Mainframe hardware course: Mainframe's internal structure

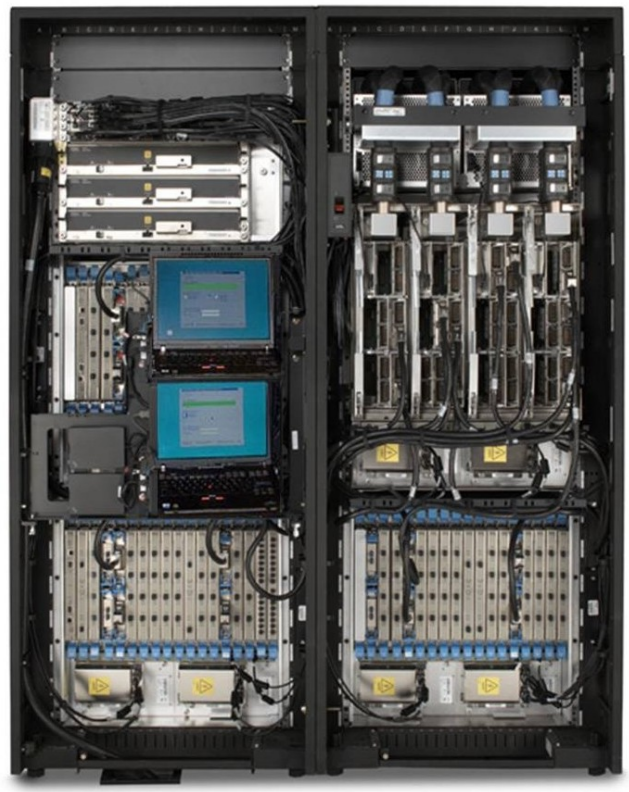
z/OS Basic Skills: The mainframe's internal structure

Mainframe's internal structure

This hardware course introduces you to one model of IBM® mainframe computer, the IBM System z9™, to help you learn about major hardware parts and their function by comparing them to hardware parts of personal computers or notebooks.

Time to complete: 15 - 20 minutes

- Introduction: Inside the System z9
- The central processor complex
- Input/output cages
- Hybrid cooling
- Power supplies and batteries
- Support elements



Introduction: Inside the System z9

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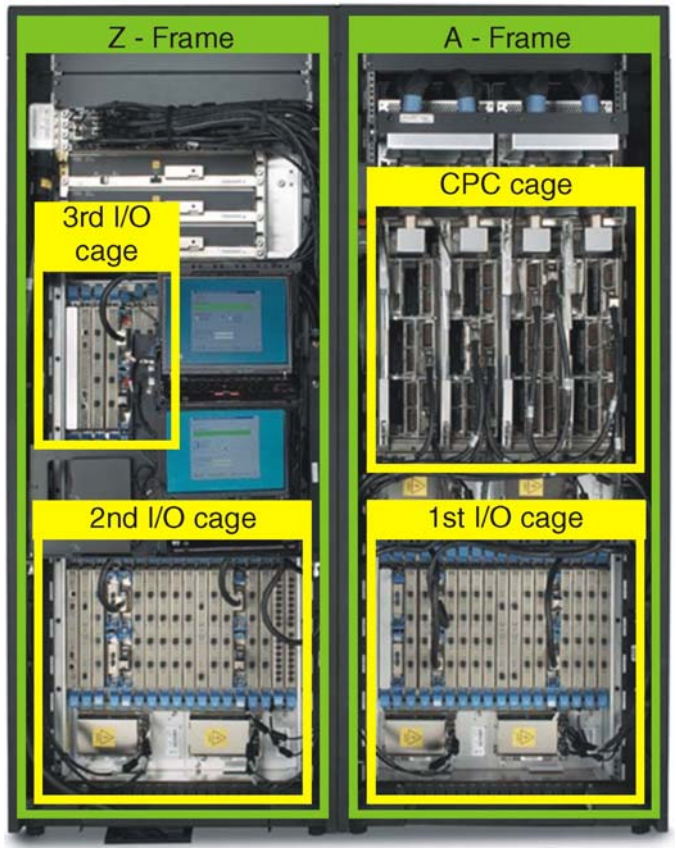
Mainframe's internal structure > Frames and cages

Under the covers, the mainframe has one or two metal frames, containing processor and input/output cages, as well as other physical elements.

