iBurst Technical Profile

1 Introduction

The iBurst system is designed to provide portable broadband wireless Internet access to all subscribers including business customers anytime, anywhere. This system promises an always on, IP-centric, high-speed wireless access that provides approximately 1 Mbps (downlink) packet data service per user while sustaining the system's spectral efficiency, coverage and capacity. The system is uniquely designed around multiple antenna spatial processing to deliver broadband consumer and business applications at economics that encourages mass-market adoption and consumption. The main technical characteristics and capabilities of the iBurst system are described in the following sections.

2 Salient Features of the iBurst System

2.1 High Data Rate

The iBurst system has an air interface with a TDD/TDMA (Time Division Duplex/Time division Multiple Access) frame structure with multi carrier aggregation support. This frame is divided into 3 uplink followed by 3 downlink slots asymmetrically to support higher data rates over downlink.

All uplink and downlink transmission are scheduled at a constant symbol rate of 500k symbol/sec. The physical and logical characteristics of TDMA/TDD frame have been chosen and optimized for efficient transport of end user IP data and to extract the maximum benefit of Adaptive Antenna Processing, thereby providing high speed data connection to mobile users.

2.2 Efficient Use of Frequency Resources

As the radio resources are scarce, efficient utilization of frequency resources being the top priority, the iBurst system design has integrated the following key radio access technologies.

1) Asymmetric TDD/TDMA frame designed for 625 kHz channelization.

2) Adaptive Array Antenna Processing

3) Spatial Division Multiple Access

4) Adaptive Modulation and Coding

2.3 Wide Service Area

The iBurst system offers wide service area coverage by maximizing the gain of Effective Isotropically Radiated Power (EIRP) and utilizing Adaptive Array Antenna technology. Although the coverage radius may vary based on the carrier frequency, BS antenna height, type of UT, topology and congestion of building, iBurst can provide more than 850kbps data rate in downlink within a range of 500m from BS in the metropolitan area, and 1km from BS in the rural area. Due to the TDD system design, the maximum cell radius from the BS is 12.75km, considering the signal latency.

2.4 Always On

The iBurst offers users with "Always-on" connectivity to INTERNET and supports the handover function between the BS. User terminal in the iBurst system randomly access BS regularly and automatically judges the communication quality or BS congestion, and maintains the connection with the most appropriate BS, once the UT is authenticated within the iBurst network and unless the users go out of the iBurst network.

2.5 Simple and Economic Connection to Internet

The wired backhaul and core transport networks of the iBurst system is based on the IP traffic. BS and Internet can be connected through Ethernet (100BASE-TX/FX), etc. Operators can chose any open data networking equipment to take advantage of higher data rates, wider coverage and higher capacity offered by iBurst air interface.

2.6 Security

The iBurst system offers a robust security for air interface encryption and authentication. The authentication for both BS and UT is based on digital certificates that use RSA algorithms. During the authentication phase, BS and UT exchanges shared secret and air interface parameters using public keys based on elliptic curve cryptography. The shared secret is used further for bulk encryption of user data and control messages as per Secure Communications Protocol of the iBurst system).

2.7 Mobility

The iBurst system maintains the connectivity of communication even in high terminal mobility environments. This is achieved due to number of different modulation classes and algorithm to appropriately select its modulation and power output control which always maintain the best signal characteristic. Due to those functions, iBurst can achieve the high data rate, even during the high speed movement of user terminals. iBurst always improves the connectivity based on the link adaptation and power control and provides "high data rate" and "always on" connectivity.

3. Typical System Configuration with the iBurst Wireless Access Network

3.1 IP Network Configuration

[1] Configuration of Access and Transport Network

In a typical deployment the iBurst radio access network allows end to end transport of user data from any IP capable application by a seamless interface with wired and backhaul IP network. The main elements of such typical deployment using iBurst radio access are:

1) User Terminal (UT)

2) Base Station (BS)

3) Packet Services Switch

4) Backhaul Network

5) Internet Service Provider

Also, followings are the operation management system for iBurst Radio Access Network:

1) Element Management System (EMS) – controls the configured element.

2) Node Management System (NMS) – controls each node.

[2] Protocol Stack

End user IP data traffic is carried over the iBurst radio interface through a series of encapsulation and decapsulation steps. iBurst air interface design includes protocol specification to utilize the legacy IP network and connects with VPN between 1) BS to PDSN, and 2) PDSN to ISP. On the other hand, the IP traffic data from end user to ISP is carried through PPP session from end user device, e.g., PC to ISP via UT, BS, and PDSN to ISP. In this case, PPP is terminated at either PDSN or ISP while, BS and PDSN are interconnected through VPN to transport user data by Layer 2 Tunnelling Protocol (L2TP). The iBurst wireless protocol handles the user-data encapsulation and decapsulation over air interface between UT and BS there by providing transparency between PC and PDSN.

