Part I: Overview
Chapter 1: Introduction

A journey into the wonderland of DB2

DB2 for z/OS Fundamentals

This fundamental course provides you with basic knowledge to work with DB2 for z/OS. Upon Completion of this course, you will be able to:

Identify DB2 components, understand DB2 architecture and the mechanism behind the scenes.

Describe the system environment of DB2, understand how DB2 cooperates with other facilities to provide the functionalities.

Develop applications with DB2 as data server.

Understand the performance issues and know how to manage them.

State basic DB2 management issues.

Understand the new challenges in today's data management world, and DB2's solution to them.

This course prepares you for further studies on:

DB2 Optimization

DB2 System Administration

DB2 Application Development

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DB2 for z/OS Fundamentals

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What is DB2?

John Godfrey Saxe's (1816-1887) version of the famous Indian legend: The Blind Men and the Elephant
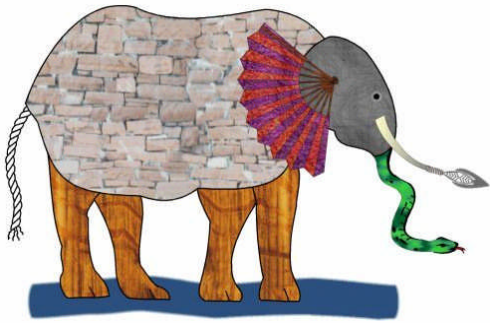
It was six men of Indostan,
To learning much inclined,
Who went to see the Elephant
(Though all of them were blind),
That each by observation
Might satisfy his mind.

The First approach'd the Elephant,
And happening to fall
Against his broad and sturdy side,
At once began to bawl:
"God bless me! but the Elephant
Is very like a wall!"

The Second, feeling of the tusk,
Cried, -"Ho! what have we here
So very round and smooth and sharp?
To me 'tis mighty clear,
This wonder of an Elephant
Is very like a spear!"

The *Third* approach'd the animal,
And happening to take
The squirming trunk within his hands,
Thus boldly up and spake:
"I see," -quoth he- "the Elephant
Is very like a snake!"

The *Fourth* reached out an eager hand,
And felt about the knee:
"What most this wondrous beast is like
Is mighty plain," -quoth he,-
"'Tis clear enough the Elephant
Is very like a tree!"

The *Fifth*, who chanced to touch the ear,
Said- "E'en the blindest man
Can tell what this resembles most;
Deny the fact who can,
This marvel of an Elephant
Is very like a fan!"

The *Sixth* no sooner had begun
About the beast to grope,
Then, seizing on the swinging tail
That fell within his scope,
"I see," -quoth he,- "the Elephant
Is very like a rope!"

And so these men of Indostan
Disputed loud and long,
Each in his own opinion
Exceeding stiff and strong,
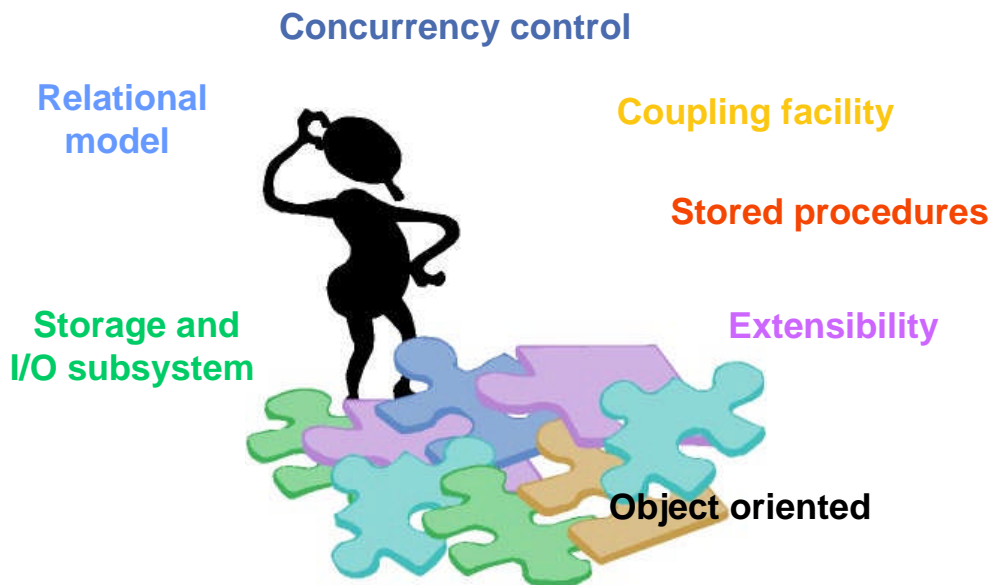Though each was partly in the right,
And all were in the wrong!

So, oft in theologic wars
The disputants, I ween,
Rail on in utter ignorance
Of what each other mean;
And prate about an Elephant
Not one of them has seen!

DB2 for z/OS Fundamentals

Where to Start?

Concurrency control

Relational model

Coupling facility

Stored procedures

Storage and I/O subsystem

Extensibility

Object oriented

We can easily be caught in the same situation as the blind men in the ancient Indian legend, when we're trying to understand something really complex and huge, like DB2.

