Power Week

Université IBM i 2019

22 et 23 mai

IBM Client Center Paris

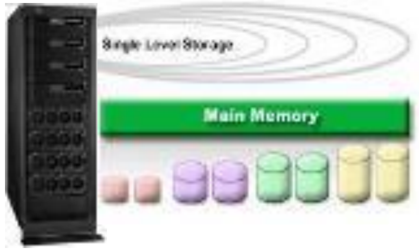
S34 – IBM i Architecture: Overview & Evolution

Thursday May 23 – 13:30-14:30

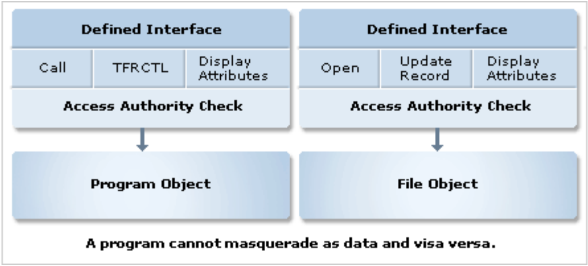
Steve Will
IBM
IBM i Chief Architect

IBM i Architecture

DB2 for i & Single Level Storage



Security & Integrity - Object Based



Defined Interface

Call | TFRCTL | Display Attributes

Access Authority Check

Program Object

Defined Interface

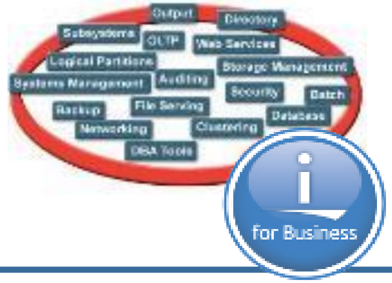
Open | Update Record | Display Attributes

Access Authority Check

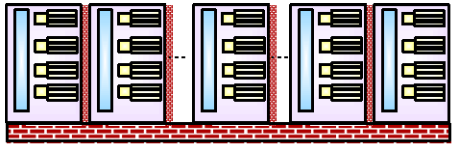
File Object

A program cannot masquerade as data and visa versa.

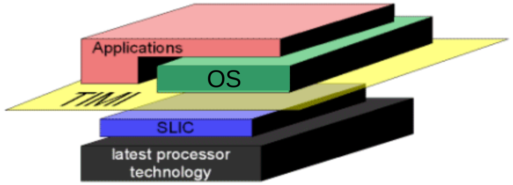
Integration & PASE



Multi-Workload Virtualization



Technology Independent Machine Interface



A system designed for business

Hey! Wait a minute.

Hey! Wait a minute.

Hey! Wait a minute.

LET ME EXPLAIN...

System/38 (1978)
System/36 (1983)

1988

AS/400®

2000

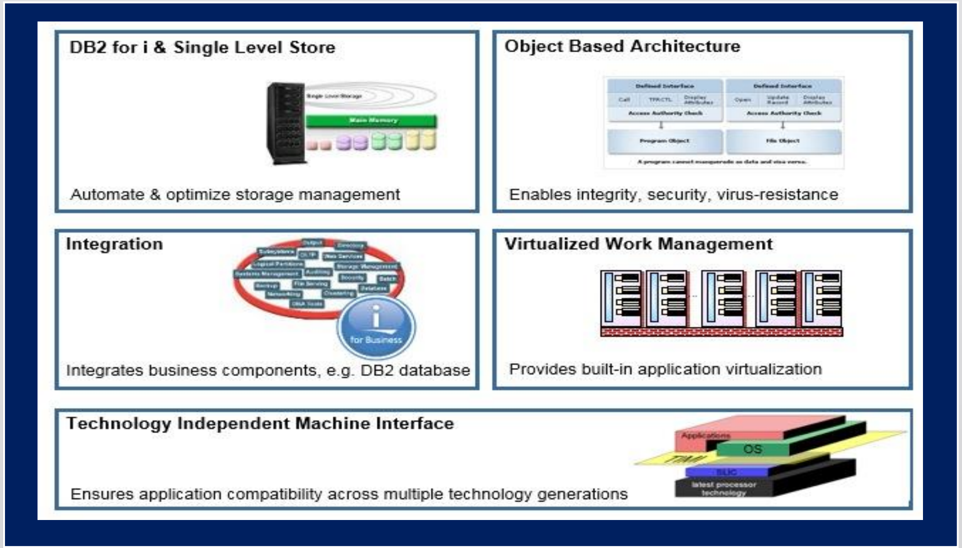
IBM iSeries

2008

i for Business

IBM Power Systems

ARCHITECTURE



DB2 for i & Single Level Store

Automate & optimize storage management

Object Based Architecture

Enables integrity, security, virus-resistance

Integration

Integrates business components, e.g. DB2 database

Virtualized Work Management

Provides built-in application virtualization

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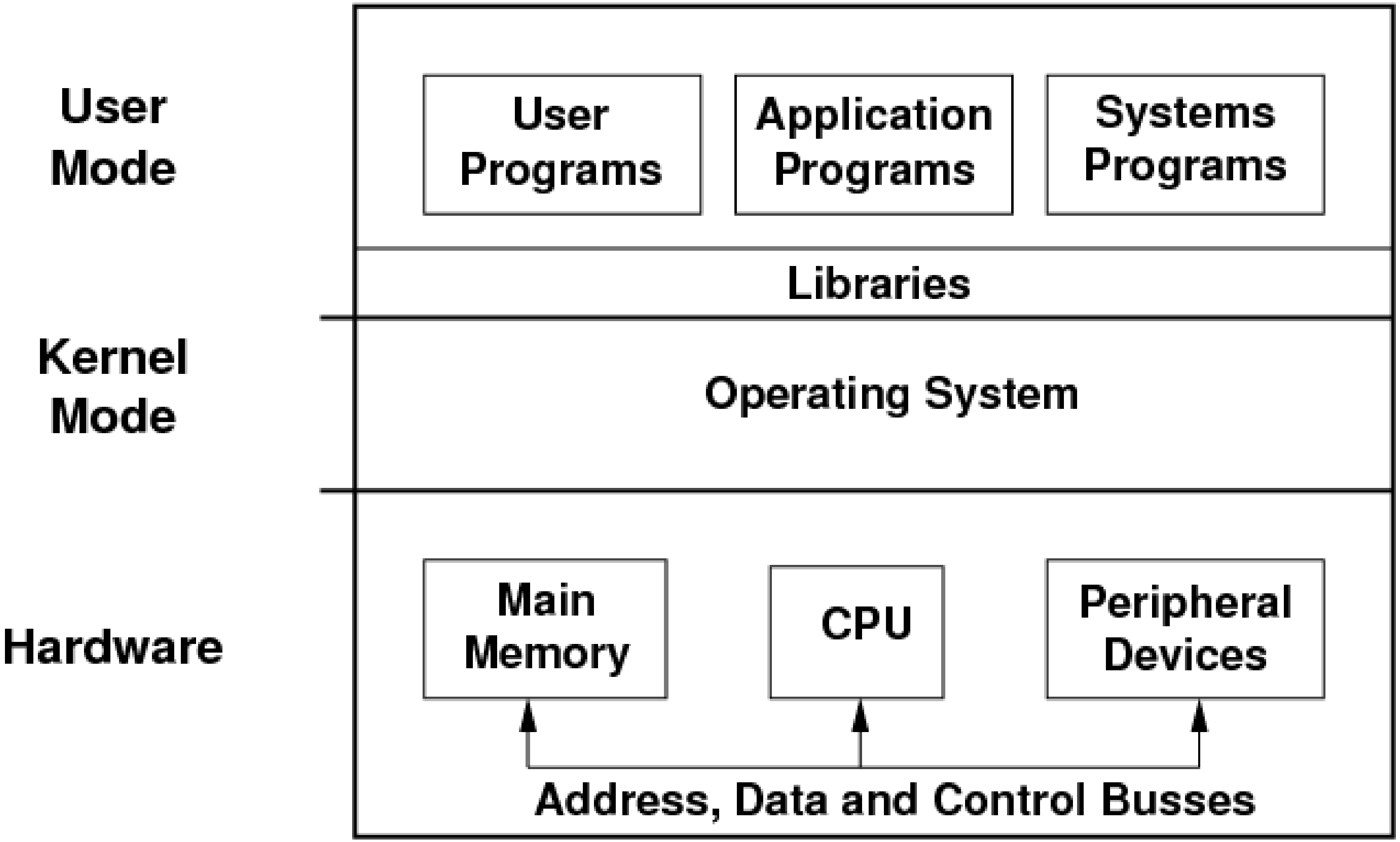
Ensures application compatibility across multiple technology generations

Academic View of an OS Architecture – a Kernel



http://minnie.tuhs.org/CompArch/Lectures/week01.html

Layered Architecture of OS/400

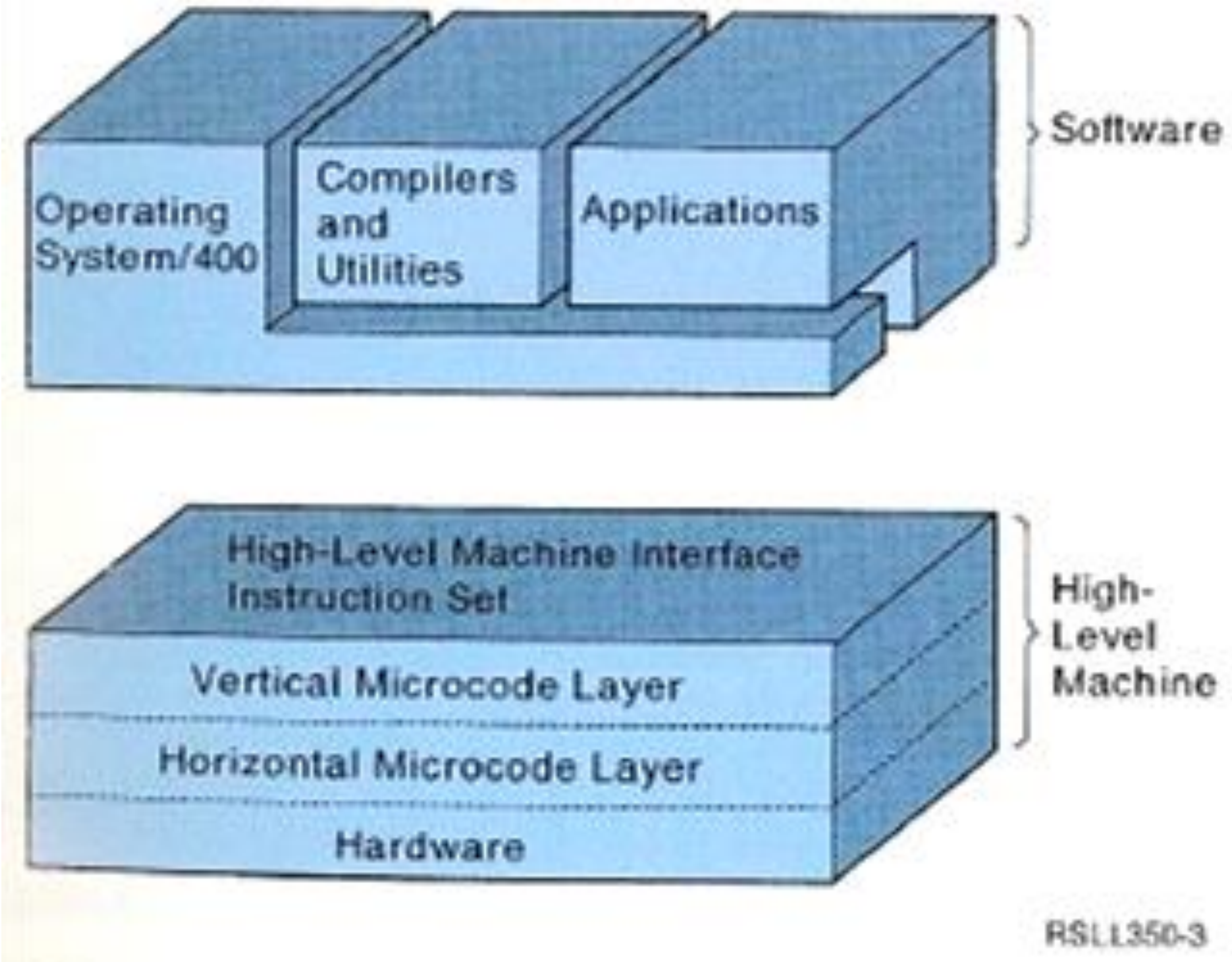
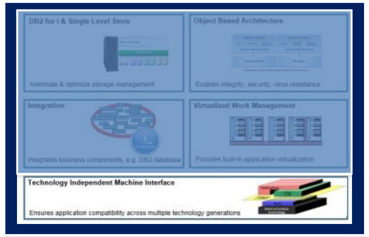


Figure 1 AS/400 Layered Architecture

Applications are compiled to an intermediate language, not processor instructions.

The “MI” (or “TIMI”) is the defined set of these instructions.



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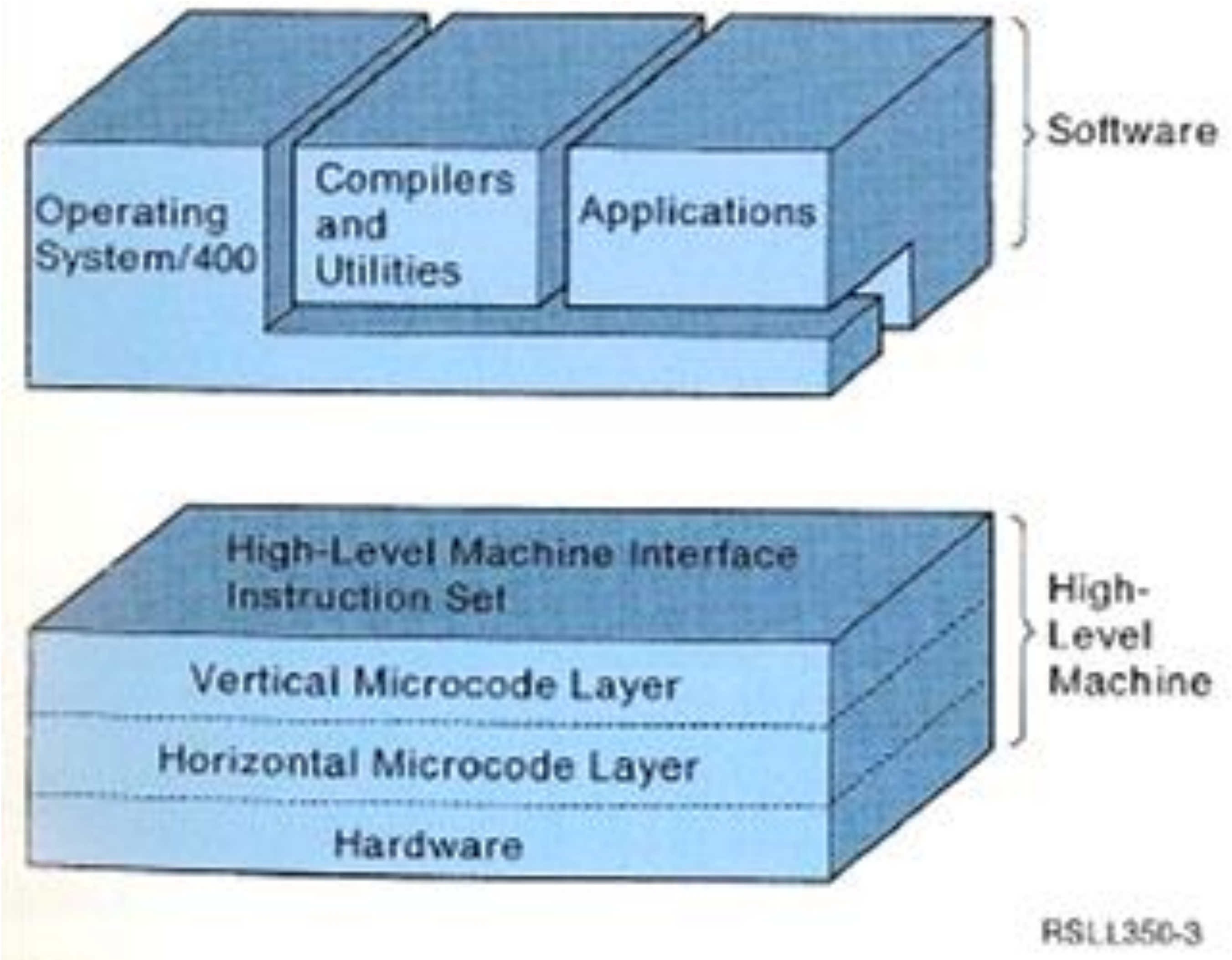

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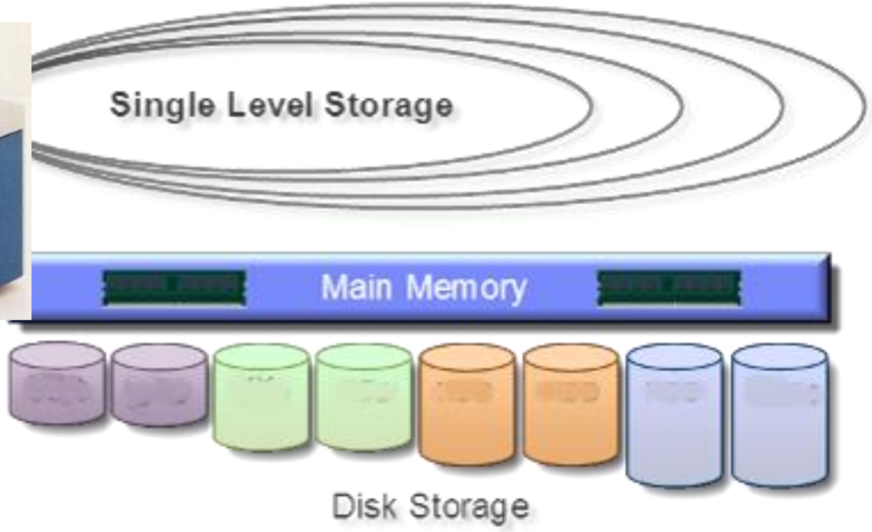
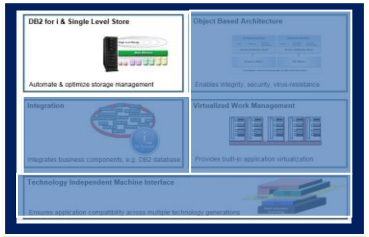
Storage Model – Back to System/38

All storage on the system is treated as a single contiguous set of memory, so mapping storage required special methods and knowledge of storage devices.

System/38 and initial AS/400 used 48-bit addresses for what became known as “Single Level Storage.”

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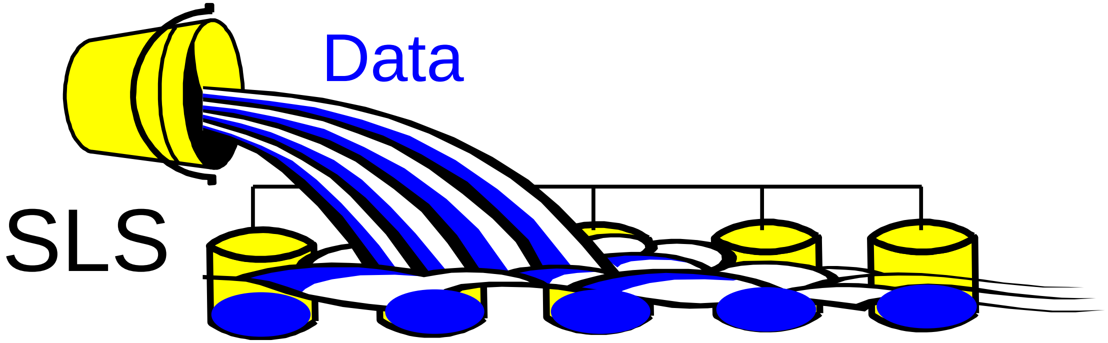

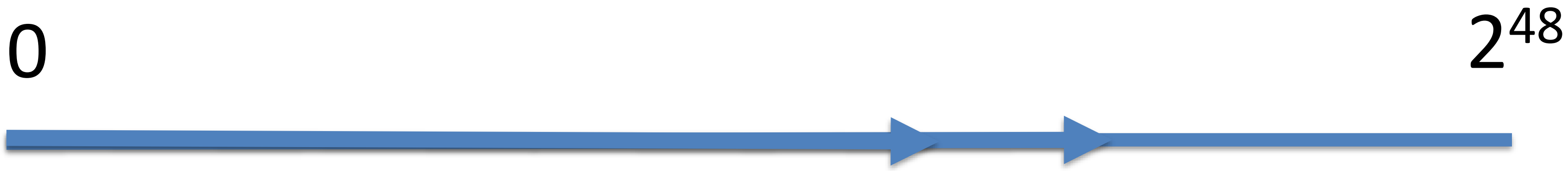

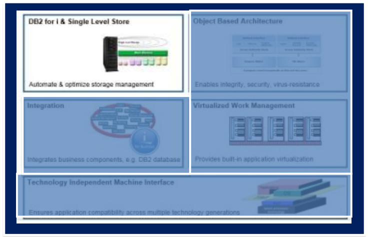

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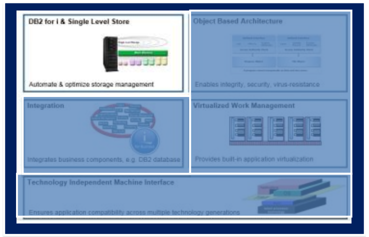
Tags

ZZZZ	ZZZZ	ZZZZ	ZZZZ



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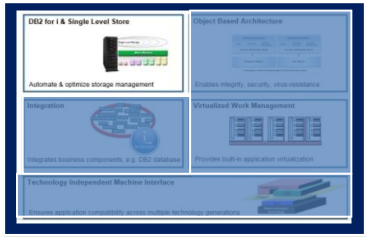
Tags

ZZZZ	ZZZZ	ZZZZ	ZZZZ

A “tag” per 32-bit word to indicate it’s part of a pointer.



