# IBM System Blue Gene/Q

*Work at the forefront of science with a reliable and efficient platform*

## Highlights

- Offers scalable HPC power for complex, general-purpose science applications
- Delivers high bandwidth, low latency performance for data-intensive applications
- Helps reduce TCO, with lower energy consumption and a smaller footprint

Whether your work involves climate modeling, nuclear simulations or life sciences research and development, you have something in common: You work with huge data sets and need massive computing power without breaking the bank on energy costs.

With IBM® System Blue Gene®/Q, completing computationally intensive projects for a wide variety of scientific applications that were previously unsolvable is not just possible, it is now probable. And—the machine saves money, because it uses less energy and floor space than other systems.[1]

Blue Gene/Q introduces innovative technologies to deliver exceptional performance, energy efficiency and ease of application portability. It reflects a key step in the ongoing evolution of Blue Gene supercomputers. An array of technical innovations in hardware, software and system design will enable Blue Gene/Q to achieve new levels of performance and energy efficiency while helping to simplify application portability and usability. By providing speed and bandwidth to keep platforms operating at the forefront of technology, Blue Gene/Q can help you accelerate leading-edge science to transform your scientific and research agendas.

## Breakthrough science today—not tomorrow

Blue Gene/Q is specifically designed to help solve large-scale problems associated with the sciences. The third generation in the Blue Gene family of supercomputers, it works at an order of magnitude faster than previous systems, with 16 cores and a scalable peak performance up to 100 petaflops—a massive leap forward in parallel computing power. Applicable to a growing set of computationally intensive workloads within the scientific community, Blue Gene/Q is the ideal platform for highly complex projects in a broad range of areas.

Designed with a small footprint and low power requirements, Blue Gene/Q was ranked as the number-one most energy efficient supercomputer in the world by the Green500 in June 2011.[2] It provides low latency, high performance runs that simplify tracing errors and tuning performance, all based on an open source and standards-based operating environment.

## Consider the capabilities

The scientific community at large needs computing capabilities that lead to breakthrough science. Blue Gene/Q is already hard at work running computationally intensive projects of the largest—and broadest—scale possible in many different areas.

- Materials science: semiconductor and silicone design
- Data analytics: financial modeling
- Fluid dynamics: engine and turbine design
- Life sciences: molecular simulations of whole organs
- Physics: quantum chromo dynamics
- Environmental science: climate and weather modeling studies

Blue Gene/Q is not only capable of solving a variety of academic and commercial problems related to science, it also offers a way to step into working with a parallelized high performance computing (HPC) system, providing an immediate benefit to complex, general-purpose scientific research.

## A supercomputer that is super-efficient

The efficient performance of Blue Gene/Q was engineered from the start to leverage innovations in thread performance and memory handling to help ensure the throughput needed for low latency and high bandwidth workloads.

- Scales to 512 racks, achieving up to 100 PF at peak performance.
- Integrated 5D torus provides tremendous bisection bandwidth.
- Quad floating point unit (FPU) for 4-wide double precision FPU SIMD and 2-wide complex SIMD allows for higher single thread performance for some applications.
- "Perfect" prefetching for repeated memory reference patterns in arbitrarily long code segments achieves higher single thread performance for some applications.
- Multiversioning cache with transactional memory eliminates the need for locks; and speculative execution allows OpenMP threading with data dependencies.
- Atomic operations, pipelined at L2 with low latency even under high contention, provide a faster handoff for OpenMP work.
- A wake-up unit allows SMT threads to sleep while waiting for an event and avoids register-saving overhead.
- A seventeenth core handles RAS event interrupts and reduces O/S noise and jitter.

## Slip into familiar software

Blue Gene/Q uses an open source and standards-based programming environment:

- IBM XL Compilers (FORTRAN, C and C++) are optimized for specific Blue Gene functions and support OpenMP.
- Linux development environment, using GNU toolchain, with GLIBC, pthreads and GBD.
- IBM Tivoli® Workload Scheduler LoadLeveler®, uses job submission and system query functions, and backfill scheduling to achieve maximum system utilization.
- IBM General Parallel File System (GPFS™) provides high performance file access in current IBM System p® and IBM System x® clusters, and on I/O nodes and disk servers.
- IBM Engineering and Scientific Software Library (ESSL/MASSV) improves application performance.
- Message Passing Interface (MPI) Library, based on MPICH2, is tuned for the Blue Gene architecture.