Course Objective

- Identify DB2® components, and understand the DB2 architecture
- Describe the DB2 system environment
- Develop DB2 applications
- Understand DB2 performance
- State basic DB2 management issues
- Know the DB2 future and trends
- Preparation for more advanced courses

DB2 for z/OS Fundamentals

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DB2 System Administration

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Chapter 1:
DB2 for z/OS® Overview

DB2 for z/OS Fundamentals

Chapter 1: Objectives

- **Understand scenarios of using DB2 in the industry**
- **Understand the features of DB2**
- **Know the history and milestones of DB2**
- **Describe the environment of DB2 and the different ways to access it within the z/OS operating system**

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DB2 for z/OS Fundamentals

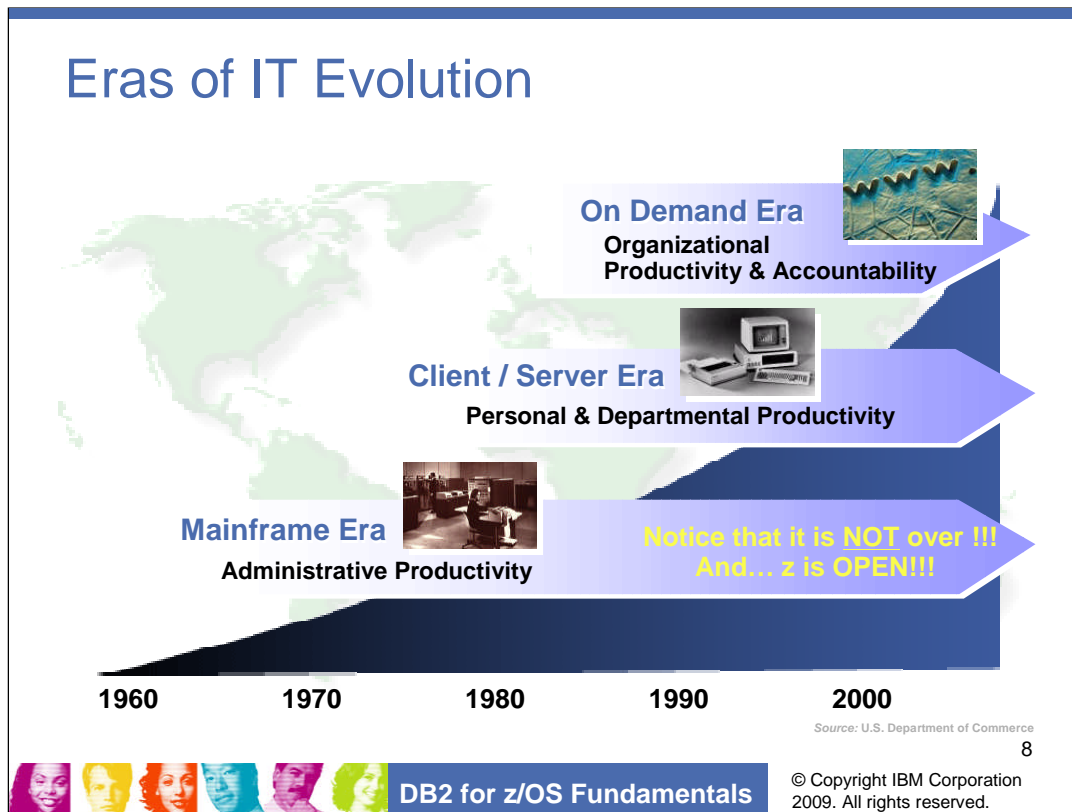Upon completion of this chapter, you'll be able to:

Think about some scenarios where DB2 manages the most important data in organizations

Understand why the most demanding businesses unanimously chose DB2 to host their critical data

Know the DB2 history and milestones

Understand the different ways for users to access DB2

Access DB2 from your own workstation by following the demos

Eras of IT Evolution

On Demand Era
Organizational Productivity & Accountability

Client / Server Era
Personal & Departmental Productivity

Mainframe Era
Administrative Productivity

Notice that it is NOT over !!! And… z is OPEN!!!

1960   1970   1980   1990   2000

Source: U.S. Department of Commerce

DB2 for z/OS Fundamentals

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We cannot talk about DB2 for z/OS without mentioning the legendary mainframe, and we have to trace back to the earlier stages of IT automation, which is called the 'Mainframe Era."

Mainframe was a wonderful technology for automating the back office. The focus was commercial processing. It penetrated what it did really well, and wasn't designed to do things like plant floor manufacturing, or departmental computing, or personal computing. Mainframe was designed for the enterprise.

So another style of computing, called "client-server" was invented to provide much greater flexibility, but which also created lots of islands of automation. Connecting those islands costs IT organizations, according to Gartner, roughly 42 percent of their IT budgets – just to make "stuff work with stuff" in the "Client/Server Era."

That's an hangover in our industry which "On Demand" needs to deal with.

The rise of the Internet and the open, standard-based, widely available and accessible networking of the Internet brought about the "e-business" boom and also provides the foundation for the "On Demand Era". The "On Demand Era" will require developing the standards, openness and interoperability, which will allow computing to move into the network.

