64 bit

an independent perspective

GSE, Large Systems Group
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Acknowledgements

- **The bulk of this presentation has been lifted with permission, from a presentation entitled “OS/390 in a 64 bit world” given by Bob Rogers of IBM Corporation, at the OS/390 Technical and Storage Symposium held in Como, May 2000.**

- **Some alterations and additions have been made therefore all inaccuracies are those of the authors.**

Agenda

- **What is 64 bit ?**
  - → **Some ‘definitions’**
  - → **Says who**
- **OS/390 Issues**
  - → **Is it a problem ?**
  - → **Architectural Constraints**
  - → **31 v 64 bits of Memory**
- **Crystal Ball Gazing**
  - → **How might it be implemented ?**
  - → **What kind of impact ?**

What does 64-bit mean ?

A casual www search produced the following 'either/ors':

- **64-bit internal busses**
- **64-bit I/O adapters**
- **64-bit offsets for large files**
- **large real storage**
- **64-bit integer arithmetic**
- **16 exabyte (264) virtual spaces**
- **UNIX '98**

One definition

"64 bit computing is an environment that contains:"

- **64 bit CPU**
- **64 bit Registers**
- **64 bit memory addressing instructions**
- **64 bit memory access**
- **64 bit kernel**

ref. "64-Bit Computing and the HP-UX 11.00 Operating Environment "
http://www.hp.com

Another one ?

Says "the worlds largest service organisation":

Question:

- **"Exactly what can 64-bit computing do for my business today?**

Answer:

- **"It can give you a massive shot in the arm !"**
- **"Dramatically accelerate your Web presence, today."**
- **"Put data mining and information analysis light-years ahead, today."**
- **"Give CAD/CAM and engineering a quantum leap in productivity, today. "**

And....(drum roll please)

"ask yourself this: Has there ever been a better time to look into 64-bit computing than today?"

Says who ?

"the worlds largest service organisation"

- **Who they then ?**
- **British Civil Service ?**
- **FBI ?**
- **SNCF ?**
- **NHS ?**
- **IBM per chance ?**

er…….actually it is… **(another drum roll please)**

COMPAQ

So who's got it then ?

Most platforms have already implemented 64-bit architectures:

- **OS/400 on AS/400**
- **AIX on RS/6000**
- **NT on Compaq/Alpha**
- **HP-UX on HP**
- **Solaris on SUN**
- **NT on Intel - not yet, probably 2000**

Well..practically 64 bit

- Most platforms have the number “64” somewhere in their architecture.
- But not necessarily true 64 bit.
- For example, several are missing the 64 bit kernel
- Certainly there are few applications that can use or even need 64 bit addressing
- Full 64 bit memory is 2^{64} or 16 odd exabytes
- At today's prices, this would cost approximately £250,000 million (or £250 billion in american)
- Placed end to end, would these memory cards reach.....

.....a decision?

Larging it - size does matter

In reality, 64 bit is large:

- **large file support**
- **large physical memory**
- **large virtual memory**
- **large addressing**

Which needs:

- **larger registers**
- **larger instructions**

What's it good for ?

Increased processor memory

- **CPU speeds and memory densities are increasing.**
- **An attractive way of improving system performance is to increase the memory size.**
- **The RISC and Intel servers hit a wall at 2 GB (231) or 4 GB (232) of memory.**
- **Therefore, an architecture which removes the storage size limitation is of paramount importance to these platforms.**

OS/390 issues

Increased processor memory

- **Expanded Storage introduced in the mid-1980s.**
- **Current maximum physical processor memory size is 32 GB (CMOS G6).**
- **Expanded Storage managed transparently by the operating system and middleware.**
- **OS/390 and middleware are more economical of memory than UNIX and manage it more efficiently.**
- **Today, OS/390 supports delivery of sub-second response time against terabyte size databases for real customer workloads.**

What's it good for ?

64-bit integer arithmetic

- **Some programs need to manipulate large integers.**
- **64-bit arithmetic can be 'emulated' on a 32-bit machine, but at 3-10x overhead for the actual operations.**
- **Value is a function of the intensity of 64-bit integer arithmetic.**
  - → **Limited value for commercial workloads**
  - → **10 times almost nothing is still almost nothing**

OS/390 issues

64-bit integer arithmetic

- **Fortran has long supported a 64-bit integer data type.**
- **OS/390 Release 6 C compiler supports Long Long Integers.**
- **Cobol also provides support with packed decimal.**

What's it good for ?