This diagram shows the interior front view of an IBM System z9 Enterprise Class (z9 EC) model that has:

- Two frames
- One central processor complex, or CPC, cage
- Three input/output cages



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Mainframe's internal structure > 24x7 design

Every hardware component inside the mainframe is designed so that the z9 can operate continuously: 24 hours a day, seven days a week.

Companies use mainframes for *mission-critical* work, which usually consists of applications and data that have to be available at all times. If the mainframe goes off line and access to these applications and data is suspended or lost, companies could potentially lose millions of dollars, sometimes in a matter of minutes. Mainframes also have to run efficiently, or they become too costly for companies to operate.

Although mainframes and personal computers have similar hardware parts, you will notice big differences in the quality of parts, design, and function that allow mainframes to process work continuously. Another difference is the mainframe's ability to expand its processing resources to match fluctuating or ever-increasing workloads. These built-in functions and features contribute to IBM's goal of achieving *five 9s* availability for its mainframes. The term *five 9s* means that a system is available and running at least 99.999% of the time.

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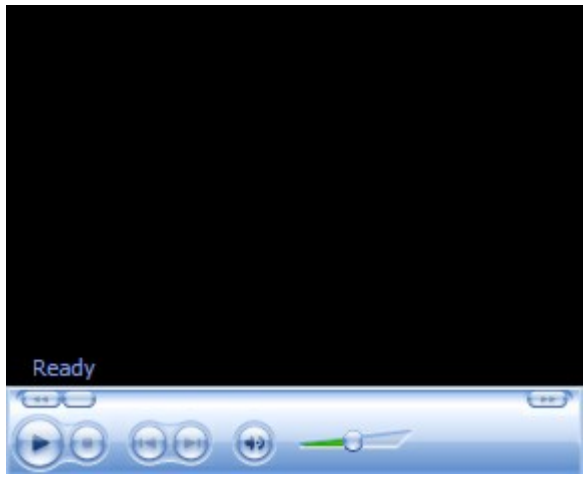
Mainframe's internal structure > Testing process

All IBM mainframes undergo a rigorous testing process before they are shipped to customer sites.

To learn more about the testing process, play this 2-minute video clip featuring Dave Anderson, a hardware expert from IBM's Customer Briefing Center team in Poughkeepsie, New York, where mainframes are designed, manufactured and tested.



The central processor complex

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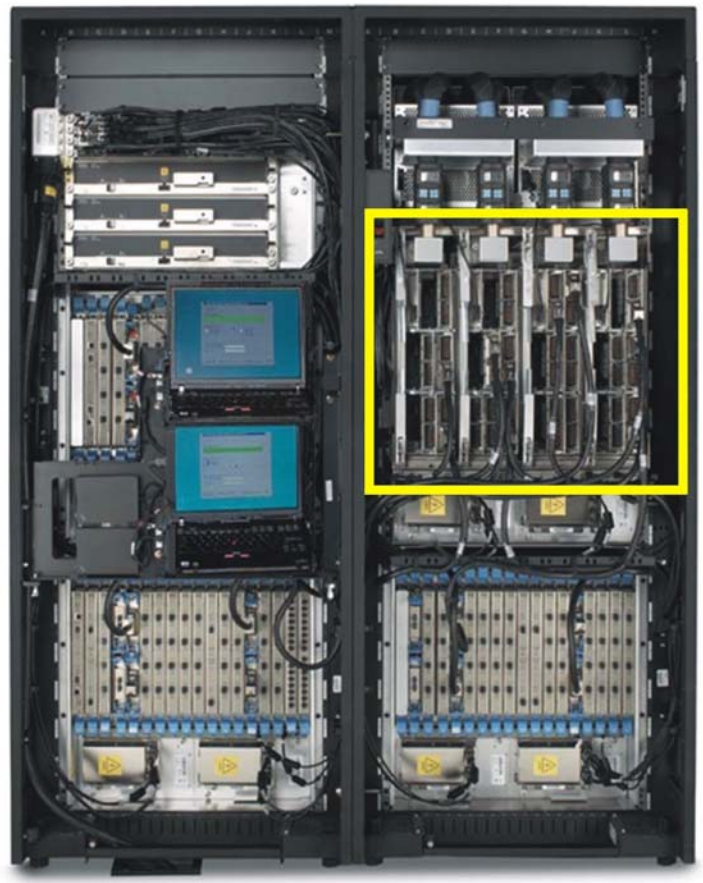
Mainframe's internal structure > Central processor complex

