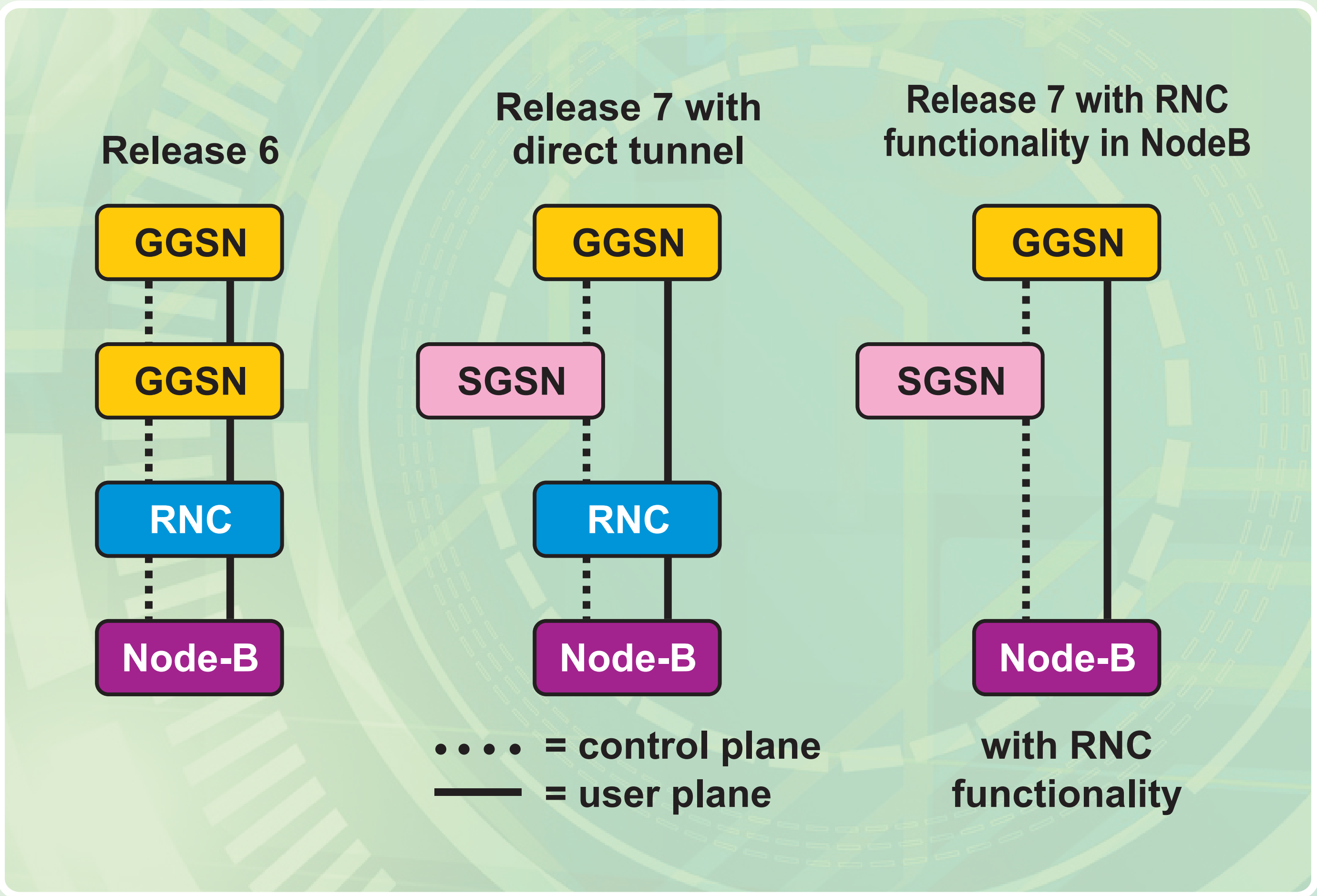
ISO 9001 : 2008
TEC

टी ई सी संचारिका
NEWSLETTER

VOL 18 NOVEMBER 2014 ISSUE 4

HSPA+ : HIGH SPEED PACKET ACCESS +



(HSPA+ Evolution Towards FLAT Architecture)