Virtually unlimited virtual

- **Applications and middleware access real memory 'through' virtual.**
- **Large virtual spaces enable the use of large real memory.**
- **But, again, most platforms hit a wall at 2 GB or 4 GB of virtual memory per address space.**
- **So, a 64-bit architecture is essential to these platforms.**

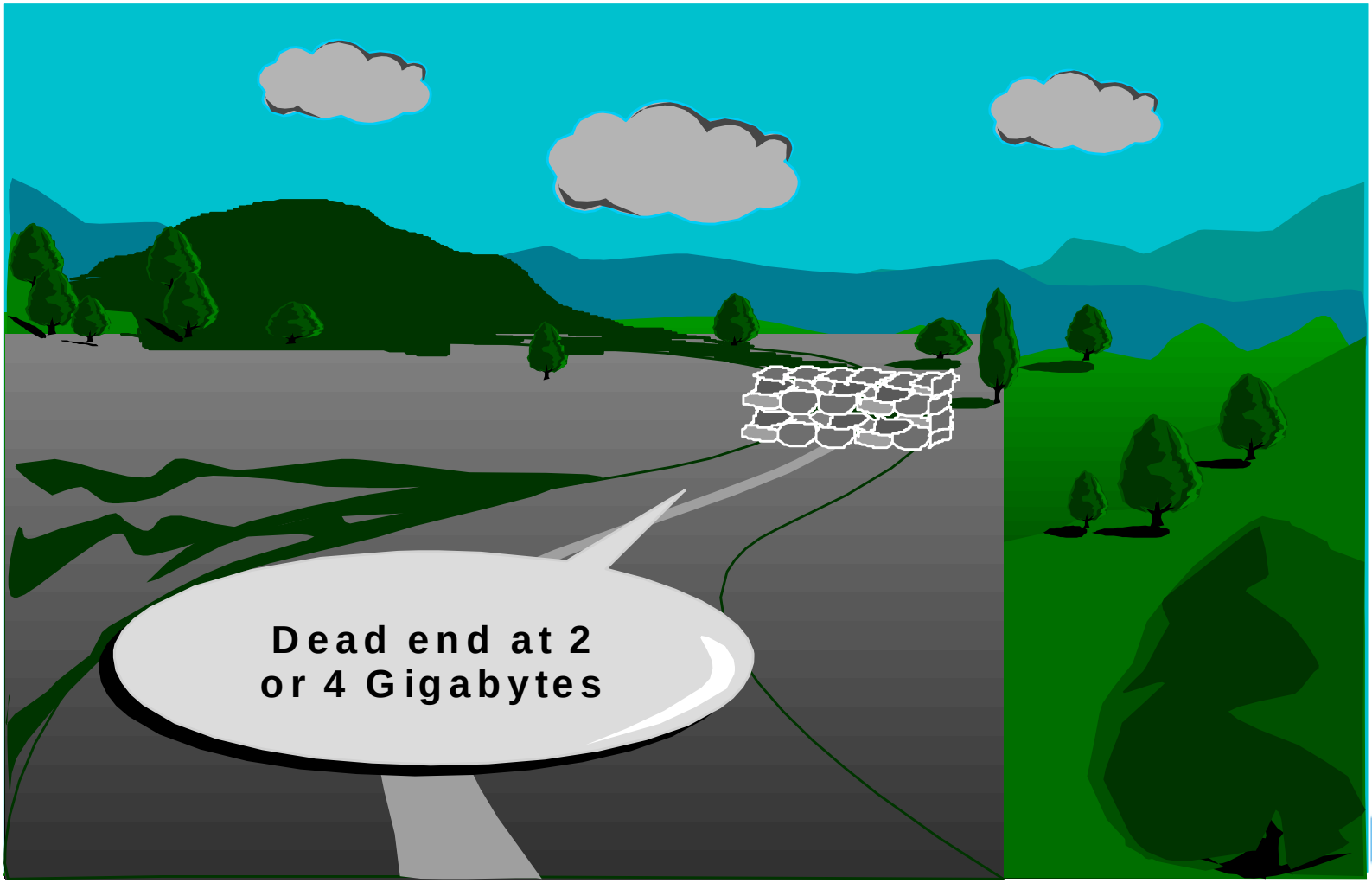
OS/390 issues

Virtually unlimited virtual

- **MVS/ESA introduced support for data spaces and hiperspaces.**
- **Middleware and applications can create as much virtual as they want or need.**
- **ESA solved the same problems as 64-bit virtual over a decade ago.**