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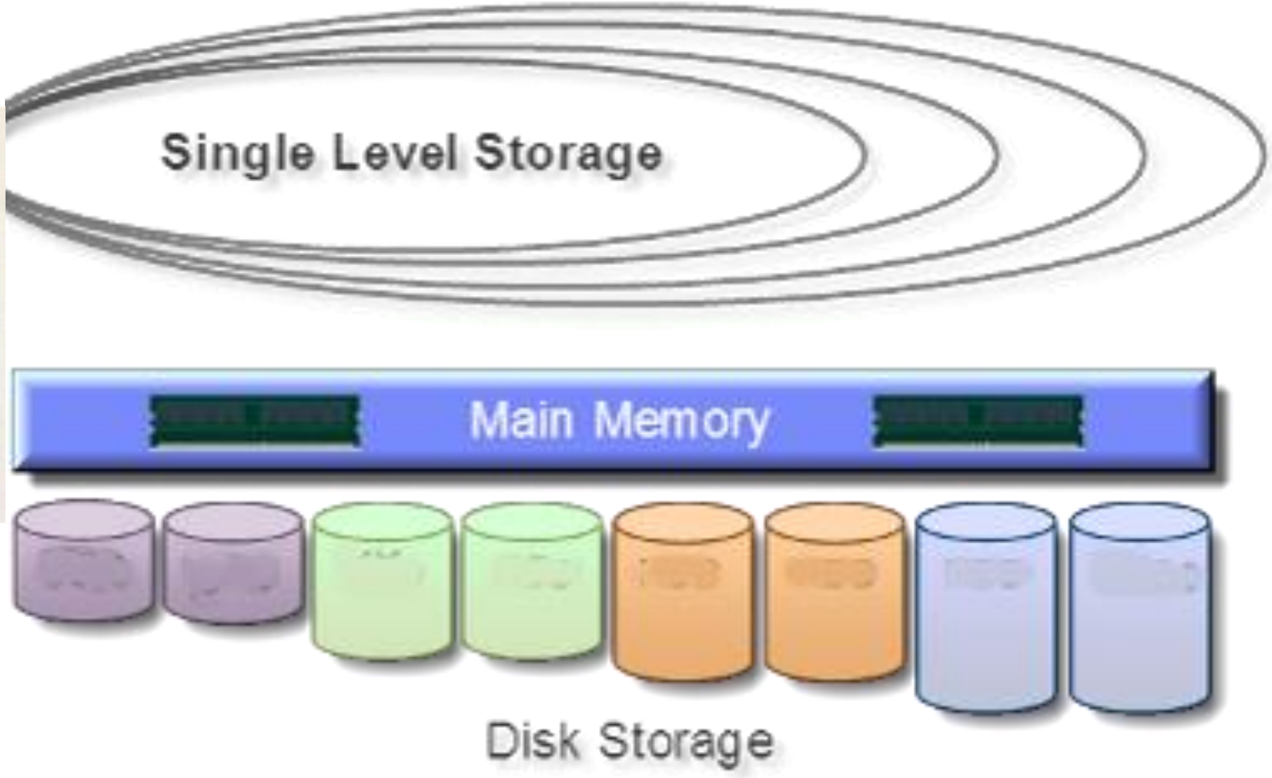
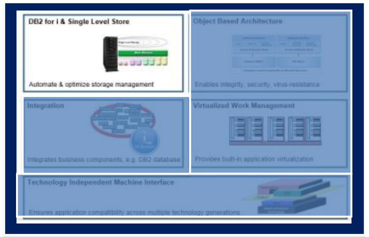
System/38 Single Level Storage





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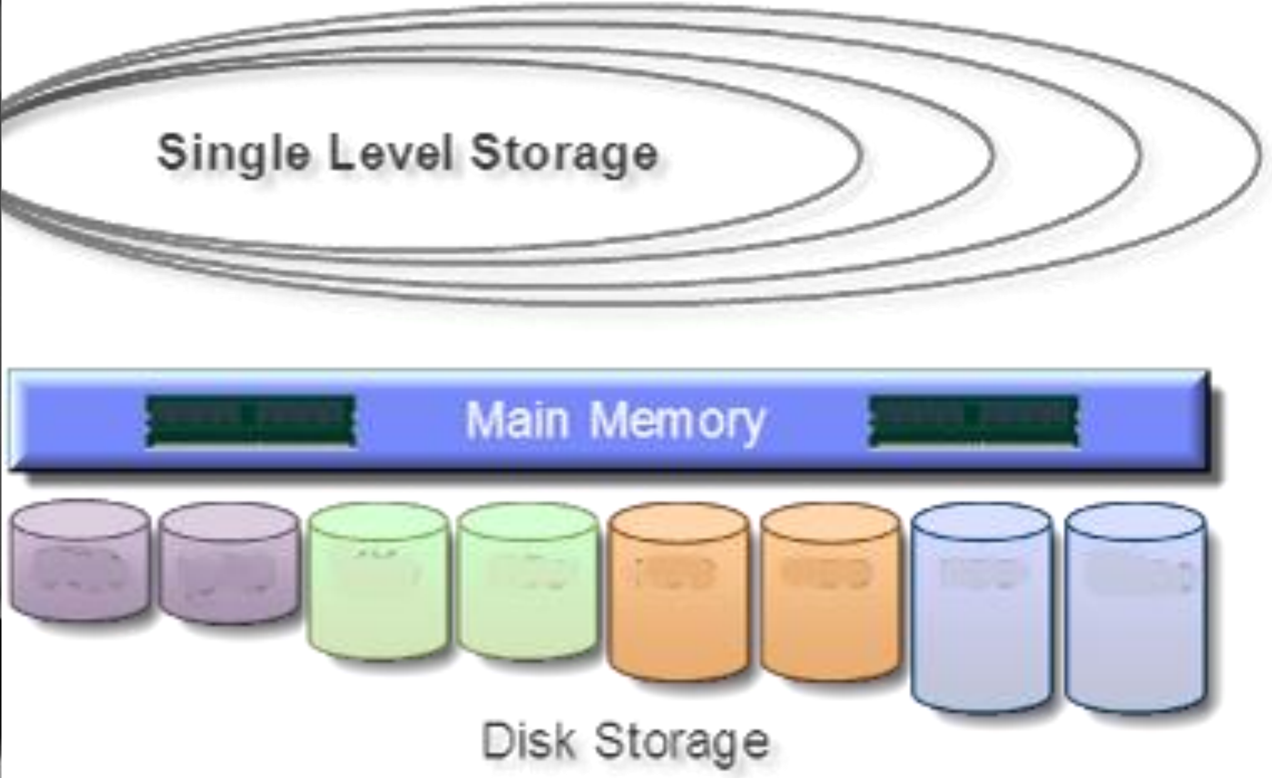
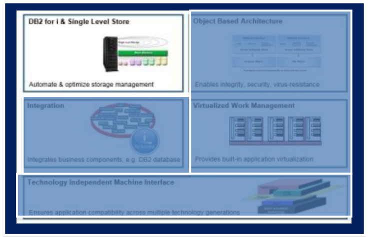
AS/400 Single Level Storage – The Same?





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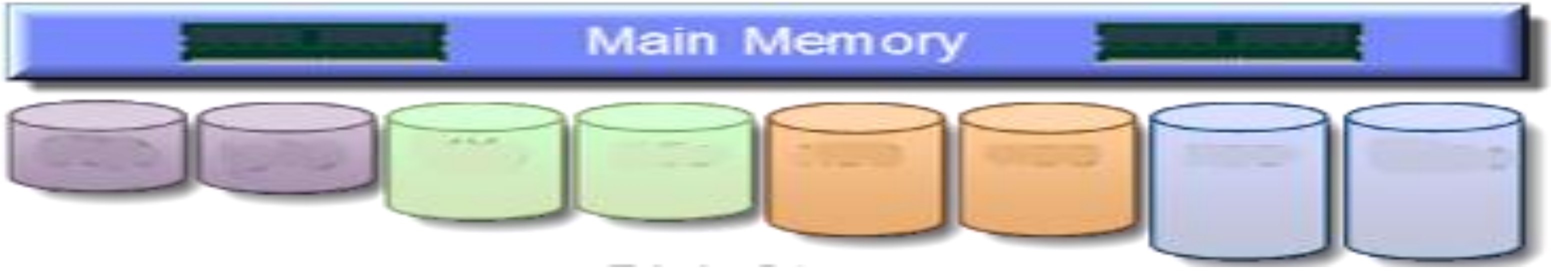
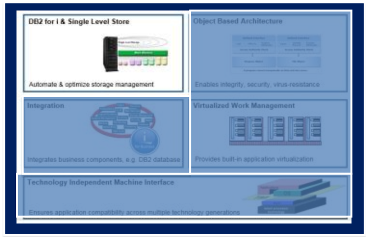
From System/38 to IBM i – “Single” Changed

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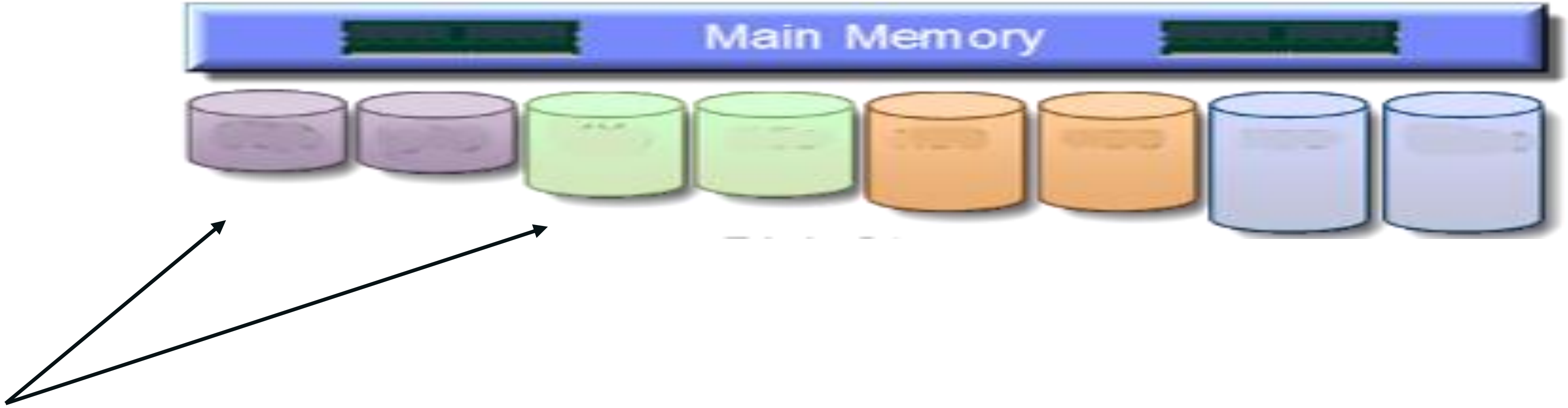
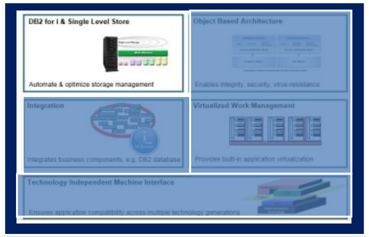


Group 1

The AS/400 architects decided they wanted to have groups of disks.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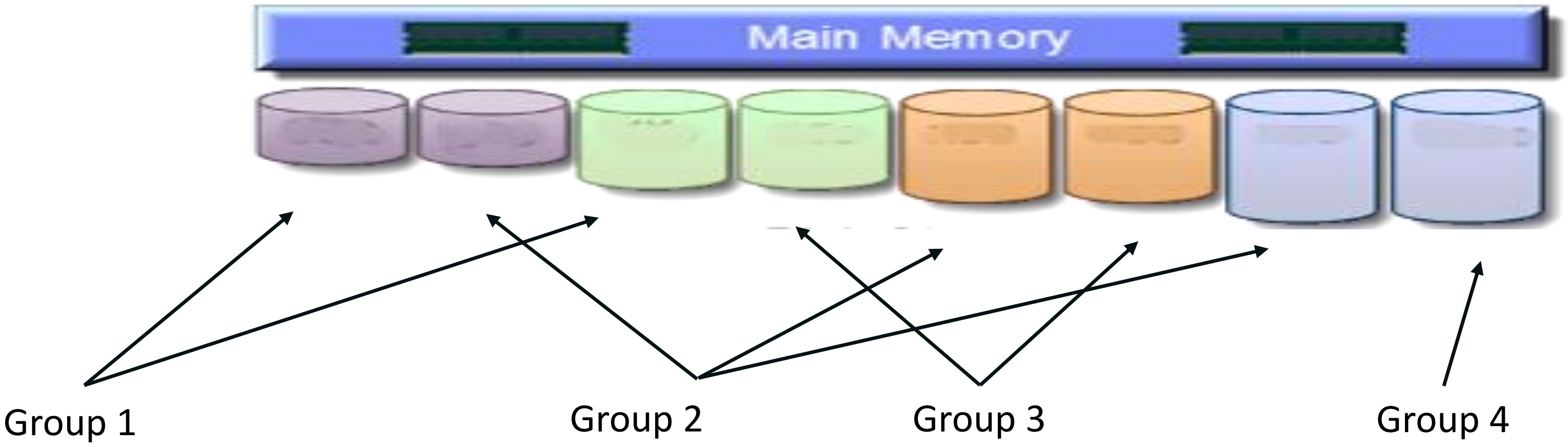


Group 1

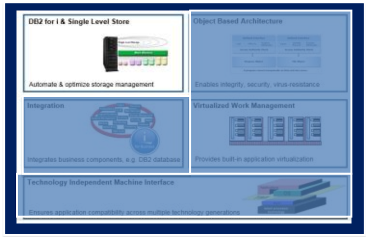
Group 2

Group 3

Group 4

The AS/400 architects decided they wanted to have groups of disks.

These groups were called Auxiliary Storage Pools.



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Object Orientation

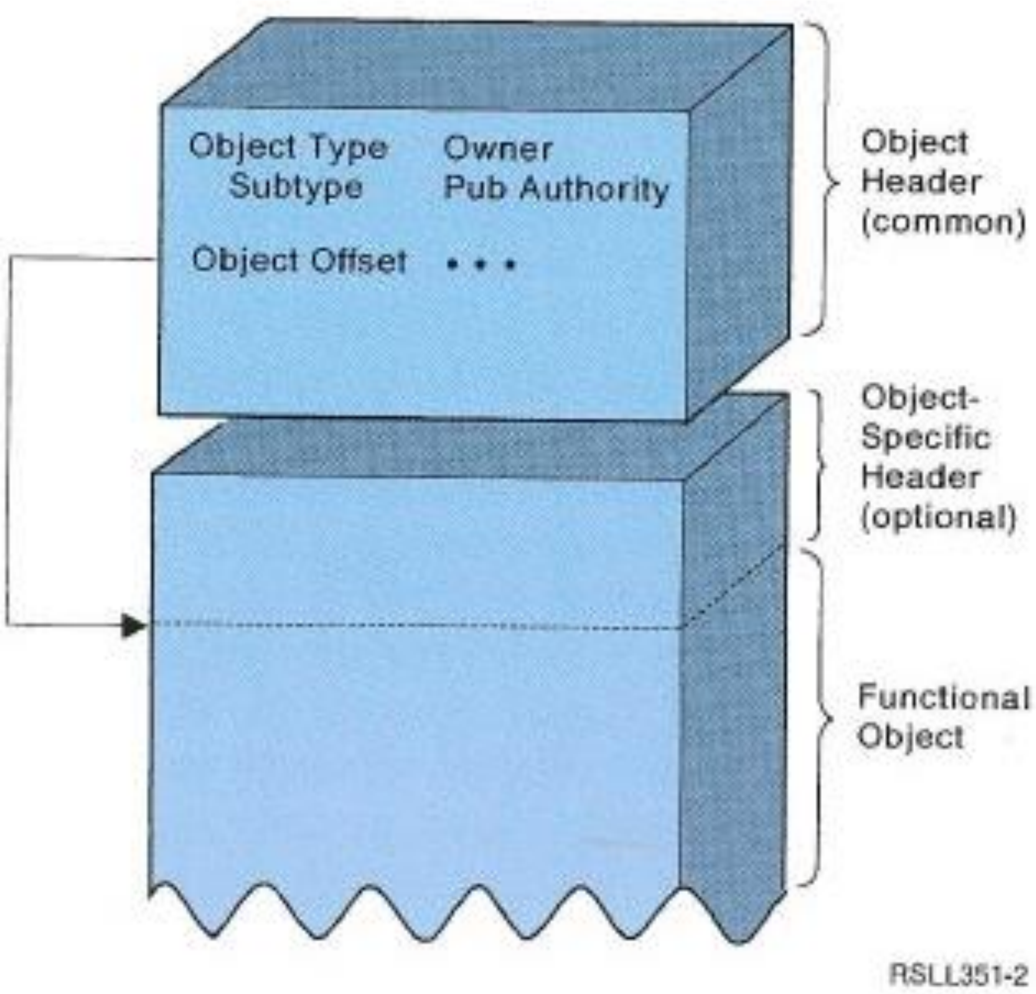
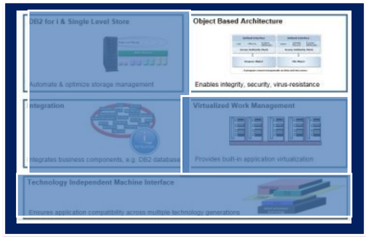


Figure 2 Structure of Generic Object

Objects protect the integrity of the system and customer data, while also allowing a strict object-based security architecture.



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What About Db2, Integration & Work Management?

What About Integration & Work Management?

So, AS/400 V1R1 had the perfect architecture …

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And then …

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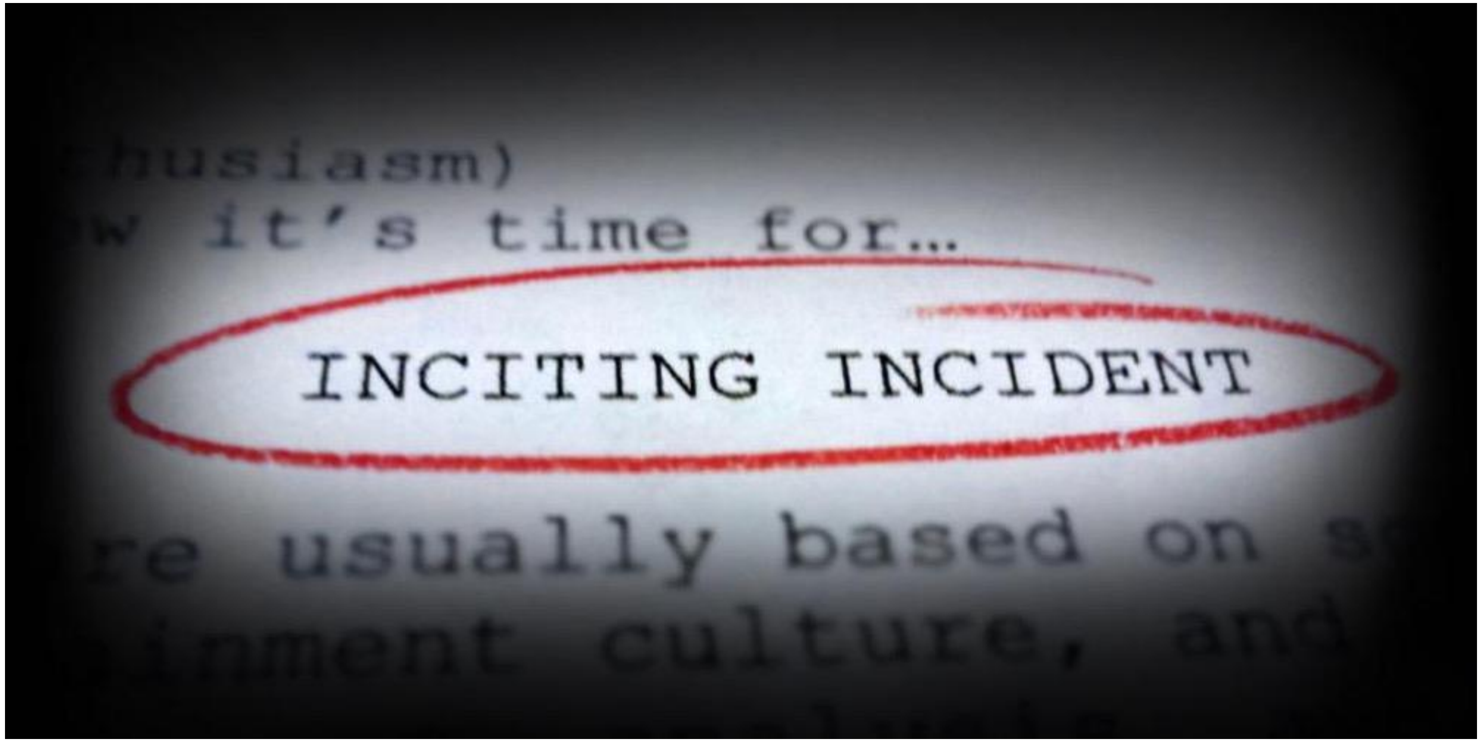
And then …



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w it's time for…

INCITING INCIDENT

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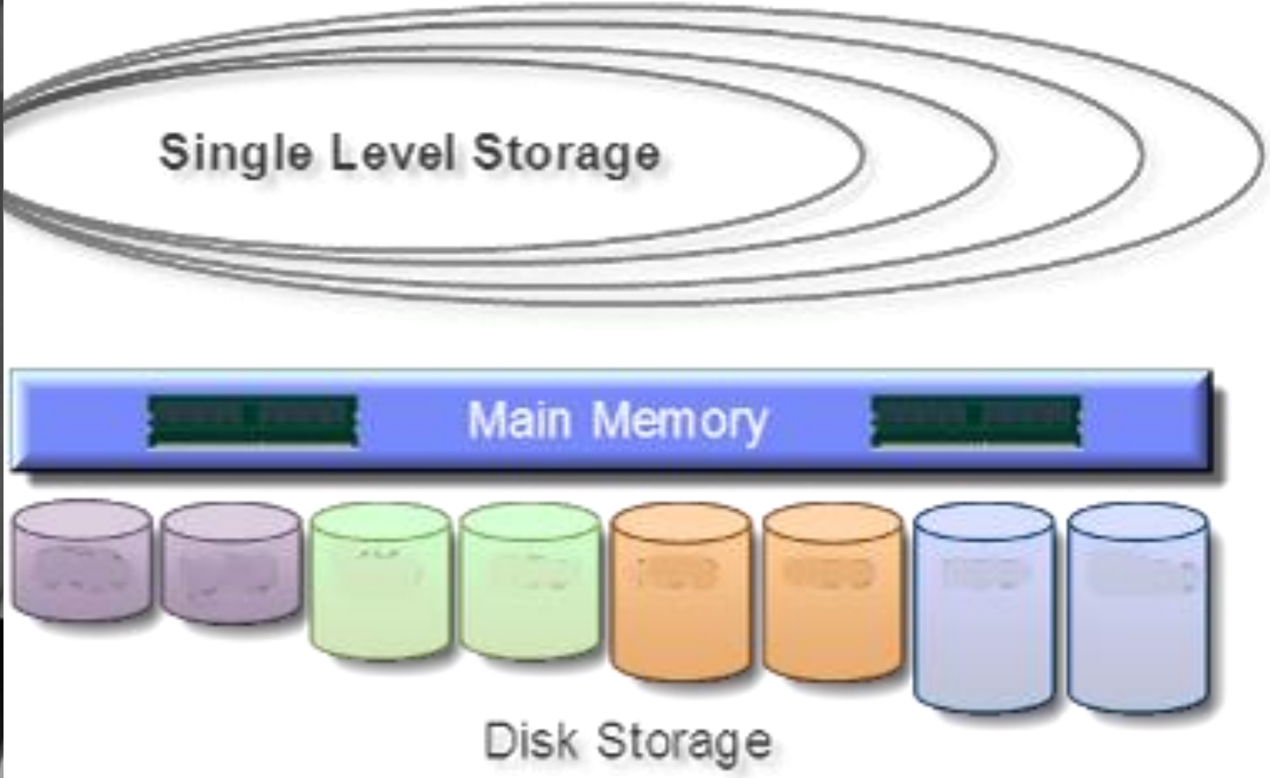
Remember that Single Level Storage Thing?



Programming Languages and Integrity

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First: RPG COBOL

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But Then: THE C PROGRAMMING LANGUAGE

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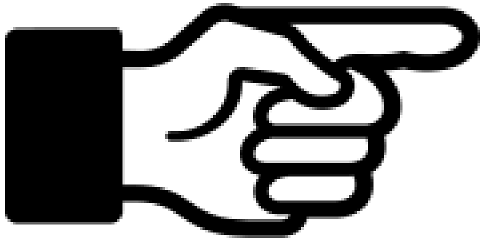

(Pointers!)

