input Power [dBm]	–86 to –104	–103 to –106
Range	35 Km	2 Km
Channel Coding	Block and Convolutional	Convolutional and Turbo

Modulation format	Channel Bit Rate (kbps)	Channel Symbol Rate (ksps)	SF	Bits/ HS-DSCH subframe
QPSK	480	240	16	960
16QAM	960	240	16	1920

HSDPA: RANGE IS THE CHALLENGE

As can be seen in the above table, the range of HSDPA is severely limited to around 2Km cells, as compared the current GSM/GPRS systems that have range that is one order of magnitude higher. This could mean that the current GSM/GPRS infrastructure is largely insufficient for HSDPA coverage, and significant additional capex may be required to deploy HSDPA into rural areas. The entire cost benefit gains of HSDPA due to its higher capacity could thus be offset due to the cost increase due to lower range.

Range is dependent on some key factors as discussed below:

- Frequency: Lower frequencies reach further. But it is highly unlikely that bandwidth in the 400 MHz bands will be made available for HSDPA in India.
- Data rate: Lower rate transmissions can span a higher range. A 100Mbps transmission can be coherently received over 200 metres, while for distances in kilometres, only 100 kbps transmission per subscriber may be realisable. This may limit the kind of services that can be provided.
- Position of the terminal antenna: Rooftop antennae can provide a range of around 30 kms [5]. The table below summarises this. Such antennas are already in use for example in the CorDect systems in India [6]. This could lead to innovative solutions of accessing HSDPA only at designated “sockets” (at Kiosks or at designated mobile van stops). This should also solve the otherwise nightmarish problem of terrain planning. Voice coverage can continue without any change.
- Using repeaters especially in rural areas, the range can be increased without substantially increasing the cost. This is an active part of Release 6 recommendations [7].

	Gain	Height	Building loss	Range	Relative site count
Rooftop – LOS	10 dBi	8 m	0 dB	> 30km	
Rooftop NLOS	10 dBi	8 m	0 dB	6.2 km	1
Terminal - upstairs window	3 dBi	5 m	0 dB	1.8 km	12
Outdoor PCcard	0 dBi	1.5 m	0 dB	780 m	60
Indoor PCcard - Suburban	0 dBi	1.5 m	10 dB	410 m	230
Indoor PCcard - Urban	0 dBi	1.5 m	20 dB	210 m	800

All figures except LOS based on COST231-Hata model with 10dB shadow margin and no cable losses. System operates at 2GHz with 1Mb/s from 24dBm EIRP terminal TX, 3dB Eb/No, 5dB NF RX. BS antenna = 18dBi Source: [5]

Increasing the range of HSDPA is a key research problem that determines its success for rural India.

COMPARISON WITH OTHER OPTIONS FOR A FAT DATA PIPE FOR RURAL INDIA

Since there is no copper laid out in rural India, DSL is not an option to deliver high bandwidth services. Given the existing and potential coverage realised by GSM/GPRS cellular systems, the incremental cost of implementing HSDPA should be much lower than that of setting up any other greenfield wireless network. In particular, it can be argued that for the same coverage, HSDPA with advanced network planning can replace around 1000 Access Points of W-LAN. WiMax could be a challenger, but its maturity is currently much lower than HSDPA, and WiMax could have similar challenges for higher range transmissions.

RICH MEDIA SERVICES ON A FAT PIPE – VIA THE CELLULAR NETWORK

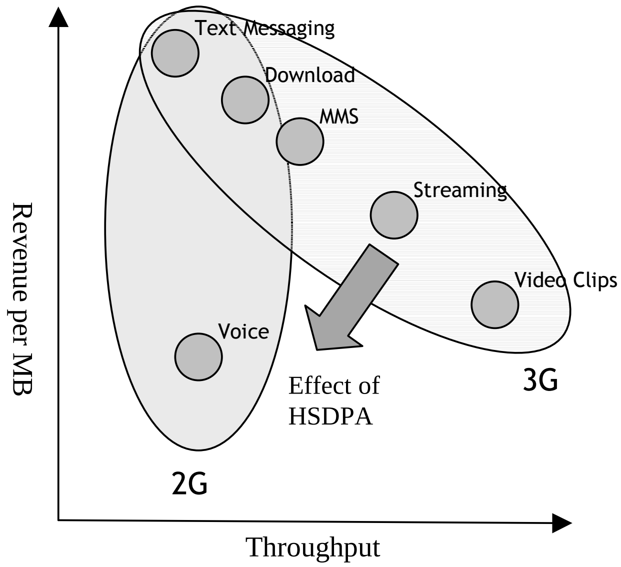
MBMS is a unidirectional point to multipoint bearer service in which data is transmitted from a single source entity to multiple recipients [8]. Services like streaming video and audio can be supported on MBMS. MBMS has been standardized in various groups of 3GPP (Third Generation Partnership Project), as part of UMTS release 6, which should see deployments in 2008. Rich Media services like MMS etc can use the MBMS bearer, depending on the intent of communication. The new MPEG-4 AVC Baseline (H.264/AVC, Advanced Video Coding) is currently being favoured in the standards for Release 6.

