

➤ Carrier requirements of core IP routers 2002

A technology benchmark from
BTextact Technologies

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Carrier requirements of core IP routers 2002

Background

The rapid growth in traffic experienced over the past few years has driven network operators to deploy high-capacity backbone networks to support data and multi-media services. At the heart of the Internet that is built upon these backbone networks lies a mesh of inter-connected routers, each capable of processing and forwarding millions of packets per second. The sophistication of the features and the levels of performance offered by these routers are improving continuously, but have not yet reached the point where they may be categorised as 'carrier-class'. Network and service providers are now faced with deploying the next generation of IP services aimed at businesses, such as secure virtual private networks, with enriched voice, video and multimedia content. There is therefore a need to reconsider the evolution of core network IP routers, and to set a benchmark for their levels of performance today and over the next twenty-four months.

BTextact Technologies has extensive experience in the design, integration and deployment of carrier-scale IP networks and has used this knowledge, and the results of a survey of major carriers around the world, to develop this statement of performance requirements of core IP routers. Service providers expect all core routers to meet the levels of performance suggested in this document, and vendors to work to improve key areas such as scalability, reliability and stability. Too often, the performance of existing devices in these key areas has failed to meet the needs of global carriers.

BTextact Technologies

BTextact Technologies is British Telecommunications' advanced research and technology business created to allow services hitherto reserved for the BT Group to be made available to external customers.

As the technical design authority for many of the networks and services operated by BT, we have a wealth of knowledge in product testing and evaluation, built up over a number of years. Our experience has allowed us to develop test and evaluation methodologies that have been proven by subsequent feedback from deployed networks. As you would expect, we also have an in-depth understanding of the specific needs of carriers that, when combined with the state-of-the-art test equipment we have available, allows us to offer our customers both accurate, well-planned testing and speed of implementation.

This report has been prepared by BTextact Technologies. The requirements contained herein do not necessarily reflect the specific requirements of any other part of the BT Group.

The global market for core routers

The deployment of the current generation of core IP routers has been driven by huge growth in data and Internet traffic. The recent failures of many "new entrant" telecommunications carriers has triggered speculation that IP traffic growth and the need for core IP routers may have peaked.

On the contrary, most industry analysts indicate further potential for significant growth as network providers launch integrated suites of broadband services covering voice, video and multi-media.

Market analysts such as the Yankee Group¹ see the market as buoyant and predict "growth averaging 200 to 300% through 2004". CIBC World Markets² predicts that the market for core routers will be worth some \$6bn by

1. Core Routers: Challengers and Challenges to the Status Quo, Yankee Group October 2001

2. Core Routers: The Dilithium Crystals of the Internet, CIBC World Markets December 2001

2006, and that more than 50% of this expenditure will be on 'super-core routers'. Finally, Gartner Dataquest predicts significant growth in the market for multi-gigabit routers through 2005³.

The predictions of these three organisations are summarised in Figure 1. Even according to the most pessimistic forecast, the market for multi-gigabit core routers appears bright over the next two years.

While demand for core routers will remain strong, the type of routers carriers are looking to deploy is changing. The current market for carrier-class core routers is dominated by a small number of manufacturers. In some cases, the suppliers of core routers have expanded from the enterprise market to serve the different needs of global carriers. However, there are also a number of start-up companies producing innovative and exciting products aimed specifically at the carrier market that offer enhanced features and reliability. It is against this background that BTextact Technologies offers this document to define the features and characteristics required of core routers by carriers over the next twenty-four months.

