



Multicore Designs

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- Intel 64bit Architecture:
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- SIMD Instructions,
- Hyper threading Technology,
- Virtualization Technology (Refer TB3)
- Systems Programming,
- Multiple Processor Management (Refer RBI)

Brief History

- 16-bit Processors and Segmentation (1978)
- The Intel® 286 Processor (1982)
- The Intel386™ Processor (1985): First IA-32
- The Intel486™ Processor (1989)
- The Intel® Pentium® Processor (1993)
- The P6 Family of Processors (1995-1999)
 - **Intel Pentium Pro processor**
 - **Intel Pentium II processor**
 - **Pentium II Xeon processor**
 - **Intel Celeron processor**
 - **Intel Pentium III processor**
 - **Pentium III Xeon processor**

Brief History

Continued...

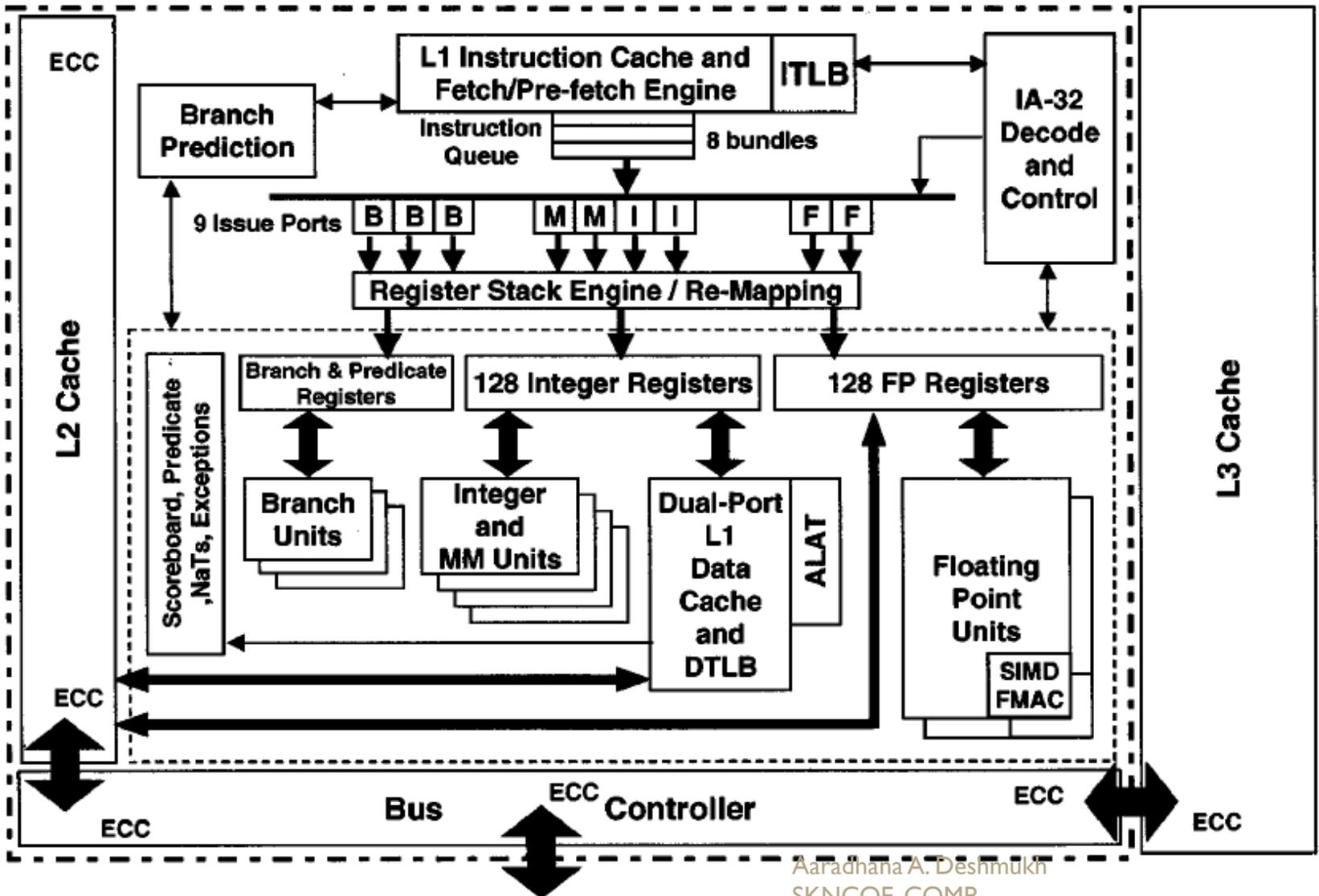
- The Intel® Pentium® 4 Processor Family (2000-2006)
- The Intel® Xeon® Processor (2001- 2007)
- The Intel® Pentium® M Processor (2003-Current)
- The Intel® Pentium® Processor Extreme Edition (2005-2007): First Intel 64bit
- The Intel® Core™ Duo and Intel® Core™ Solo Processors (2006-2007)
- The Intel® Xeon® Processor 5100, 5300 Series and Intel® Core™2 Processor Family (2006-Current)
- The Intel® Xeon® Processor 5200, 5400, 7400 Series and Intel® Core™2 Processor Family (2007-Current)
- The Intel® Atom™ Processor Family (2008-Current)

Brief History

Continued...