Please note, the emerging of the new eras does not replace the old ones. The Mainframe era is not over, it's open, and is vigorous to face new challenges.

Mainframe – Legend Never Ends

- 1964: IBM® System/360™
- Obsolete? New trend? – Longevity!
- Trusted for mission-critical data
- Capability to maintain both old and new applications
- SOA (Service-Oriented Architecture) enabled
- z/OS – Most widely used mainframe operating system
- DB2 for z/OS – IBM's mainframe relational database management system

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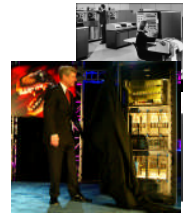
The history of mainframe can be traced back to 1964, when IBM System/360 was introduced.

It seems the mainframe is not made for spotlight, it is generally invisible to public eyes since its early days. Few people know it today. Though it also underwent upheavals and was once labeled 'obsolete', it turns out, even today, the mainframe computers are playing a central role in the daily operation of most of the world's largest corporations; the mainframe is still a trusted choice to host their mission-critical data.

The popularity and longevity of the mainframe is due to the high reliability and stability it has always demonstrated, more over, it's a result of continuous technological advances since the invention day.

Over many years the mainframe has made continuous and evolutionary changes, while maintaining compatibility with existing application.

With all the innovations and advances in technology, the new mainframe demonstrates incredible strength in SOA environment. The new mainframe, which are labeled zSeries, are often referred to as System z.

Several operating systems are currently available for the mainframes. z/OS is the new name, and mostly widely in use.

DB2 is IBM's mainframe relational data management system, with most complete System z integration and exploitation.

DB2 in the Industry

- Financial services
  - Banking
  - Brokerages
  - Stock exchanges
- Insurance providers
- Transportation
- Manufacturing

- Retail
- Government
- Education
- Healthcare
- More…

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A good point to start observing is to see what challenges the real life organizations are requesting and how DB2 continuously answers that..

An international bank that provides uninterrupted services to its customers 24 hours a day.

The volume of trading that goes on at the major stock exchanges can reach over one billion shares in a single day.

A brokerage company might have a network of thousands of financial advisors and hundreds of thousands of customers who need online access to highly sensitive financial information daily.

A transportation company might deliver more than 10 million packages in a single day. Each package requires several steps in the delivery process, such as pick up, transit points, and final delivery. The status of the package can be shown to customers on the Web.

A healthcare company shall provide services to large geographic region.

These are companies that process very high volumes of transactions that require millions of concurrent updates everyday. They require very high availability and scalability and have very low tolerance of failure.

Another common characteristic in each situation is that DB2 is a key ingredient in the data processing environment of each organization.

Facts and Figures

- *Used by…*
  - The top 56 banks in the world
  - 23 of the top 25 U.S. retailers
  - 9 of the top 10 global life/health insurance providers
- *Performance, Performance, Performance*
  - Delivered the largest banking benchmark ever at the Bank of China, a record 9,445 transactions per second
  - Supports the world's largest known peak database workload - 1.1 billion SQL statements per hour at UPS
  - The world's largest known transaction processing database – 23.1 TB at UK Land Registry

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DB2 for z/OS Fundamentals

Figures can usually explain more.

Note the amazing data volume Bank of China is processing on DB2. for the Online Workload Scalability: The customer's original goal was 4,100 transactions per second according to their anticipated transaction volume. The benchmark reached this goal easily, in the established application in BOA, it has 380 million client accounts, 34 million transactions per hour, and 9,445 transactions per second.

Application on IBM mainframe redefines **transaction processing performance** in the **banking industry**.

Why DB2 for z/OS

- Where the data is kept is vital to the business

- OLTP (Online Transaction Processing) performance
- Reliability
- Availability
- Security
- Serviceability

>>>>The Choice of demanding businesses

DB2 for z/OS Fundamentals

Where data is kept is vital to the businesses.

•The following statements quoted from 'IBM Strengthens the Mainframe as a Premier Data Platform With Plans for Breakthrough Processor ' by IBM

When users centralize their data on the mainframe, they may decrease the risks associated with having multiple copies of data across diverse systems. Audit, compliance, control and business recovery may be easier to manage when there is a single copy of the data.

For many years, DB2 for z/OS has been striving to meet the challenges of the demanding needs from its customers, and has always been known for its leading OLTP performance and capabilities, and for its reliability and availability to support mission-critical business operations. Let's examine the DB2 evolution with a brief review of DB2 history.

DB: In the Early Days

- File system

- Relational model
  - Landmark paper by Ted Codd, 1970
  - IBM System R ➔ DB2
  - Invention of SQL (Structured Query Language)

DB2 for z/OS Fundamentals

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The invention of 'Relational Model' is marked with a paper by Ted Codd in the year 1970. Ted was then an IBM researcher. In his famous paper, 'A Relational Model of Data for Large Shared Data Banks', Ted describes the data model as:

Independence of Data from the Hardware and Storage Implementation

It allows automatic navigation to the data set, and supports a high level nonprocedural language for data access (Record => Set)

Pointers => keys (primary, secondary)

Theoretical proposal, no practical design or implementation

The relational model is simple but provides powerful logical constructs for ensuring data integrity, providing the ease to modify the data schema, improves the productivity of application programmers and database administrators.