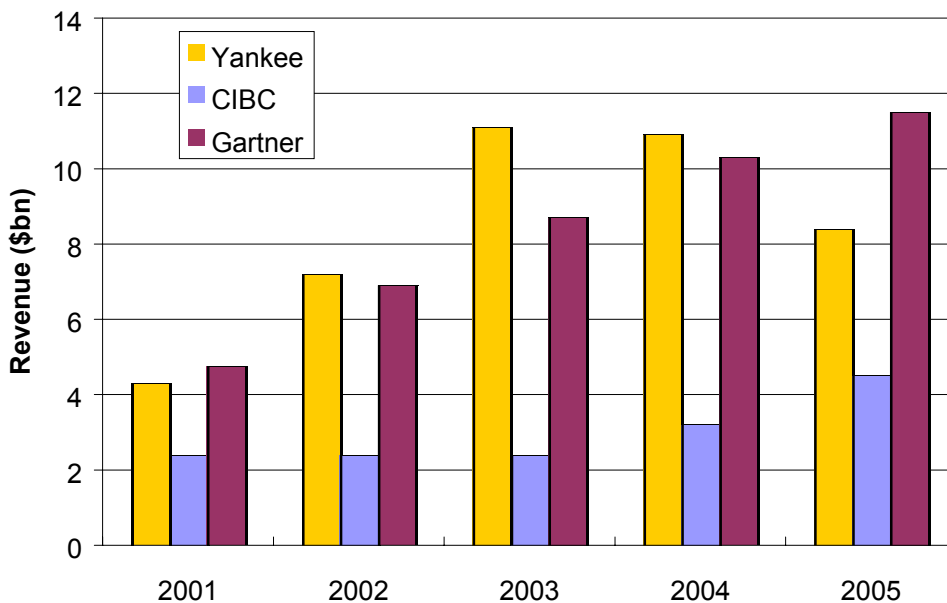


Figure 1 - Worldwide Core Router Market Forecast

The key requirement of an IP routing platform within the core of a carrier's network is to process and forward a high volume of IP packets, and to do so very quickly. Differentiation between devices may thereafter be made upon the basis of a host of features including stability, reliability, interface density, type and rate, and support for additional features.

These issues are common to the deployment of routers in many types of network. However, there are specific aspects of performance that are of key importance to global service providers.

While IP services have experienced tremendous growth in the past 5 years, they have delivered significantly lower profit margins than traditional voice and data services. The key challenge for carriers is to design IP networks that continue to enable rapid growth, but to do so at lower cost resulting in greater profitability.

3. LAN Equipment and Routers Worldwide 2000-2001, Gartner Dataquest, January 2002

The carrier perspective

Current issues

A survey conducted by BTextact Technologies of the major global carriers has indicated that router reliability and stability are the parameters of greatest concern to carriers today. Operators need core routers that can be relied upon to unfailingly process packets 24 hours a day, 365 days per year to support high levels of service availability; far different from the general requirements of the enterprise market from which routers emerged. The next generation of routers must offer hitherto unrealised levels of reliability and dependability, especially in the area of software stability.

The scalability of core routers is another area of concern to carriers - the ability of a router to accommodate rapid traffic growth through modular and linear expansion. Too often, carriers are forced to replace an entire router just because a single feature cannot scale as demand increases. If the Internet is to become carrier-class, the foundations upon which it is built must be solid enough to cope with growth in demand.

Other areas of concern to the major global carriers are the low-level of overall performance, and poor support for advanced features.

According to our survey, the major network operator are currently less concerned about issues such as cost of ownership and equipment accommodation; although this may indicate a degree of short-term focus upon stronger concerns in other areas of performance. Cost of ownership is likely to become an increasingly important issue for carriers as they seek to improve the profitability of IP services. To date, service providers have struggled to meet rising demand for IP services, which has led to the rapid deployment of new networks. The downturn in the sector means that the emphasis is now upon generating profit from deployed assets.

BTextact Technologies has a view of the levels of performance and features required of IP routers if they are to meet the needs of global carriers. In setting this view, we have reflected areas of current concern to carriers, but have also considered the features that will be needed over the next twenty-four months.

Prioritised concerns of carriers	
1.	Equipment reliability and stability
2.	Scalability
3.	Performance
4.	Feature support
5.	Management
6.	Total cost of ownership
7.	Environmental considerations

Future requirements

When questioned about the future development of core routers, the key priorities for global carriers are the need to support full wire-rate performance on every interface, and facilities to provide mitigation of denial of service attacks. In fact, security from denial of service attacks was considered to be of vital importance by almost every carrier surveyed. It is therefore essential that core routers support flexible and scalable generation of control lists to prohibit Denial of Service attacks whilst ensuring that such features do not degrade forwarding performance.

Security in the wider sense emerged as a key issue from our survey and may reflect a heightened awareness of the issue following the events of September 2001.

Global carriers are generally concerned less about areas such as racking practice, support for ATM, and IP-optical

New features required by carriers	
1.	Denial of service attack mitigation
2.	Wire-Rate performance of interfaces
3.	System access security
4.	Port density improvements
5.	Quality of service support

convergence. IP-optical convergence was a key issue in 2001 but the market downturn and a lack of international standards has reduced the drive for this. Similarly, the requirement for ATM interfaces on core routers is limited to a small number of operators who prefer to inter-operate and sweat existing assets rather than introduce ubiquitous IP networks. There is a divergence of views between different carriers on the importance of new features such as support for IP multicast, support for advanced management information, and IPv6 which perhaps reflects uncertainty and a difference of emphasis within the carrier community. BTextact Technologies believes that the importance of IPv6 has been underrated by our survey, dominated as it was by carriers in the U.S.A.. IPv6 has a greater importance in other parts of the world where IPv4 address exhaustion is a real issue and where third generation mobile demand is likely to be most buoyant. It is likely that when demand arises for IPv6 support, it is likely to be an immediate requirement. We therefore consider it essential that core routers support dual protocol stacks and hardware forwarding of IPv6 packets.