The central processor complex, or CPC, resides in its own cage, and consists of one to four *book packages*. Just like its personal-computer counterpart, the motherboard or system board, each book package consists of processors, memory, timers, and input/output connections.

These collections of hardware parts are called *book packages* because you can slide them in or out of the CPC cage almost as easily as you can slide a book on or off a bookshelf.



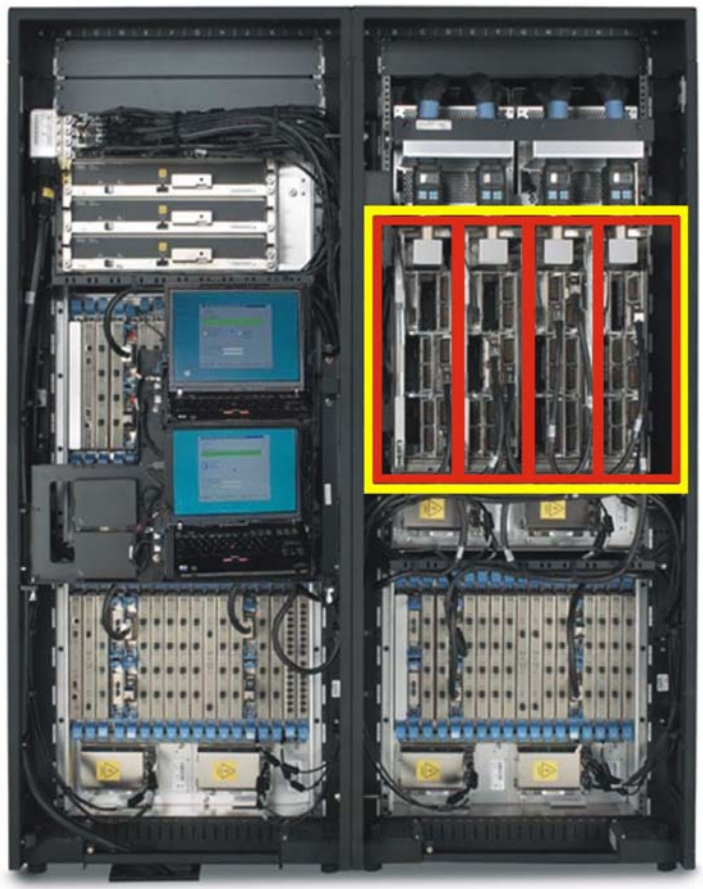
Mainframe's internal structure > Modular design

This modular packaging allows you to add or remove book packages without disrupting any work that the server is currently processing.

With System z9 models, you can *add* computing resources (processors, memory, or input/output connections) to your system at any time, without powering down the server.

You also can *replace* System z9 book packages as necessary, without powering down the server.

Having this capability is like being able to change a tire on your car while it is traveling at 70 miles (or 110 kilometers) per hour!