3.2 Technical Performance of Typical iBurst Deployment

While the demand from the wireless broadband user for “high data transfer rate” at low cost is obvious, the spectrum (frequency) is limited resource. In order to meet such user demand while not compromising user experience, achieving high system spectral efficiency has become necessary objective in the design of iBurst air interface. To achieve this goal, iBurst air interface layers and protocols have been optimized while adopting the following key technological elements: 1) TDMA/TDD system, asymmetric slot frame structure, 2) Adaptive Array Antenna technology, 3) Spatial Division Multiple Access, 4) Adaptive Modulation and Coding method:

[1] TDMA/TDD system, asymmetric slot frame structure

In a typical deployment, where 5MHz blocks of spectrum available, iBurst air interface supports wireless data transfers over single carrier of 625 KHz or multiple (maximum aggregation of 8) carriers of 625 KHz, simultaneously. With a TDMA/TDD frame length of 5ms, there are 3 uplink slots followed by 3 downlink slots but uplink time slot length is half of that of downlink leading to asymmetrical TDD frame. This TDMA/TDD frame is designed for possible deployments in spectrum as narrow as 625 kHz with a constant baud rate corresponding to 2µ /symbol. This kind of TDMA/TDD frame design has the following advantages:

- **Uplink before downlink transmission facilitates the spatial temporal processing for adaptive antenna arrays at BS.**
- **Narrow Carrier bandwidths of 625kHz simplifies equalization, channel estimation and Network deployment in TDD spectrum**
- **Narrow frequency channelization reduces wireless access latency**

The iBurst air interface supports 9 modulation and coding classes for downlink and 8 modulation and coding classes for uplink. For downlink transmissions the highest modulation class 24QAM can carry 4 bits/symbol, while for uplink the highest modulation class 16QAM can carry 3.5bits/symbol. Therefore, the maximum data transferred within 1 time slot over downlink and uplink is:

Downlink: (920µ/2µ) x 4 bits =1840 bits

Uplink: (364µ/2µ) x 3.5bits =637 bits

When control information is ignored, the actual data amount becomes 1,768 bits for downlink and 576 bits for uplink. iBurst protocol design offers time slot aggregation of maximum 3 slots. The maximum data rates when all of 3 slots are allocated to single user are as follows:

Downlink: 1,768 bits x (1/5ms) x 3 slots = 1,060,8000 bps = 1,061 kbps

Uplink: 576 bits x (1/5ms) x 3 slots = 345,600 bps = 346 kbps

[2] Adaptive Array Antenna technology

A Base Station of the iBurst system employs Adaptive Array Antenna elements coupled with sophisticated signal processing to control the energy radiated and received by the base station. An adaptive algorithm controls the amplitude and phase of the symbols to be transmitted based on the correlation of each receiving signal from multiple antennas. Adaptive Array Antenna technology has following characteristics.

1) It maximizes the signal strength by "spatial temporal processing".

2) It mitigates the interference by making "null points" in the direction of undesired signals.

These dynamic characteristics improve the original signal level and reduce the interference. As a result, it improves the dynamic range of original signal.

[3] Spatial Division Multiple Access technology

To achieve higher spectral efficiency, the iBurst system supports Space Division Multiple Access, which reuses the bandwidth by multiplexing user signals based on spatial signatures. When the appropriate directional antenna control is done by utilizing adaptive array antenna technology, each UT will have sufficient interference removal and maintains the desired signal. As a result, it makes simultaneous communication possible over same carrier and same time slot. A typical deployment of the iBurst system uses 12 antenna elements and realizes maximum 3 spatial channels. As a result, the iBurst system with 5MHz spectrum availability can handle 72 streams of data transfer:

(8 carriers) x (3 time slots) x (3 spatial channel) = 72 stream

However, 1 carrier out of 8 carriers is used as control channel; therefore number of maximum simultaneous data streams becomes 69. In order to provide maximum data rate to users, iBurst has features to aggregate 3 data streams over 3 time slots. Due to this aggregation function, 24 users can experience maximum data rate transfers simultaneously while 3 users can have data rates corresponding two time slot aggregation.

[4] Adaptive Modulation Modulation and Coding

Adaptive modulation and Channel coding, along with uplink and downlink power control, which are incorporated in iBurst system, provide reliable transmissions across wide range of radio link conditions. There 9 modulation and coding classed defined for downlink, while uplink transmissions can use 8 modulation and coding classed. In order to obtain the high spectrum efficiency even under the fading environment, the iBurst system always compares the RSSI (Receive Signal Strength Indicator) and SNR (Signal to Noise Ratio), and selects the most appropriate modulation and coding class for every 2 frames (10ms).

3.3 Higher System Spectral Efficiency

In summary, all of the above technical characteristics in a typical iBurst system deployment scenario in a 5MHz spectrum, can be put together to explain how efficient use of frequency is achieved by iBurst system. The maximum data rate per user becomes 1,061 kbps for downlink and 346 kbps for uplink there by resulting in the total throughput per BS of 32.361Mbps as illustrated below.

Max cell Throughput (downlink) 1,061kbps x 21 + 707kbps x 3 = 24,402kbps

Max cell Throughput (uplink) 346kbps x 21 + 231kbps x 3 = 7,959kbps

Max cell Throughput (total) 24,402kbps +7,959kbps =32,361kbps

Since the spectrum (frequency bandwidth) is 5 MHz in typical deployments, theoretical iBurst system's spectral efficiency of total throughput per Base station becomes 32.361kbps/5MHz =**6.47bps/sec/Cell**