Based on the Relational Data Model, A team of IBM Researchers started building System/R, which becomes DB2, and Structured English Query Language, which becomes Structured Query Language (SQL).

The Evolution of DB2 for z/OS – Part 1
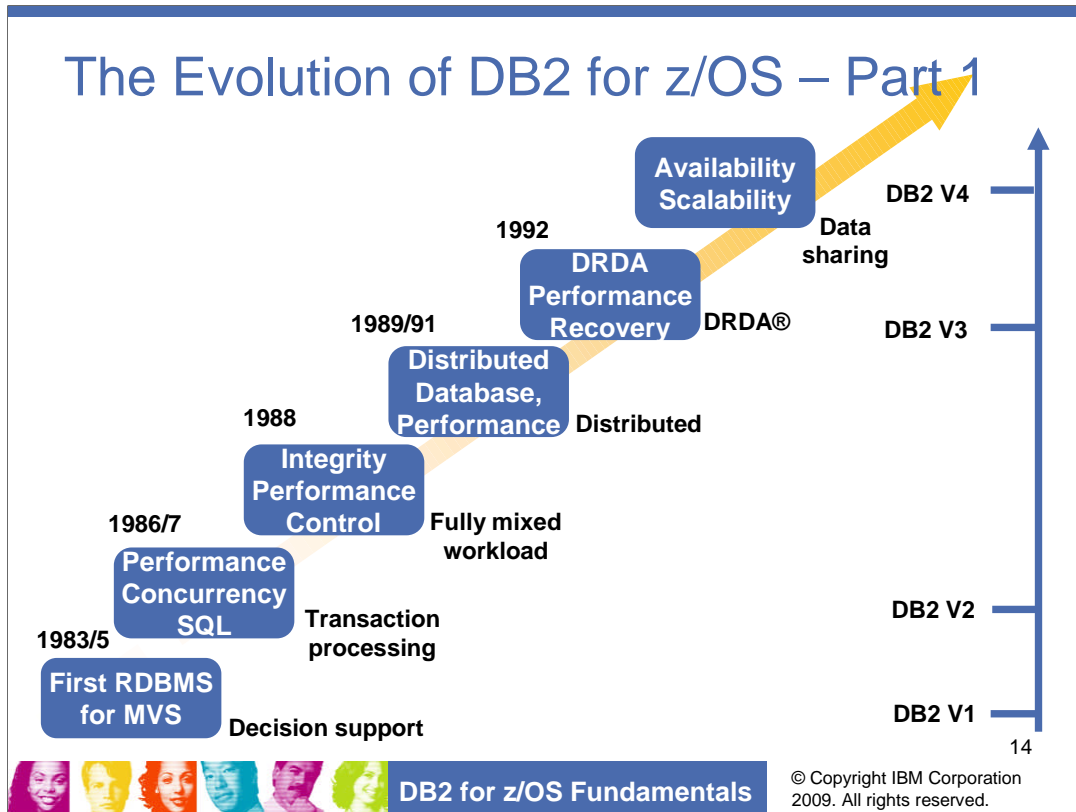
This chart shows the evolution and milestones of DB2 for z/OS.

DB2 is developed from System R.

Over the years the advancing of mainframe technology, and the demanding needs of customers have driven numerous innovations of DB2. In the same way, DB2 has also driven numerous enhancements on the mainframe.
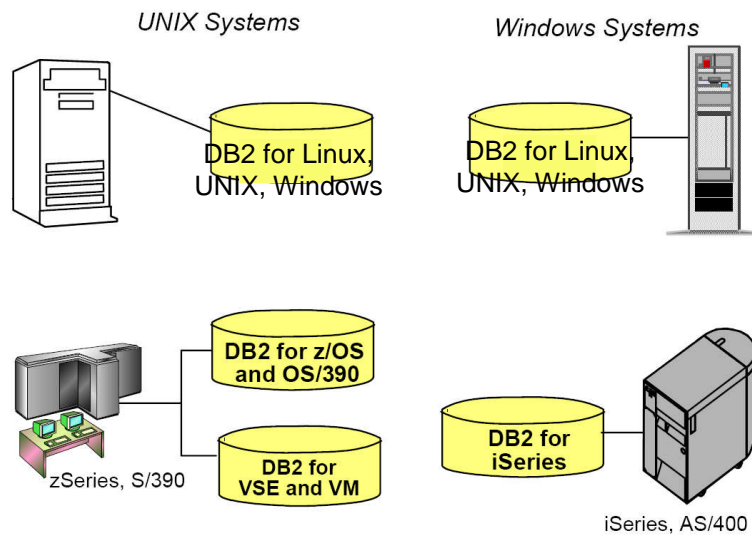
The Evolution of DB2 for z/OS – Part 2

On-going themes:
Performance, Scalability
Reliability, Availability, Serviceability,
Security, Productivity,
Application development,
SQL, XML, SOA

1995 — Scalable Performance
1997 — Networking Utility Performance
1999 — Manageability Reliability Universality
2001 — DRDA Performance recovery
2004
2007 — Availability Scalability Unicode

DB2 V5
DB2 V6
DB2 V7
DB2 V8
DB2 9

Parallel processing
Enterprise Server
Universal Server
Exploitation of environment
Powered for z
data definition on demand
pureXML tm

DB2 for z/OS Fundamentals

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The themes for future versions will continue to focus on core platform strengths of performance, scalability, reliability, stability, availability, resilience, and security.