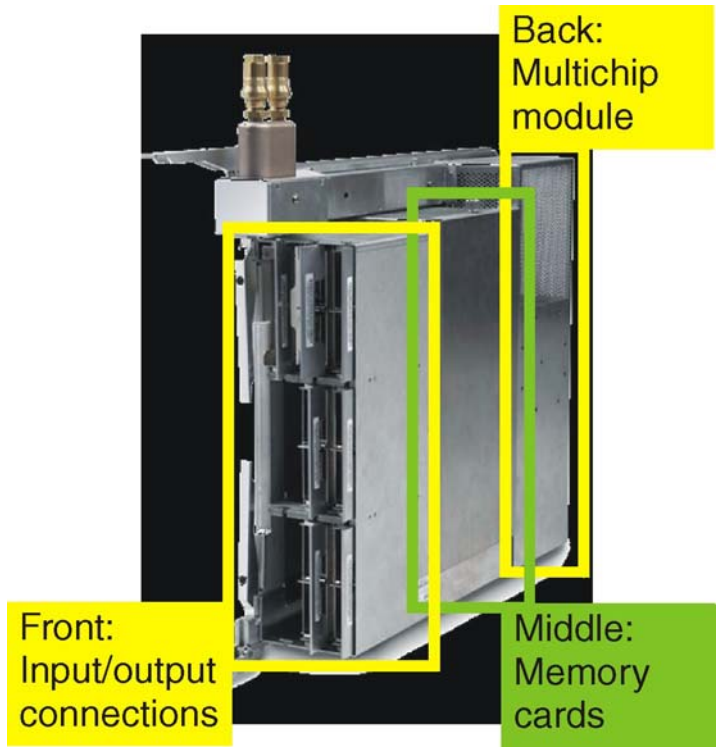


Mainframe's internal structure > Inside the book package

The book package consists of three distinct areas, one each for:

- The z9 EC's processors, which are inside one multichip module
- Memory cards
- Connections to input/output devices

All of the book packages plug into a *backplane* in the z9 EC's frame. A backplane is a circuit board that allows all connected book packages to share resources.



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Mainframe's internal structure > More about the CPC

The book package and multichip module design, as well as the design of other internal hardware, allows the z9 EC to provide continuous processing power and the capability to handle fluctuating or increasing workloads. These mainframe characteristics are known as *reliability*, *availability*, and *scalability*.

To learn more about the CPC and its contents, take the on-line hardware basics course: *The mainframe's processors*.

Input/output cages

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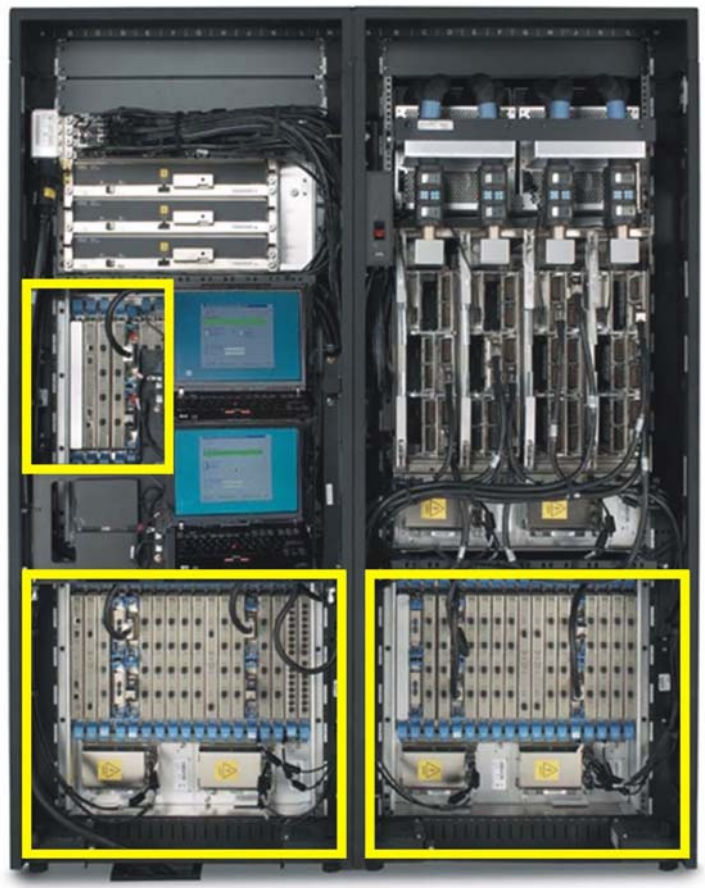
Mainframe's internal structure > Input/output subsystem