ISO 9001: 2008
TELECOMMUNICATION ENGINEERING CENTRE

IN THIS ISSUE

*High Speed Packet Access +

1.0 Introduction

HSPA+ was introduced in 3GPP Rel.7 and is a combination of HSDPA (3GPP Rel.5) and HSUPA (3GPP Rel.6). HSPA+ is a further enhancement of HSPA that introduces higher order modulation and MIMO, CPC, carrier aggregation, Layer-2 enhancements, architecture improvements in the uplink and downlink. With each new 3GPP release, the improvements and new features added to HSPA+ improve the uplink and downlink speed, reduce the latency and increase number of simultaneous data connections that can be supported.

2.0 Background

There is continuous thrust to improve data rates in both uplink and downlink in mobile telecom networks. In second generation or 2G, the main thrust was on circuit switched voice calls while circuit switched data services were provided at 9.6kbps. Internet services like web browsing are inherently bursty and did not optimally use the dedicated bandwidth and also, billing was done on the basis of minutes and not on the basis of data volume. GPRS, a software upgrade from GSM, offered the first always-on data connection which supported bursty data traffic at 171 kbps maximum in the downlink. Next was EDGE or Enhanced Data-rates for GSM Evolution which was conceived as an easy way for operators of GSM networks to squeeze more performance without investing lot of money. Meanwhile, ITU specified the technical requirements for third generation technology while also stipulating that compatible technologies should offer smooth migration paths from 2G networks. To that end, UMTS rose to the top as the 3G choice for GSM operators.

UMTS or Universal Mobile Telecommunication System which is based on WCDMA technology was fixed in Release-99 of 3GPP and published in 2000. It was the next step after GSM/GPRS/EDGE and supported improved voice and data services with 5MHz bandwidth. UMTS Rel-99 was initially conceived as a circuit switched based system and was not well suited to IP packet based data traffic. Once the basic UMTS system was released and deployed, the need for better packet data capability became clear, especially with the rapidly increasing trend towards Internet style packet data services which are particularly bursty in nature. The initial response to this was the development and introduction of HSDPA, followed by HSUPA to provide the combined HSPA service. These were defined in 3GPP Release 5 & 6. With growing demand from the industry for even higher data rates, increased spectral efficiency and reduced latency HSPA evolved with each 3GPP Release from Release-7 onwards.

For operators that have already deployed HSPA, HSPA+ provides a way to fully realize the potential of WCDMA air interface and to protect their investment before moving onto LTE.

2.1 HSDPA (Release-5)

HSDPA (High Speed Downlink Packet Access) is an upgrade to UMTS/WCDMA with improvements to the downlink, providing peak theoretical data rates of up to 14.4Mbps. HSDPA speeds are ideal for bandwidth-intensive applications, such as large file transfers, streaming multimedia and fast Web browsing. HSDPA also offers latency as low as 70 to 100 milliseconds (ms) making it ideal for real-time applications such as interactive gaming and delay-sensitive business applications such as Virtual Private Networks (VPNs).

High Speed Downlink Packet Access is predominately a software upgrade to Release 99 of the UMTS standard. HSDPA usually requires only new software and base station channel cards, instead of necessitating the replacement of major pieces of infrastructure from UMTS and does not require additional spectrum for deployment. As a result, UMTS operators could deploy HSDPA quickly and cost-effectively. HSDPA provides peak theoretical data rates of up to 14.4Mbps and it achieves its performance gain through following radio features:

a) High speed shared channel
b) Reduced transmission time interval (TTI)~2ms which allows the NodeB to respond to changing radio conditions quickly and allows faster scheduling
c) Fast Hybrid Automatic Repeat Request- which improves the efficiency of error processing and is implemented in Node B as compared to RNC for faster response.

On the receiving side, initial HSDPA User Equipment (UE) solutions were based on single antenna CDMA rake receiver structures, similar to Release 99 UMTS receiver structures. While these worked well for conventional UMTS and met initial system needs for HSDPA, advanced receiving technologies were later used to achieve even higher HSDPA throughputs. To achieve this goal, 3GPP studied two applicable techniques (receive diversity and advanced receiver architectures) as well as their minimum performance improvement and has specified them in Release 6. HSDPA is backward compatible with UMTS, EDGE and GPRS.