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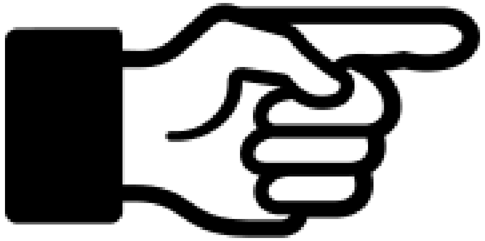
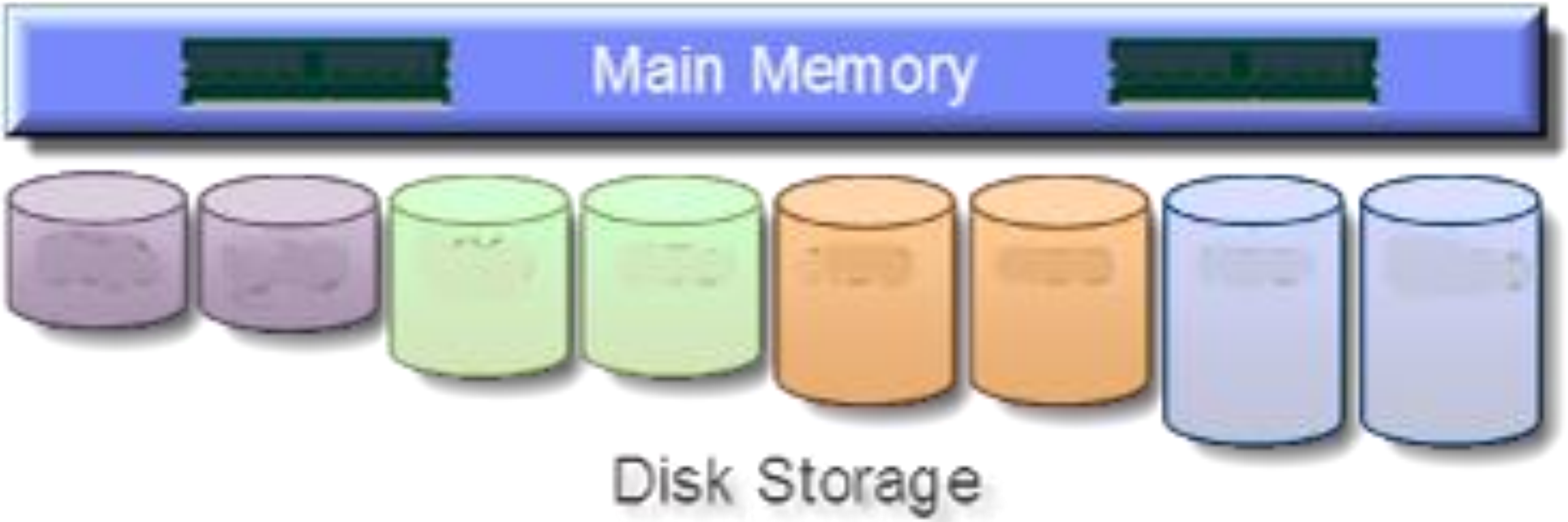
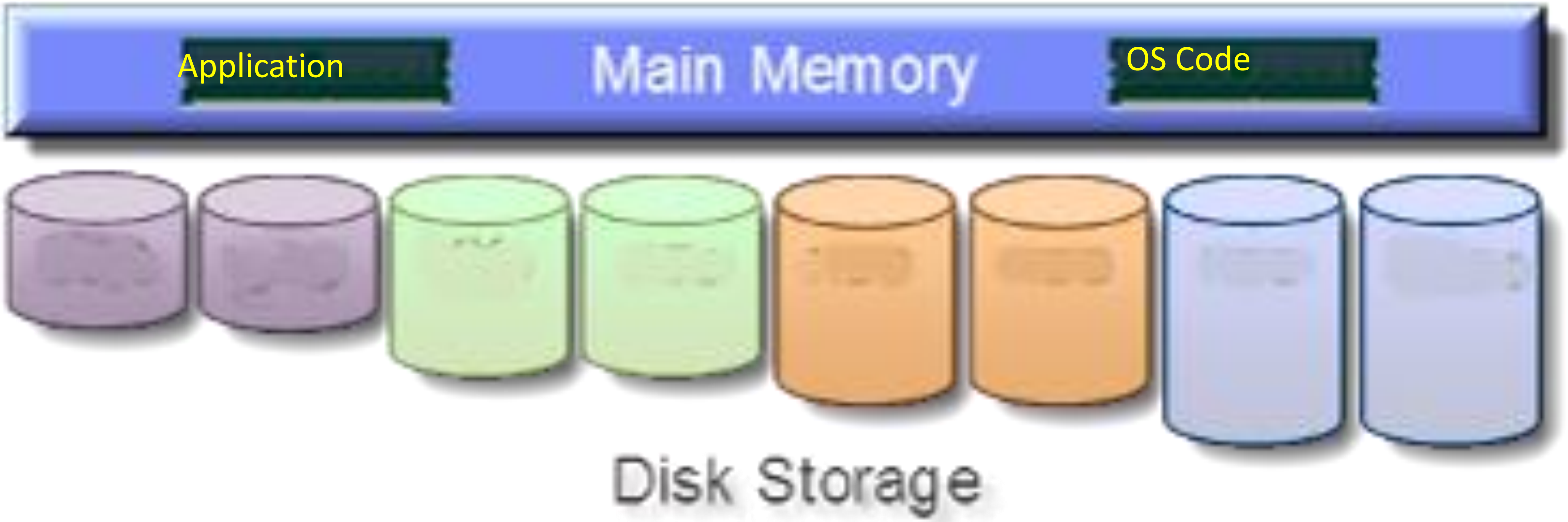


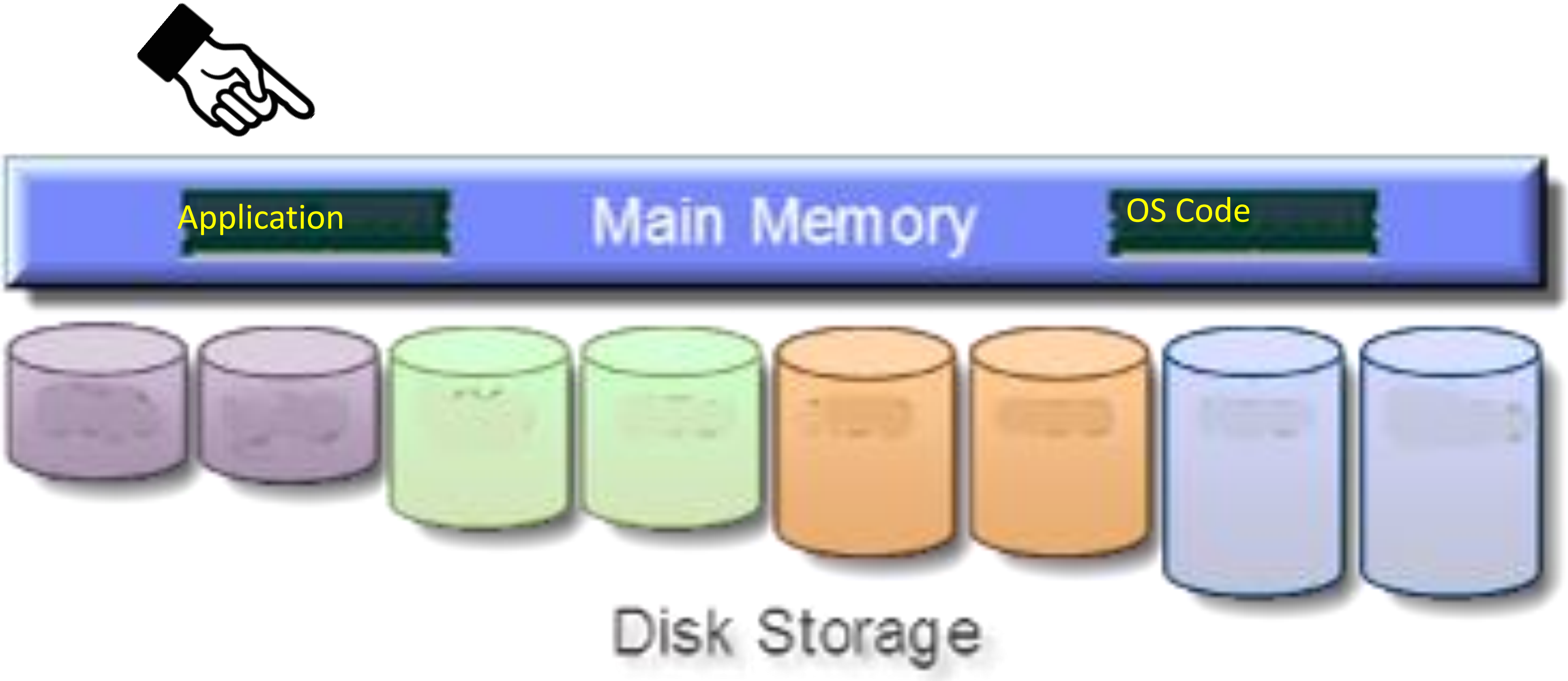
(Pointers!)

So What?



Main Memory
Disk Storage


Application
Main Memory
OS Code
Disk Storage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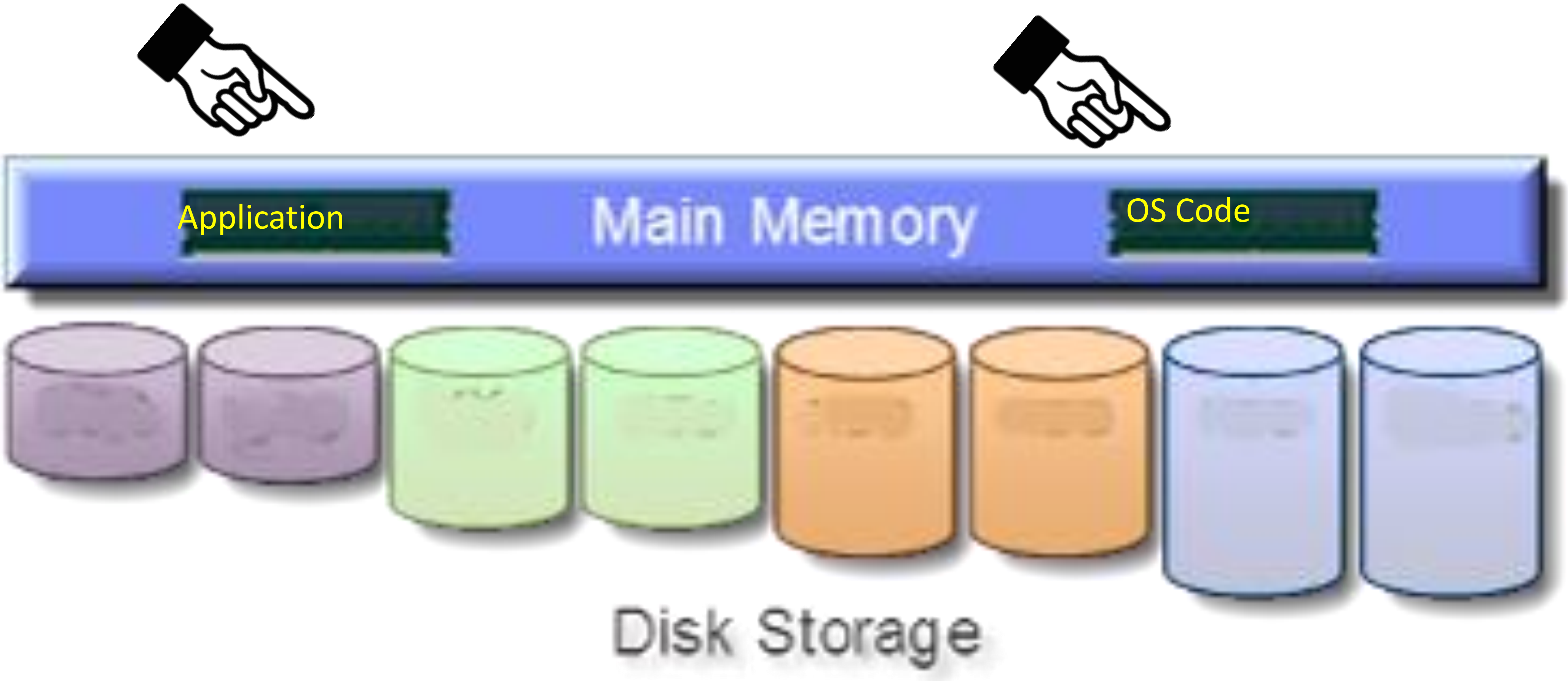
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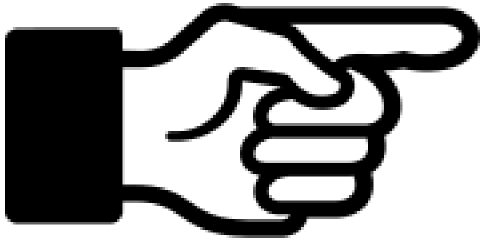
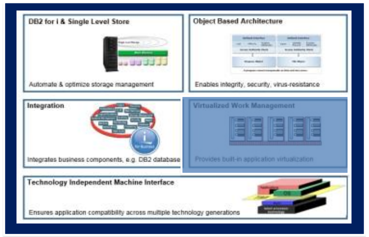


So …

Security level 50 & initial HW support for Integrity (Storage Protection, Privileged/Problem state support)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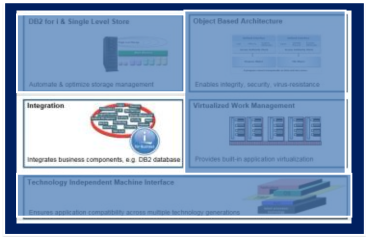
File Systems

- System/38 had one file system – QSYS.LIB – which was (is) “flat”
  - By the late ’70s, hierarchical file systems were proving their value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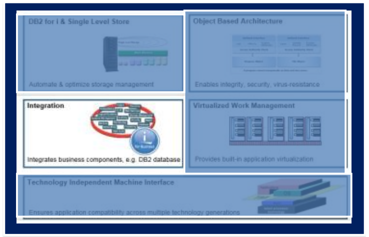

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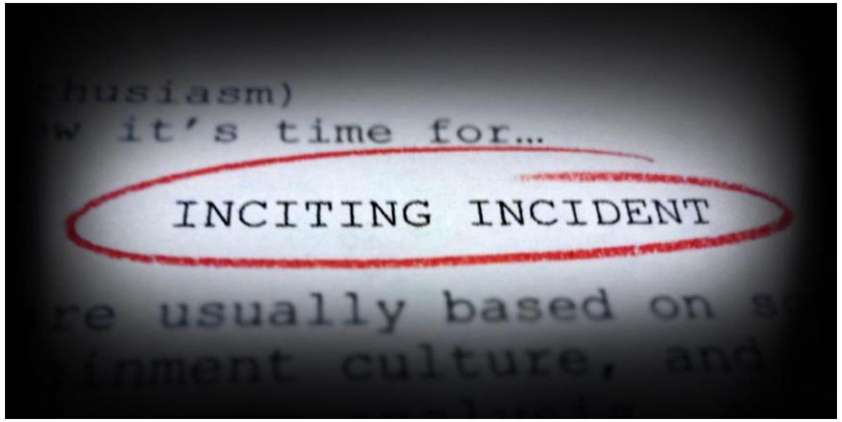
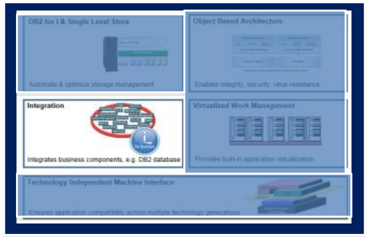
- The industry defined a standard hierarchical file system, as part of the POSIX standards



POSIX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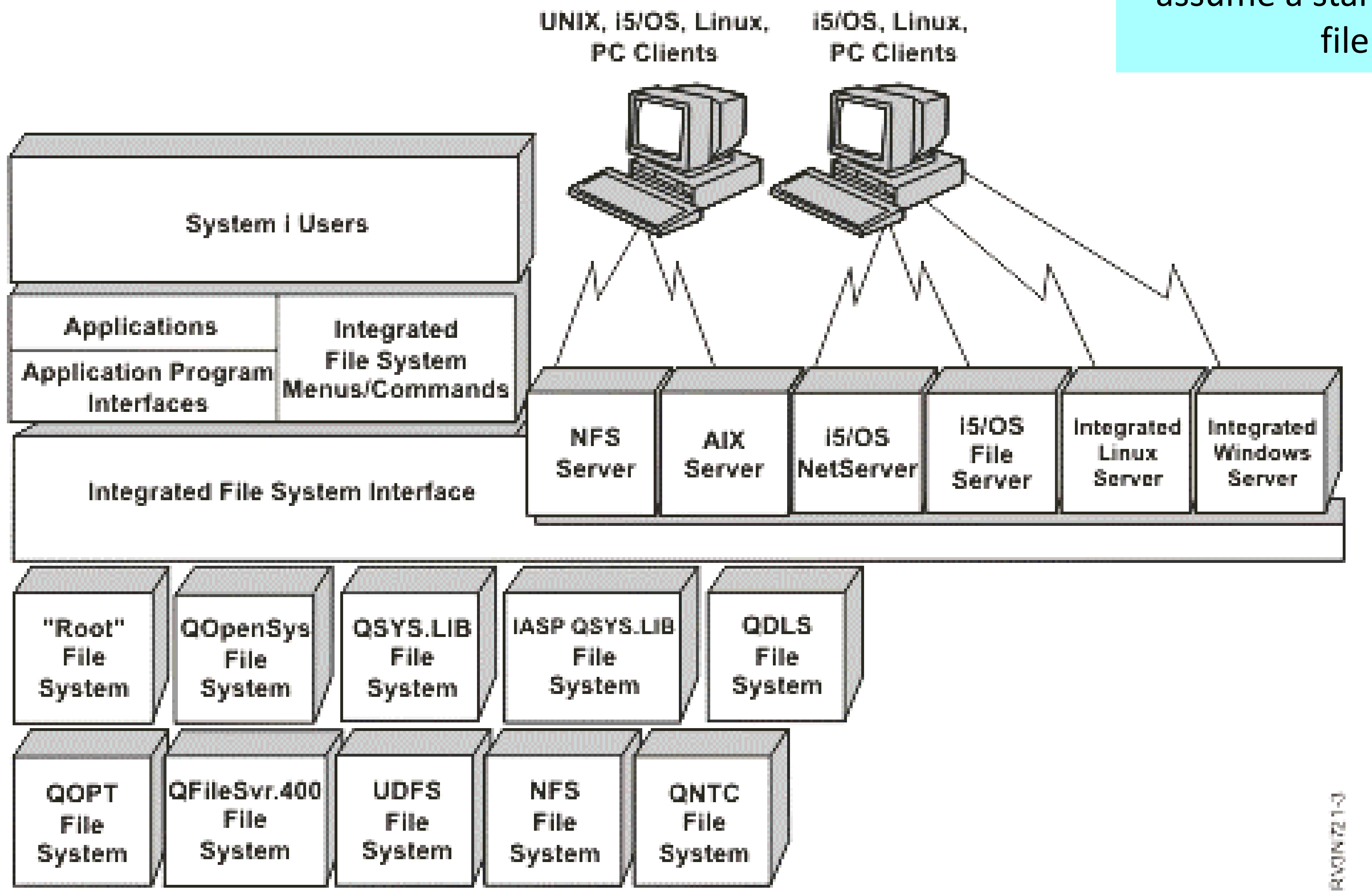
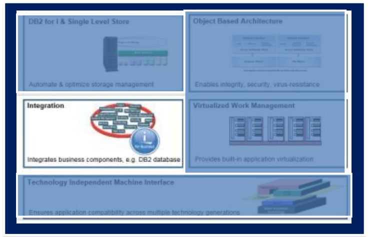
Integrated File System - IFS

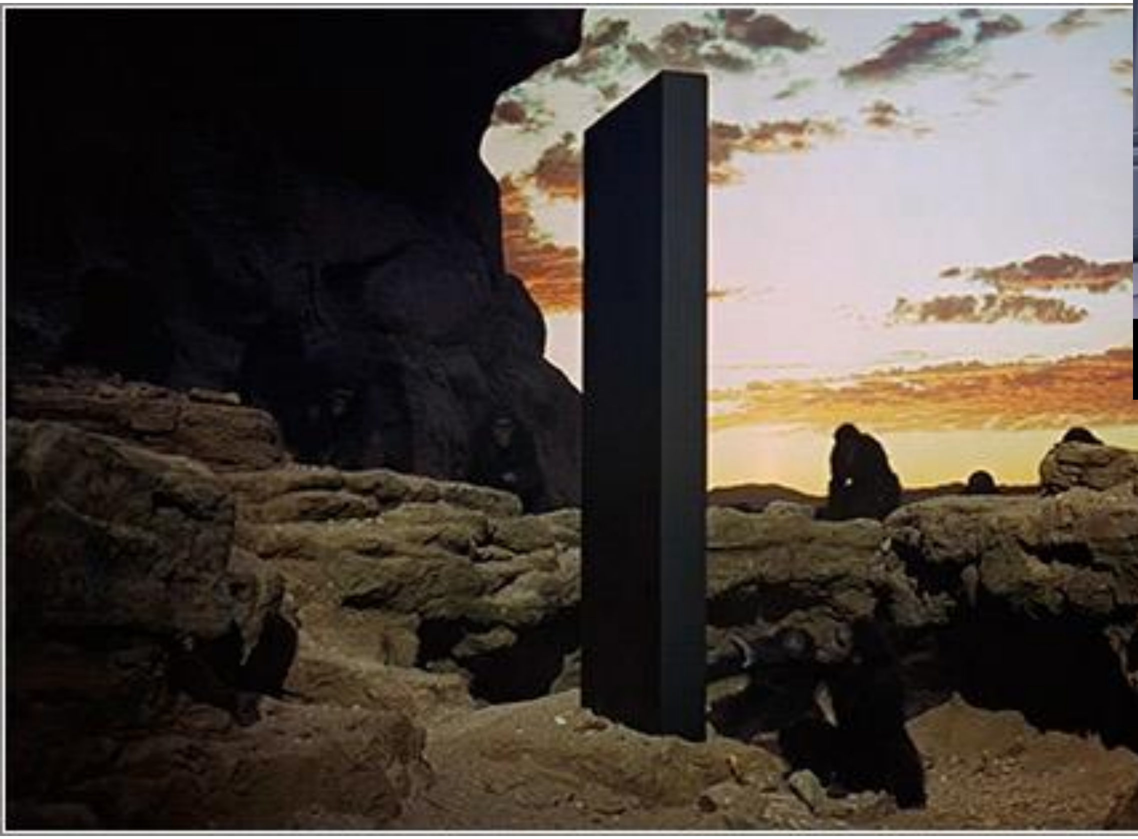
Today’s modern applications assume a standard, hierarchical file system





Once Upon a Time

For very good reasons, early software was written in large, **monolithic**, programs.



The Monolith

But the Programming World Kept Changing

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Computer architectures made resources more available, compilers made calls between programs more efficient, and languages developed to assume **modularity**.