System z9 models can have up to three input/output cages, which consist primarily of slots for input/output adapters.

Together with hardware parts in the z9 EC's central processor complex, or CPC, cage and other specialized input/output equipment on the raised floor, the hardware elements in the input/output cages constitute the high-speed subsystem that provides a path between the mainframe and peripheral devices such as printers, directors, and storage units.

The capacity of this subsystem is measured by the number of available channels, which are independent pathways that transfer data.



Mainframe's internal structure > Channel types

Just as a personal computer has different types of bus adapters (for example, USB or SCSI), the z9 EC has different types of channels. Specific slots in the input/output cages are reserved for specific types of channels, which include the following:

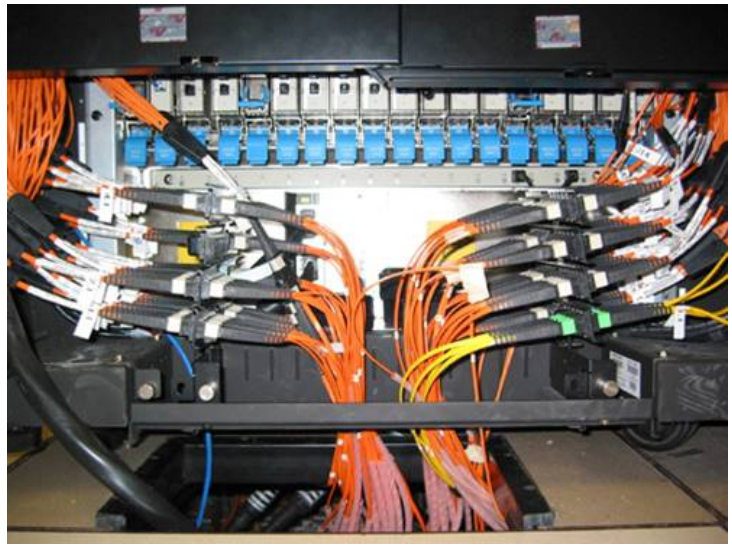
- Open Systems Adapter, or OSA Express2, which provides connectivity to various industry-standard networking technologies, including Ethernet, Token Ring, and asynchronous transfer mode (known as ATM).

- Fiber Connection, or FICON® Express2, which is the most flexible channel technology. With FICON Express2, input/output devices can be located many miles or kilometers from the z9 EC to which they are attached.

- Enterprise Systems Connection, or ESCON®, which is an earlier type of fiber-optic cabling and technology. ESCON channels can provide performance almost as fast as FICON channels.

Mainframe's internal structure > Channel characteristics

Many System z customers still use ESCON channels in their data centers. You can tell the difference between FICON (yellow) and ESCON (orange) cables in the view of cables routed from the input/output cages through the z9 EC's tailgate.



Regardless of the channel type, each z9 EC channel is an independent pathway that transfers data concurrently with other channels and the z9 EC's processors.

In contrast, the SCSI bus in a personal computer is a shared channel between all devices plugged into it. With independent channels, I/O performance on the z9 EC is significantly faster.