This design benefits customers when they travel to areas that have not yet been upgraded to HSDPA, as their HSDPA-enabled handsets and modems will still provide fast packet-data connections.

2.2 HSUPA (Release-6)

HSUPA (High Speed Uplink Packet Access), standardized in Release 6, constitutes a set of improvements that optimizes uplink performance using the Enhanced Dedicated Channel (E-DCH). These improvements include higher throughputs, reduced latency, and increased spectral efficiency.

For applications like VoIP, improvements balance the capacity of the uplink with the capacity of the downlink. HSUPA achieves its performance gains through the following approaches:

a) An enhanced dedicated physical channel in the uplink
b) A short TTI, as low as 2 msec, which allows faster responses to changing radio conditions and error conditions.
c) Fast Node B-based scheduling, which allows the base station to efficiently allocate radio resources.
d) Fast Hybrid ARQ, which improves the efficiency of error processing and is implemented in Node B as compared to RNC for faster response.

The combination of TTI, fast scheduling, and Fast Hybrid ARQ also serves to reduce latency, which can benefit many applications as much as improved throughput. HSUPA can operate with or without HSDPA in the downlink, although it is likely that most networks will use the two approaches together. Beyond throughput enhancements, HSUPA also significantly reduces latency. In optimized networks, latency will fall below 50 msec, relative to current HSDPA networks at 70 msec.

HSUPA-HSPA is an upgrade to UMTS networks that usually requires only new software and base station channel cards, instead of necessitating the replacement of major pieces of infrastructure. As a result, operators can deploy HSPA quickly and cost-effectively. HSPA is backward-compatible with UMTS, EDGE and GPRS. This design benefits customers when they travel to areas that haven't yet been upgraded to HSPA, as their HSPA-enabled handsets and modems will still provide fast packet-data connections.

2.3 HSPA+ (3GPP Release7 and onwards)

HSPA+, standardized in 3GPP Release-7 and now continuing through Release-12, comprises of series of enhancements to the HSPA radio interface and the RAN, which increases the throughput of HSPA and significantly extends the life of sizeable operator infrastructure investments. It takes advantage of the increase in digital signal processing power to maximize CDMA-based radio performance.

3.0 High Speed Packet Access Evolution, HSPA+

HSPA+ provides an evolution of High Speed Packet Access, from 3GPP Release-7 onwards with data rates up to 336Mbit/s to the mobile device (downlink) and 69 Mb/s from the mobile device (uplink) in 3GPP Release 11. The improved data rates support high bandwidth services like video streaming and the reduced latency improves the performance of real-time applications like VoIP. Other data services like file transfer, online gaming, corporate-mail etc also give better performance with HSPA+. New features and improvements in HSPA+ with each Release from Release-7 onwards are discussed below in detail.

3.1 Higher order Modulation

Higher order modulation is a way of increasing performance. HSPA uses 16 QAM on the downlink and QPSK on the uplink. But radio links can achieve higher throughputs by adding 64 QAM on the downlink and 16 QAM on the uplink and this has been added in HSPA+ with further increase in order of modulation in later releases.

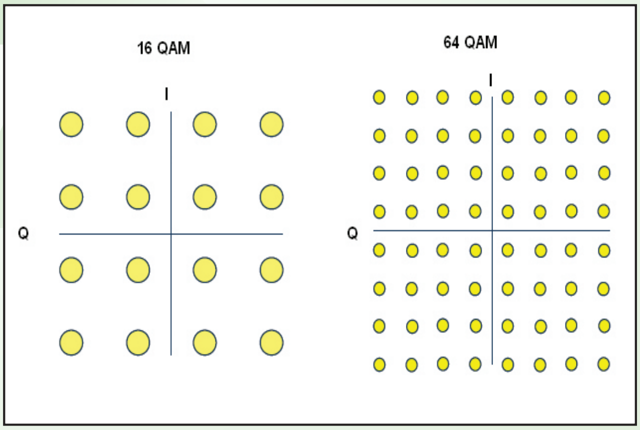


Figure 1 . Higher Order Modulation (HOM)

Higher order modulation requires a better SNR, which is enabled through other enhancements such as receive diversity and equalization. It is advantageous in indoor and small cell deployment where SNR is good. While HOM can be used in conjunction with MIMO, it is important in its own right in those cases where deployment of MIMO systems is prohibited by physical, budgetary limitations at the transmitter.