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ILE

The Integrated Language Environment: aka ILE, aka New Program Model

The creation of ILE required the creation of the **Activation Engine**

- A new architectural component
- Controls the birth, life, and death of the process and its **activation groups**

ILE Benefits

- Binding
- Modularity
- Reusable Components
- Common Runtime Services through bindable APIs
- Source Debugger
- Better Control Over Resources

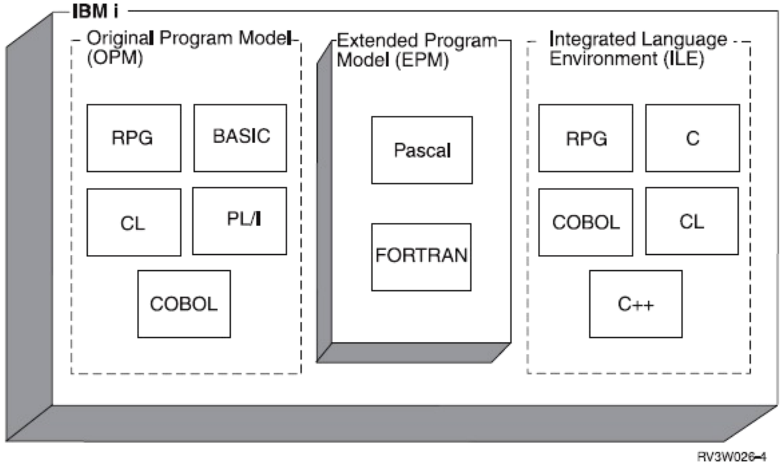
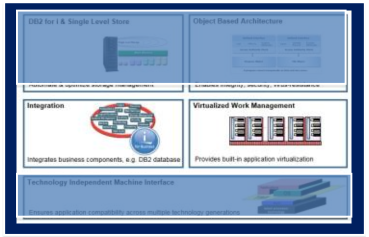

IBM i
Original Program Model (OPM)
RPG
BASIC
CL
PL/I
COBOL
Extended Program Model (EPM)
Pascal
FORTRAN
Integrated Language Environment (ILE)
RPG
C
COBOL
CL
C++
RV3W026-4

Figure 2-5. Relationship of OPM, EPM, and ILE to IBM i



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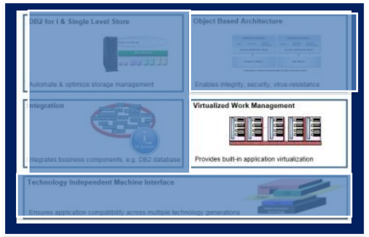
Jobs and Processes Were Enough, Until They Weren’t

- Job: the user-visible, user definable container of work

- Process: the underlying above-MI construct for processing, which has information about
  - The process itself
  - What’s running in the process


DB2 for i & Single Level Store
Automate & optimize storage management
Object Based Architecture
Enables integrity, security, virus-resistance
Integration
Integrates business components, e.g. DB2 database
Virtualized Work Management
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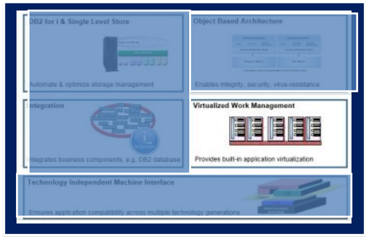

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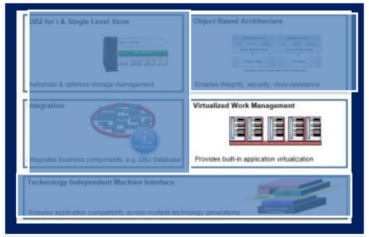

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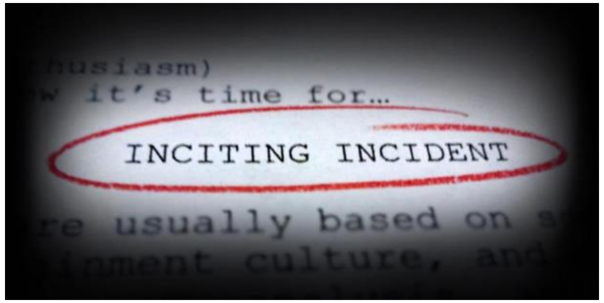

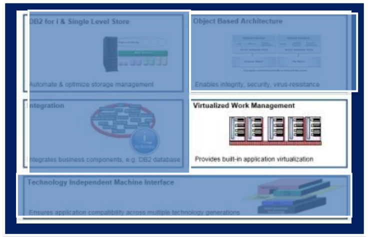

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Applications Drive Adaptation

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Lotus Notes

Applications Drive Adaptation

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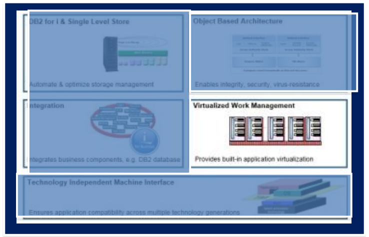

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CISC to RISC

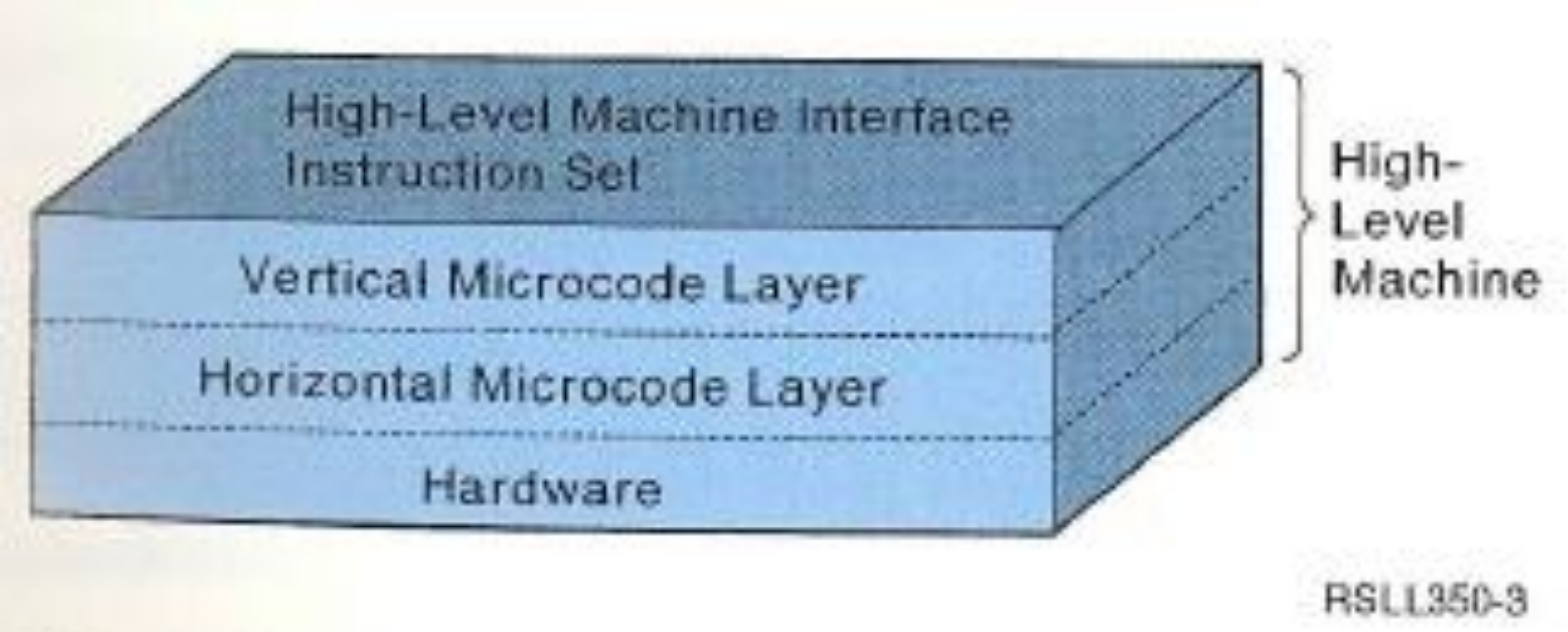
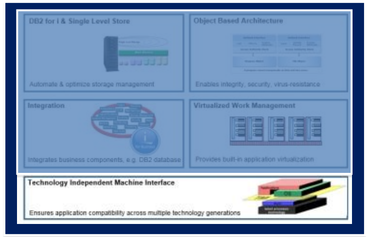


Figure 1 AS/400 Layered Architecture

The original AS/400 hardware was a 48-bit processor, which implemented a “Complex Instruction Set.”



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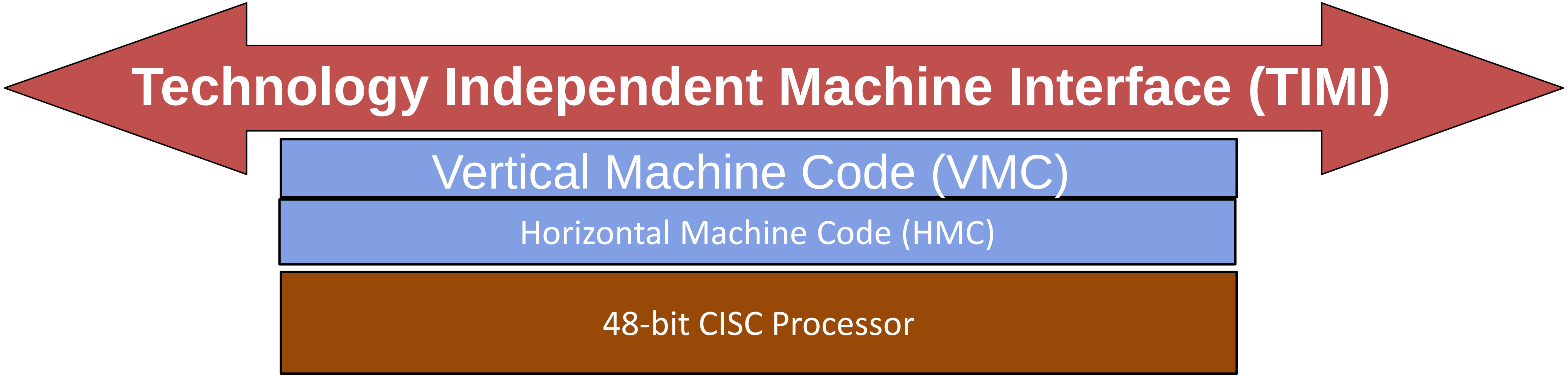
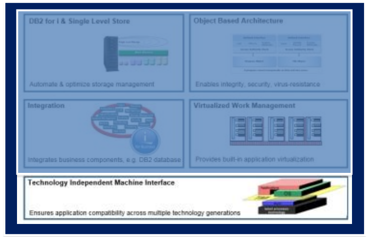

Technology Independent Machine Interface (TIMI)
Vertical Machine Code (VMC)
Horizontal Machine Code (HMC)
48-bit CISC Processor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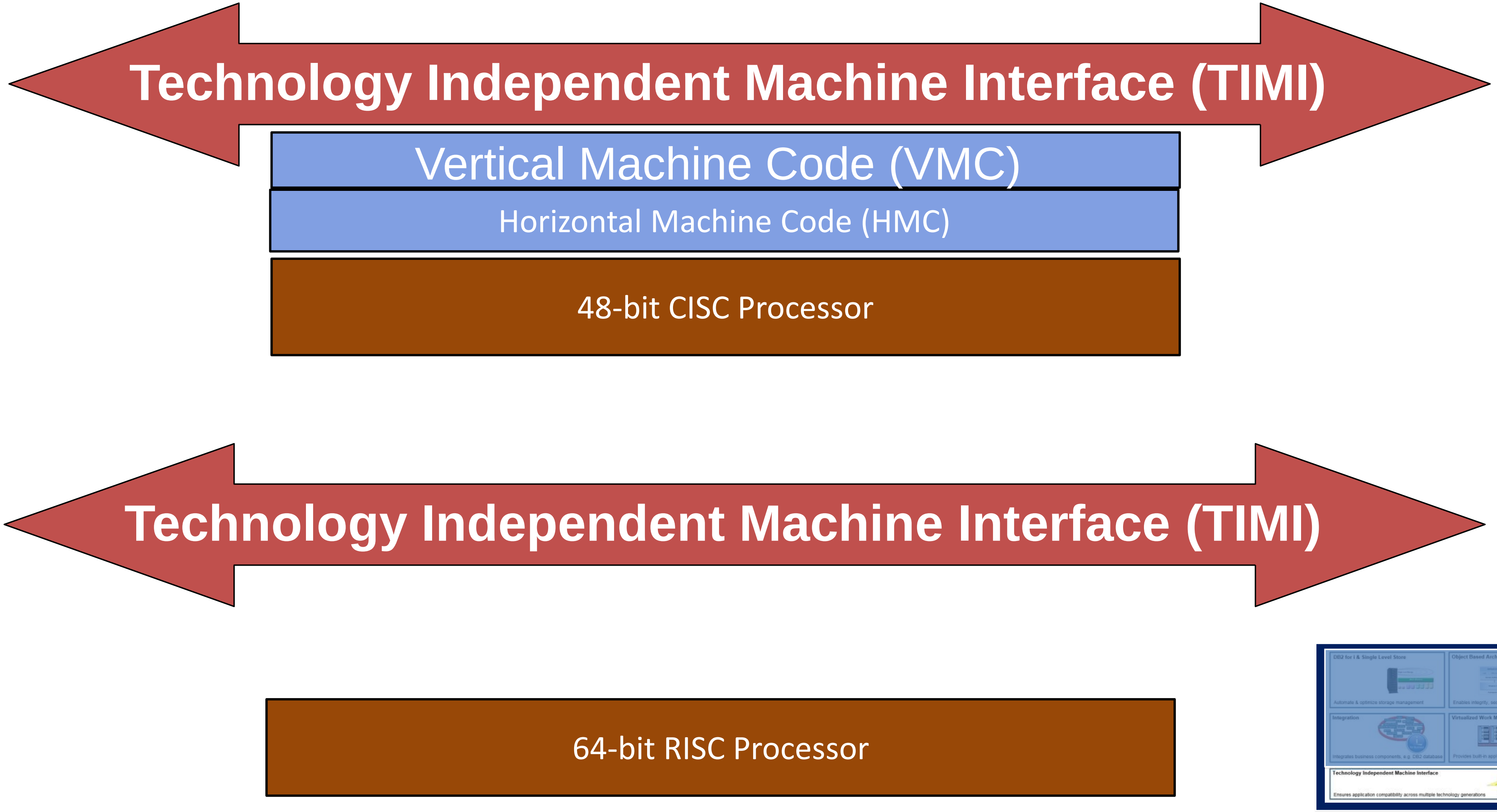
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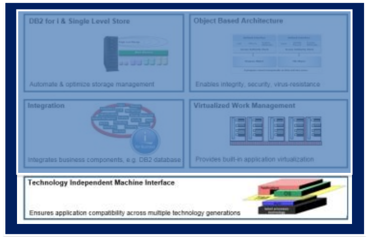

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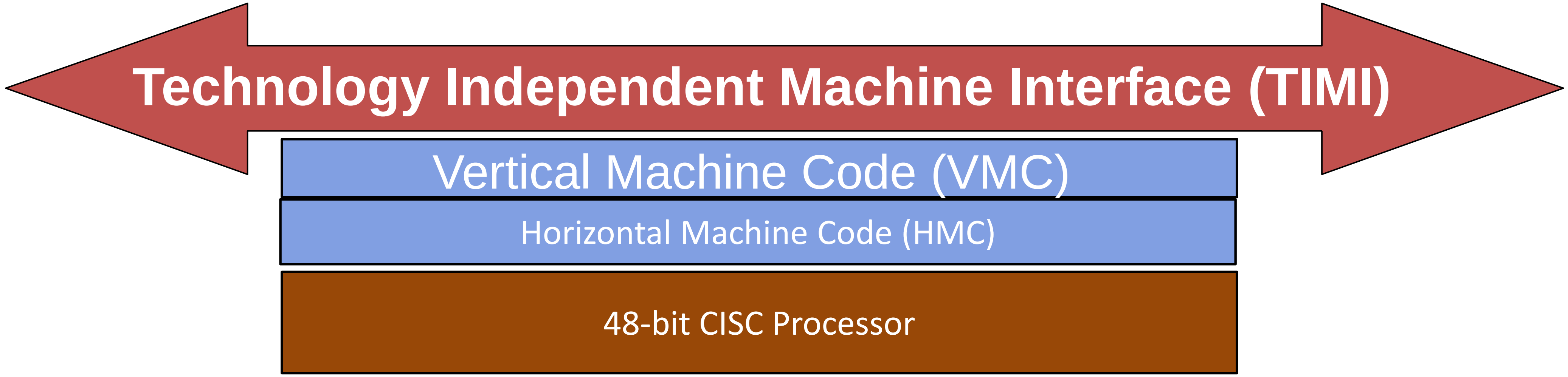

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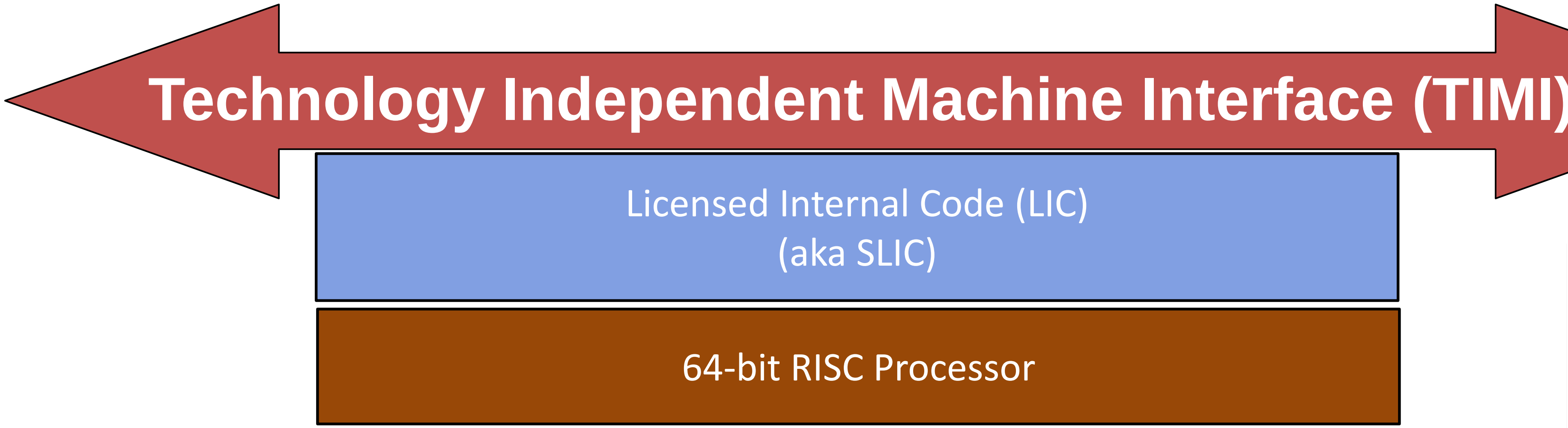

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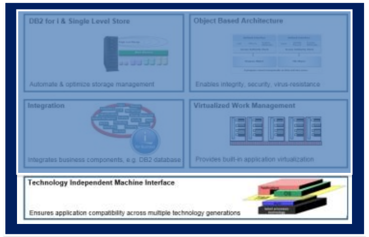

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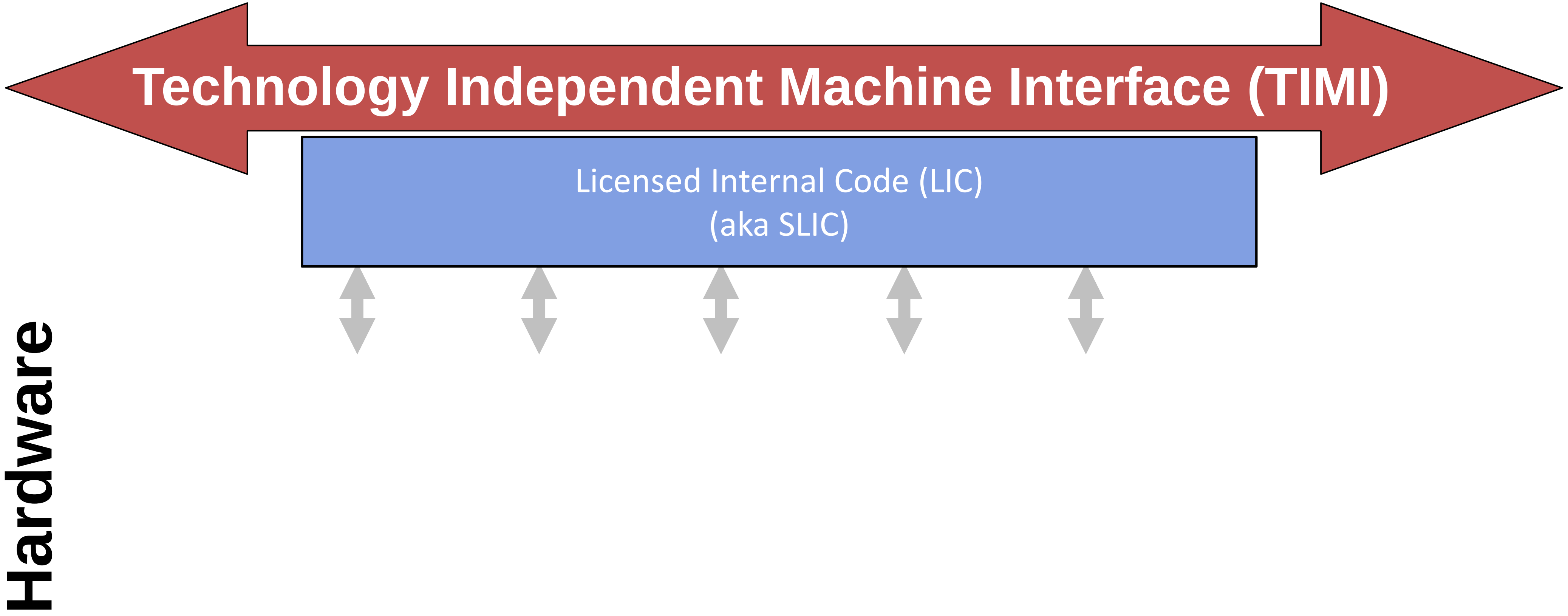
The Architecture – post-CISC



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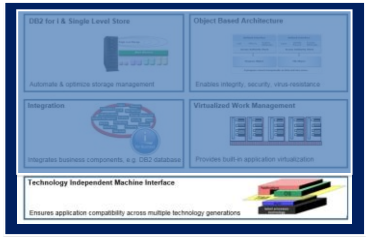
Hardware

So, did the "Architecture" change?