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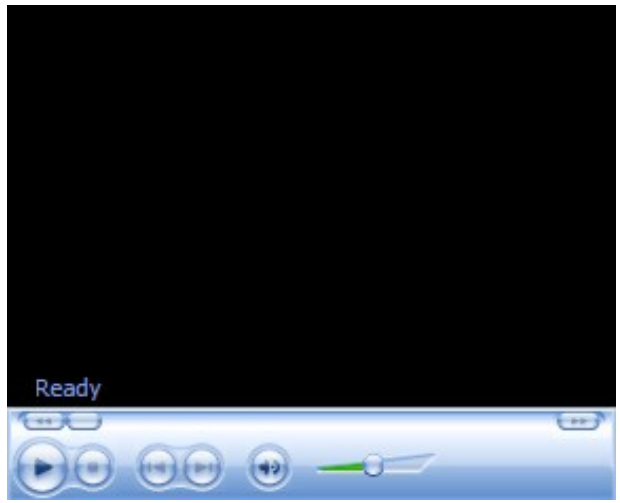
Mainframe's internal structure > Design and technology

As with other hardware elements in the z9 EC, the input/output cage provides built-in redundancy; that is, the cages are designed to contain several identical functional units to prevent any interruptions in processing because of hardware failures.

To learn more about FICON technology and other facts about z9 EC input/output capabilities, play this 1-minute video clip featuring Dave Anderson, a hardware expert from IBM's Customer Briefing Center team in Poughkeepsie, New York, where mainframes are designed, manufactured and tested.



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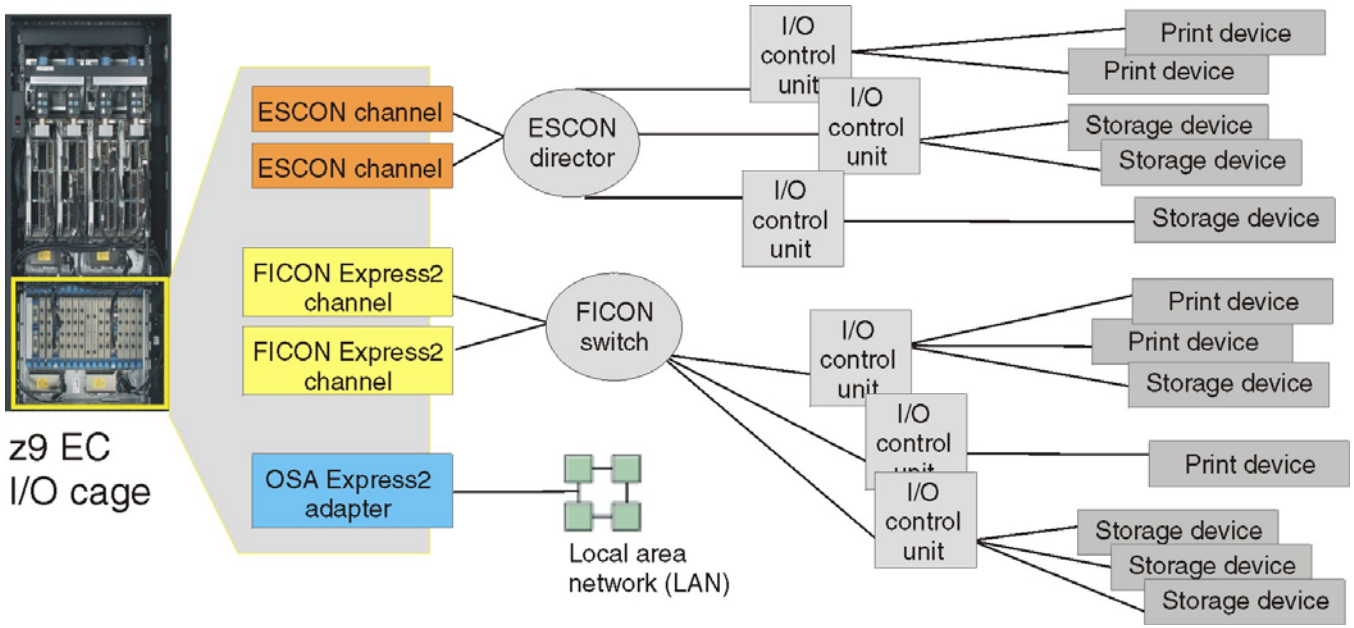
Mainframe's internal structure > Input/output capacity