- The Intel® Core™ i7 Processor Family (2008-Current)
- The Intel® Xeon® Processor 7500 Series (2010)
- 2010 Intel® Core™ Processor Family (2010)
- The Intel® Xeon® Processor 5600 Series (2010)
- Second Generation Intel® Core™ Processor Family (2011)

Block Diagram



Architecture Overview

- The processor instruction set architecture is designed to achieve a large degree of instruction level parallelism by using speculation and predication.
- There are two types of speculation:
 - **Control speculation** is the execution of an operation before the condition governing its execution.
 - **Data speculation** refers to the execution of a memory load prior to a store that might change its value.

Continued....

- Predication is the conditional execution of instructions that removes branches used for conditional execution eliminating associated miss-predict penalties.
- Predication and speculation work together to give the compiler a significantly increased scheduling scope across which performance optimizations can be performed more effectively.

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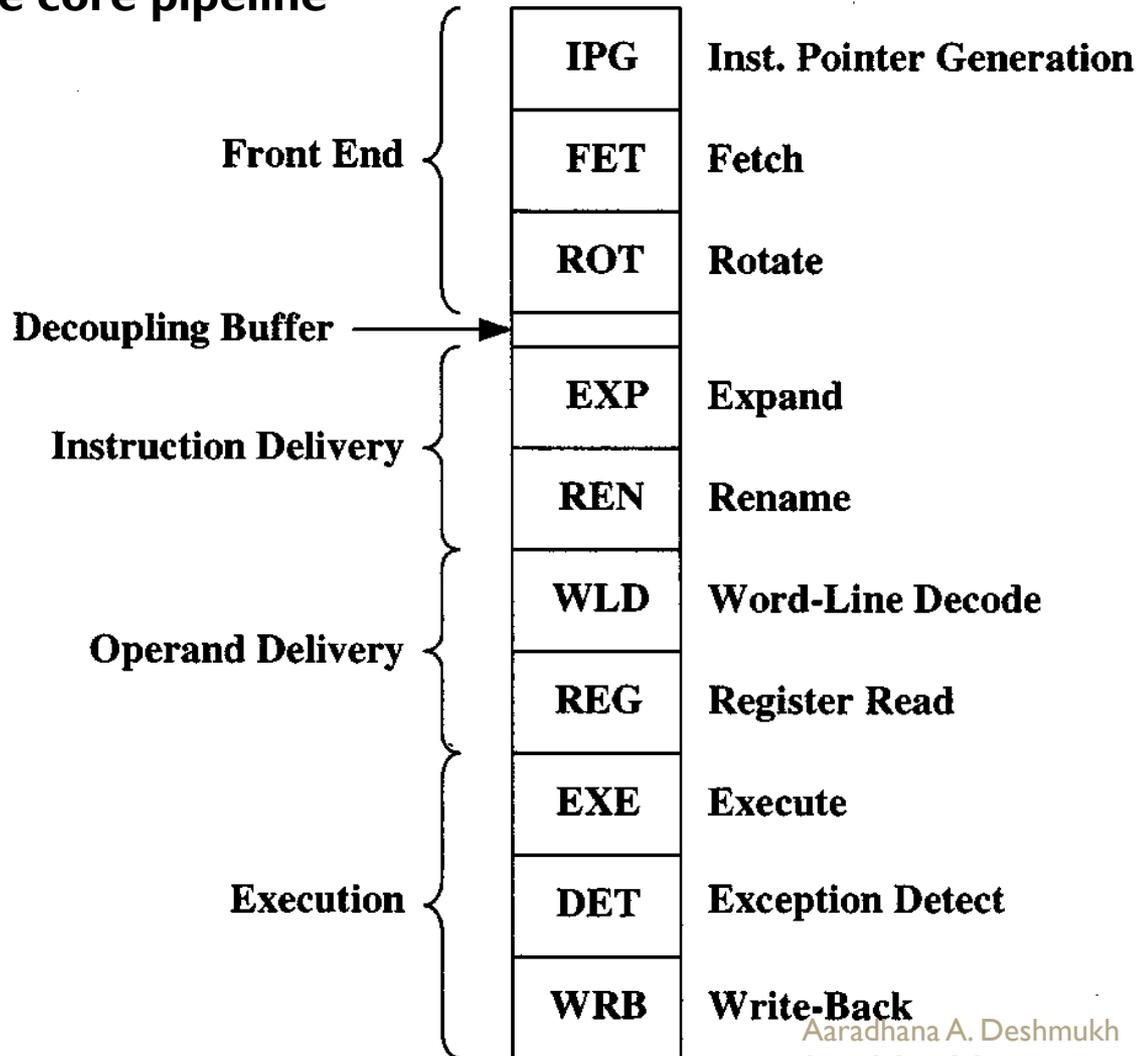
- The hardware resources are exposed to the compiler in this explicitly parallel instruction computing (EPIC) machine.
- Each memory load and store has a 2-bit cache hint field in which the compiler encodes its prediction of the spatial and temporal locality of the memory area being accessed.
- The processor uses this information to determine the placement of cache lines in the cache hierarchy.

Continued....

- The branch prediction table (BPT) contains 512 entries and uses a two-level adaptive algorithm. Each entry tracks the four most recent occurrences of that branch.
- The processor hardware is organized into a ten-stage core pipeline, shown in figure below, that can execute up to six IA-64 instructions in parallel each clock.

Continued....

Ten-stage core pipeline



Continued....

- The first three pipeline stages perform the instruction fetch and deliver the instructions into a decoupling buffer that enables the front-end of the machine to operate independently from the back-end, by allowing the front end to speculatively fetch ahead and by hiding the instruction cache and branch prediction latencies.

Continued....