Standards, interoperability, portability and security along with secure access using the latest technologies are key touch points. Productivity improvements for application developers and for database administrators are very important as data grows in scale and complexity.

DB2 is the first relational database to store XML "natively". business intelligence/data warehousing-related improvements, more self-tuning and self-managing features, additional 64-bit exploitation, stored procedure performance enhancements for z/OS, and continued convergence of the SQL vocabularies

The net result is the reduction of total **cost of ownership**.

DB2 UDB Family

UNIX Systems

Windows Systems

DB2 for Linux, UNIX, Windows

DB2 for Linux, UNIX, Windows

DB2 for z/OS and OS/390

DB2 for VSE and VM

DB2 for iSeries

zSeries, S/390

iSeries, AS/400

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[PubIntro: p3]

In this course, we'll only focuses on DB2 for z/OS, however, as a student of DB2, you should know that there are more DB2 products other than DB2 for z/OS

Different versions and editions of DB2 are running on devices ranging from handhelds to mainframes, and supported by operating systems including Linux, UNIX, Windows, i5/OS, and z/OS with the following products:

DB2 for z/OS

DB2 for i5/OS

DB2 Database for Linux, UNIX, and Windows

DB2 for Linux on System z9

Different DB2 family products have different underlying code that exploits the individual capability of the various operating systems. However, they encompass characteristics like compatible data types, open standards, supporting same SQL and similar functions etc, making the upgrading within DB2 family relatively easy.

DB2 for z/OS Features Overview

- 64-bit storage
- High-speed communication
- Dynamic workload management
- Processor improvements
- Trusted data platform
- SQL enhancements
- Open software technology
- DB2 in a Parallel Sysplex® environment

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DB2 for z/OS Fundamentals

[PubIntro, chapter 3: DB2 for z/OS architecture]

What strength does DB2 possess to encompass all these demands? Let's look into it by examining DB2 features in the following slides.

The tight integration that DB2 has with the System z architecture and the z/OS environment creates a synergy that allows DB2 to **exploit advanced z/OS function**. DB2 gains a tremendous benefit from z/ Architecture. The architecture of DB2 for z/OS takes advantage of the key z/ Architecture.

DB2 Features (cont.)

- 64-bit storage
- Increased central memory capacity
  - Performance improved
  - Availability and scalability improved
- High-speed communication
  - Communication across partitions of the same zSeries® Server
- Dynamic workload management
  - Intelligent Resource Director (IRD)
  - Workload Manager (WLM)
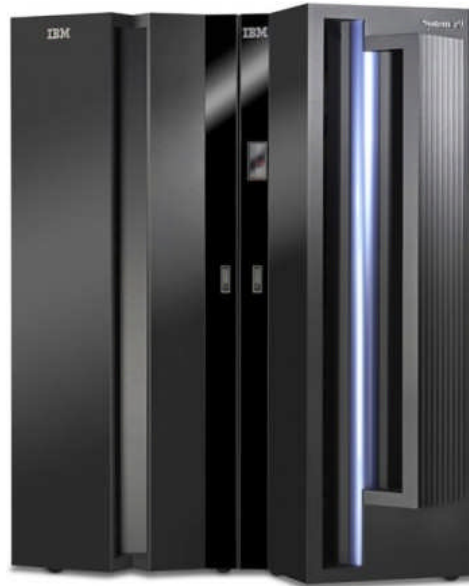
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DB2 for z/OS Fundamentals

[PubIntro, Chapter 3: DB2 for z/OS architecture]

Increased capacity of central memory from 2 GB to 64 GB eliminates most storage constraints. 64-bit storage means 16 exabytes of virtual address space, a huge step in the continuing evolution of increased virtual storage. In addition to improving DB2 performance, 64-bit storage improves availability and scalability, and it simplifies storage management.

HiperSockets™ enable high-speed TCP/IP communication across partitions of the same zSeries server, for example, between Linux for zSeries and DB2 for z/OS.

The storage manager of the z/OS architecture, Intelligent Resource Director (IRD), expands the capabilities of the Workload Manager (WLM) by managing resources dynamically based on workload priorities

DB2 Features (cont.)