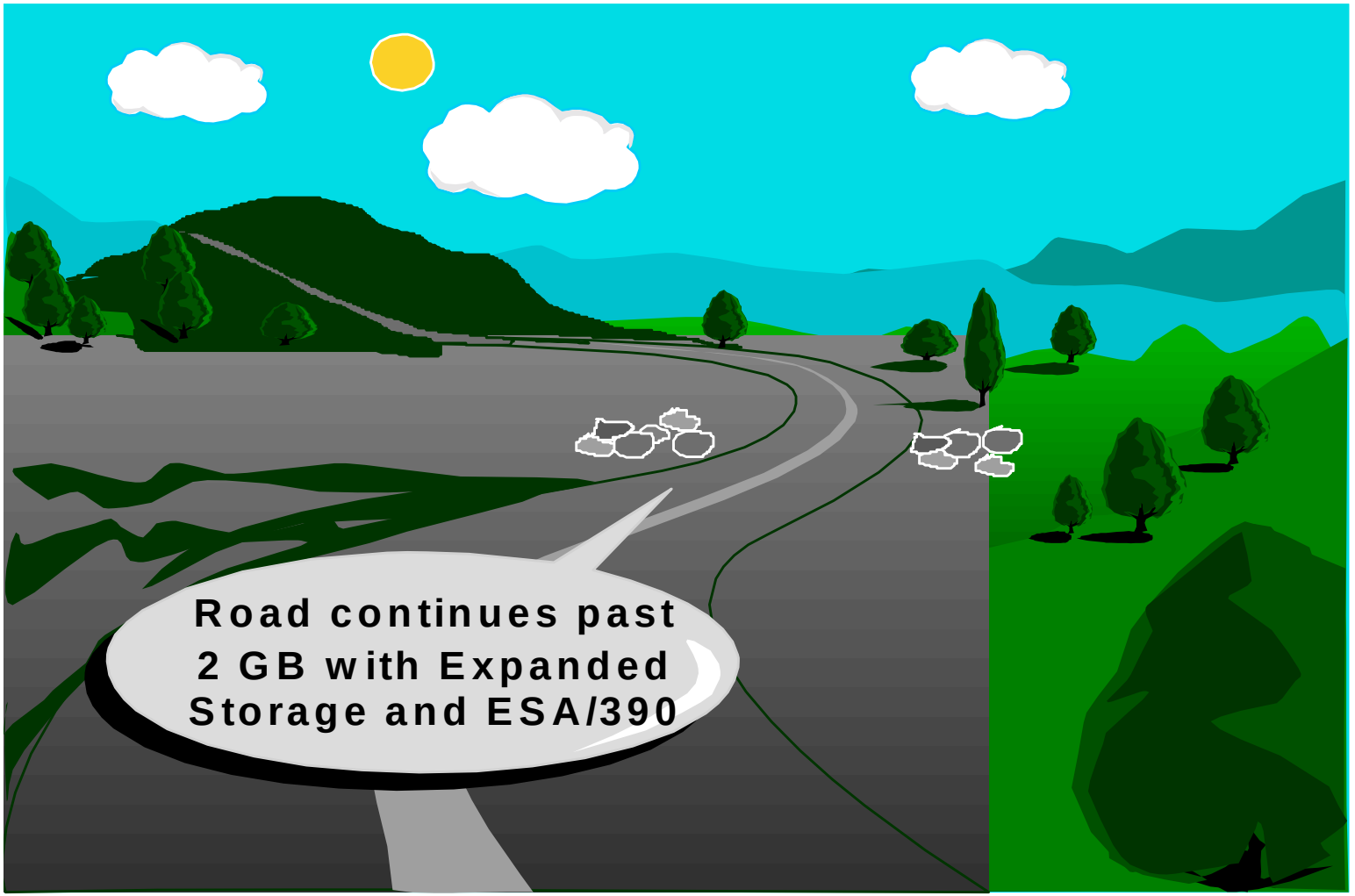
Architecture Constraint

RISC-UNIX, WINTEL 31- and 32-bit systems



Architecture Constraint

OS/390 Enhanced 31-bit



Actual benefits

Who can use it?

- **Not many applications benefit directly.**
- **Some examples - mostly databases:**
- **DB2 for OS/390**
- **Oracle**
- **File systems**
- **Text search engines**

Why 64-bit for OS/390 ?