3.2 MIMO

MIMO is a technique that employs multiple transmit antennas and multiple receive antennas, often in combination with multiple radios and multiple parallel data streams. The transmitter sends different data streams over each antenna. Whereas multipath is an impediment for other radio systems, MIMO exploits multipath, relying on signals to travel across different uncorrelated communications paths. This results in multiple data paths effectively operating somewhat in parallel and, through appropriate decoding, in a multiplicative gain in throughput.

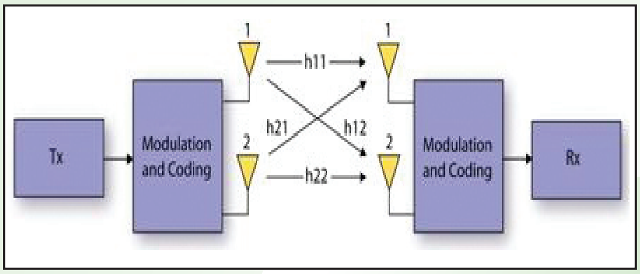


Figure 2 : 2X2 MIMO

MIMO was first standardized in 3GPP TS 25.308 Release 6 , and was further developed in Release-7 with spatial multiplexing for HSPA+ using Double Transmit Adaptive Array (D-TxAA). With MIMO, the use of multiple antennas at both transmitter and receiver allows:

i. Substantial increase in peak data rates
ii. Significantly higher spectrum efficiency, especially in low-interference environments
iii. Increased system capacity (number of users)

In 3GPP Release 7 MIMO cannot be used in combination with 64 QAM, but this feature is available in Release 8. Subsequently, in Releases-9, 10 and 11, 2X2 MIMO is combined with carrier aggregation to double the peak data rate.

3.3 Advanced Receivers

One important area is advanced receivers for which 3GPP has specified a number of designs. These designs include Type 1, which uses mobile-receive diversity; Type 2, which uses channel equalization; and Type 3, which includes a combination of receive diversity and channel equalization. Type 3i devices, which became available in 2012, employ interference cancellation. The different types of receivers are release-independent. For example, Type 3i receivers will work and provide a capacity gain in a Release 5 network. These enhancements are attractive as the networks do not require any changes other than increased capacity within the infrastructure to support the higher bandwidth. Moreover, the network can support a combination of devices including both earlier devices that do not include these enhancements and later devices that do. Device vendors can selectively apply these enhancements to their higher performing devices.

3.4 HSPA+ Architecture Evolution

The UMTS network is increasingly being used for IP based packet services and for better user experience it is important that the network latency should be reduced. A flat architecture (as shown at cover page) improves the latency and also increases the user and control plane efficiency and this was introduced in 3GPP Release 7. In this figure, the integrated RNC/NodeB architecture option for HSPA+ is compared to the traditional HSPA architecture and the architecture with One Tunnel Solution.

Benefit of this new architecture option is that there are fewer nodes, which reduces latency, making it flatter and simpler. Further, the distribution of RNC functions out to the NodeBs could provide scaling benefits for potential Home NodeB HSPA deployments by not having a centralized RNC acting as the Controlling RNC for thousands of Home NodeBs. Finally, the integrated RNC/NodeB architecture is similar to the SAE/EPC architecture in 3GPP Release-8. From an architecture point of view, especially on the PS core side, the integrated RNC/NodeB option provides synergies with the introduction of LTE/EUTRAN. The architecture evolution is designed to be backward compatible i.e. existing terminals can operate with new architecture and the radio and core network functional split is the same.

3.5 Dual Carrier HSPA+

DC-HSPA / DC-HSDPA was introduced in 3GPP TS 25.308 Release-8 and the concept is to provide the maximum efficiency and performance for data transfers that are bursty in nature - utilising high levels of capacity for a short time.