- Dispersal and register renaming are performed in the next two stages.
- Operand delivery is accomplished across the WLD and REG stages, where the register file is accessed and data is delivered through the bypass network after processing the predicate control.
- Finally, the last three stages perform the wide parallel execution followed by exception management and retirement.

Continued....

- The processor has 15 execution units: four integer, four multimedia, two floating point, three branch and two load/store units.
- The processor implements 128 integer and 128 floating point registers, 64 one-bit predicate registers and eight branch registers.

Continued....

- The processor includes three levels of cache organized in a hierarchical manner. The L1 and L2 caches are integrated on die.
- At the first level, instruction and data caches are split, each 16kB in size, four-way set-associative and with a 32-byte line size.
- The second level of cache is unified, 96 kB in size, six-way set-associative and with a 64-byte line size.

Continued....

- The L3 cache contains up to 4 MB of custom designed on-cartridge memory and is accessed through a dedicated 128-bit BSB source-synchronous interface running at the processor's core frequency.
- The L3 cache is four-way set-associative with a line size of 64 bytes.

Continued....

- Both L2 and L3 caches are completely error correction code (ECC) protected.
- To enable software-guided optimal utilization of the cache hierarchy, the processor uses a set of memory locality hints that indicate the temporal locality of each access at each level of hierarchy.
- The processor uses these hints to determine the allocation and replacement strategies for each level of cache.
- In addition, the processor uses a bias hint to indicate that the software intends to modify the data of a given cache line.

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- The floating-point unit delivers up to 6.4 Gflops and provides full support for single, double, extended, and mixed-mode precision computations.
- Parallel IA-64 FP instructions which operate on pairs of 32-bit single precision numbers increase the single-precision FP computation throughput.
- The chip also supports multimedia instructions that treat the general registers as vectors of eight 8-bit, four 16-bit, or two 32-bit elements.

Continued....

- The floating-point execution units support simultaneous multiply-add to provide performance for scientific computation.

Continued....

- The processor includes special hardware support to ensure full binary compatibility with the IA-32 instruction set.
- The dynamic out-of-order scheduler optimizes performance on legacy binaries.
- Shared caches and execution resources increase the area efficiency.
- The processor can run a mix of IA-32 and IA-64 applications on an IA-64 operating system, as well as IA-32 applications on an IA-32 operating system, in both uni-processor and multi-processor configurations.

Continued....

- The processor implements a machine check architecture (MCA) that provides the ability to Continue, Recover, or Contain detected errors.
- All significant structures on the chip are protected by parity or ECC.

Basic Execution Environment

- Describes how the processor executes instructions and how it stores and manipulates data.
- The execution environment described here includes memory (the address space), general-purpose data registers, segment registers, the flag register, and the instruction pointer register.

MODES OF OPERATION

- The operating mode determines which instructions and architectural features are accessible
- The IA-32 architecture supports three basic operating modes:
 - protected mode,
 - real-address mode, and
 - system management mode.

Protected mode

- This mode is the native state of the processor.
- Among the capabilities of protected mode is the ability to directly execute “real-address mode” 8086 software in a protected, multi-tasking environment.
- This feature is called virtual-8086 mode, although it is not actually a processor mode.
- Virtual-8086 mode is actually a protected mode attribute that can be enabled for any task.

Real-address mode

- This mode implements the programming environment of the Intel 8086 processor with extensions (such as the ability to switch to protected or system management mode).
- The processor is placed in real-address mode following power-up or a reset.

System management mode (SMM)

- This mode provides an operating system or executive with a transparent mechanism for implementing platform-specific functions such as power management and system security.
- The processor enters SMM when the external SMM interrupt pin (SMI#) is activated or an SMI is received from the advanced programmable interrupt controller (APIC).

SMM

Continued....

- In SMM, the processor switches to a separate address space while saving the basic context of the currently running program or task.
- SMM-specific code may then be executed transparently.
- Upon returning from SMM, the processor is placed back into its state prior to the system management interrupt.
- SMM was introduced with the Intel386™ SL and Intel486™ SL processors and became a standard IA-32 feature with the Pentium processor family.

Intel® 64 Architecture (2.2.10)

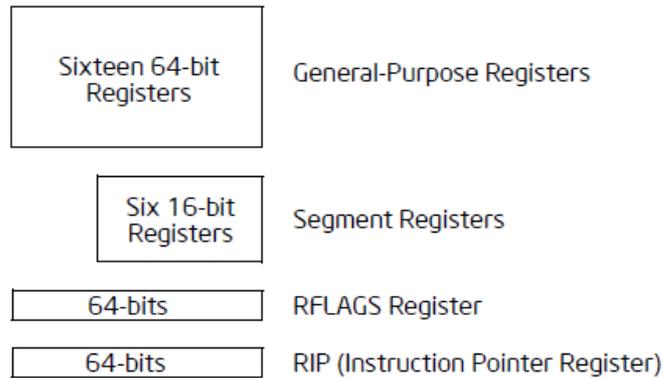
- Intel 64 architecture increases the linear address space for software to 64 bits and supports physical address space up to 40 bits.
- The technology also introduces a new operating mode referred to as IA-32e mode.
- IA-32e mode operates in one of two sub-modes:
 - Compatibility mode enables a 64-bit operating system to run most legacy 32-bit software unmodified,
 - 64-bit mode enables a 64-bit operating system to run applications written to access 64-bit address space.