## Reliable, available and serviceable

Performance means nothing without availability, and Blue Gene/Q is designed with the class-leading features needed for consistent operations.

- Very stable, low temperature environment
- N+1 redundant AC-DC and DC-DC power supplies
- Spare optical link on every processor link
- Error correction on all optical links prior to CRC and retry
- Memory retry on error
- Enhanced partitioning and reduced messaging hops
- Partition blocks are isolated from other blocks, with no interference
- Isolated I/O nodes that are always on during partitioning

## HPC advances from IBM

Our experience in technical computing goes back nearly 60 years, beginning in 1953 with the IBM 701, the first commercially available scientific computer. Advancements throughout the 1960s include the IBM 360-95 "super speed" computer used at the NASA Goddard Space Flight Center. Next, we began focusing on multiple processors in a single SMP server, as well as parallel architectures. Our company changed the HPC landscape in 1993 with the introduction of the IBM RS/6000® SP, the first sustainable and viable parallel RISC machine in the industry. In 1997, we completed the IBM DEEP BLUE® project, which addressed the computation, data and algorithmic complexity that challenged the limits of the existing computing capabilities.

Recognizing that many HPC needs could be met by clusters, our company applied its extensive experience to the development and deployment of parallel UNIX machines to the Linux cluster space. Over time, the solution evolved, becoming the IBM eServer™ Cluster 1350. In 1999, IBM Research began a project to design a new supercomputer to address the challenge of protein folding, a foundational element in drug design in the life sciences field. This was the origin of the Blue Gene system, which is now in use across a broad range of applications in the scientific community.

In 2002, the IBM BladeCenter® was introduced, combining one or two processors per blade with storage and adapters in a dense package with communication networks and power built into the blade chassis. We then brought Cluster System Management (CSM) and GPFS into our portfolio.
And in 2011, IBM Watson, named after IBM founder Thomas J. Watson, became the first supercomputer contestant to play—and win—the challenging game-show Jeopardy!.

IBM continues to innovate and be a leader in HPC, extending the capabilities of its server and cluster systems while introducing new solutions and business models to address the supercomputing challenges of today.

## IBM System Blue Gene/Q at a glance

| **System configurations** | |
|---|---|
| Processor | IBM PowerPC® A2 1.6 GHz, 16 cores per node |
| Memory | 16 GB SDRAM-DDR3 per node (1333 MTps) |
| Networks | 5D Torus—40 GBps; 2.5 µsec latency<br>Collective network—part of the 5D Torus; collective logic operations supported<br>Global Barrier/Interrupt—part of 5D Torus<br>PCIe x8 Gen2 based I/O<br>1 GB Control Network— System Boot, Debug, Monitoring |
| I/O Nodes<br>(10 GbE or InfiniBand) | 16-way SMP processor; configurable in 8,16 or 32 I/O nodes per rack |
| Operating systems | Compute nodes—lightweight proprietary kernel |
| Performance | Peak performance per rack—209.7 TFlops |
| Power | Typical 80 kW per rack (estimated) 380-415, 480 VAC 3-phase; maximum 100 kW per rack;<br>4×60 amp service per rack |
| Cooling | 90 percent water cooling (18°C - 25°C, maximum 30 GPM); 10 percent air cooling |
| Acoustics | 7.9 bels |
| Dimensions | Height: 2095 mm<br>Width: 1219 mm<br>Depth: 1321 mm<br>Weight: 4500 lbs with coolant (LLNL 1 IO drawer configuration)<br>Service clearances: 914 mm on all sides |

## For more information

To learn more about the IBM System Blue Gene/Q, please visit: **ibm.com**/systems/deepcomputing/solutions/bluegene

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[1] "IBM Blue Gene/Q: The Most Energy Efficient Green Solution for High Performance Computing," Cabot Partners, June 2011.

[2] The Green500, June 2011

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