- **Processor improvements**
  - System z9® Integrated Information Processor (zIIP)
- **Trusted data platform**
  - Safe data environment secured by zSeries and z/OS
  - Privacy, integrity, and isolation
  - Network and transaction security
- **Most complete System z™ integration and exploitation**
  - Cooperation with major subsystems
  - Cooperation with major software vendors
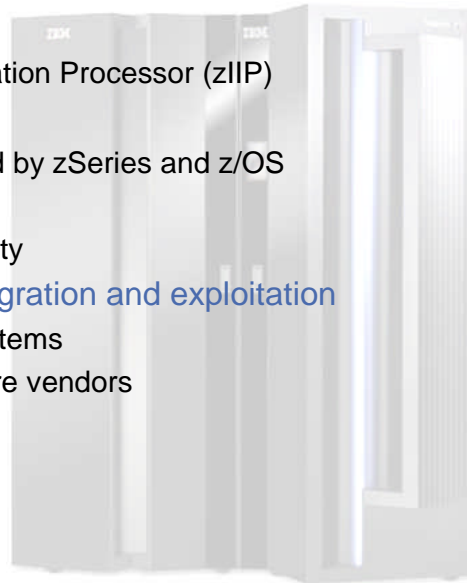
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DB2 for z/OS Fundamentals

[PubIntro, Chapter 3: DB2 for z/OS architecture]

The System z9 Integrated Information Processor (zIIP) is a specialty engine. It is especially designed for running eligible workloads and helps to free up the general processors, hence lowers software costs on workloads selection.

The legendary mainframe and its operating systems have provided robust security for decades. Security features deliver privacy for users, applications, and data, and these features protect the integrity and isolation of running processes. Current security functions have evolved to include comprehensive network and transaction security that operates with many other operating systems. Enhancements to the z/OS Security Server provide improved security options, such as multilevel security. The System z9 environment offers highly secure cryptographic functions and provides improved Secure Sockets Layer (SSL) performance

DB2 Features (cont.)

- SQL enhancements
  - New data types
  - New built-in functions
  - Easier to migrate to
- Open software technology
  - Latest software technology support
  - Enterprise JavaBeans™, XML, Unicode
  - Service Oriented Architecture (SOA)
- DB2 Query Management Facility (QMF™)
  - Improved ability to distribute reporting information

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DB2 for z/OS Fundamentals

[PubIntro: Chapter 1]

DB2 has a rich SQL support, including new data types for decimal floating point and spatial data, and new built in functions provide better compatibility within the DB2 family products and throughout the industry. Data moved to z/OS from other platforms has become easier.

Query Management Facility (QMF) is a tightly integrated, powerful, and reliable query and reporting tool set for the DB2 database.

DB2 QMF exponentially increases the ability to distribute reporting information through a WebSphere component.

DB2 Features (cont.)

- DB2 in a Parallel Sysplex environment
  - Concept: Parallel Sysplex clustering
  - Increase availability without disruption
  - Grow data capacity without impacting performance
- Solution to business merge and acquisition

z/OS DB2

z/OS DB2 User Data **DB2 Catalog** User Data **z/OS** DB2
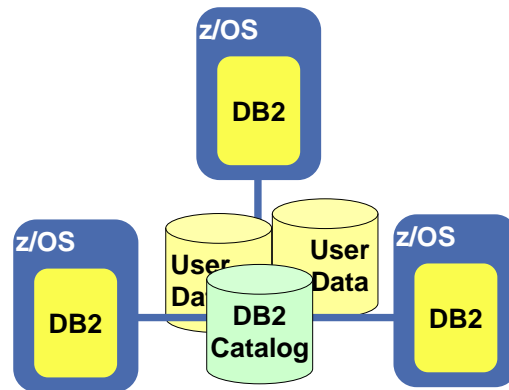
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[PubIntro, Chapter 1-3]

Parallel Sysplex clustering technology in DB2 is the answer to availability and scalability. A *Parallel Sysplex* is a *cluster*, or complex, of z/OS systems that work together to handle multiple transactions and applications. This technology implements a data sharing design.

The DB2 data sharing design gives businesses the ability to add new DB2 subsystems into a data sharing group, or cluster, as the need arises and without disruption. As applications run on more than one DB2 subsystem, they can read from and write to the same set of shared data concurrently.

The Parallel Sysplex can grow incrementally without sacrificing performance. Parallel Sysplex architecture is designed to integrate up to 32 systems in one cluster. In a shared-disk cluster, each system is a member of the cluster and has access to shared data.

An integral component of a Parallel Sysplex is the *coupling facility*, a mechanism that coordinates transactions between the different members within a cluster. Other solutions attempt to implement similar capabilities through software, but messaging by using software can cause high overhead and directly impact the ability to scale and perform.

When Parallel Sysplex technology is used, the applications from each bank can easily be integrated into a data sharing group and can access shared data.

DB2 Features (cont.)

- Reduced TCO (total cost of ownership)
  - Measurement of direct and indirect costs related to software and hardware (from Wikipedia)
  - Reduced maintenance cost, hardware-software-operating system synergy
  - Improved value

DB2 for z/OS Fundamentals

[PubIntro, Chapter 1]

The net result is the reduction of total **cost of ownership.**

•Following statements are quoted from Wikipedia:
'http://en.wikipedia.org/wiki/Total_cost_of_ownership'

Total cost of ownership (TCO) is a financial estimate designed to help consumers and enterprise managers assess direct and indirect costs commonly related to software or hardware. It is a form of full cost accounting.