(i) DC-HSDPA: DC-HSDPA, introduced in 3GPP TS 25.308 Release-8, principle is to aggregate the multiple carriers that may be available to an operator. By scheduling packets across two carriers, there is better resource utilization, resulting in trunking gain. This joint resource allocation over multiple carriers requires dynamic allocation of resources to achieve the higher peak data-rates per HSDPA user within a single Transmission Time Interval (TTI), as well as enhancing the terminal capabilities.

The use of DC-HSDPA is aimed at providing a consistent level of performance across the cell, and particularly at the edges where MIMO is not as effective.

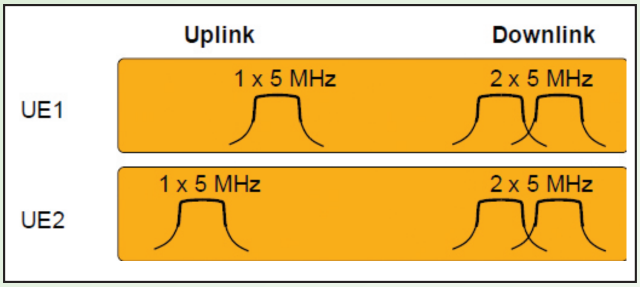


Figure 3. DC HSDPA

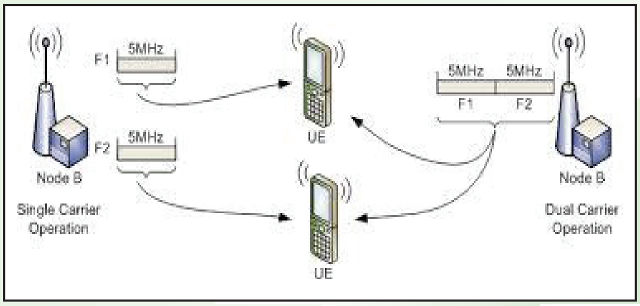


Figure 4. Example of DUAL Carrier Operation

(ii) DC-HSUPA : The data rate improvements in the downlink call for improved data rates also in the uplink. Therefore, support for dual-carrier HSUPA operation on adjacent uplink carriers is introduced in 3GPP TS 25.319 Release 9. The dual-carrier HSUPA user can transmit two E-DCH transport channels with 2ms TTI, one on each uplink carrier. Dual-carrier HSUPA operation can only be configured together with dual-carrier HSDPA operation and the secondary uplink carrier can only be active when the secondary downlink carrier is also active. This is because the secondary downlink carrier carries information that is vital for the operation of the secondary uplink carrier (F-DPCH, E-AGCH, E-RGCH, E-HICH). The secondary downlink carrier can, on the other hand, be active without a secondary uplink carrier being active or even configured, since all information that is vital for the operation of both downlink carriers (HS-DPCCH) is always only carried on the primary uplink carrier.

(iii) DB-DC-HSDPA: In order to provide the benefits of dual-carrier HSDPA operation also in deployment scenarios where two adjacent carriers cannot be made available to the user, (e.g. due to spectrum distributed over different bands), 3GPP TS 25.308 Release 9 introduces dual-band DC-HSDPA (DB-DC-HSDPA) operation, where in the downlink the primary serving cell resides on a carrier in one frequency band and the secondary serving cell on a carrier in another frequency band. In the uplink transmission takes place only on one carrier, which can be configured by the network on any of the two frequency bands.

Figure 5. DUAL Carrier DUAL Band HSPA

(iv) Four Carrier HSDPA: To keep up with increasing traffic volumes, support for non-contiguous four carrier HSDPA (4C-HSDPA) operation was introduced in 3GPP TS 25.308 Release 10. 4C-HSDPA enables the base station to schedule HSDPA transmissions on up to four 5 MHz carriers simultaneously. The performance gain from multi-carrier operation is based on the resource pooling principle. If multiple downlink carriers are pooled an increased spectrum utilization efficiency can be achieved since the probability of having unused resources reduces.

Figure 6: Four Carrier HSDPA

(v) Eight Carrier HSDPA: The feature, introduced in 3GPP TS 25.308 Release 11, extends the HSDPA carrier aggregation potential up to 40 MHz aggregate bandwidth by enabling simultaneous transmission on up to eight carriers towards a single UE. The carriers do not necessarily need to reside adjacent to each other on a contiguous frequency block, as it is possible to aggregate carriers together from more than one frequency band.