The importance attached by carriers to the provision of a range of new features is summarised in Figure 2, where a value of 1 indicates that the feature is considered essential, a value of 5 that the feature is not needed.

According to our survey, most global carriers are influenced more by the capital cost of core routers than by whole-life or operational cost considerations, although there was a divergence of views on this matter. The business cases of carriers are generally based on an operational lifetime of four to six years for core routers, with an assumption that any cost benefits should be realised within perhaps three or four years.

A significant number of global carriers perceive architectural complexity as an issue of concern and would change their network architecture if router reliability were to improve to become carrier-class, 99.999%. BTextact Technologies also foresees a convergence of the functions currently performed separately by core and edge routers. Increases in router reliability and scalability will drive this convergence and architectural simplification, and it is likely that the next generation of router equipment will require combined edge/core functionality. If this vision is realised, the fluidity of edge services will require the architecture of core routers to be flexible.

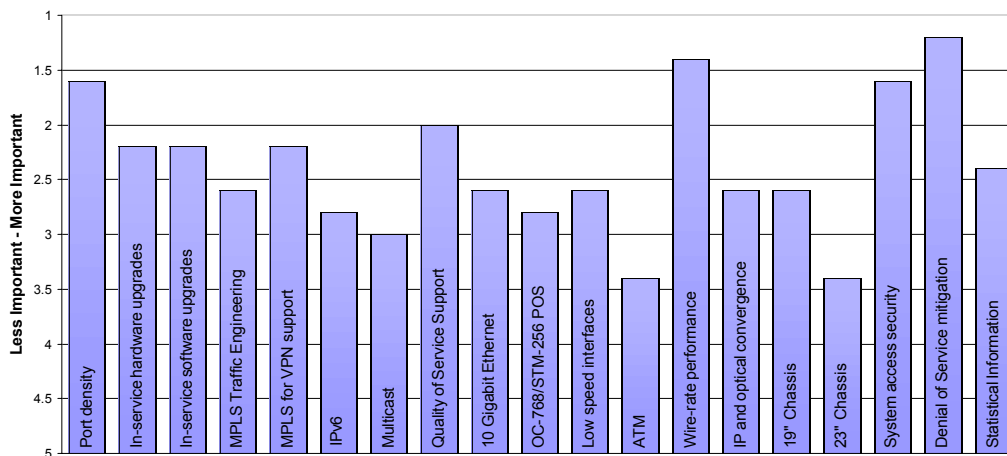


Figure 2 - Importance to Carriers of New Features

Detailed carrier requirements

BTextact Technologies believes that IP routers to be used in the core networks of global carriers must, as a minimum, offer the features and levels of performance described in the following sections. The requirements are described in order of their importance to carriers.

Where possible, we have sought to assign an appropriate metric of performance. However, there are certain areas where the assignment of a specific metric would not be appropriate. In these cases we have stated the parameter to highlight it as an area of concern.

Reliability & stability

The reliability and stability of router hardware and software are absolutely vital to global carriers as they seek to deliver a reliable, resilient network capable of meeting service availability targets. Significant improvements are required in these areas, particularly in the area of software reliability, if carriers are to realise their ambitious plans to support a range of mission critical and real-time services for business customers.

BTextact Technologies believes that routers deployed in core networks should offer carrier-class levels of reliability and stability. The key requirements and metrics are summarised in Table 1.

Table 1 - Reliability requirements and metrics

Feature	Requirement	Metric
System availability	To minimise downtime of network services	Availability to underwrite a maximum of 2 hours downtime of overall network service in 40 years.
		Full system reboot within 180s
Hardware redundancy	1+1 redundancy for route processor	Changeover to 'hot' standby with no loss of traffic
	1:n power supply redundancy	Any individual power card may be removed without impact on traffic.
	1:n redundancy of fans	The failure of any individual fan shall not affect traffic.
	1:n redundancy in the switch fabric	Changeover to backup within 50ms with no loss of traffic
	1:n redundancy on interface cards	Changeover to backup within 50ms with no loss of traffic
Software redundancy	1+1 control plane	Changeover to backup with no loss of traffic
	Core base operating system with separate sub-components (i.e. for BGP)	Demonstrable isolation of software failures
Hitless software upgrades	Minimise downtime	Full operating system upgrade without loss of control plane peerings (e.g. BGP) or data traffic
		Sensible fallback - different software release supported on each controller card
		Isolated sub component upgrade resulting in no packet loss

Table 1 - Reliability requirements and metrics cont.