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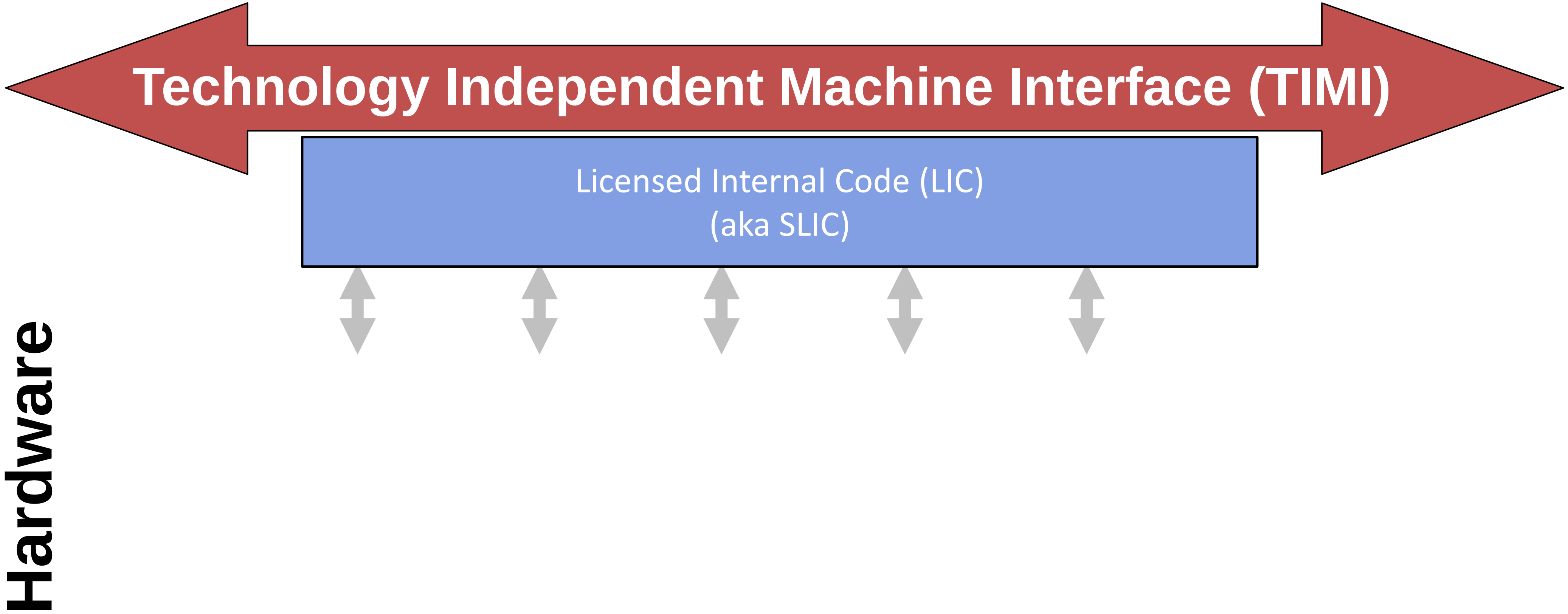
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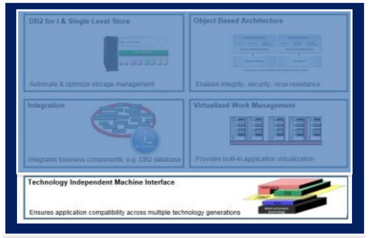

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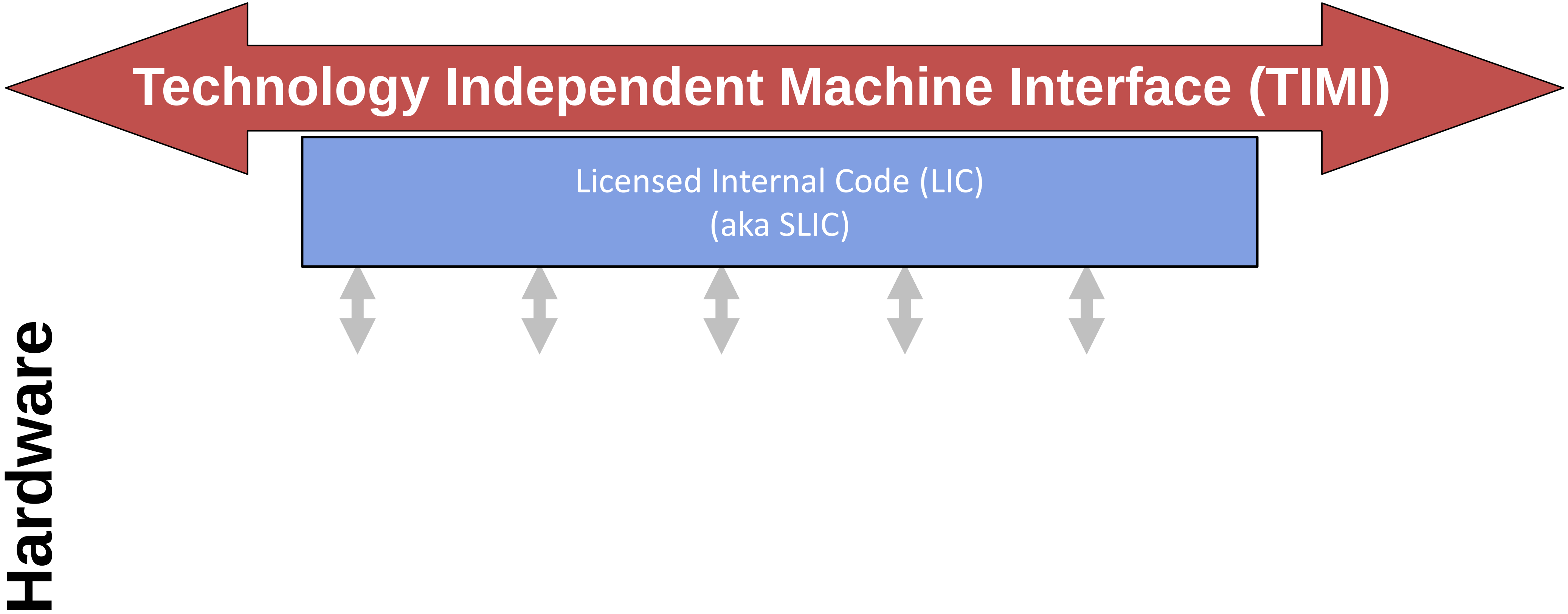

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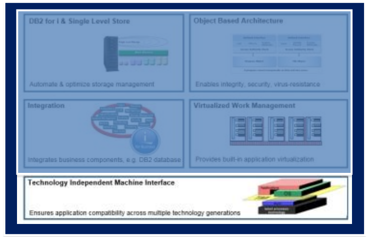

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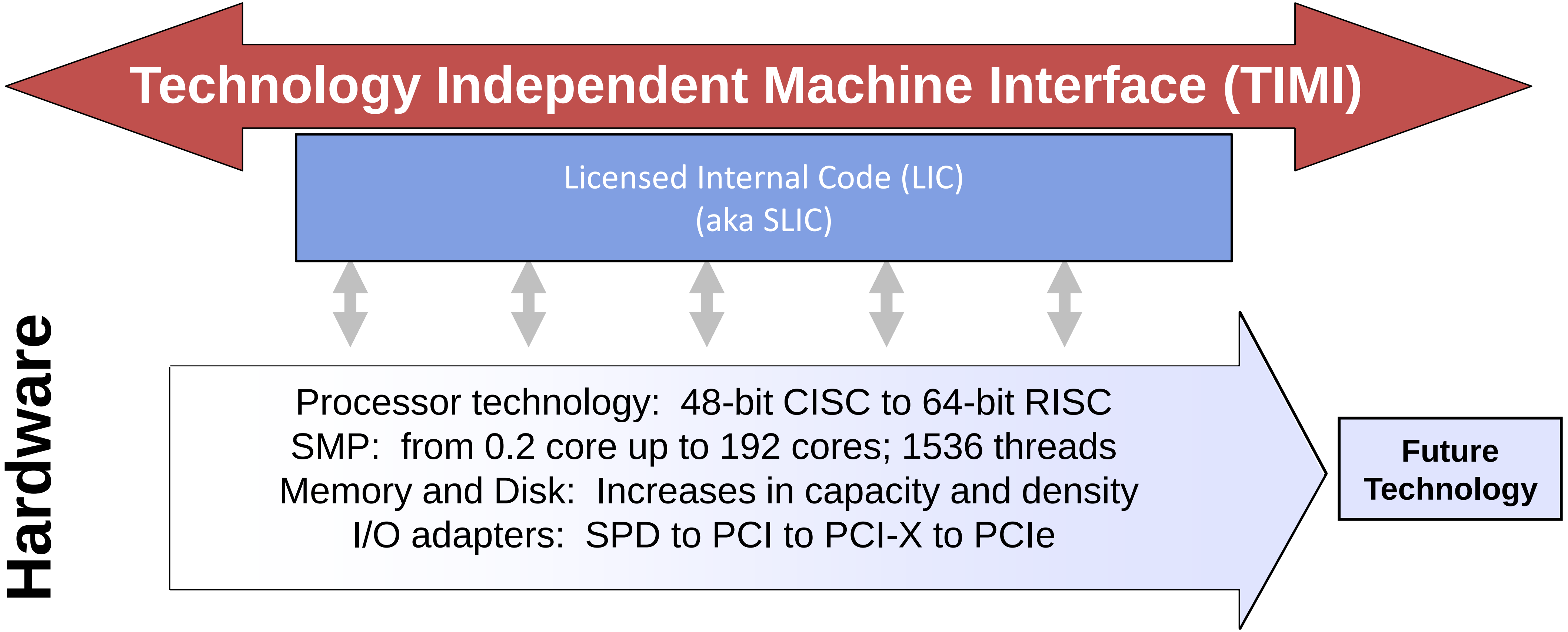

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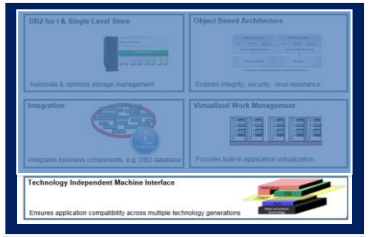
Hardware

Processor technology: 48-bit CISC to 64-bit RISC
SMP: from 0.2 core up to 192 cores; 1536 threads
Memory and Disk: Increases in capacity and density
I/O adapters: SPD to PCI to PCI-X to PCIe

Future Technology

So, did the "Architecture" change?

Above TIMI?	Not so much.
Below TIMI?	You betcha!



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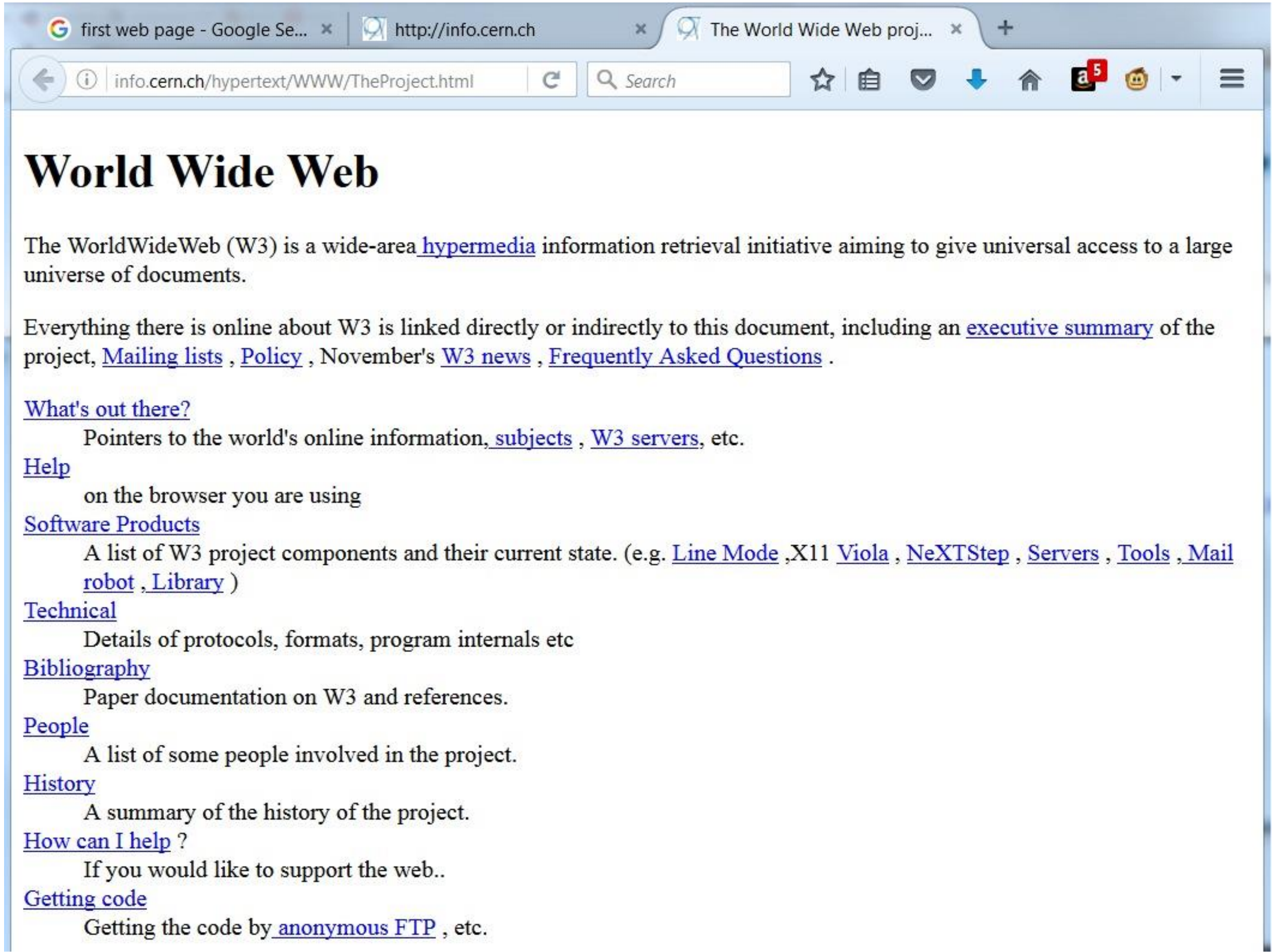


first web page - Google Se...
http://info.cern.ch
The World Wide Web proj...
info.cern.ch/hypertext/WWW/TheProject.html
Search

World Wide Web

The WorldWideWeb (W3) is a wide-area hypermedia information retrieval initiative aiming to give universal access to a large universe of documents.

Everything there is online about W3 is linked directly or indirectly to this document, including an executive summary of the project, Mailing lists , Policy , November's W3 news , Frequently Asked Questions .

What's out there?
    Pointers to the world's online information, subjects , W3 servers, etc.
Help
    on the browser you are using
Software Products
    A list of W3 project components and their current state. (e.g. Line Mode ,X11 Viola , NeXTStep , Servers , Tools , Mail robot , Library)
Technical
    Details of protocols, formats, program internals etc
Bibliography
    Paper documentation on W3 and references.
People
    A list of some people involved in the project.
History
    A summary of the history of the project.
How can I help ?
    If you would like to support the web..
Getting code
    Getting the code by anonymous FTP , etc.

Hypertext Transfer Protocol
(HTTP)

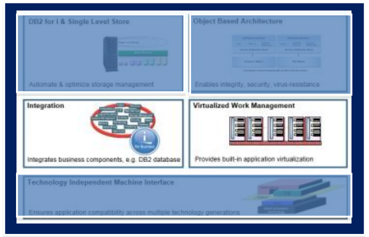
The first web page ever!

Web Serving Drove Changes

- HTTP was gaining strength as a presentation protocol
  - With imbedded data retrieval from a web server
- V3R7 – CERN-based web server
  - Single instance only; V4R1 – Multiple servers allowed
- V4R5 – Apache-based web server

- Benefited from Multi-threading

- Drove requirements for
  - Digital Certificates
  - Server Architecture
  - Teraspace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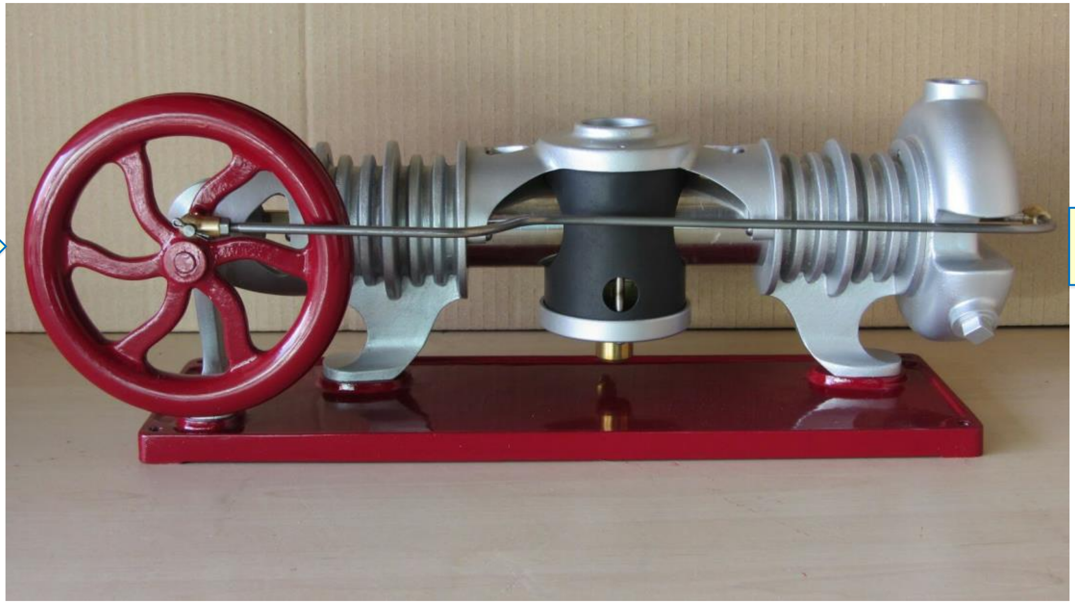
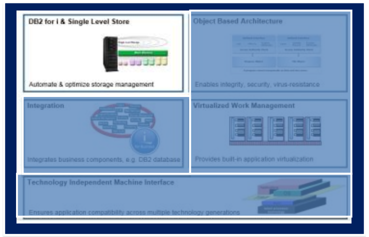
What about the Database?

The Classic Query Engine - CQE

User Question in the Form of a Query



DB2 Answer



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- DB2 Architects wanted a Query Engine which could

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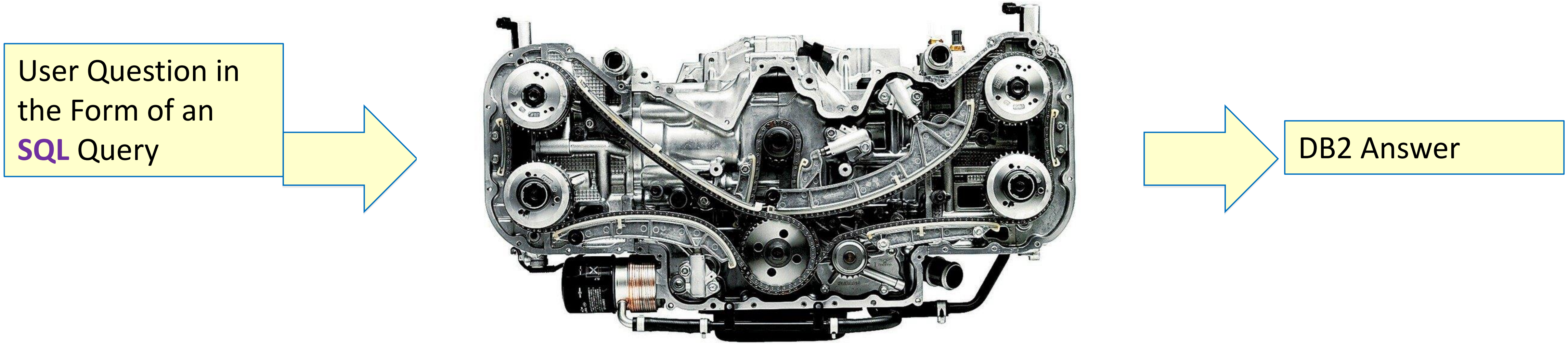
SQL

DB2 Architects Saw Opportunities

- DB2 Architects wanted a Query Engine which could
  - Take advantage of knowing it was dealing with SQL
  - Learn from the past
  - Use what it learned from queries for one application to improve queries for other applications.

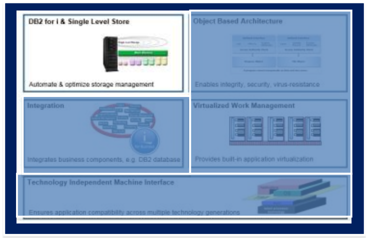
SQL

The SQL Query Engine



User Question in the Form of an **SQL** Query

DB2 Answer



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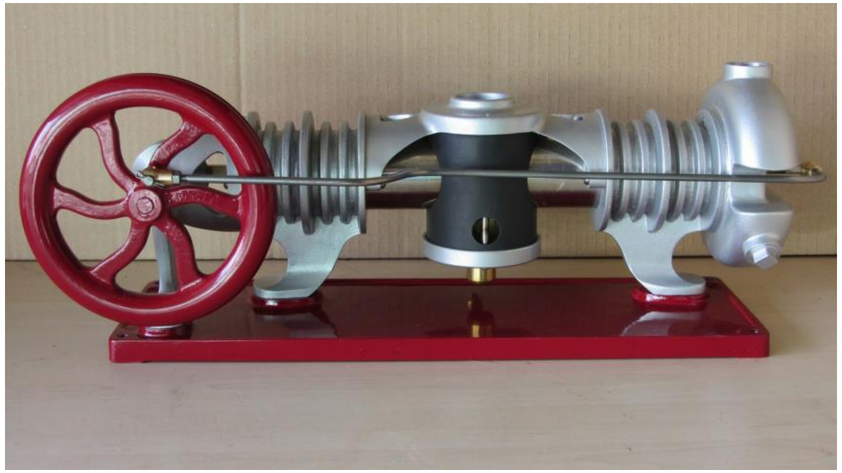
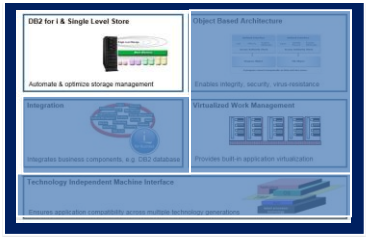
Avoiding Disruption Was Paramount



Time



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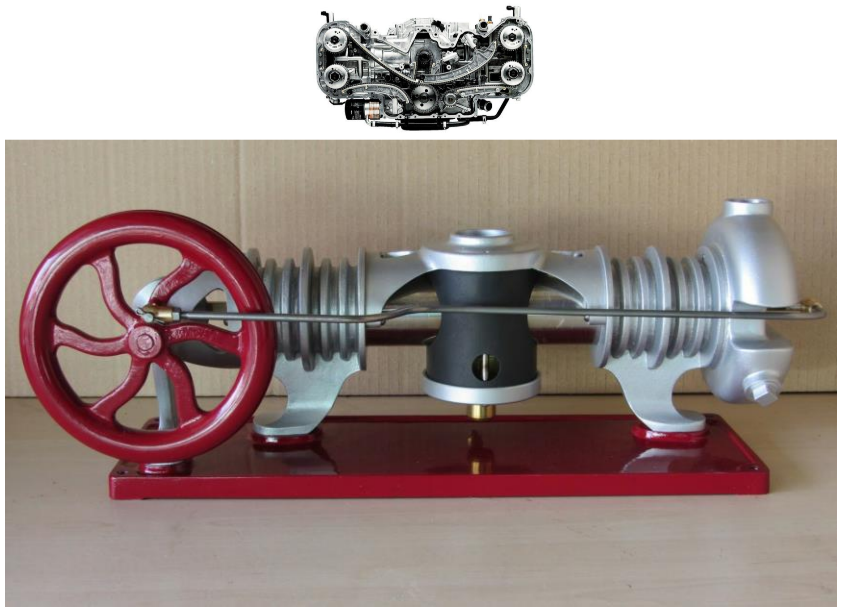