Real Memory

- **Improve price/performance by eliminating data movement**
- **Rebalance the overall system**
- **Cost of ES/CS movement grows non-linearly with ES/CS ratio**

Integer Arithmetic

- **Some performance benefit**
- **Helps interoperability**

Why 64-bit for OS/390?

Virtual Memory

- **Large virtual enables exploitation of large real memory**
- **Support porting of emerging applications from other 64-bit platforms**
- **"If it's there, programmers will use it”**

OS/390 doesn't need 64-bit just yet !!

But, need will emerge over next few years

Predictions

- **What do we call it ?**
  - → **WWW - Woof Woof Woof**
  - → **XXL - extra extra large**
  - → **OSFA - One size fits all**
  - → **Probably something with ‘e’ in it ?**
- **What will it look like ?**
- **What impact will it have ?**
- **When will it be ready ?**
  - → **Staged implementation**
  - → **First Physical then Virtual**

64 bit Real in OS/390

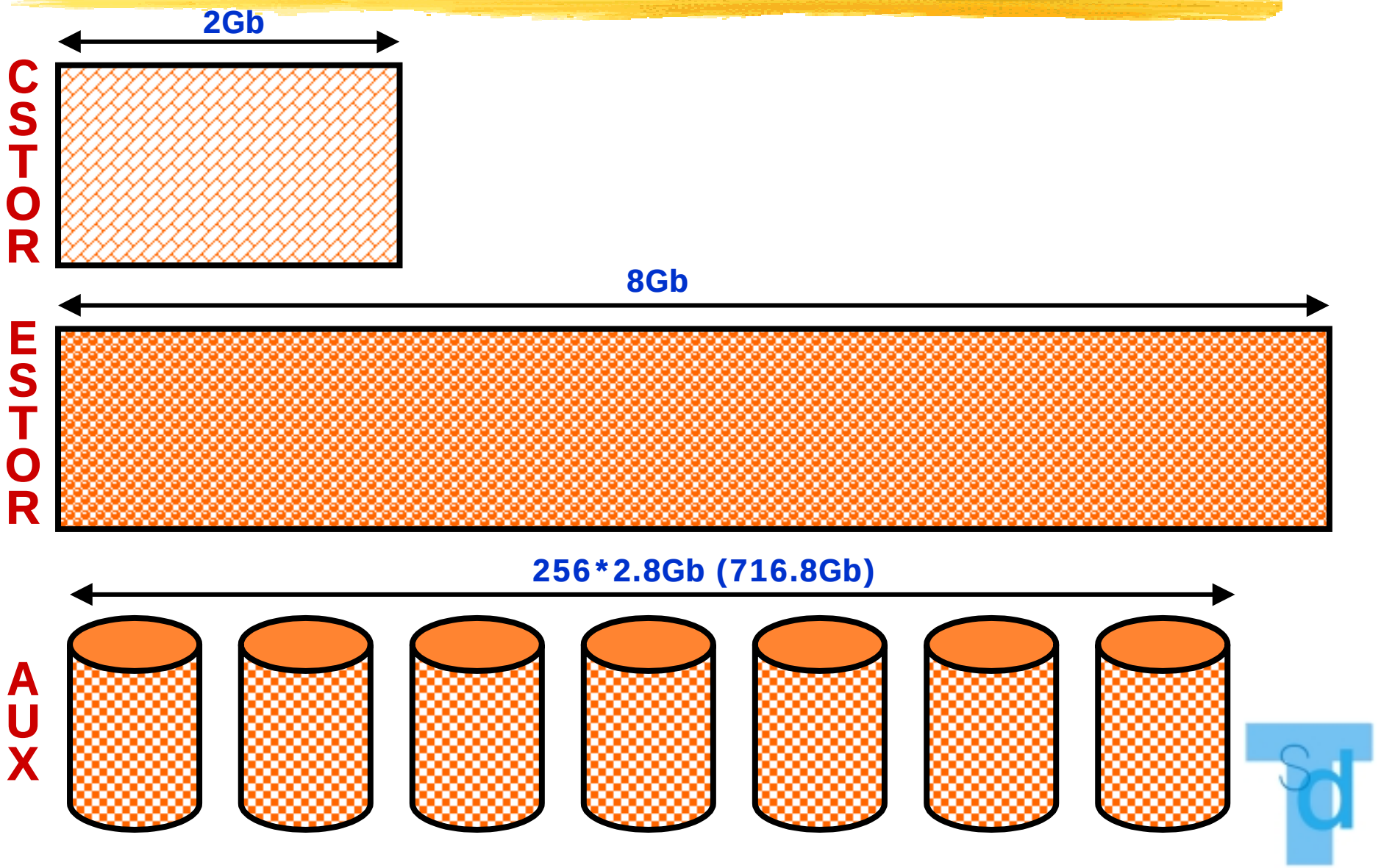
Nearly Invisible - except for performance