Feature	Requirement	Metric
Hitless software upgrades	Minimise time and complexity	Significant reduction in operational cost of upgrades, an initial target being 60%.
	Minimise impact on service	No loss of device manageability during software upgrades and no loss of traffic forwarding.
Hitless hardware upgrades	Minimise downtime and operational impact	Hot-swappable line cards, route processor, power supply, fans.
Software availability	High MTBF	Comparable to existing PSTN switches
Hardware availability	High MTBF	Comparable to existing PSTN switches

Scalability

A core router must be able to evolve to satisfy changing network demands without requiring a full platform replacement. The hardware of a core router must be expandable in service and the software must scale in a proportionate manner.

All components of a core router including, but not limited to, the core switch fabric, the number and type of interface cards, the processor capacity and the ancillary functions should scale linearly. Such linear expansion should not be restricted by the physical chassis of the router, which should scale without introducing additional cost. Solutions must also take account of practical accommodation constraints, which may require non-contiguous expansion.

Scalability should be possible over a five-year lifetime without the need for replacement of the chassis. It should be possible to upgrade any component of the router without affecting traffic.

Software components should scale proportionately with increasing demands and complexity of hardware. Hardware should offer a high port density and slot capacity, and interface slots should be flexible and suitable for in-service upgrade.

Equipment performance

For carrier networks it is vital that the performance of core routers be maintained under normal, stressful operational conditions such that all features operate to their full design parameters when used collectively, not just individually. Hence, for example, support for management functionality or performance monitoring should not degrade interface throughput performance even under conditions of severe route recalculation.

Table 2 - Performance requirements and metrics

Feature	Requirement	Metric
Wirespeed packet forwarding	Enable maximum revenue to be generated from link circuits and minimise number of ports required.	100% line rate forwarding for all IP and MPLS packet sizes with all features enabled (e.g. QoS, ACL) in a fully loaded chassis.
Efficient protocol implementations	Efficient algorithm calculations and lookups to facilitate fast traffic flow.	BGP route table capacity of 1M with 100,000 routes flapped every 2 minutes (withdraw-advertise time of 1 minute) for 8 minutes
		BGP route table capacity of 1M with 10,000 routes flapped every 2 minutes (withdraw-advertise time of 1 minute) for 1 hour
		BGP convergence time of 30 seconds for 100,000 routes on OC-48/STM-16 or higher rate links
		BGP route reflector capability with 500 peers (not all clients)
		IGP convergence time of 5 seconds
		IGP route table capacity of 20,000 routes
		IGP traffic engineering support
		IGP ECMP support
		LDP ECMP support
		40,000 MPLS-TE tunnels as midpoint
		100 MPLS-TE tunnels as ingress and egress
		5000 LDP FECs
		MPLS fast re-route (link and node) of less than 50ms

Equipment features

IP core routers do not sit in isolation within a carrier's core network. Although the specific requirements for interoperability vary between different carriers, there remains a general requirement for a router to inter-work with other, possibly non-IP, equipment. Hence, carriers place great value upon the implementation of interfaces and features that are compliant with international standards, and generally require a demonstration of interoperability as part of an equipment procurement exercise. This creates a conflict between the need for standards compliance and the need for rapid deployment of new, innovative services for commercial advantage. Thus, flexibility of architecture and stable, software configuration are likely to prove key areas of differentiation in the next generation of equipment.

Table 3 - Feature requirements and metrics

Feature	Requirement	Metric
Range of interfaces	Support connections to lower tiers and for interconnecting PoPs	Must support now: OC-48 SONET/STM-16 SDH OC-192 SONET/STM-64 SDH Gigabit Ethernet
		Must support upon ratified standards: 10 GigabitEthernet OC-768 SONET/STM-256 SDH
		Support Very Short Reach (VSR) optics
Multicast	PIM-SM	50,000 multicast groups joins
	MSDP	30 peers
	MBGP	Equivalent capacity to BGP
Quality of service	Support differentiated services to include VoIP	The port-to-port latency when forwarding highest priority traffic (IP and MPLS) should be less than 50ms
	Queuing	At least 8 queues - one to be strict priority
	WRED	At least 8 WRED profiles per queue WRED profile configurable on TCP, UDP, DSCP marking
IPv6 support	Hardware support for IPv6 forwarding and routing lookups	Introduction of IPv6 does not require a forklift upgrade of hardware.No loss of performance when using IPv6 when compared to IPv4
IP/Optical interworking	Full support of standardised protocol for interworking	

Security features

As the Internet becomes more important to the business community, so the consequences of network failure become ever greater. It is therefore vital that the core IP networks operated by global carriers are protected from attack.