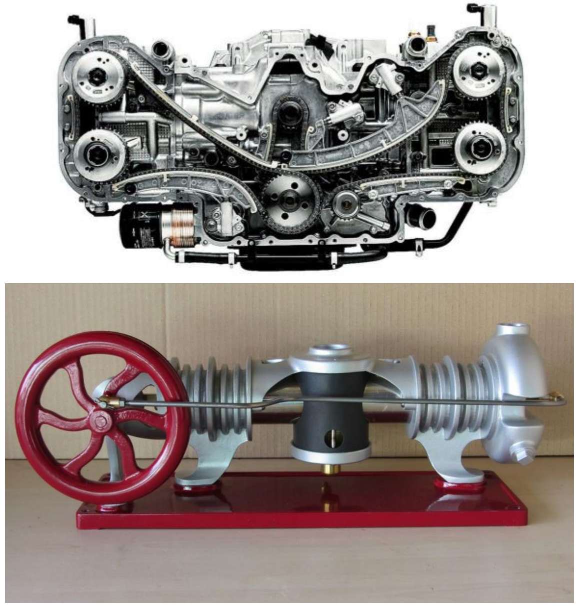

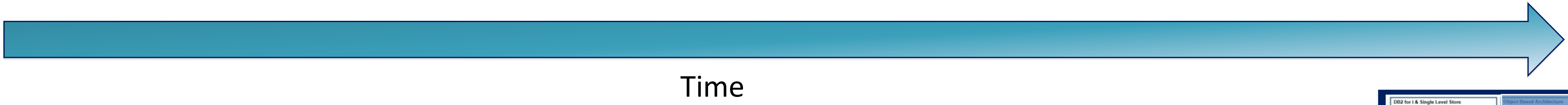

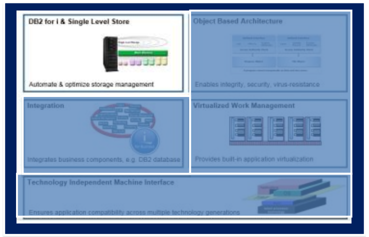

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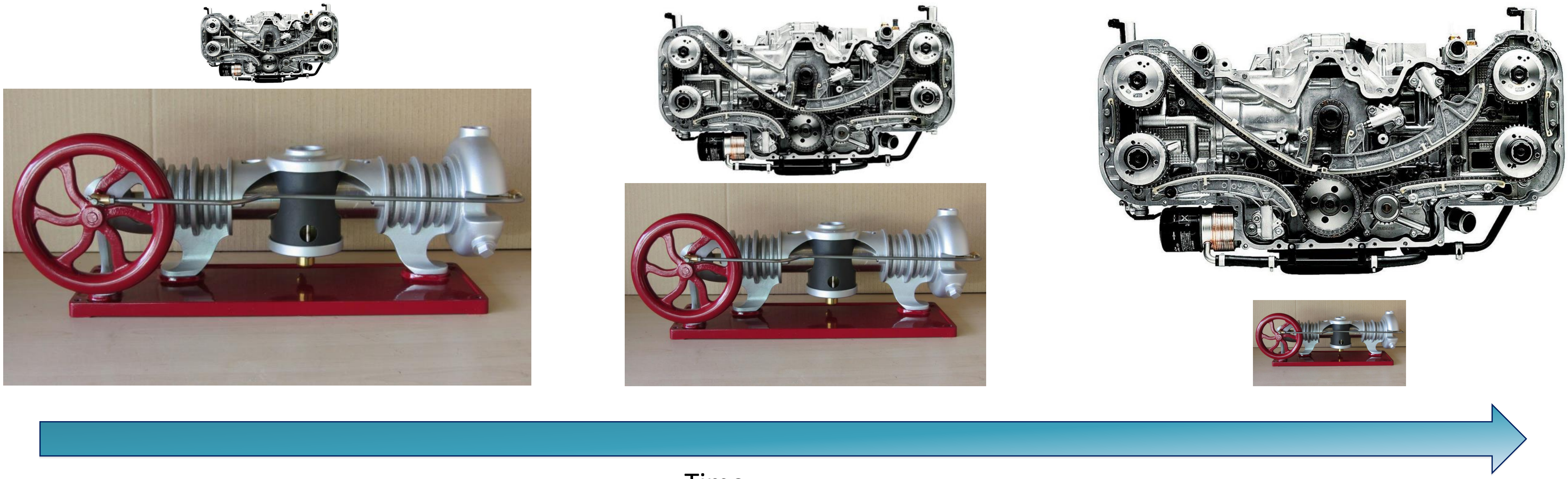

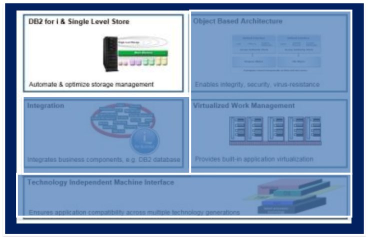

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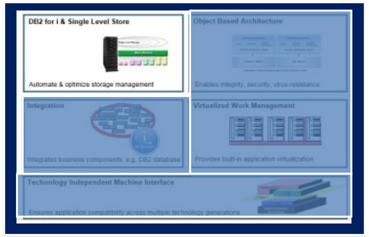
Teraspace: Storage Revolution

- 1 Terabyte (= 2^{40} bytes)
  - flat (non-segmented), process-local storage
  - Temporary
- Lightweight 8-byte pointers available
  - high performance, untagged
- And definitely NOT Single-Level Store!



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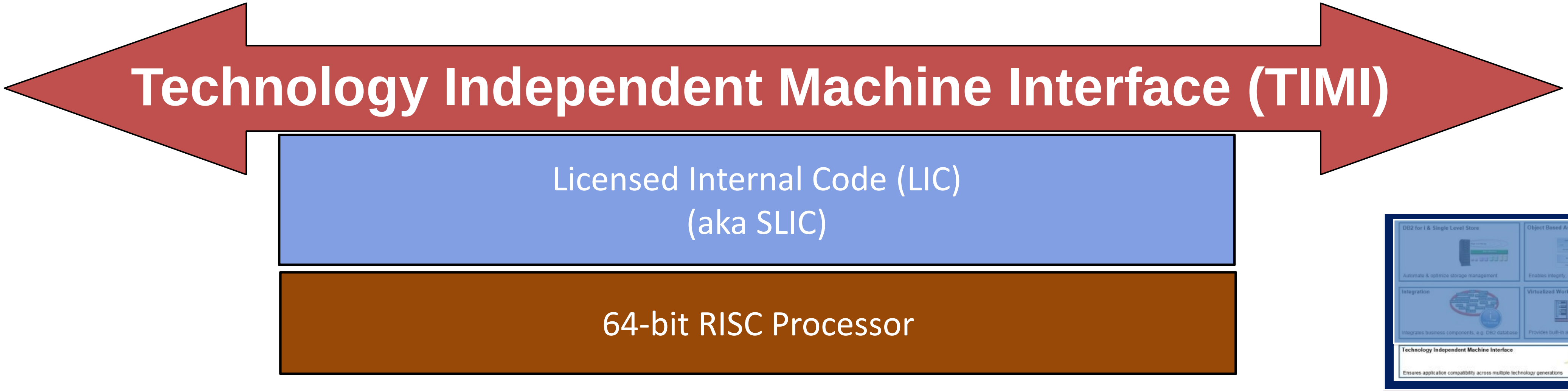
6.1

Retranslation at 6.1

In IBM i 6.1, Retranslation occurred to for three purposes:

- Improving security & integrity
- Performance
- Removing limits



Technology Independent Machine Interface (TIMI)

Licensed Internal Code (LIC)
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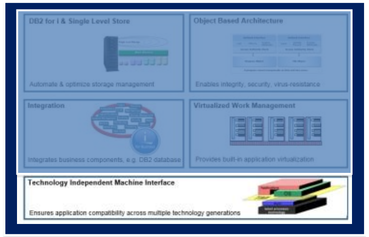
64-bit RISC Processor



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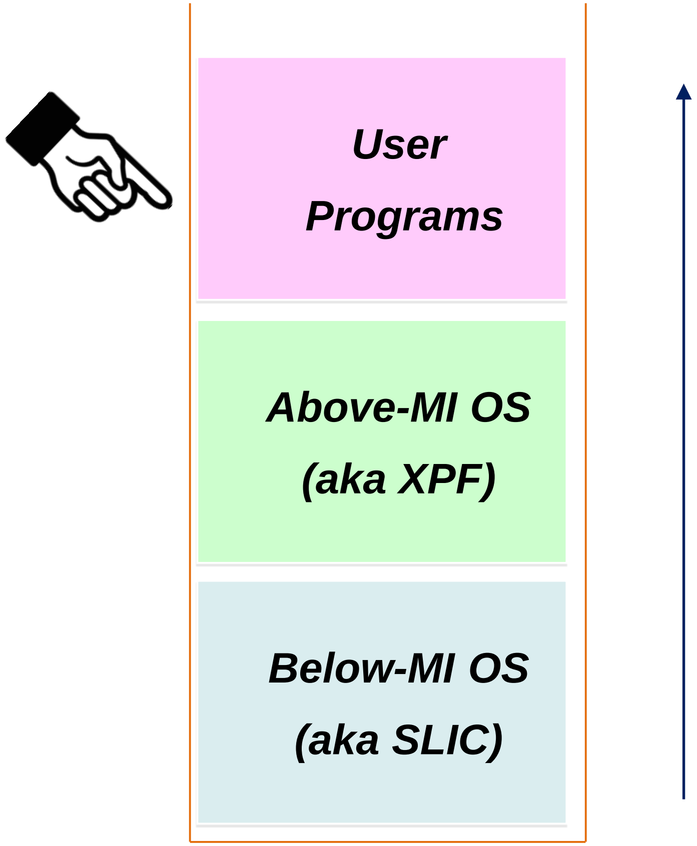
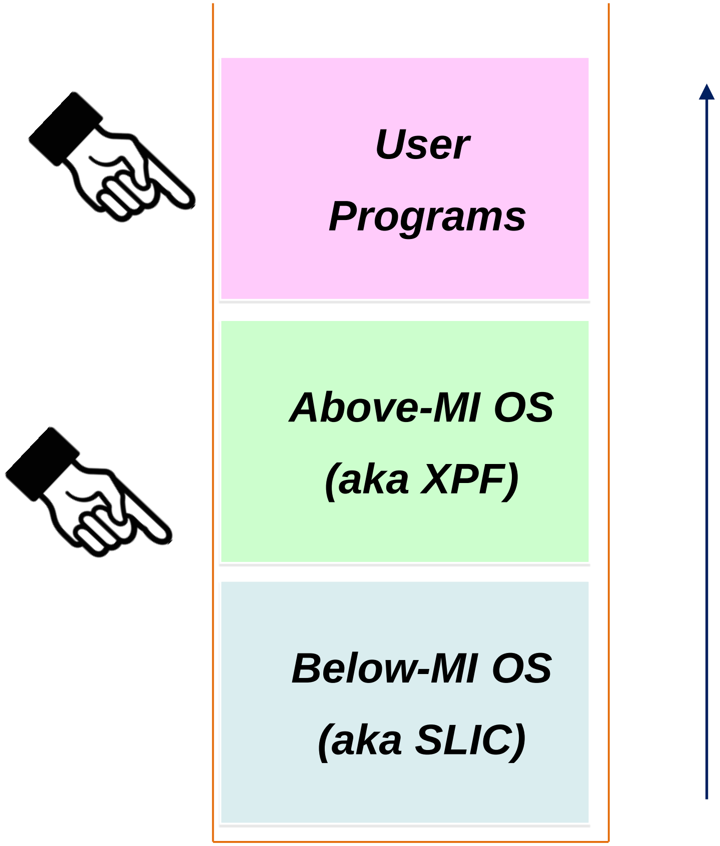
6.1 Retranslation Integrity Part 1: The Execution Stack



Before 6.1
Single Stack

6.1 Retranslation Integrity Part 1: The Execution Stack



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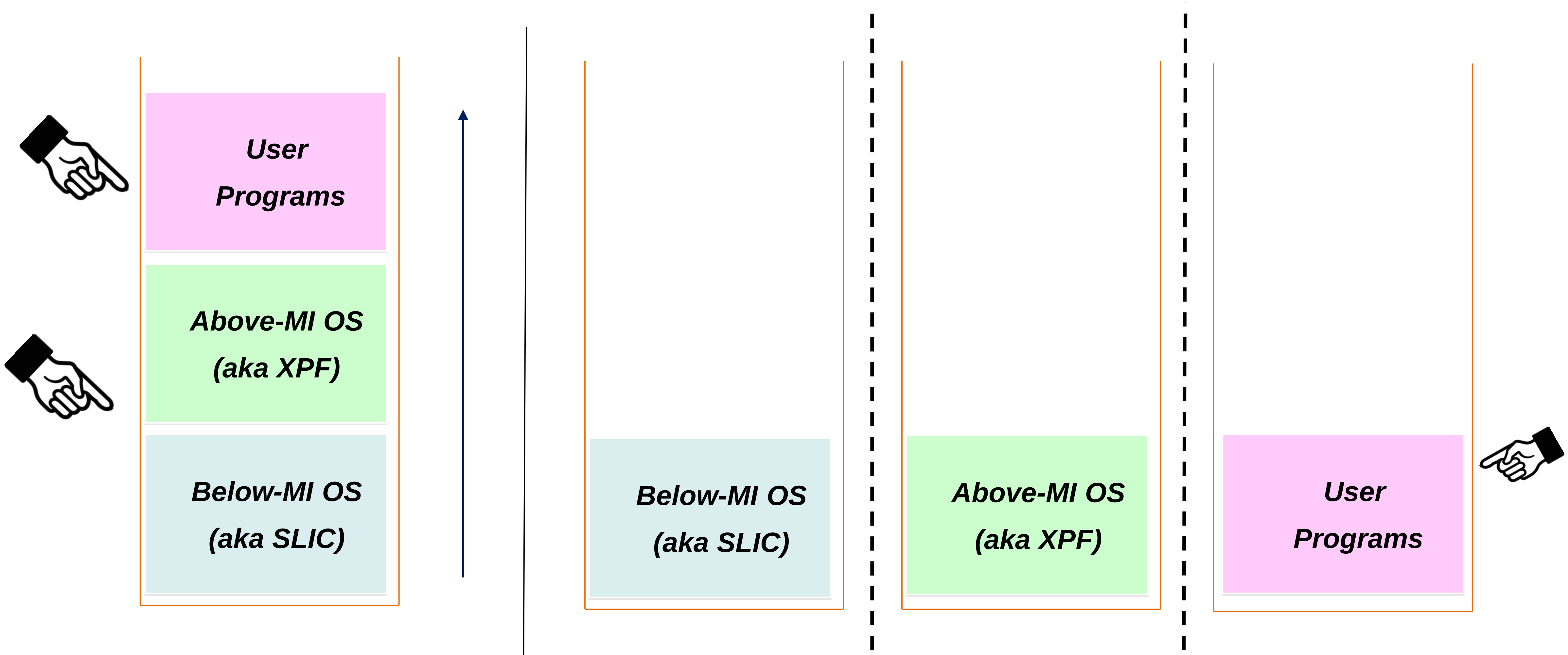


User Programs

Above-MI OS (aka XPF)

Below-MI OS (aka SLIC)

Below-MI OS (aka SLIC)

Above-MI OS (aka XPF)

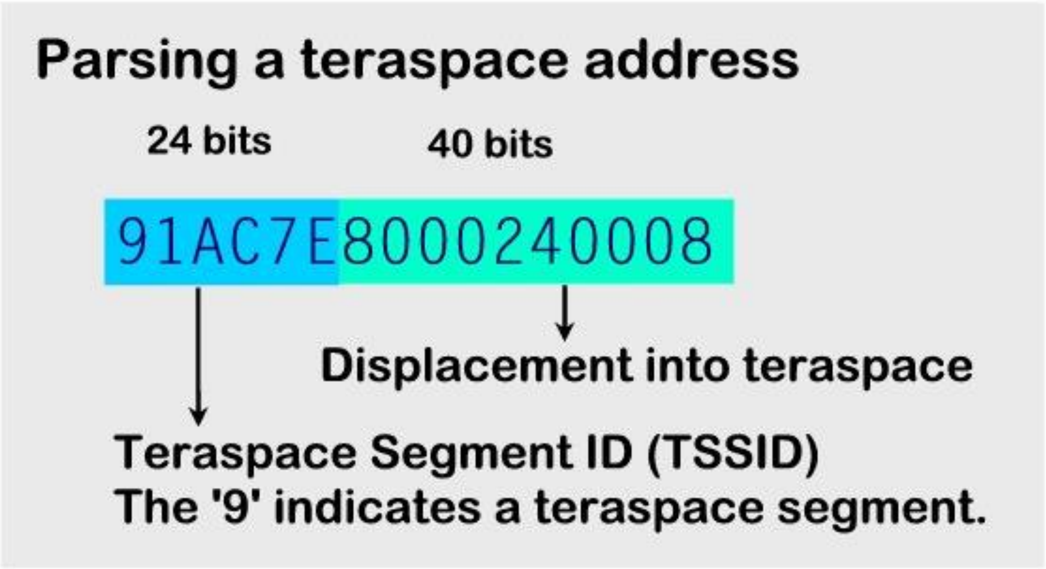
User Programs

Before 6.1
Single Stack

Starting 6.1
Split Stack

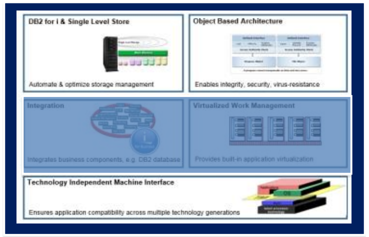
Retranslation Integrity & Performance Part 2: Teraspace

- Teraspace initially implemented in software – in SLIC
- Over time, processor support was added to improve use and integrity of addressing.
- By 6.1, all supported machine types had the necessary processor support to do teraspace “right.”
- Retranslation accomplished true “hardware protection” and use of teraspace.



Parsing a teraspace address

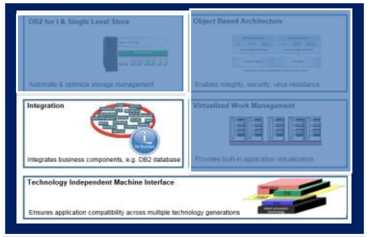
24 bits
40 bits
91AC7E8000240008
Displacement into teraspace
Teraspace Segment ID (TSSID)
The '9' indicates a teraspace segment.



DB2 for i & Single Level Store
Automate & optimize storage management
Object Based Architecture
Enables integrity, security, virus-resistance
Integration
Integrates business components, e.g. DB2 database
Virtualized Work Management
Provides built-in application virtualization
Technology Independent Machine Interface
Ensures application compatibility across multiple technology generations

PASE – Portable Application Solutions Environment

- By 2000, AIX and OS/400 were able to run on the same POWER processors.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OS

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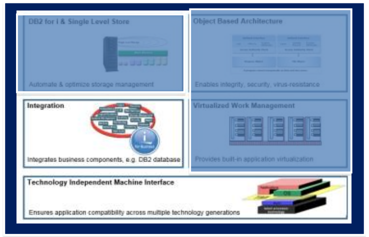
- PASE makes it possible for those binaries to run in the same process.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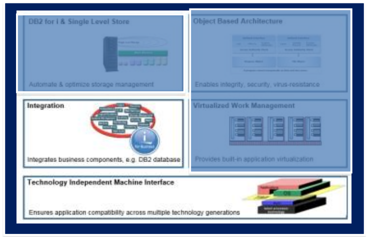
- PASE makes it possible for those binaries to run in the same process.

- PASE is a release of AIX
  - Fitted to talk to SLIC rather than directly to the AIX kernel.

- PASE gets the memory from same SLIC teraspace pools used by ILE
  - for program run stack, heap, and shared memory
  - PASE can ONLY see memory that PASE acquired through its own syscall APIs



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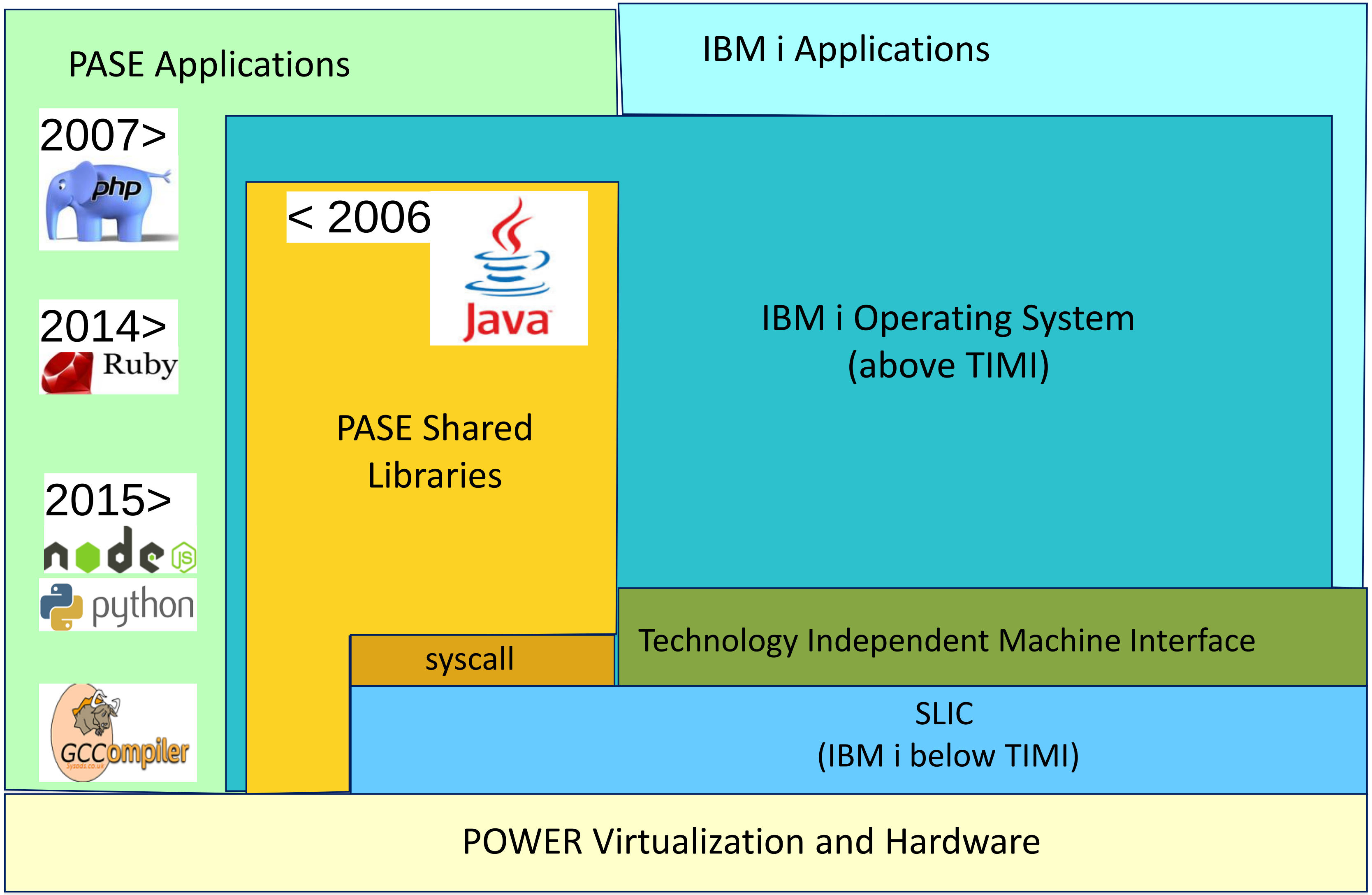
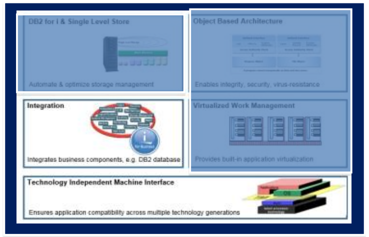
Pictorial View of PASE