3.6 CS Voice Over HSPA

CS voice over HSPA, an optional feature introduced in 3GPP TS 25.306 Release 8, takes the mobile circuit-switched voice service, using the circuit core switches in the network and tunnels it over an underlying IP bearer. Thus, the application is not VoIP, but circuit telephony while the wireless transport is IP. The feature supports both adaptive multi rate (AMR) and AMR wide band (WB) operation.

The reasons to consider running CS speech over HSPA are:

i) The use of DCH in a cell can be minimized and thus more power and code resources are available for HSPA use.

ii) The setting up of CS Call when using HSPA for Signalling radio Bearer is accelerated.

iii) The availability of the benefit of features from Continuous packet Connectivity for packet data users.

iv) Faster setup of PS service in parallel to CS speech as HSPA is already on.

v) Transparent to existing CS infrastructure.

The following figure shows the difference between CS Voice over DCH (Rel 99), VoIP over HSPA and CS voice over HSPA. With this approach, legacy mobile phones can continue using WCDMA-dedicated traffic channels for voice communications, while new devices use HSPA channels. HSPA CS voice can be deployed with Release 7 or later networks.

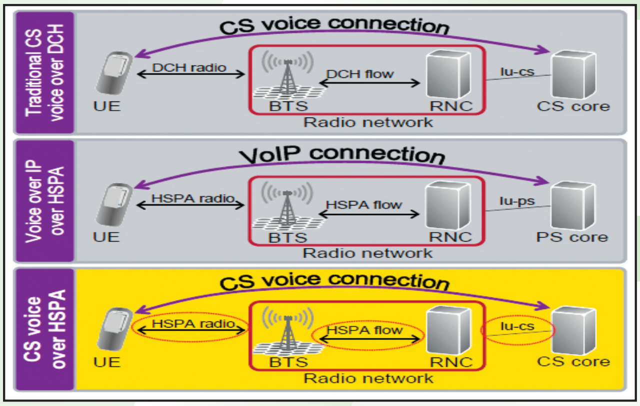


Figure 7. CS Voice Over HSPA

The main solution in CS over HSPA is to introduce a Jitter Buffer Management (JBM) on each receiver end (RNC and UE), which allows to compensate varying delays on the air interface at the expense of an acceptable absolute delay.

Implementation of CS over HSPA depends on UE capability too. The UE indicates its *Support for CS voice over HSPA* to the network, which defines whether the UE is able to route CS voice (AMR and AMR WB) data over HS-DSCH and E-DCH transport channels. The feature capability indication bit for UE support of CS voice over HSPA was introduced to Rel-7 specifications making the feature 'early implementable', that is, a Release 7 compliant UE is able to support CS voice over HSPA even though the feature is technically part of Release 8 specifications.

4.0 Conclusion

With increasing user demand for data services, telecom network is straining under the load to satisfy the users. This sharp increase in data services has been fuelled by the mass availability of smartphones and popular applications like VoIP, online multiplayer games, instant messaging, mobile television, Youtube etc. Some of these applications require increased throughput while others like VoIP and online gaming have stringent latency requirements. To support the large number of users with high data rate needs, either the spectral efficiency is to be improved or the technology should include scalable bandwidth. HSPA+, starting from 3GPP Release 7 has improved these features and has added several others like CPC, layer-2 enhancements, fast dormancy, downlink multi-flow etc. which improve the throughput as well as the latency and can support increased number of data users simultaneously.

Currently, VoIP services are becoming popular, but are offered free by third party service providers. Network operators, with HSPA+, can now offer tailored VoIP solutions to their customers while ensuring the performance and optimum utilization of their network.

Also, features like one tunnel architecture and CS voice over HSPA help in moving towards an all IP core network. The advancements in HSPA+ also help in protecting the operator's investments in their network by moving towards the IMT-A 4G requirements. The table at figure 8 provides a comparison between HSPA+ release 11 features and requirements of the IMT-A 4G network.