In the 64-bit mode,

Applications may access:

- 64-bit flat linear addressing
- 8 additional general-purpose registers (GPRs)
- 8 additional registers for streaming SIMD extensions (SSE, SSE2, SSE3 and SSSE3)
- 64-bit-wide GPRs and instruction pointers
- uniform byte-register addressing
- fast interrupt-prioritization mechanism
- a new instruction-pointer relative-addressing mode

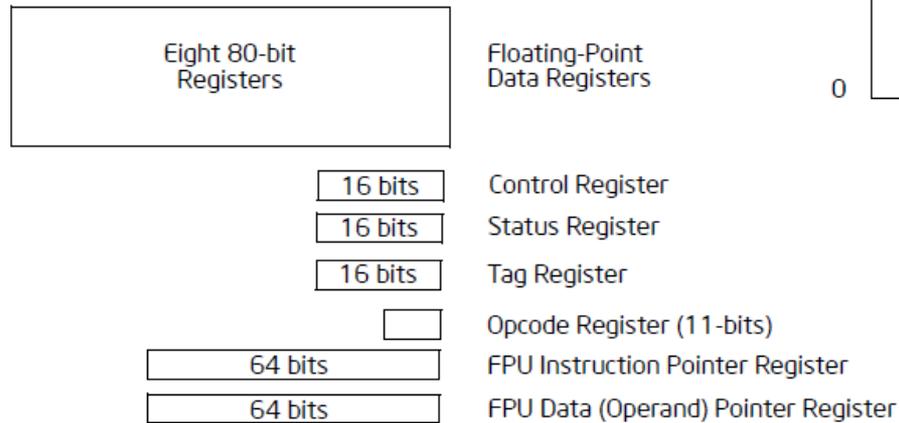
Basic Program Execution Registers



Address Space



FPU Registers



MMX Registers



XMM Registers



Data Types

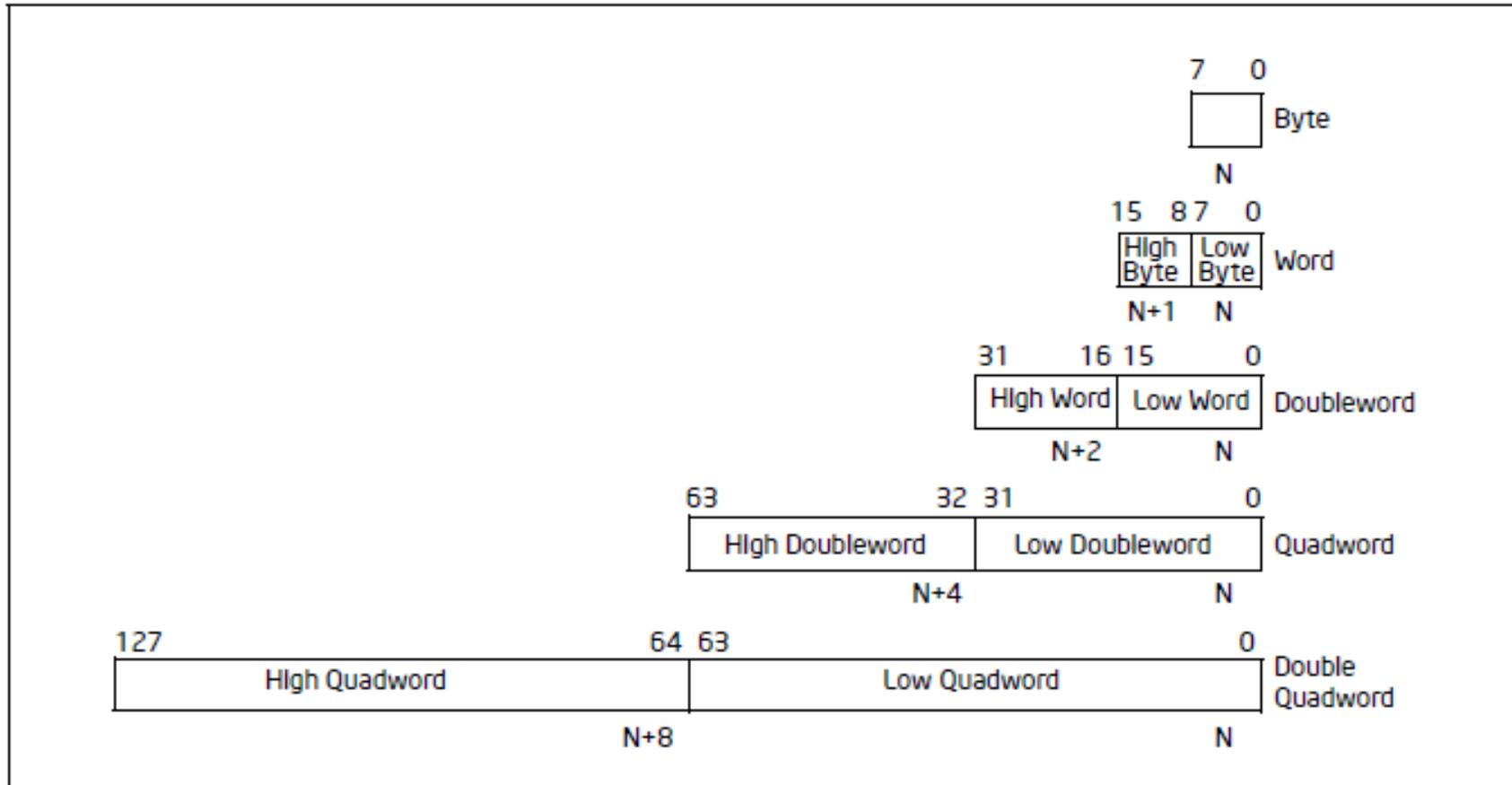


Figure 4-1. Fundamental Data Types

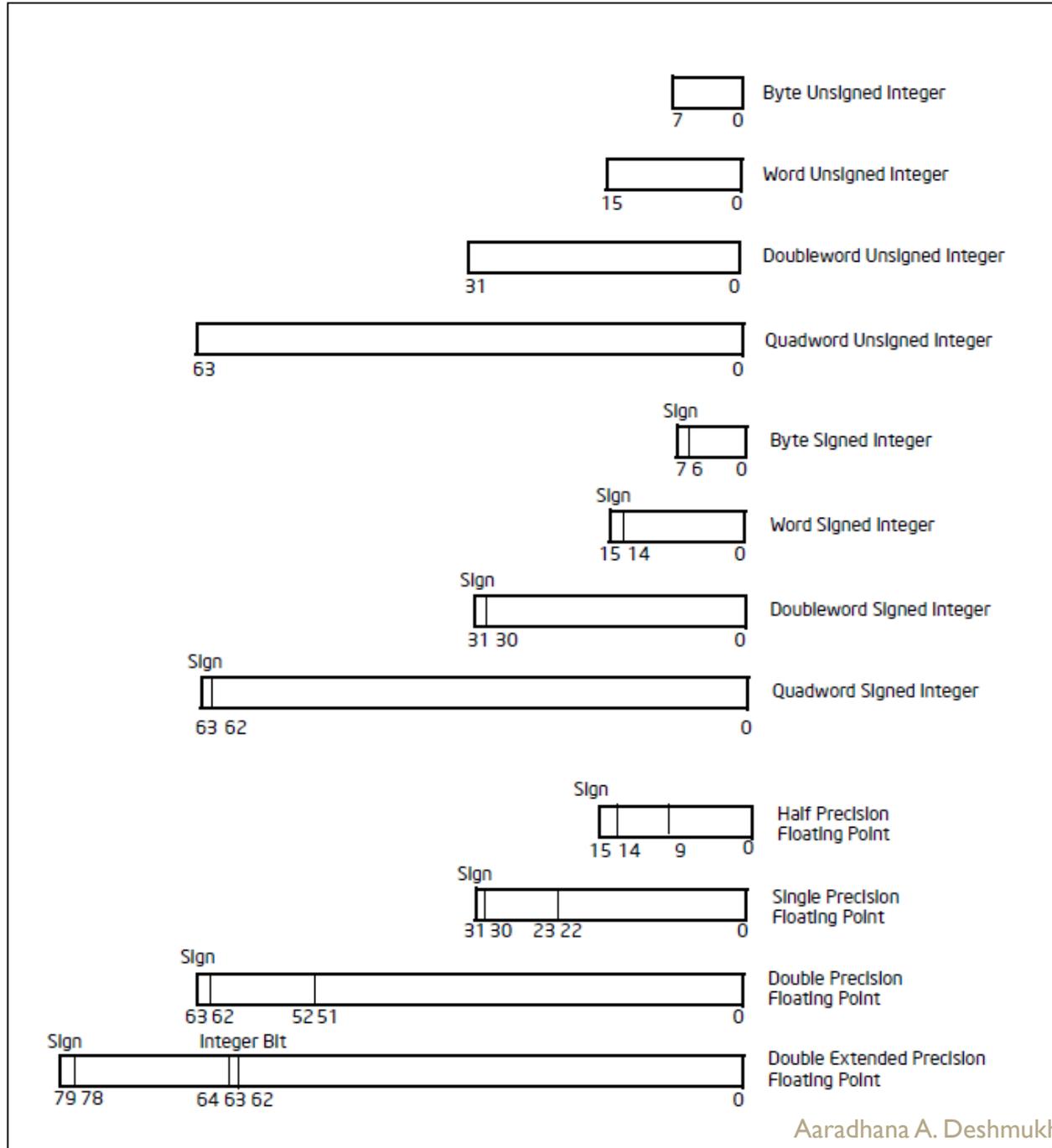


Figure 4-3. Numeric Data Types

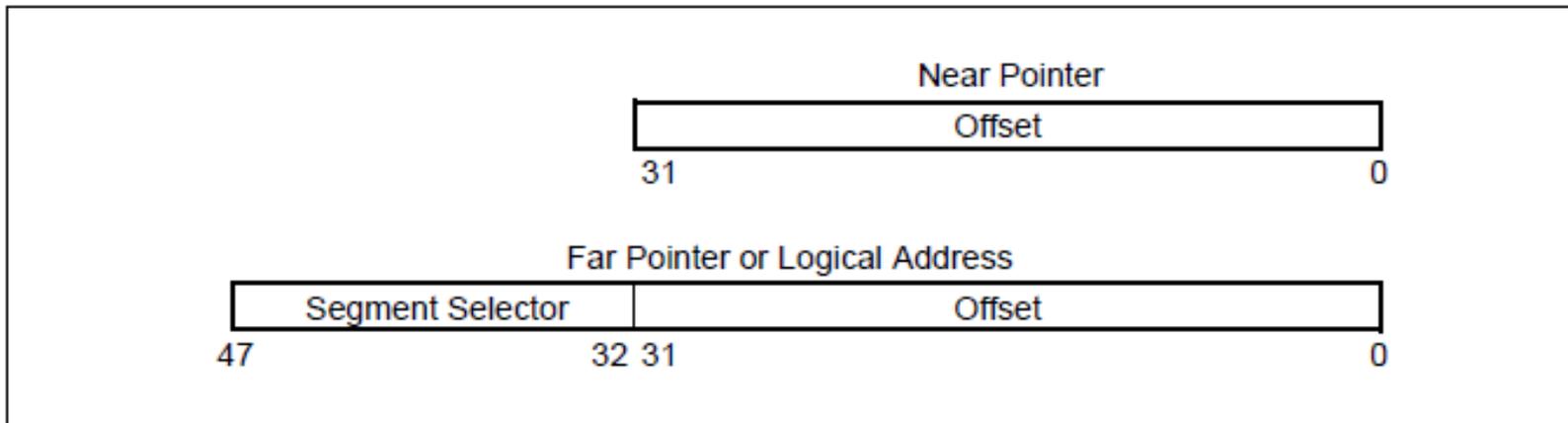