PASE allows IBM i to host

- Java
  - SAP
- PHP
- Ruby
- And many other open source options



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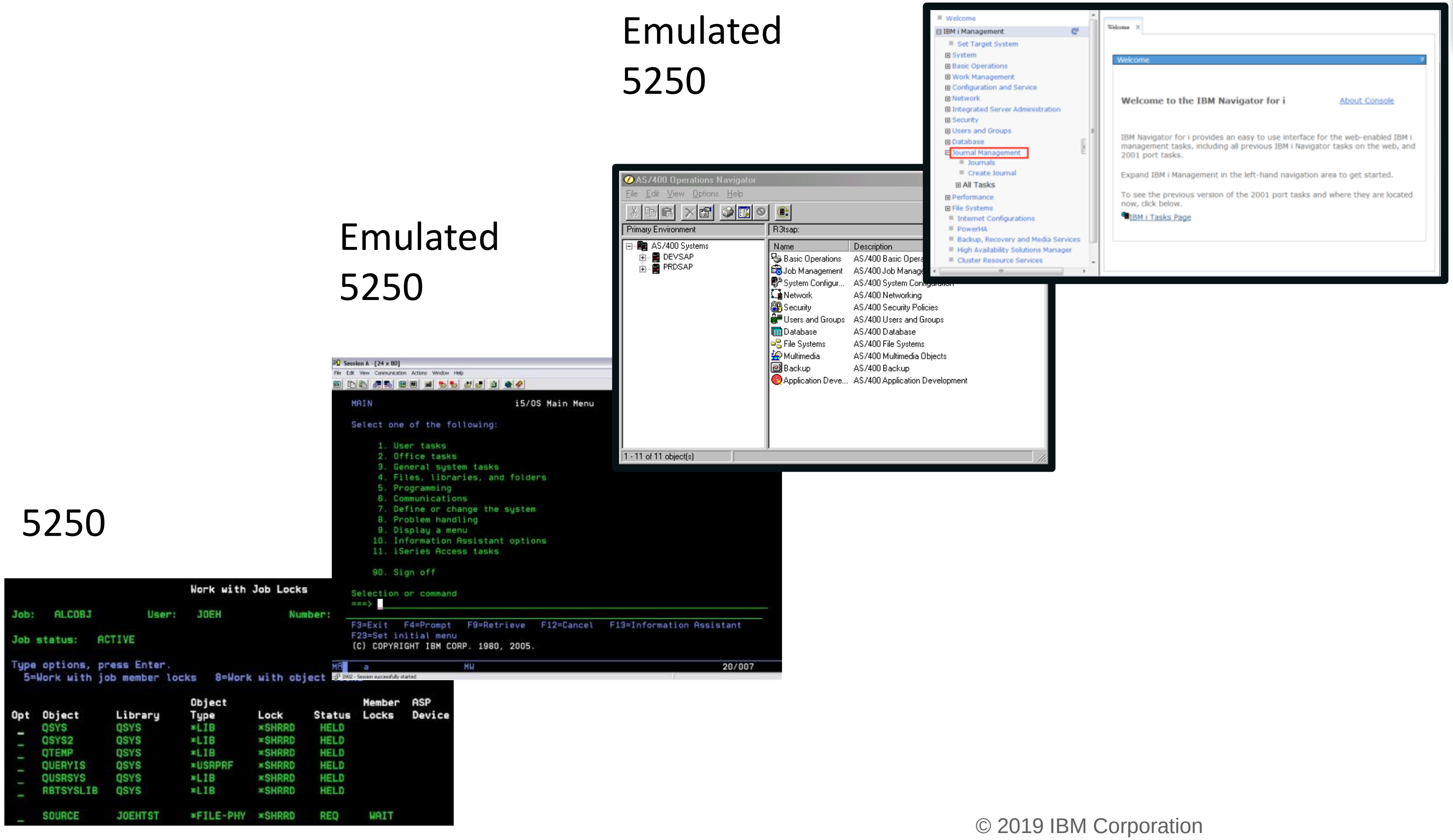
Managing/Accessing the System

5250

Emulated 5250

GUI Emulated 5250

Java & Web + Server Jobs



```
                                Work with Job Locks

Job:   ALCOBJ          User:   JOEH            Number:

Job status:   ACTIVE

Type options, press Enter.
  5=Work with job member locks   8=Work with object

                                Object                          Member   ASP
Opt  Object       Library       Type        Lock       Status   Locks    Device
 _   QSYS         QSYS          *LIB        *SHRRD      HELD
 _   QSYS2        QSYS          *LIB        *SHRRD      HELD
 _   QTEMP        QSYS          *LIB        *SHRRD      HELD
 _   QUERYIS      QSYS          *USRPRF     *SHRRD      HELD
 _   QUSRSYS      QSYS          *LIB        *SHRRD      HELD
 _   RBTSYSLIB    QSYS          *LIB        *SHRRD      HELD

 _   SOURCE       JOEHTST       *FILE-PHY   *SHRRD      REQ       WAIT
```

Session A - [24 x 80]

```
 MAIN                            i5/OS Main Menu

 Select one of the following:

      1. User tasks
      2. Office tasks
      3. General system tasks
      4. Files, libraries, and folders
      5. Programming
      6. Communications
      7. Define or change the system
      8. Problem handling
      9. Display a menu
     10. Information Assistant options
     11. iSeries Access tasks

     90. Sign off

 Selection or command
 ===> _________________________________________________________________________

 F3=Exit   F4=Prompt   F9=Retrieve   F12=Cancel   F13=Information Assistant
 F23=Set initial menu
 (C) COPYRIGHT IBM CORP. 1980, 2005.
MA    a                MW                                                 20/007
```

1902 - Session successfully started

AS/400 Operations Navigator

Primary Environment

- AS/400 Systems
  - DEVSAP
  - PRDSAP

R3tsap:

Name	Description
Basic Operations	AS/400 Basic Opera
Job Management	AS/400 Job Manage
System Configur...	AS/400 System Configuration
Network	AS/400 Networking
Security	AS/400 Security Policies
Users and Groups	AS/400 Users and Groups
Database	AS/400 Database
File Systems	AS/400 File Systems
Multimedia	AS/400 Multimedia Objects
Backup	AS/400 Backup
Application Deve...	AS/400 Application Development

1 - 11 of 11 object(s)

- Welcome
- IBM i Management
  - Set Target System
  - System
  - Basic Operations
  - Work Management
  - Configuration and Service
  - Network
  - Integrated Server Administration
  - Security
  - Users and Groups
  - Database
  - Journal Management
    - Journals
    - Create Journal
    - All Tasks
  - Performance
  - File Systems
  - Internet Configurations
  - PowerHA
  - Backup, Recovery and Media Services
  - High Availability Solutions Manager
  - Cluster Resource Services

Welcome

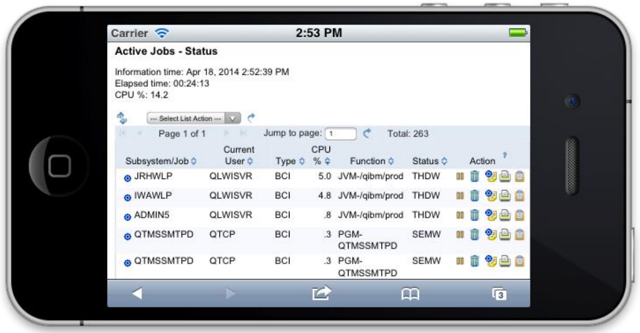
Welcome to the IBM Navigator for i About Console

IBM Navigator for i provides an easy to use interface for the web-enabled IBM i management tasks, including all previous IBM i Navigator tasks on the web, and 2001 port tasks.

Expand IBM i Management in the left-hand navigation area to get started.

To see the previous version of the 2001 port tasks and where they are located now, click below.

IBM i Tasks Page



Carrier 2:53 PM

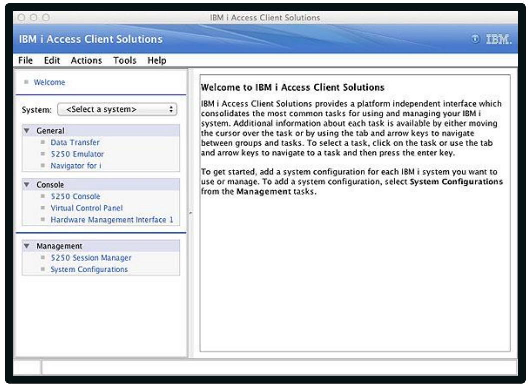
Active Jobs - Status

Information time: Apr 18, 2014 2:52:39 PM
Elapsed time: 00:24:13
CPU %: 14.2

--- Select List Action ---

Page 1 of 1 Jump to page: 1 Total: 263

Subsystem/Job	Current User	Type	CPU %	Function	Status	Action
JRHWLP	QLWISVR	BCI	5.0	JVM-/qibm/prod	THDW	
IWAWLP	QLWISVR	BCI	4.8	JVM-/qibm/prod	THDW	
ADMIN5	QLWISVR	BCI	.8	JVM-/qibm/prod	THDW	
QTMSSMTPD	QTCP	BCI	.3	PGM-QTMSSMTPD	SEMW	
QTMSSMTPD	QTCP	BCI	.3	PGM-QTMSSMTPD	SEMW	



IBM i Access Client Solutions

IBM i Access Client Solutions

File Edit Actions Tools Help

- Welcome

System: <Select a system>

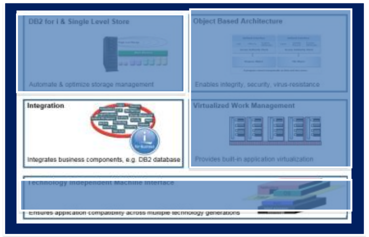
- General
  - Data Transfer
  - 5250 Emulator
  - Navigator for i
- Console
  - 5250 Console
  - Virtual Control Panel
  - Hardware Management Interface 1
- Management
  - 5250 Session Manager
  - System Configurations

Welcome to IBM i Access Client Solutions

IBM i Access Client Solutions provides a platform independent interface which consolidates the most common tasks for using and managing your IBM i system. Additional information about each task is available by either moving the cursor over the task or by using the tab and arrow keys to navigate between groups and tasks. To select a task, click on the task or use the tab and arrow keys to navigate to a task and then press the enter key.

To get started, add a system configuration for each IBM i system you want to use or manage. To add a system configuration, select **System Configurations** from the **Management** tasks.

Java, Mobile, BYOD
SQL Services



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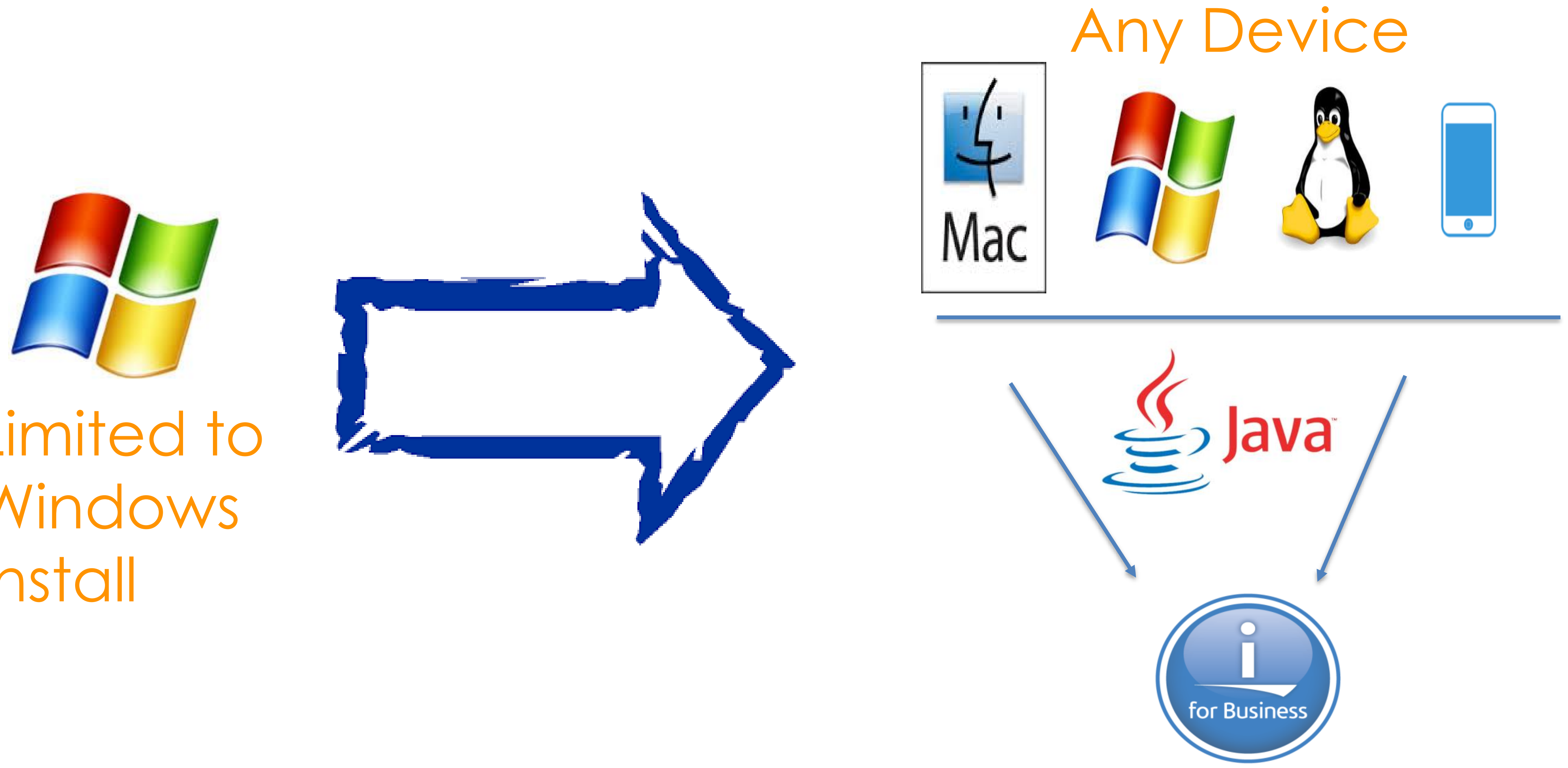
IBM i Access and Management



Limited to Windows Install

Any Device

Some things I’ll just mention

- Development Tools
- National Language Support
- Display & Print
- LDAP

- Object Signing
- Enterprise Identity Mapping
- Scaling
- Nodal Affinity
- Independent ASPs

- Logical Partitioning
- N-2 Support
- Technology Refreshes
- Evolution to Waiting Servers
- Integration of Open Source

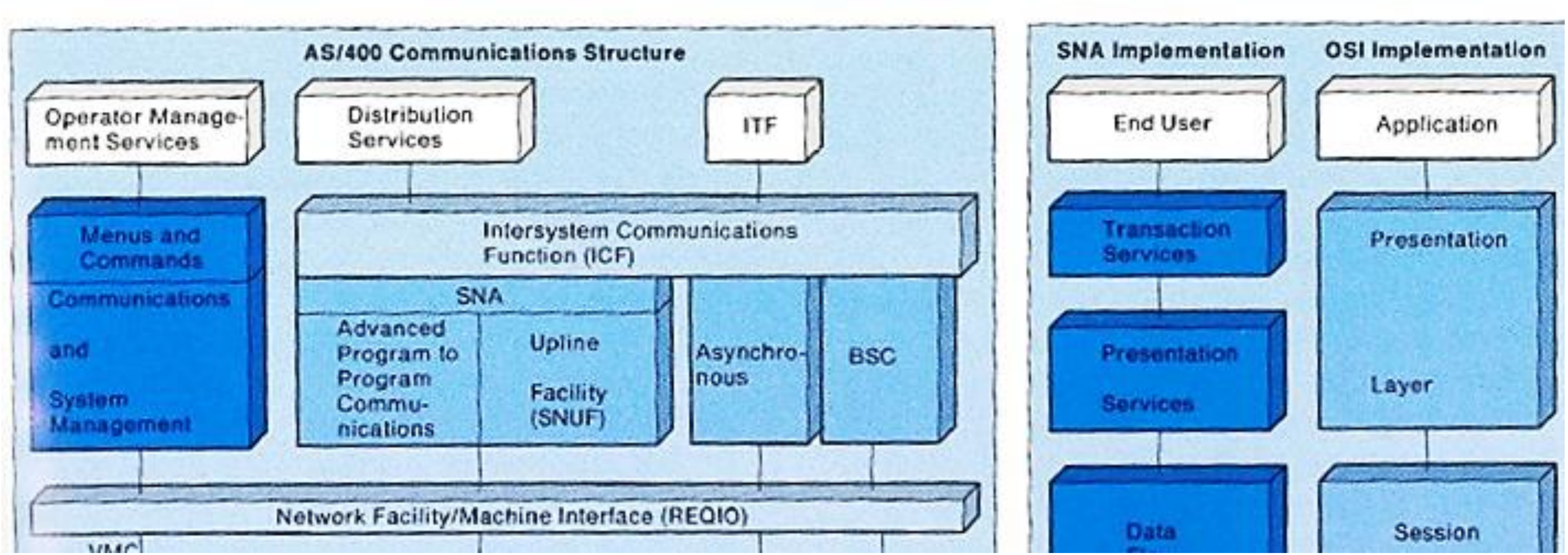
And things I'll mention for a particular point

- Storage Technology
  - From 520-byte **proprietary,** to 512-byte commodity, to SAN

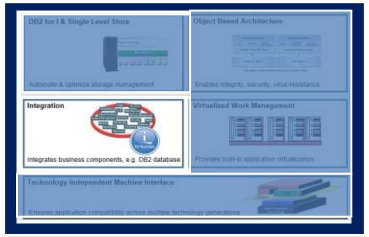
- I/O
  - During the CISC-to-RISC transition, the move from **IOP-based I/O** to IOA-based I/O was happening

- Networking
  - O. M. G. Does anyone remember **SNA**? Used to be interwoven. I mean, look at this:

AS/400 Integrated Data Communications


AS/400 Communications Structure
Operator Management Services
Distribution Services
ITF
Menus and Commands
Communications and System Management
Intersystem Communications Function (ICF)
SNA
Advanced Program to Program Communications
Upline Facility (SNUF)
Asynchronous
BSC
Network Facility/Machine Interface (REQIO)
SNA Implementation
OSI Implementation
End User
Application
Transaction Services
Presentation Services
Presentation Layer
Data
Session

No TCP/IP in sight.
The REQIO TIMI instruction survived.



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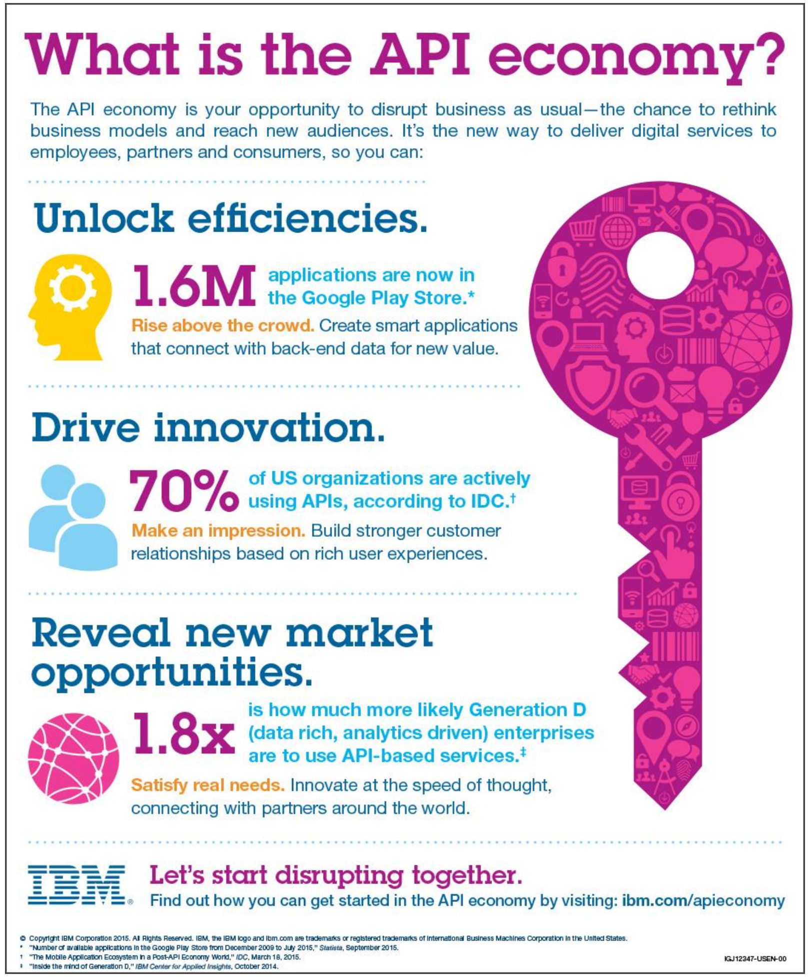
Major pieces of the architecture of S/38 & AS/400: Gone or transformed to be nearly unrecognizable.

What
now?

What's
Next?

Continuous Availability



What is the API economy?

The API economy is your opportunity to disrupt business as usual—the chance to rethink business models and reach new audiences. It's the new way to deliver digital services to employees, partners and consumers, so you can:

Unlock efficiencies.

1.6M applications are now in the Google Play Store.*

Rise above the crowd. Create smart applications that connect with back-end data for new value.

Drive innovation.

70% of US organizations are actively using APIs, according to IDC.†

Make an impression. Build stronger customer relationships based on rich user experiences.

Reveal new market opportunities.

1.8x is how much more likely Generation D (data rich, analytics driven) enterprises are to use API-based services.‡

Satisfy real needs. Innovate at the speed of thought, connecting with partners around the world.

IBM®

Let's start disrupting together.

Find out how you can get started in the API economy by visiting: **ibm.com/apieconomy**

* "Number of available applications in the Google Play Store from December 2009 to July 2015," *Statista*, September 2015.

† "The Mobile Application Ecosystem in a Post-API Economy World," *IDC*, March 18, 2015.

‡ "Inside the mind of Generation D," *IBM Center for Applied Insights*, October 2014.