- **Much of the value delivered by the operating system itself**
- **Transparent to application programs**
- **Only visible when doing to-the-metal I/O**
- **Basically, support for greater than 2Gb physical**
- **Needs h/w and s/w**
- **Limited exploiters**
  - → **RSM view of greater than 2Gb only**
  - → **No "POP" for new instructions, yet**
  - → **No more ES or ASM paging**
- **Delivered by Q2/2001 ?**

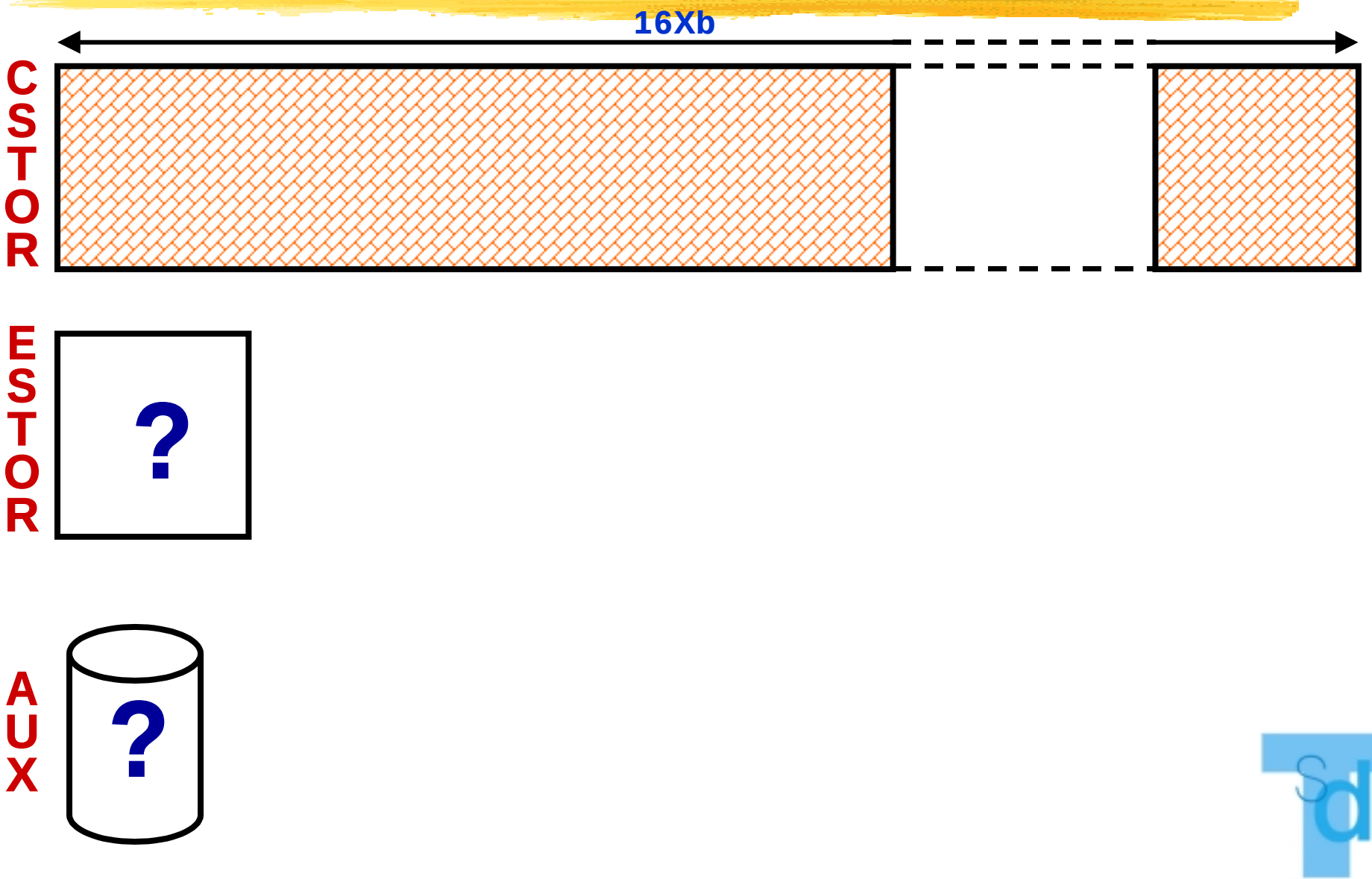
Immediate seamless value

- **Used for all pageable data**
  - → **This is 80-95% of real storage for current workloads**
- **Direct usage by OS/390 elements**
  - → **Access Methods**
  - → **VSAM Extended Format**