Another innovative media delivery system taking shape is IMG (Internet Media Guides). These provide details of rich media content like Television clips, etc. The entire IMG infrastructure can be deployed over a fat-data pipe like HSDPA. An IMG browser application provides a window into the available media content. The user selects the content he desires to view. This is then viewed using another application (codec/ media player etc).

In terms of digital TV content, the DVB standards are the ones more suited to mobile terminals. Demos of DVB-H (Handheld) on early prototype mobiles have already been showcased. Several ad-hoc groups are studying the possibilities of integrating DVB into UMTS. Some of the key features of DVB-H are time-slicing, 4K-FFT and FEC. DVB-H employs a mechanism where bursts of data are received at a time. This means that the receiver is inactive for much of the time and result in power saving. Using the 4K mode with some 3409 active carriers, DVB-H benefits from the compromise between the high-speed small-area SFN capability of 2K DVB-T and the lower speed but larger area SFN of 8K DVB-T. The addition of an optional, multiplexer level, forward error correction scheme means that DVB-H transmissions can be robust.

PRICING OF SERVICES ON A FAT DATA PIPE

Currently, Streaming, downloads, video clips etc are high-bandwidth and high-revenue opportunity for 3G operators in the western markets, as shown in the figure below. The effect of introducing higher capacity through HSDPA at a small incremental cost should provide an unique opportunity to offer these services at much more affordable prices. High reliability and lower RTT increases the effective bandwidth available for user data. This in turn should have a cascading effect of the cost of offering these services. This could lead to the introduction of innovative services tailored to the rural subscribers as shown in the box below.



SERVICES FOR RURAL AREAS

- Mobile Crop Auctions
- Commodity Futures
- Game Score updates
- Weather forecasts
- News
- Advertisements
- e-Coupons
- Micro-credit
- Tele-medecine

COST OF TERMINALS

A key success factor in the rural areas will be the availability of low cost terminals. GSMA has initiated a sub-$40 GSM handset effort with very good response. The price of a GSM phone has fallen to less than a fifth on its original price over 10 years. The same is expected for 3G terminals, except that it will happen in half the time frame. Thus, there is optimism that low-cost HSDPA terminals will be available in 5 years time. This ties in well with the network coverage expansion timelines.

REFERENCES

[1] "Growth in Telephony Continues in June, 2005", Telecom Regulatory Authority of India (TRAI) Press Release No. 59/2005, 11th July, 2005. http://www.trai.gov.in/pr11jul05.pdf

[2] "TRAI recommendations on spectrum related issues", May 13, 2005. Table 1.5 (pp 27) and Fig 1.3 (pp 29).

[3] "Growth of telecom services in rural India – the way forward", TRAI consultation paper # 16/2004, October 2004. http://www.trai.gov.in/27octconspap.pdf

[4] "HSDPA: More effective and cost-efficient use of precious bandwidth", Lucent Tech White Paper, 2005.

[5] Michael Walker, "Our wireless world moves on", Future Generation Conference, Sophia Antipolis Dec 2004, and Vodafone Group R&D, 2004.

[6] "corDECT Wireless in Local Loop", Analog Devices, Boston, USA, IIT, Madras, and Midas Communication Technologies (Pvt.) Ltd., Madras, July 1997.

[7] "Digital cellular telecommunications system (Phase 2+): Radio network planning aspects", ETSI Technical Report 3GPP TR 43.030 version 6.0.0 Release 6, Feb/Mar 2005.

[8] "Multimedia Broadcast/Multicast Service", Stage 1, Release 6, 3GPP TS 22.146.