Reduced people costs and hardware-software-operating system synergy ensure more resilience, better function, and improved value in DB2 for z/OS:
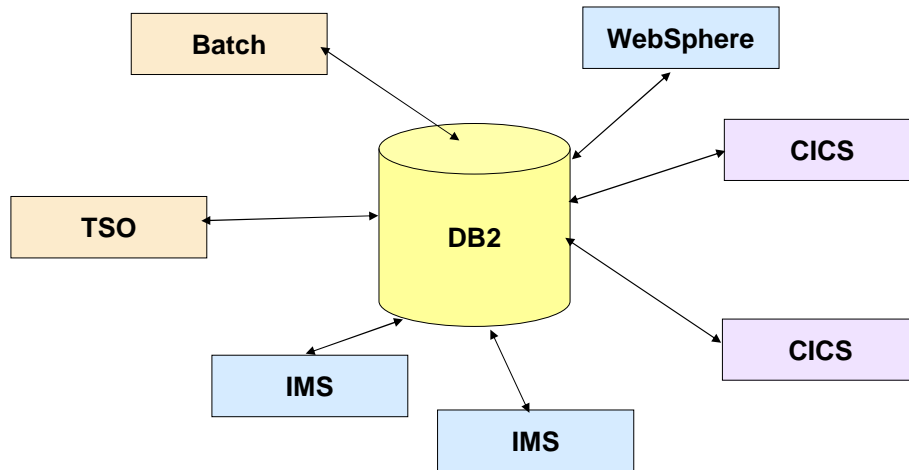
DB2 operates as a formal subsystem of z/OS, A subsystem is a secondary or subordinate system that is usually capable of operating independently.

DB2 works efficiently with other z/OS subsystems and components. Key components include z/OS Security Server and zSeries Parallel environment.

DB2 is with other environment with attachment facilities as interfaces. You can begin sessions from other environments on clients such as Windows or UNIX by using interfaces that include ODBC, JDBC and SQLJ. With attachment facilities, DB2 cooperate with CICS, IMS, WebSphere, and TSO.

The System's View
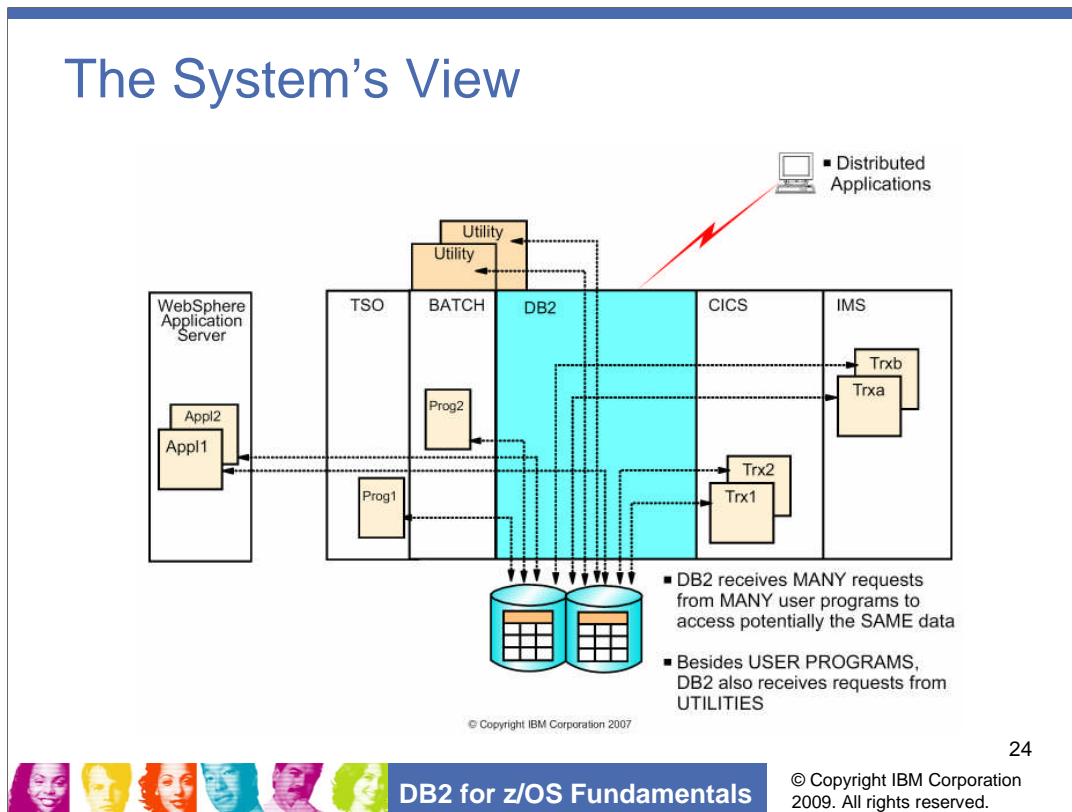
[CF83: 1-11]

There are many different ways that DB2 data can be accessed concurrently such as:

• User written applications

• SQL statements that users key in dynamically

• DB2 Utilities

A distributed environment enables applications to access data on different DB2 systems located at, say, different sites in a network.

 Distributed data is data that resides on a DB2 system other than your local DB2 system. Your local DB2 system is the one on which you bind (see later). All other DB2 systems are remote.