  - → **Program Loader**
  - → **Hierarchical File System**
  - → **Sorting**
  - → **XRC/Remote Dual Copy**
- **DB2 and other IBM and ISV Middleware**

31 bit Physical today



31 bit Physical tomorrow ?



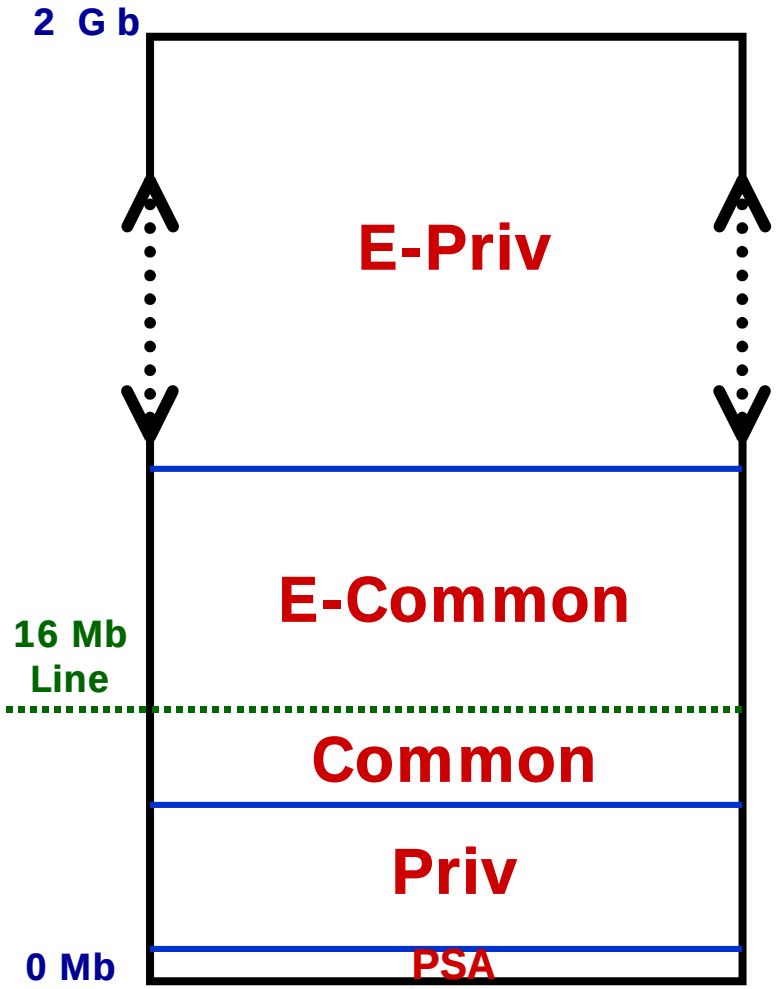
Value with a bit of effort

- **Change customisation using hiperspace buffers to use address space buffers:**
  - → **VSAM buffers in hiperspace with CICS**
  - → **Batch LSR**
  - → **Hipersorting with DFSort**
  - → **DB2 hiperpools**
- **Increase buffer amounts overall**
  - → **JCL**
  - → **CICS IMS and DB2 configuration definitions**
  - → **Batch performance optimising products**