Figure 4-4. Pointer Data Types

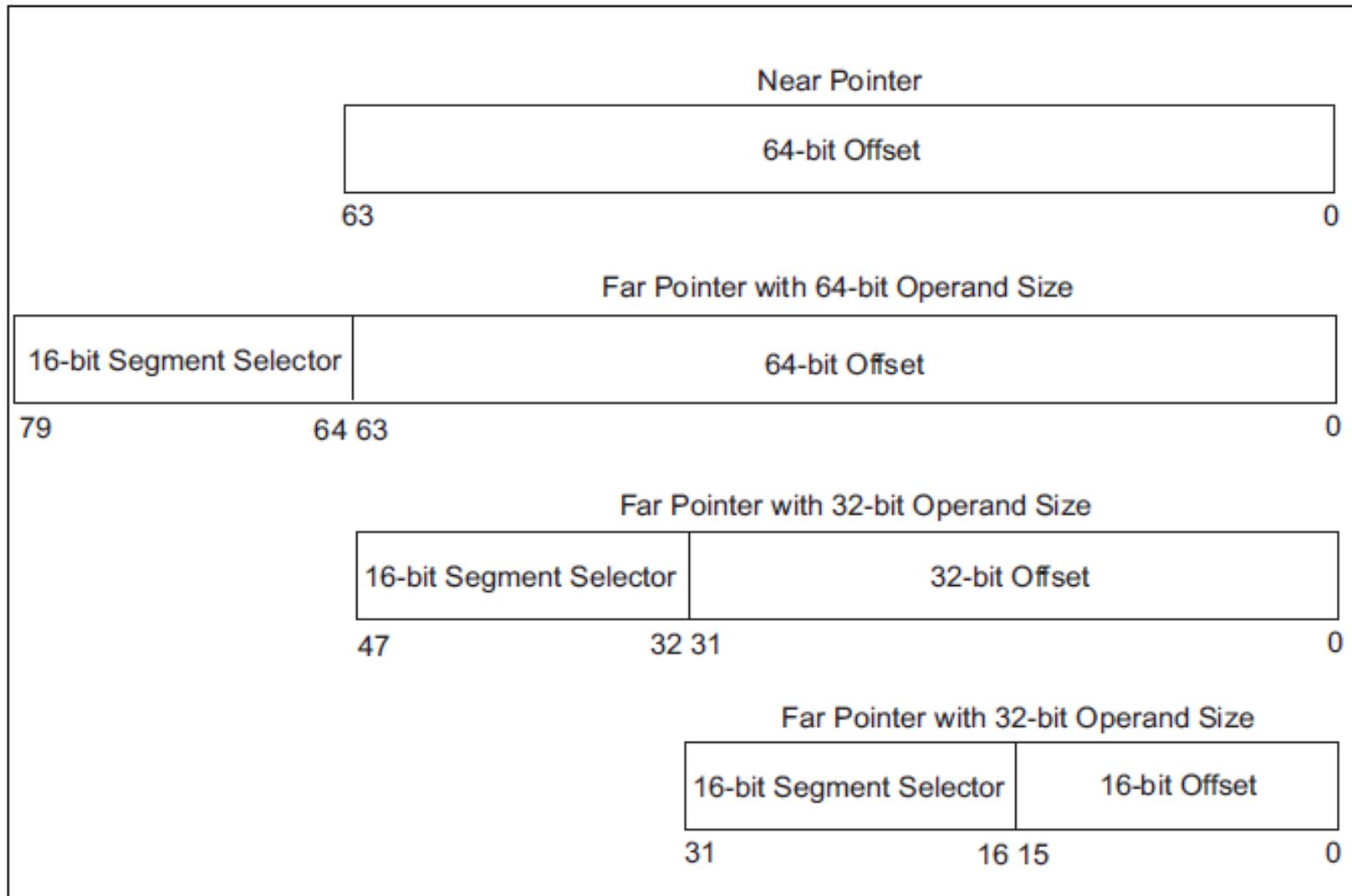


Figure 4-5. Pointers in 64-bit Mode Aradhana A. Deshmukh
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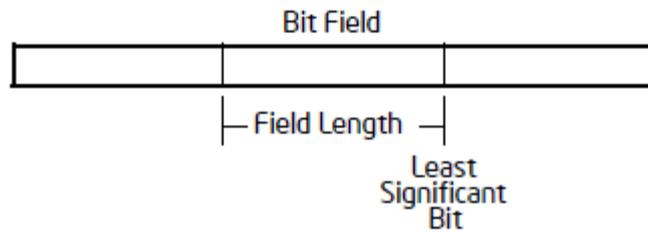
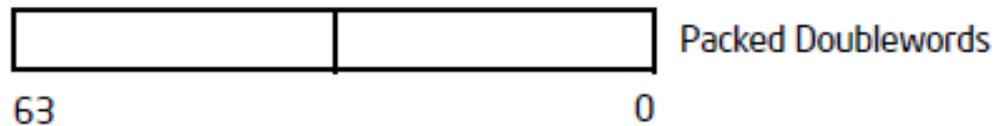
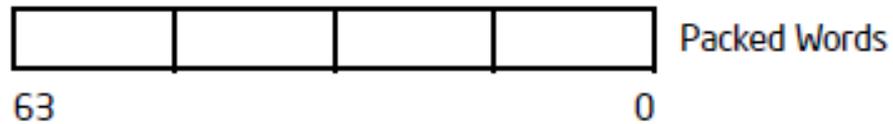
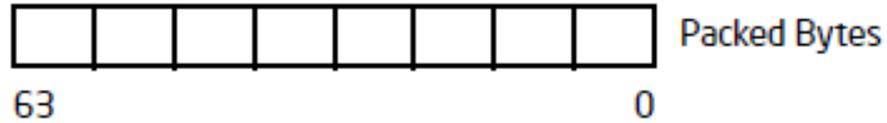