	IMT-A minimum requirement	HSPA prior to Rel-11 (Pre-Rel-11 state of the art)	HSPA Rel-11 (Rel-11 improvement)
Peak spectral efficiency, Downlink	15.0 bits/s/Hz	8.6 bits/s/Hz (2x2 MIMO + 64QAM)	17.2 bits/s/Hz (4x4 MIMO)
Peak spectral efficiency, Uplink	6.75 bits/s/Hz	2.3 bits/s/Hz (16QAM)	6.9 bits/s/Hz (2x2 MIMO + 64QAM)
Spectrum flexibility	Scalable bandwidth, up to 40 MHz	Scalable up to 20 MHz (4-carrier HSDPA)	Scalable up to 40 MHz (8-carrier HSDPA)

Figure 8. Comparison between IMT-A and HSPA

HSPA+ will thus offer cost effective wide-area broadband mobility and play a significant role in stimulating the demand for data services, whether they be consumer multimedia and gaming or corporate email and mobile access.

Activities at NTIPRIT

1. In-service Courses for DOT Officers on Understanding IPv6, NGN Basics, Hindi Karyashala 2014
2. Induction courses for Officer Trainees Training in NGN, Mobile Communications, TERM Functions, Licensing Functions, Wireless Planning & Spectrum Management, USO Fund, Regulation & Dispute Settlement, TEC Functions conducted as a part of Induction programme for ITS 2012 batch.
3. Right to Information Act Workshop conducted in New Delhi
4. Two training courses on "Public Protection, Disaster Relief and Mobile Networks" of one week duration each, were conducted for Directorate of Coordination Police Wireless (MHA) at Central Police Radio Training Institute, New Delhi
5. FDP on "Advance Course in IPv6" for NTIPRIT officers
6. Sports Week was celebrated in NTIPRIT.

हिन्दी पखवाड़ा : दूरसंचार अभियांत्रिकी केंन्द्र, नई दिल्ली में दिनांक 15 से 29 सितंबर, 2014 तक हिंदी पखवाड़े का आयोजन सफलता एवं उत्साहपूर्वक किया गया। पखवाड़े का शुभारंभ श्री ए.के.मित्तल, वरिष्ठ उप-महानिदेशक टी.ई.सी. द्वारा दीप प्रज्वलित कर किया गया एवं उन्होने सभी उपस्थित अधिकारियों को हिंदी के प्रचार एवं प्रसार हेतु अधिक से अधिक योगदान करने के लिए प्रेरित किया। इस अवसर पर श्री मित्तल ने माननीय गृह मंत्री जी का संदेश पढ़कर सुनाया। हिन्दी पखवाड़े में राजभाष हिंदी से संबधित विभिन्न विषयों पर कुल 10 प्रतियोगिताओं का आयोजन किया गया। पखवाड़े में आयोजित प्रतियोगिताओं में अधिकारियों एवं कर्मचारियों ने बढ़-चढ़कर भाग लिया। पखवाड़े के दौरान दिनांक 24-9-2014 से 26-9-2014 तक हिंदी पुस्तकों के नये संस्करणों की प्रदर्शनी लगाई गई।

समारोह का समापन श्री ए.के. मित्तल, वरिष्ठ उप-महानिदेशक की अध्यक्षता में सम्पन्न हुआ जिसमें सभी विजेताओं को पुरस्कार राशि एवं प्रशस्ति पत्र प्रदान किये गये।

(हिन्दी पखवाड़े की विभिन्न झलकियां)

इस पखवाड़े के दौरान दिनांक 23-9-2014 को एक हिंदी कार्यशाला का आयोजन किया गया जिसमें अतिथि वक्ता श्री हरिन्द्र कुमार मक्कड़, निदेशक (तकनीकी) राजभाषा विभाग द्वारा कार्यशाला में उपस्थित अधिकारियों कर्मचारियों पर टिप्पणियां लिखने के बारे में बारीकी से बताया एवं अभ्यास करवाया तथा हिंदी के बारे में काफी रोचक जानकारियां उपलब्ध कराई।