Table 4 - Security requirements and metrics

Feature	Requirement	Metric
System access	Authenticate users and OSS systems' access onto the router	SSH, RADIUS, Password access (to allow multiple levels of users)
Peer authentication	Authentication of peer at start of session	Authentication MD5, for BGP, OSPF, IS-IS, LDP (multiple levels of users)
	Authentication of protocol updates as standards are ratified	
In-band security	Resistant to DOS attacks, hacking	Filters Report hacking attempts Rate limiting Session resource limiting
Port mirroring	Monitoring of traffic sent/received (especially at peering points) to meet any future legal requirements	Filters, ACLs to specify traffic to mirror
MPLS label reverse lookup	Prevent MPLS label spoofing	Rejection of spoofed labels

Management features

Global carriers have stringent requirements for management of core routers including, but not limited to device, network and service management. Such devices will in the future have to operate in a mixed management environment where the use of SNMP, CORBA, and other techniques are common. It is vital that core routers evolve to support a carrier-class management environment, driven by the requirements of individual markets.

Table 5 - Management requirements and metrics

Feature	Requirement	Metric
Provisioning	Support for in-band and out-of-band management	CLI, SNMP support for OSS systems
		Serial and Ethernet interfaces
Packet accounting	Support for SLA verification	SNMP, MIB support for, for example, per LSP and class of service accounting
Billing information	May be needed in certain applications. e.g. transit network services	
Seamless integration	Integrate with existing OSS	Open management architecture Standards based interfaces
Alarms	In and out-of bound notifications	SNMP trap support, report failovers, status of redundant components

Environmental & accommodation features

The accommodation and environmental requirements of core routers must improve to meet evolving carrier needs. Within certain markets, we foresee a drive to reduce the power consumption of devices, reduce the heat dissipation and improve the recycling capability of the hardware to meet tighter environmental standards. Such pressure is not yet universal.

Table 6 - Environmental requirements and metrics

Feature	Requirement	Metric
Environmental opex	Low power consumption	Comparable to existing PSTN equipment
	Low heat dissipation	Comparable to existing PSTN equipment
	Low physical mass	No special floor loading requirements
	Small footprint	Proportional to capacity
Flexible power options	AC and DC support	
Certification	Conforms to International standards requirements	NEBS, ETSI
Safety	No hazard to staff	No direct human access to fans No sharp metalwork
EMC		Compliant to international standards
Build Quality	Reliability	No undue flexing of cards Stability of connectors

Interoperability

The absolute need to ensure interoperability between equipment was a strong theme that emerged from our survey of global carriers. Carriers cannot operate IP core routers in isolation; they form but one component of a complicated mix of technologies that must work seamlessly to deliver service. Such interoperability encompasses client and server networks, peers supplied by competing vendors and management. It also requires both physical and logical interoperability.

Table 7 - Interoperability requirements and metrics

Feature	Requirement	Metric
Protocol	L2 and L3 Interoperability	Full compliance to appropriate standards Full interoperability between all network protocols
Interfaces	L1 interoperability	Full standards compliance on all types of interfaces. All SONET/SDH interfaces must be software configurable to either standard. Routers should support both types of interface and interoperability between interfaces.
	Support for real-time network services	Clock performance of SDH/SONET interfaces must meet appropriate transmission standards. Timing performance of interfaces, and timing transfer between interfaces must meet the requirements of appropriate international standards.
Management	Seamless service delivery	Ability to manage IP services across a multi-vendor, mixed-technology environment.

Summary

BTexact Technologies has extensive experience in the design, integration and deployment of carrier-scale IP networks and has used this knowledge, and the results of a survey of major carriers around the world, to develop this vision for the future evolution of core IP routers. The purpose of the document is to provide router manufacturers with a statement of the required characteristics of such devices needed by carriers over the immediate to short term. In some cases it is recognised that these parameters and metrics represent a challenge; a challenge that we hope suppliers will rise to meet.

It is our intention to update this document on a regular basis as technology develops in order to provide a benchmark for the performance of core routers.

BTexact Technologies are specialists in advanced communication technologies and their application. We provide insight, inspiring ideas and integrated solutions to the communication industry and communication-intensive businesses and organisations.

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