Figure 4-6. Bit Field Data Type

4.5 STRING DATA TYPES

Strings are continuous sequences of bits, bytes, words, or doublewords. A **bit string** can begin at any bit position of any byte and can contain up to $2^{32} - 1$ bits. A **byte string** can contain bytes, words, or doublewords and can range from zero to $2^{32} - 1$ bytes (4 GBytes).

Fundamental 64-Bit Packed SIMD Data Types



64-Bit Packed Integer Data Types

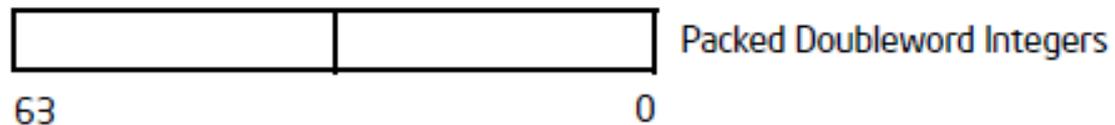
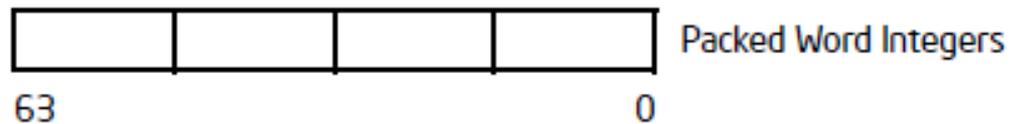
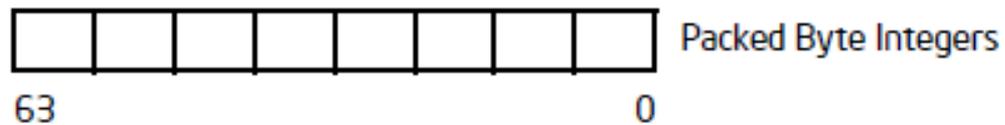
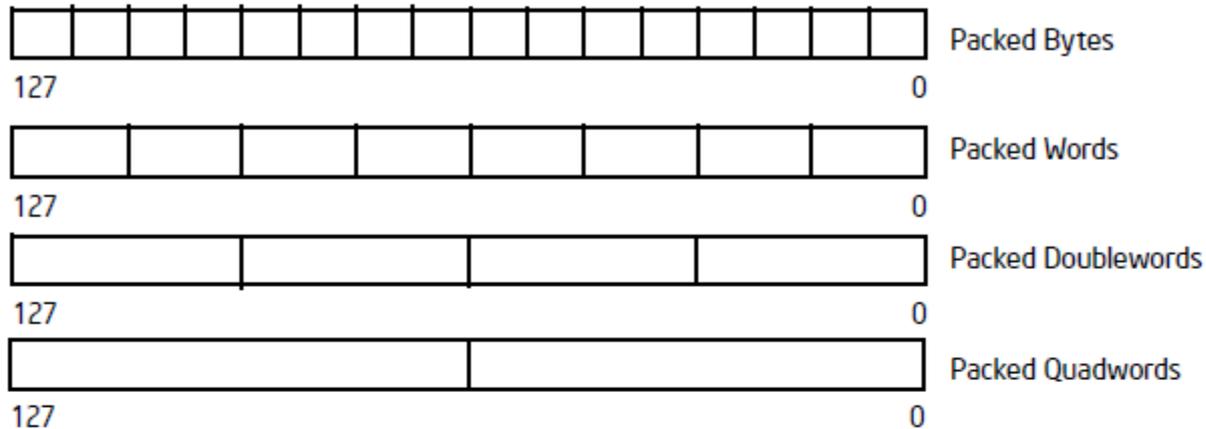