IGJ12347-USEN-00

IBM Db2 Mirror for i

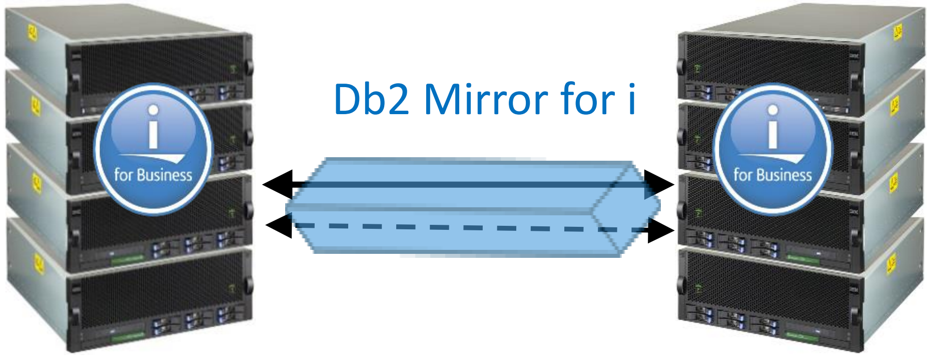
Operating System Synchronous Replication

Continuous Availability

24 x 7 Up Time

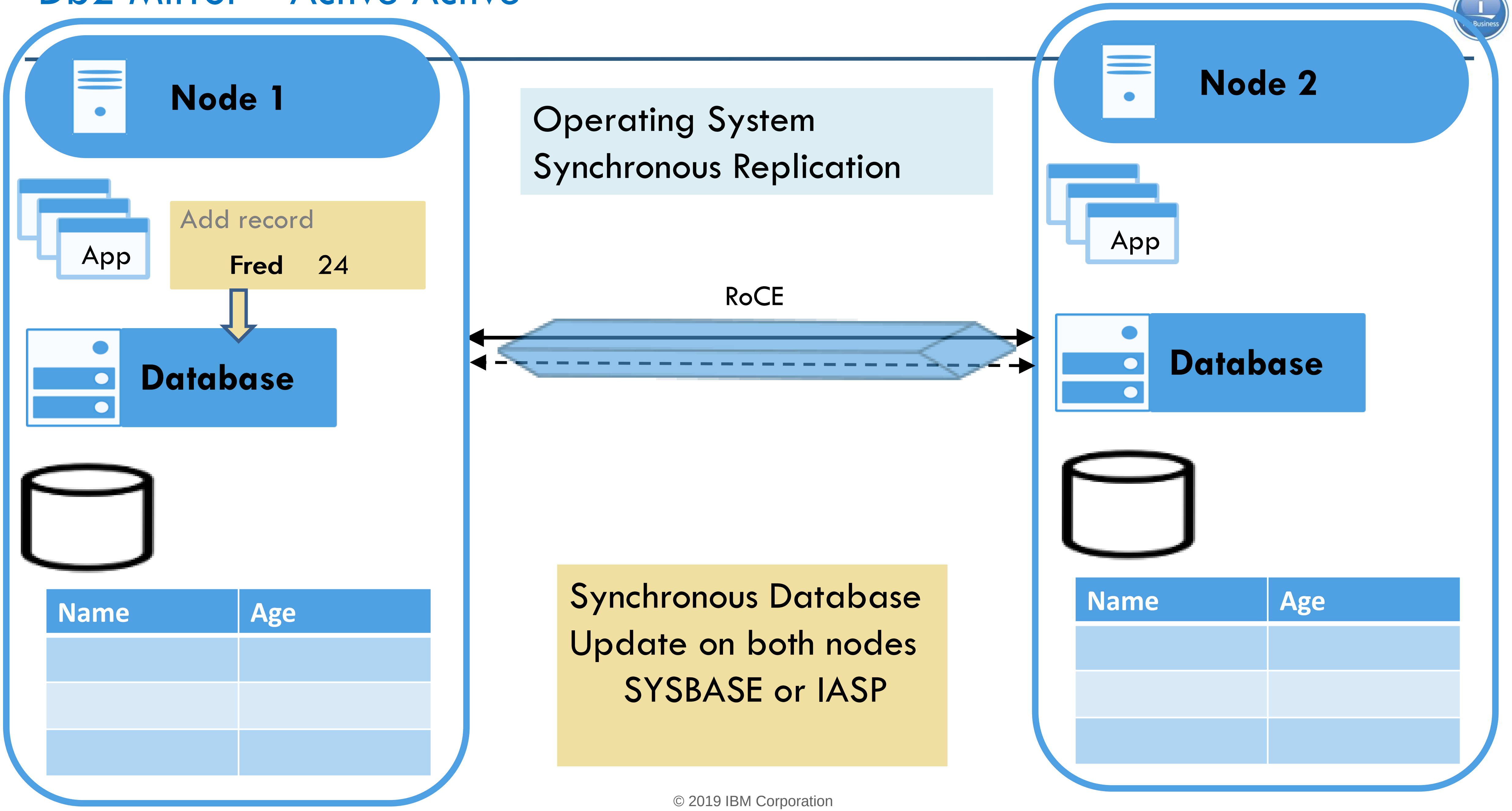
Rolling Upgrades

RTO/RPO Near Zero



POWER8 or later & IBM i 7.4
+ External Storage

Db2 Mirror – Active Active



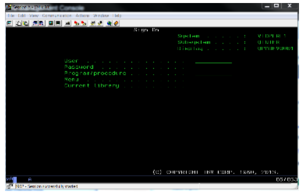
Operating System
Synchronous Replication

Synchronous Database
Update on both nodes
SYSBASE or IASP

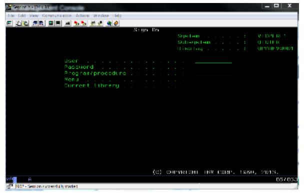
Db2 Mirror – Database Supported Objects

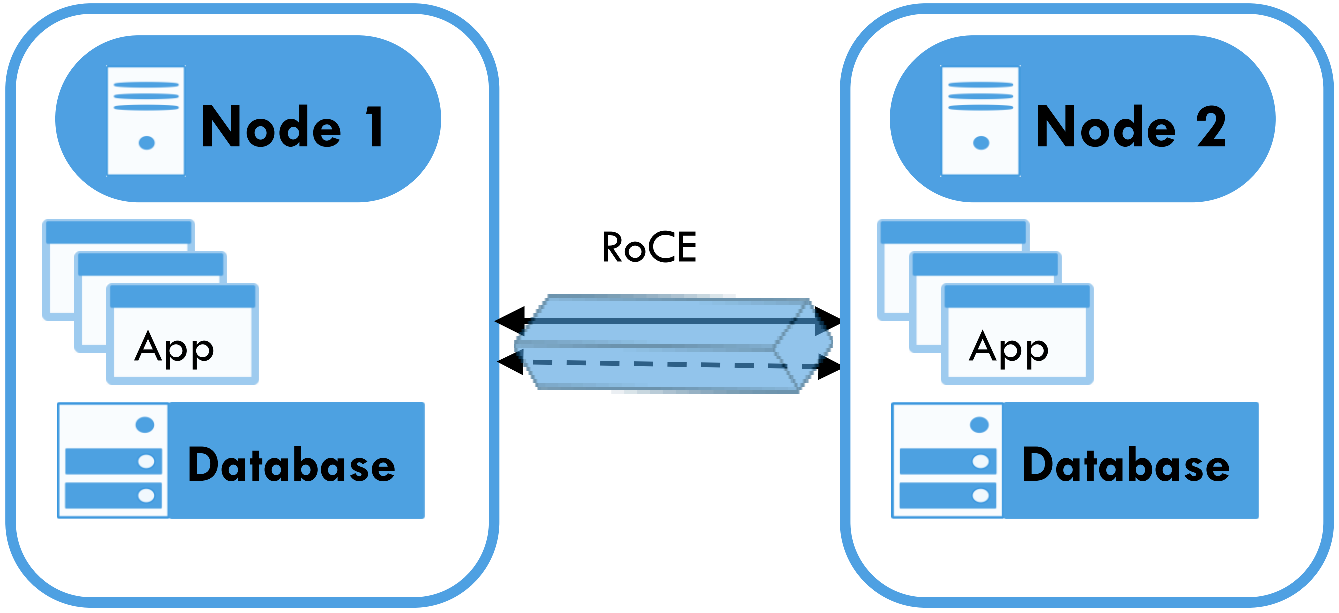
- Database replication eligible:
  - Native:
  - -- Database physicals & logical files
    SQL:
    -- Aliases
    -- Functions
    -- Indexes
    -- Permissions
    -- Procedures
    -- Schemas
    -- Sequences
    -- *SQLPKG (not extended dynamic SQL Packages)
    -- Tables
    -- Triggers
    -- Types
    -- Global
    Variables
    -- Views
    -- XSR Objects

- DDS / Record Level Access
- SQL / Set Based Access



Application running separate on each node

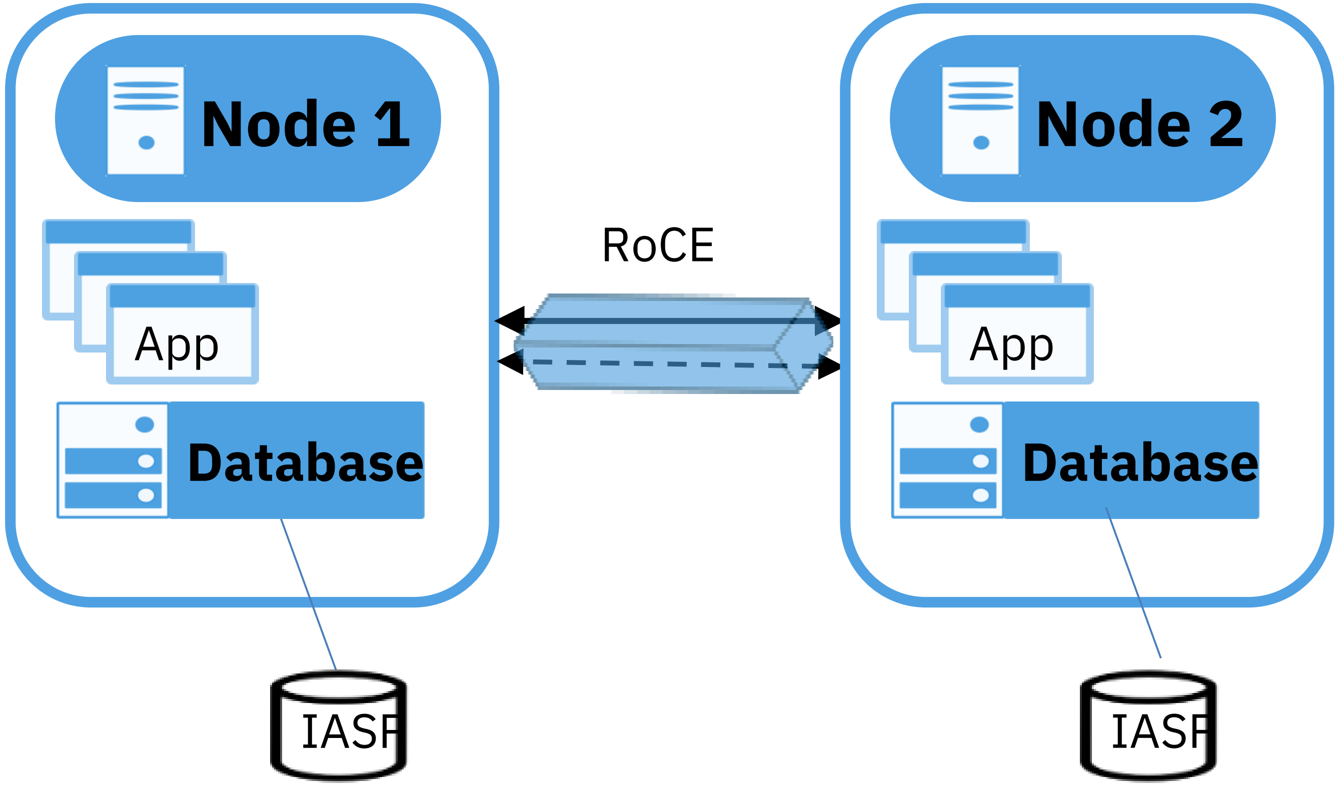




Db2 Mirror – Other Supported Objects

- Other Objects
  - User profiles
  - Authority
  - Ownership
  - Security
  - PGM/SRVPGM
  - Data Areas
  - Data Queues (DDL Only)
  - SYSVALs
  - ENVARs
  - LIB
  - JOBD
  - Journals
  - Files (also has DDL Only option)
- Special Handling
  - OUTQ / Spool
  - Job Queue

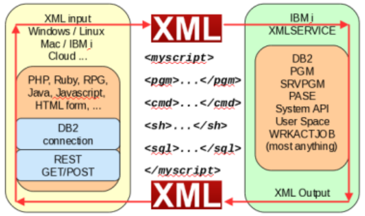
Objects can be in either **SYSBAS** or **IASP**s



Delivered with every new open source language/version

- FastCGI
  - Allows fast connection from HTTP server to backend PASE environment

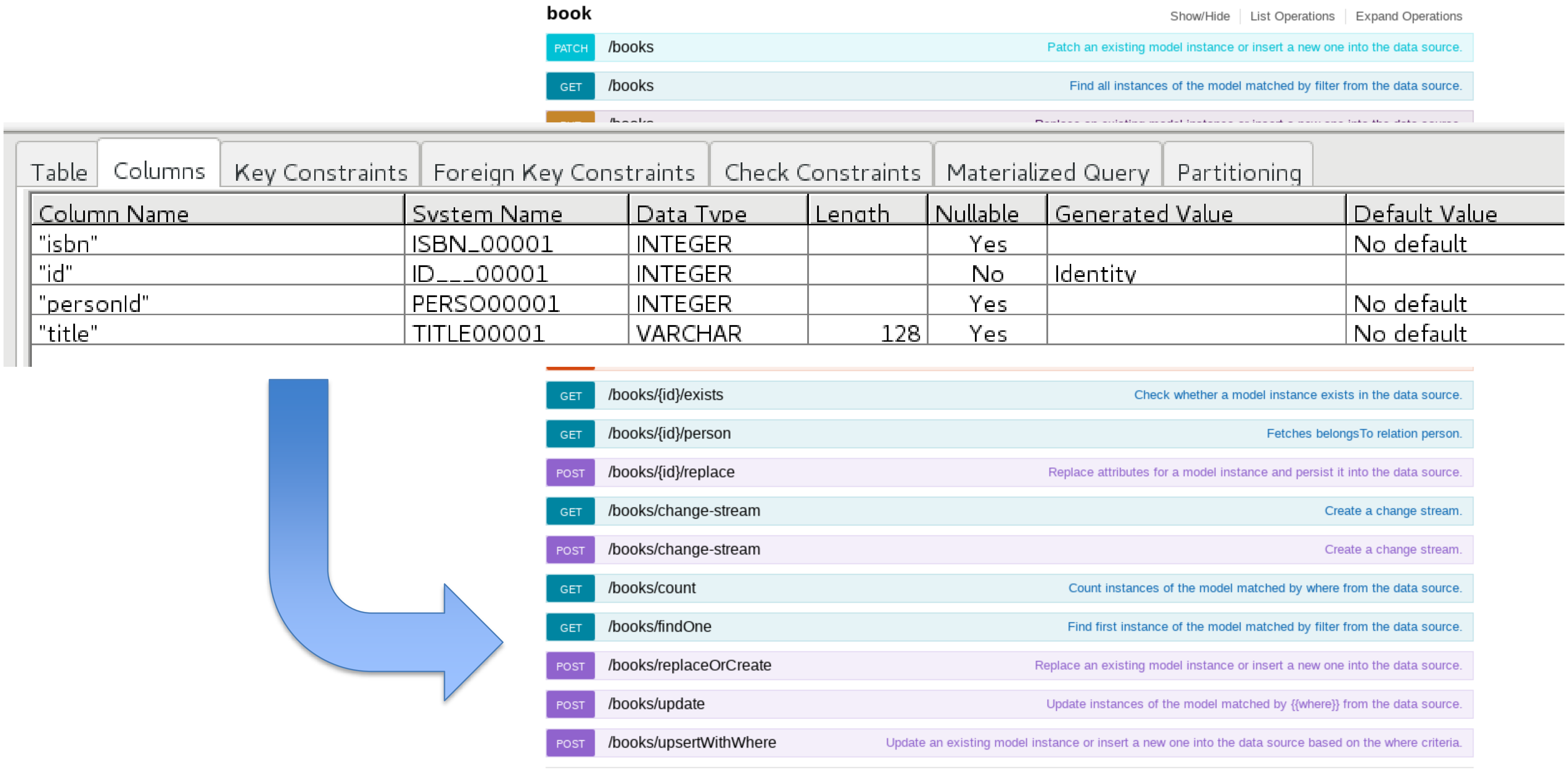
- ILE Object Toolkit
  - Toolkit for each environment to easily allow connections to ILE objects and information



- SQL Connector
  - Easy integrated (from the open source language) way to transfer data to and from DB2 for i leveraging SQL

Loopback support

- Easily create REST APIs with a popular Node.js framework



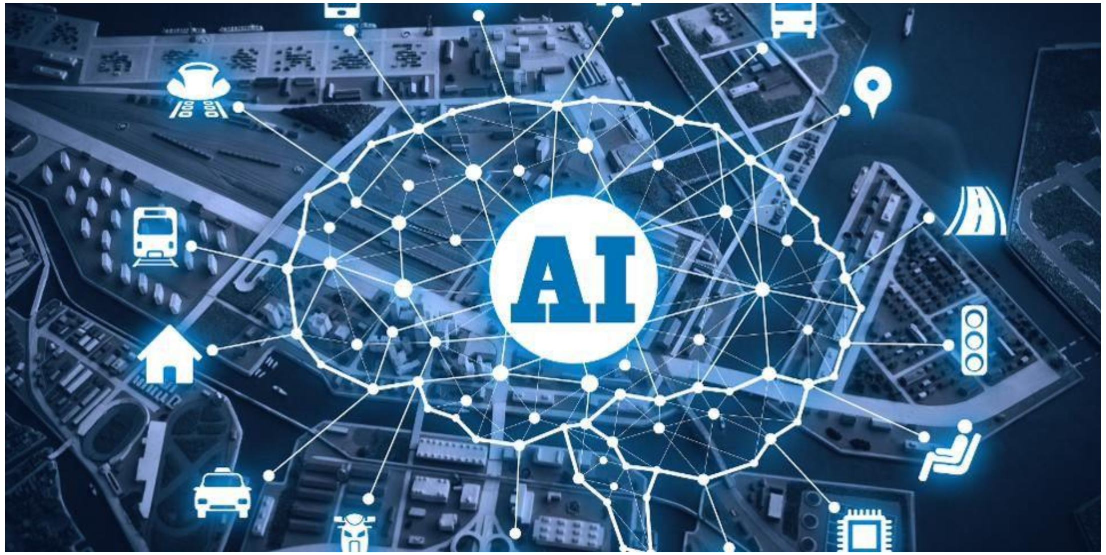
book Show/Hide | List Operations | Expand Operations

PATCH	/books	Patch an existing model instance or insert a new one into the data source.
GET	/books	Find all instances of the model matched by filter from the data source.

Column Name	System Name	Data Type	Length	Nullable	Generated Value	Default Value
"isbn"	ISBN_00001	INTEGER		Yes		No default
"id"	ID___00001	INTEGER		No	Identity	
"personId"	PERSO00001	INTEGER		Yes		No default
"title"	TITLE00001	VARCHAR	128	Yes		No default

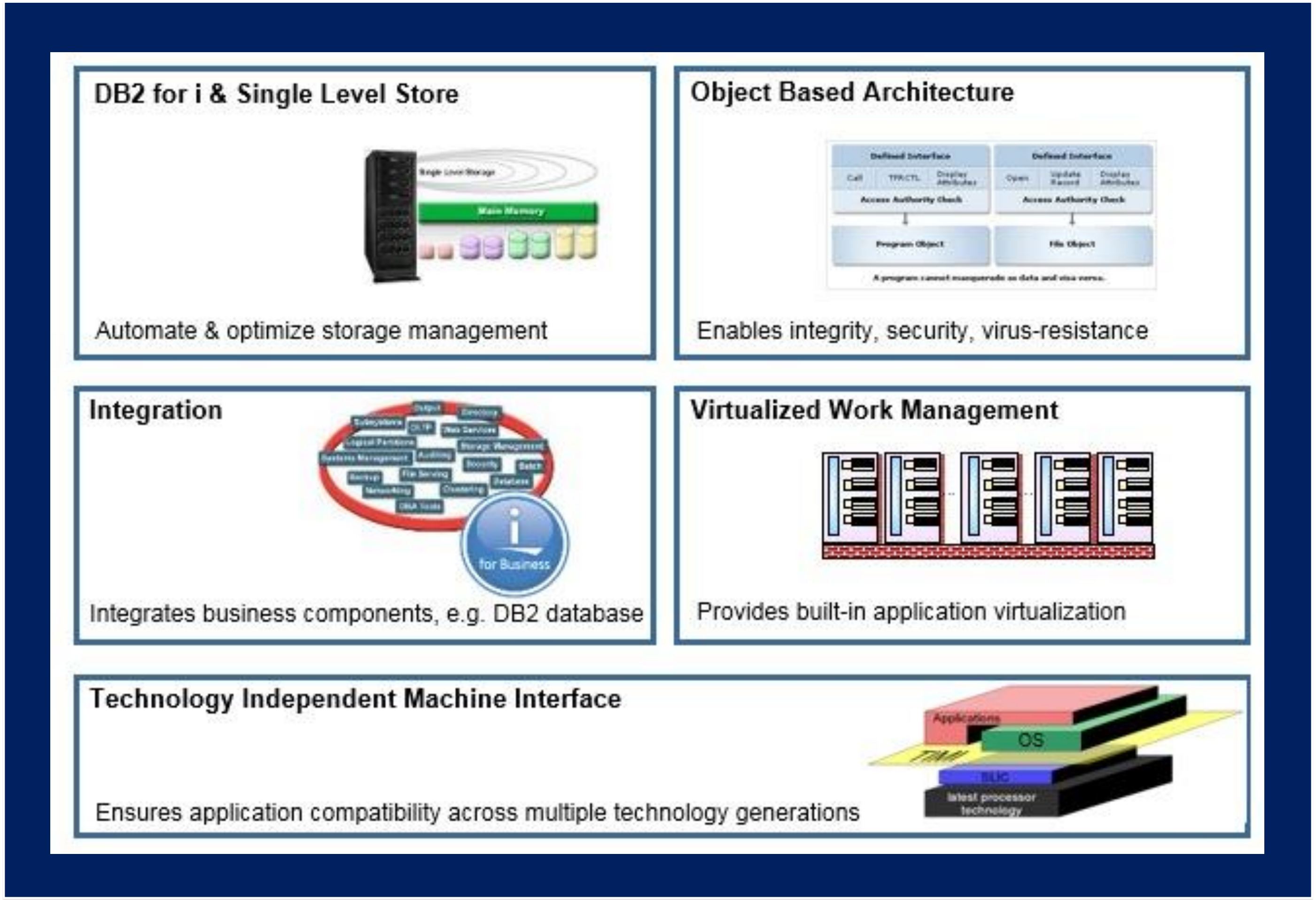
GET	/books/{id}/exists	Check whether a model instance exists in the data source.
GET	/books/{id}/person	Fetches belongsTo relation person.
POST	/books/{id}/replace	Replace attributes for a model instance and persist it into the data source.
GET	/books/change-stream	Create a change stream.
POST	/books/change-stream	Create a change stream.
GET	/books/count	Count instances of the model matched by where from the data source.
GET	/books/findOne	Find first instance of the model matched by filter from the data source.
POST	/books/replaceOrCreate	Replace an existing model instance or insert a new one into the data source.
POST	/books/update	Update instances of the model matched by {{where}} from the data source.
POST	/books/upsertWithWhere	Update an existing model instance or insert a new one into the data source based on the where criteria.

IBM Watson



LET ME EXPLAIN...

LET ME EXPLAIN...
NO, THERE IS TOO MUCH. LET ME SUM UP.



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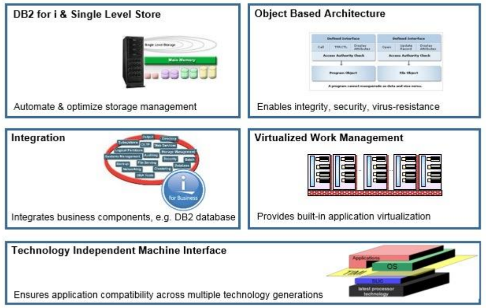

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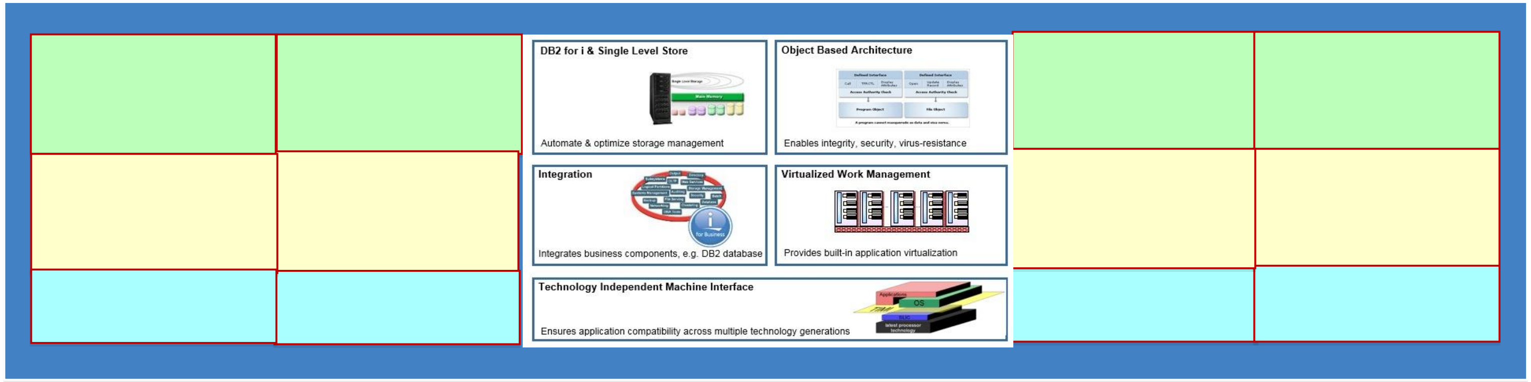

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IBM i - "Technology will change and IBM i is built to change with it"

Link

MERCI