Personal computers typically have a limited number of channels for input/output, but a single z9 EC can have up to 1 024 individual channels. This capacity is one factor that contributes to the mainframe's legendary scalability. This diagram is a high-level conceptual map of input/output hardware in the mainframe environment, which shows how the z9 EC can be connected to many devices:



Mainframe's internal structure > Input/output superhighway

The scale of mainframe input/output capacity is difficult to imagine… The number of potential devices is great enough that mainframes often use several input/output control units to offload some of the input/output processing. These control units are actually small computers that run software programs to transfer data back and forth.

To get a better idea of the mainframe's input/output capacity, just compare the connections for your personal computer to these views of typical collections of cables and switches in patch panels on the raised floor.

Close-up of FICON cables in a patch panel

Patch panel with FICON (yellow) and ESCON (orange) cables

Hybrid cooling

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Mainframe's internal structure > Internal cooling system

Mainframes rely on both internal and external cooling systems. The z9 EC has an internal cooling system that uses both air and liquid to keep its internal temperature low. The z9 EC uses liquid to cool only the processor chips; all other hardware parts, even within the book package, are cooled by air.

For the liquid cooling, the z9 EC uses the same coolant found in most of the automobiles made today. This hybrid cooling system keeps the z9 EC's processing chips at the lowest temperature in the industry. Low temperature means better performance and great reliability.

In a personal computer, a CPU heat sink draws heat off the processor; an internal fan forces cool air across the heat sink, and forces hot air out of the computer case. Similarly, the z9 EC has a heat sink and a sophisticated arrangement of fans to circulate air through the frame. Sensors in the cooling system monitor and control fan speeds to maintain the internal temperature within its optimum range.

Mainframe's internal structure > External cooling system

A typical customer site has a large area of building space, called the *data center* or *raised floor*, that is devoted to housing mainframes and other computing equipment. As you might imagine, a bank of mainframes blowing air out into the raised floor can make even a large room hot, so raised floor areas require air-conditioning to dissipate the excess heat.

The raised floor and the crawl space below it are both cooled with powerful air-conditioning, and air from the crawl space keeps the mainframe cool internally as well.

When a mainframe is positioned on the raised floor, the solid floor tiles on that spot are replaced with perforated tiles; some of the openings in the tiles are for cabling to be routed from the mainframe into the crawl space, but other perforations allow cool air from the crawlspace to blow up inside the frame.

Power supplies and batteries

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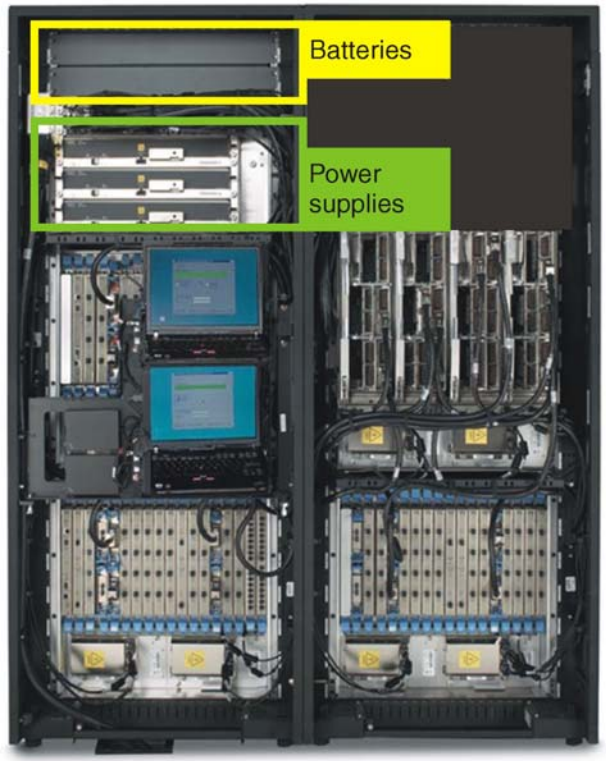
Mainframe's internal structure > Powering the mainframe

Personal computers and notebooks use power supplies and batteries for their operation; the z9 EC also has power supplies and batteries that provide similar functions.