Figure 4-7. 64-Bit Packed SIMD Data Types

Fundamental 128-Bit Packed SIMD Data Types



128-Bit Packed Floating-Point and Integer Data Types

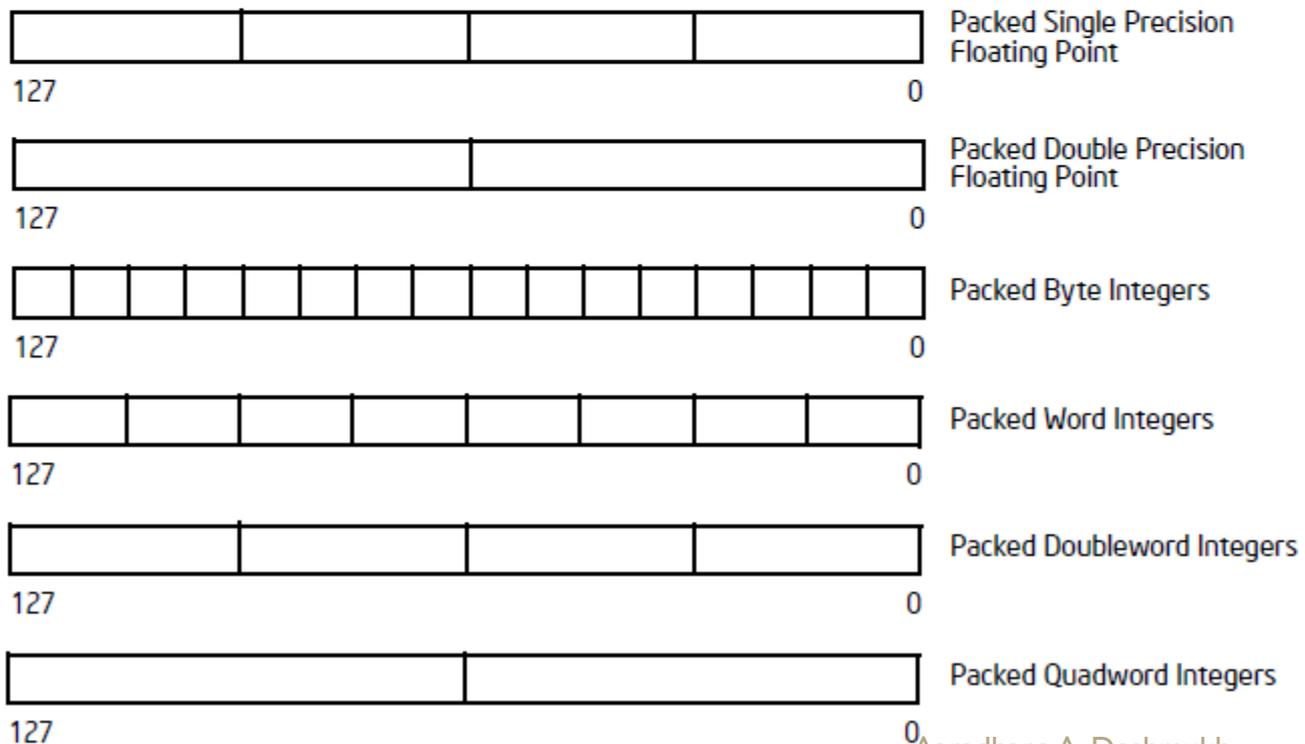


Figure 4-8. 128-Bit Packed SIMD Data Types

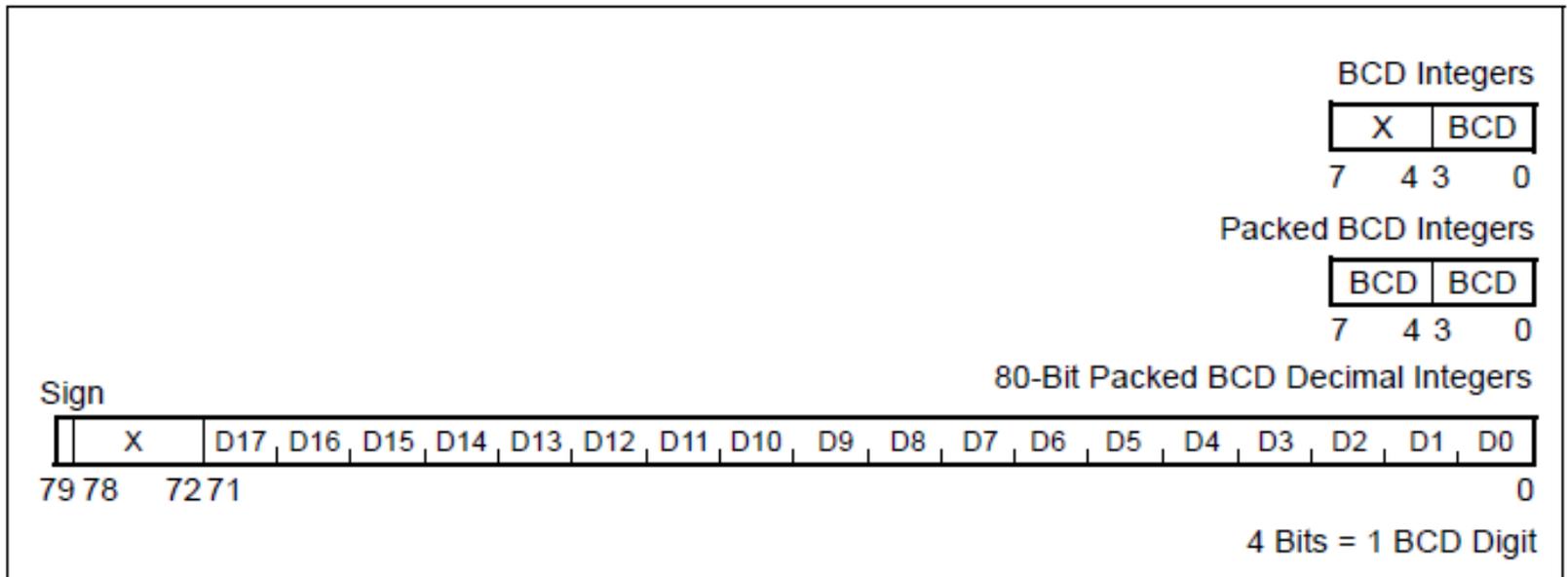


Figure 4-9. BCD Data Types

Reference

Intel® 64 and IA-32 Architectures Software
Developer's Manual

Volume I: Basic Architecture

253665.pdf

Thank you !