64-bit Virtual in OS/390

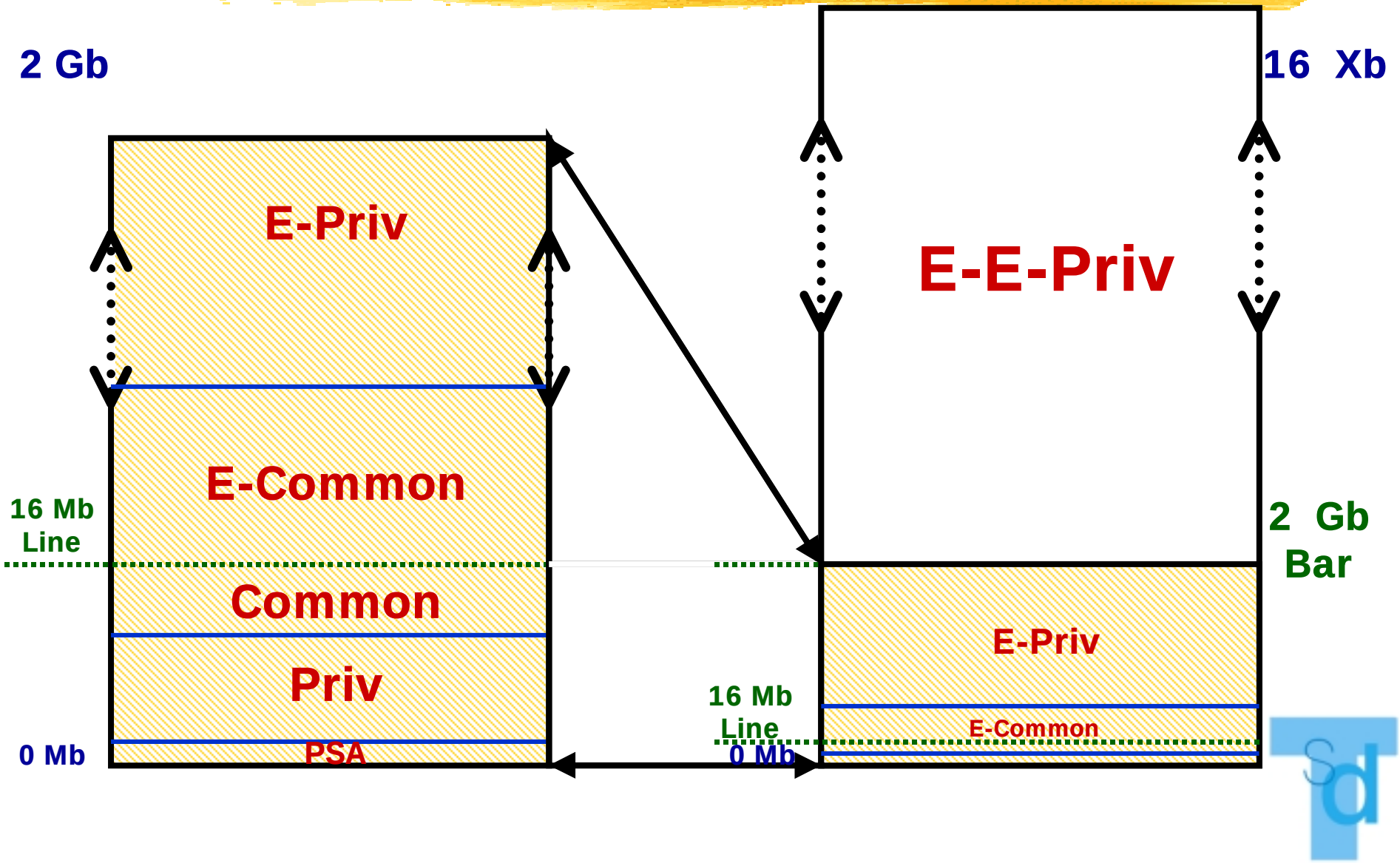
- **Virtual below 2 GB like it is today**
- **Virtual above 2 GB greatly simplified**
  - → **Entire 2^{64} space available to applications**
  - → **Large allocation quanta (e.g. 1 MB)**
  - → **Byte-level management done by Run-Time Library**
  - → **Limits based on usage rather than address range**
- **Application access mainly through Unix APIs**
  - → **Traditional MVS APIs enhanced only as required**
  - → **UNIX kernel services and other new APIs available to non-UNIX programs**