When you request services from a remote DB2 system, the remote DB2 system is a server and your local DB2 system is a requester or client. A remote server can be many miles away or it can run under the same operating system as the local client. The remote server can be another DB2 for z/OS system or another member of the DB2 Family.

Dynamic SQL Example

ACCT_NO	CUST_NO	CUST_NAME	BALANCE	ACCT_STS
0110032483	0242148148	JOE SMITH	352.52	A
0324312423	0823573821	ANNA FENG	23100.32	A
0359283713	0382503923	JOSEPH T SWAN	**5432.52**	D
0923758325	0385920350	MICHAEL LAWREN	9285.22	I

Table: ACCT

SELECT BALANCE FROM ACCOUNT WHERE ACCT_NO = '0359283713'

Result: 5432.52

QMF / SPUFI

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DB2 for z/OS Fundamentals

[CF83: 1-6]

You can code and executing SQL in **SPUFI** (SQL Processing Using File Input) from TSO interactively.

User Applications

ACCT_NO	CUST_NO	CUST_NAME	BALANCE	ACCT_STS
0110032483	0242148148	JOE SMITH	352.52	A
0324312423	0823573821	ANNA FENG	23100.32	A
0359283713	0382503923	JOSEPH T SWAN	**5432.52**	D
0923758325	0385920350	MICHAEL LAWREN	9285.22	I

Table: ACCT

SELECT BALANCE FROM
ACCOUNT WHERE
ACCT_NO = :ACCT_NO

Applications

Put
Get
Move
execute
Put

IMS, VSAM, etc

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DB2 for z/OS Fundamentals
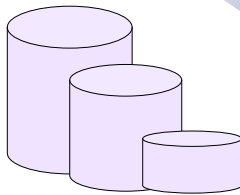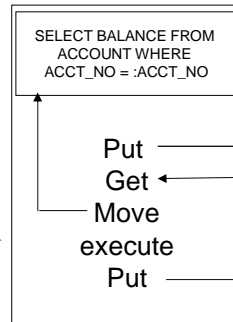
[CF83, 1-7]

A major responsibility of any program is to group its statements in **Logical Units of Work** (LUW).

User written programs and applications contains SQL statements. The statements are interpreted by DB2 into access paths, executed and return the result set to the users.

Programming Interfaces

- Developer communities
  - COBOL, PL/I, C, C++,
  - REXX™, APL2®, Assembler, Fortran
  - Java™ (JDBC / SQLJ)
  - .NET (C#, VB .NET)
  - PHP
  - Perl
  - Python
  - Ruby on Rails
  - Toad for DB2
  - …
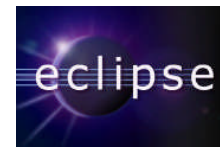
DB2 for z/OS Fundamentals

DB2 for z/OS handles many more languages than most people think. There are many different interfaces used for the languages to fit the style appropriate to the language. This is a complete list of languages supported by DB2 for z/OS

The DB2 for z/OS precompiled works with assembler, C, C++, COBOL, PL/I and Fortran. The DB2 for z/OS coprocessor works with C, C++, COBOL, and PL/I. ODBC or CLI APIs are provided for C and C++. Java has JDBC and SQLJ, with JLINQ on the way. REXX and APL2 interfaces are provided. Other languages and application generators connect to DB2 using call attach or RRS attach for local connections, DRDA or private protocols for remote connections. Other languages use these of APIs or those implemented in DB2 Connect and other client deliveries. Some examples include WebSphere Developer for z, Enterprise Generation Language. Both Microsoft .NET and open source languages use this variety of connections.

DB2 Utilities
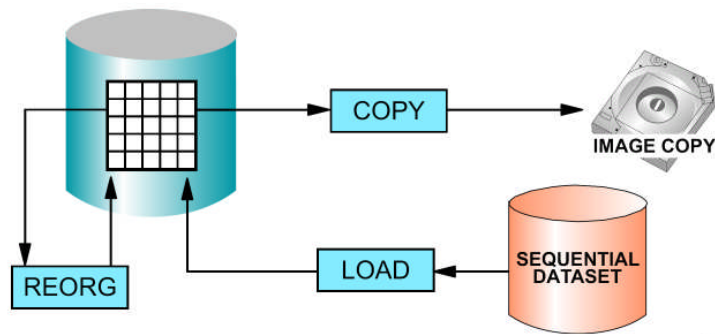
- Work at the OBJECT level
- Run in BATCH
- Compete with user programs for resources
- Specify your requirements using CONTROL STATEMENTS mostly
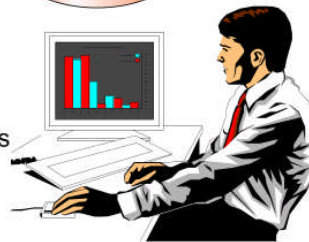
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Detail could be found in Chap. 19: Commands, Utilities and Tools.

Utilities are "special" programs that can be run by submitting JCL or calling the DSNUTILS stored procedure. They run in batch and get their control information via *control statements* (not SQL).

Utilities are used, for example, to take backups of tables (COPY utility), to reorganize table data (REORG), or to load them with data from sequential data sets (LOAD utility).

Demo 1: Query from SPUFI

Demo 2: A 3270 Transaction on DB2