Approvals from JUL 2014 to SEP 2014

S.No.	Name of the Company /Name of Product & Modal No.
1	M/s Huawei Telecommunications India Co Pvt Ltd
1.1	Switching Node with Network-Network Interface at STM1, MSOFTX 3000 with UMG 8900
1.2	Switching Node with Network-Network Interface at 2048 kbps, MSOFTX 3000 (V1R9) with UMG 8900
1.3	Switching Node with Network-Network Interface at 2048Kbps, MSOFTX 3000(V200R009) with UMG 8900
1.4	Switching Node with Network-Network Interface at STM1, UGC 3200 with UMG 8900
2	M/s Matrix Comsec Pvt Ltd
2.1	PABX, ETERNITY LE
3	M/s NEC India Pvt Ltd
3.1	PABX, SV 8300
3.2	PABX, SV 8100
3.3	PABX, SV 8500
4	M/s Tejas Networks Ltd., Banglore
4.1	STM-4 Synchronous Multiplexer (TM/ADM) TJ1400 (STM-4)
4.2	STM-1 Synchronous Multiplexer (TM/ADM) TJ1400 (STM-1)
5	M/s CLIXXO Broadband Pvt. Limited, Noida (U.P.)
5.1	PABX IPX-22K
6	M/s Coral Telecom Limited, Solan (H.P.)
6.1	PABX IRIS IVDX
7	Avaya India Private Limited, Gurgaon Haryana
7.1	PABX Avaya Outbound Contact Express
7.2	PABX IPO 500 V2
8	M/s Hewlett Packard India (Sales) Pvt. Ltd., Mumabi
8.1	G - 3 FAX Machine SNPRC-1005-01
8.2	G - 3 FAX Machine SNPRC-1101-01
8.3	G - 3 FAX Machine SNPRC-1402-01
9	M/s Sunren Technical Solutions Pvt. Ltd., Mumbai
9.1	V.90 MODEM (Analog) USR 3453C
9.2	PABX Mediant 2000
9.3	PABX SBC 2000
9.4	Terminal for Connecting to PSTN SCW 9055-433
10	M/s ZTE Telecom India Private Ltd
10.1	Switching node with network-network interface at 2048 Kbits ZXC10-3GCN(MSCe/MGW/SGW)

Important Activities of TEC during JUL 14 to SEP 14

DCC Conducted on

- IR on LAN Switch, Firewall system
- IR on Data interface to G.703 converter
- IR on UTP to Optical converter
- IR on 2048 kbps and STM-1 Interface
- IR on IP based media gateway
- IR on ADSL2+ for CO and remote office applications
- IR between BSNL and MTNL network and Private broadband network
- IR on Electronic Telephone Instrument
- GR on Optical converter
- GR on PON Power Meter
- GR on WAN optimization for Satellite Network
- GR on 1.6 GHz High Performance Antenna
- GR on Remote Fibre Monitoring System
- GR on Ethernet Traffic Analyser
- GR on Optical Variable Attenuator
- GR on Optical Fixed Attenuator
- GR on Optical Talk Set

White paper/study item issued

- Mobile Data Offload- WiFi Offload
- Supplementary Downlink (SDL)
- High Speed Packet Access +
- Security Accreditation Scheme in SIM
- Penetration Testing Methodologies
- Telecommunication/ICTs for rural and remote areas of INDIA

Approvals issued by TEC during the period from JUL 2014 to SEP 2014

Interface Approvals....................................... 20
Type Approvals 2
Certificate of Approval.................................... 0

----------- Regional TEC Contact : -----------

Eastern Region	:	033-23570008
Western Region	:	022-26610900
Northern Region	:	011-23329464
Southern Region	:	080-26642900

Other Activity

- NWG meeting for ITU-T Study Group 12 held in TEC in SEP 2014
- Meeting of NWG-5 of Radio sector held on 5 & 19 Sep 2014
- 16 M2M conference Call were held. Meeting of all the vertical groups and the Joint working Group (JWS) were held on 29 & 30 Sep 2014
- Testing of CDOT GPON for IPv6 Ready Logo
- Testing of CISCO & HP MSR/HSR Routers in NGN Lab.

टी ई सी संचारिका	:	दूरसंचार इंजीनियरी केंन्द्र
नवम्बर 2014	:	खुर्शीद लाल भवन
भाग 18	:	जनपथ
अंक 4	:	नई दिल्ली-110001

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