A key difference in the z9 EC is the redundancy that is required for a state-of-the-art mainframe system to provide continuous availability. *Redundancy* is the use of several identical functional units to prevent any interruptions in processing because of hardware failures.

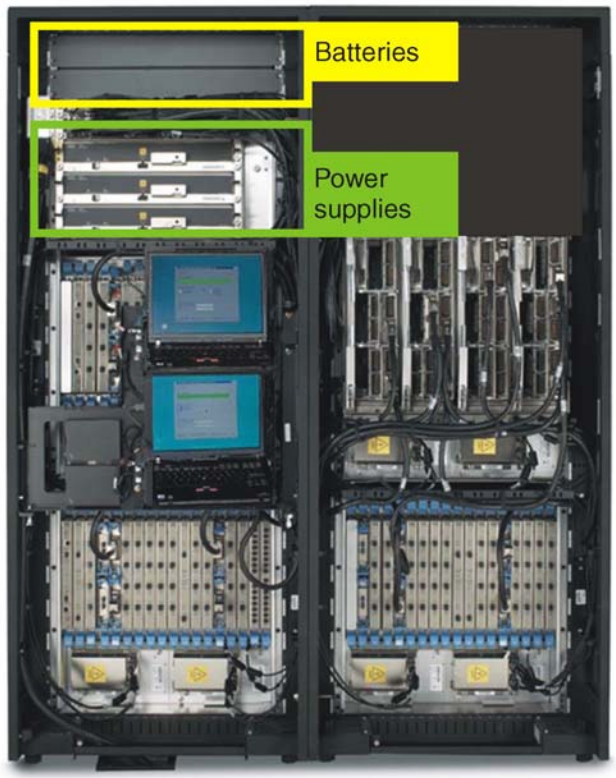
In the z9 EC, two internal bulk power units provide power from an external source; the electrical current is delivered through two independent cables attached to the power units. These power units are designed so that the z9 EC can continue to operate even if one of the units fails.



Mainframe's internal structure > Power supply and battery design

The power units also are designed to work with the internal batteries in such a way that, if the power supply from the external source is interrupted, the z9 EC can switch from the power units to internal batteries without any loss of work.

The z9 EC also has subsidiary power units in the central processor complex cage and the input/output cages. These subsidiary units provide independent power so that, for example, one book package can be removed from the central processor complex cage without shutting down power to the other book packages.



Support elements

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Mainframe's internal structure > Support elements

The z9 EC has two support elements that constitute part of the hardware control system for the mainframe. These support elements are Lenovo™ ThinkPads™ that are used primarily by IBM customer engineers (known as CEs), who install, start and service mainframes on the raised floor.

Customers use a standard Web browser to access the Hardware Master Console, or HMC, which is used to operate and monitor the z9 EC. Like the support elements, HMCs also may be ThinkPads or another type of computer.

Mainframe's internal structure > Hardware control system

The two support elements on the z9 EC constitute only part of the mainframe's hardware control system. The other elements of this control system include:

- Flexible support processors, which are IBM microprocessors located inside each power supply, each book package, and each input/output cage in the z9 EC's frames.

- Two internal Ethernet® local area networks, or LANs, which connect the support elements to all of the flexible support processors. The z9 EC has two internal LANs and two support elements for redundancy; if one LAN or support element fails, the hardware control system can be dynamically switched over to the backup LAN or support element.

- An external Ethernet LAN, which connects both of the z9 EC's support elements to one or more Hardware Master Consoles, or HMCs, through which customers operate and monitor the z9 EC.

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