31 bit Virtual today

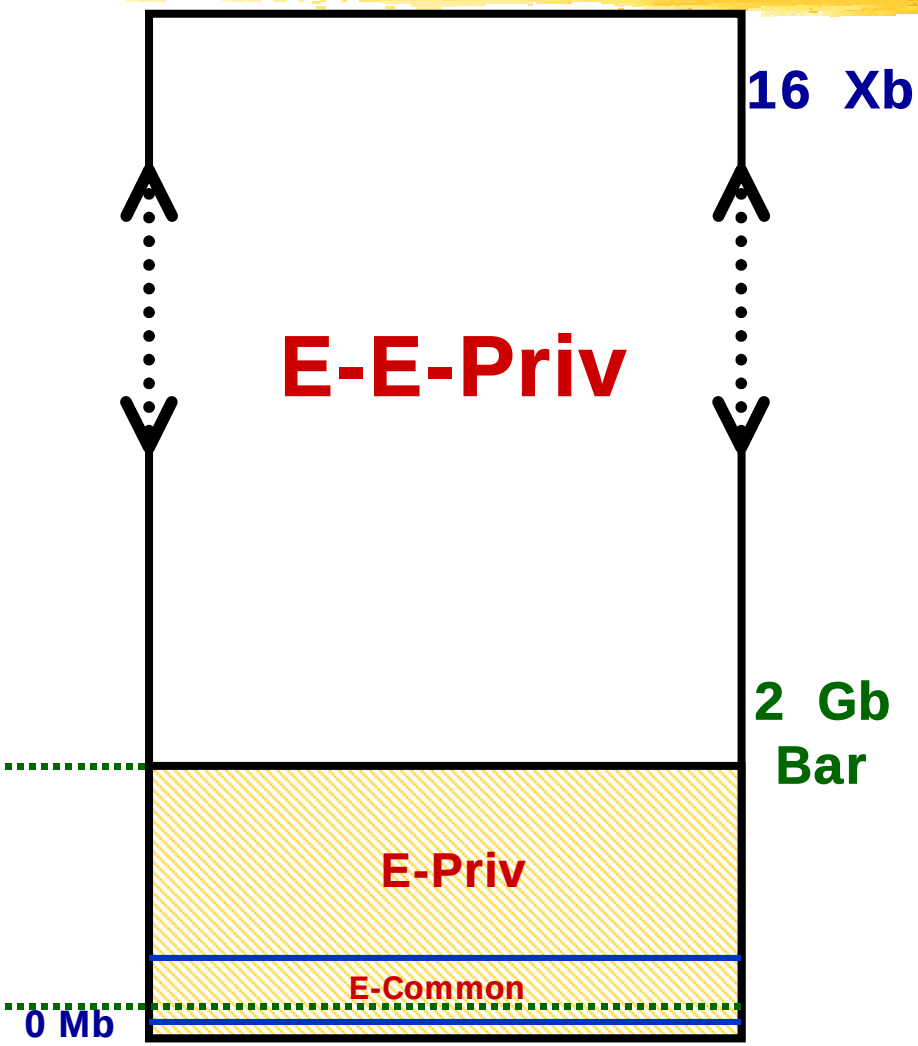


- Managed by VSM
- All A/S's see same common
- Up to 2Gb per A/S
- 31 bit instructions to address it
- DAT conversion
- Real Backed by ESTOR and AUX
- Few users of full 2Gb

64 bit Virtual tomorrow ?



64 bit Virtual tomorrow ?



- Above the bar managed by loader?
- All A/S's see same common
- Up to nn Gb per A/S
- 64 bit instructions to address it
- Need POP !
- DAT conversion below the bar only ?
- Real Backed by ?
- Zero users of full 16Xb

What about compatibility?

New OS/390 will run on both 64-bit-capable and non-64-bit capable processors.

- **Old OS/390 will continue to run on 64-bit-capable processors.**
- **Old and new OS/390 can coexist in a multisystem complex.**
- **64-bit capable and non-64-bit capable processors can coexist in a multisystem complex.**
- **New OS/390 can run in non-64-bit-capable mode even on 64-bit capable processors.**
- **Existing applications can run unchanged on new OS/390 on 64-bit capable processors.**

Architecture Changes

- **S/370 to 370/XA to ESA/370 to ESA/390**
  - → some cost and some pain
- **ESA/390 to OFSA**
  - → cost and pain ?
- **Architecture Level Sets**
  - → "The release of the operating system planned to be available in the first half of 2001 will only run on servers that implement the architectural enhancements, and will not run on servers that have not implemented them."
  - → G5+ and Multiprise 3000
  - → http://www.ibm.com/s390/os390/plug1.html

Strong indication that when IBM provide 64-bit support, it will be a smooth migration

Summary

- **Alternate platforms are implementing 64-bit right now - They need to !!**
- **Expanded Storage and ESA solved the same problems years ago.**
- **As memories get larger, a 64-bit architecture will be needed to re-balance the system.**
- **Few application programs can take direct advantage of 64-bit virtual. Most will continue to be 31-bit.**
- **IBM S/390 is committed to implementing the hardware and software technologies for S/390 to support emerging applications and workloads.**

Architecture Constraint

OS/390 with 64-bit support

Questions

???