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**Assignment: 64 bit Processors**

**Introduction:** When talking about modern computing, it would be lax if we started from 10-year-old machines using 32-bit processors, as those do not cut it at any form of operation that requires remotely high processing power. Traditionally, most business computer systems have run on 32-bit processors, but 64-bit processors are the standard nowadays, and power all ranges of computers, from personal to scientific.

64-bit processors use and access far more memory than their 32-bit counterparts (a mere 4GB vs more than 2^64 bytes or 16 Exabyte - RAM capacity).Hence, 64-bit systems process more data per cycle, greatly enhancing their performance as well as scalability.

64-bit processors can come in **multi core versions** for even general purpose usage. This allows for an increased number of calculations per second that can be performed, which can greatly increase the processing power and help make a computer run faster. Software programs that require many calculations to function smoothly can operate faster and more efficiently on the multi-core 64-bit processors, while they might be slow and sluggish in the 32 bit variants.

64-bit processors can also perform operations such as multi-tasking, data encryption, etc. on a larger scale and more efficiently than 32 bit processors. 64-bit systems also increase mapping efficiency of larger (>4GB) files. In 32 bit systems, for >4GB files, only portions of the file can be accessed at a time. This shortcoming is negated by using a 64-bit system. This also applies to RAM usage – a 64-bit computer can access more than 4 GB of RAM. In a 32-bit system, only 4GB RAM can be put into the PCI-E bus, while the limit for a 64-bit system is the motherboard manufacturer's specification or the absurdly high 2^64 bit value.

**Some disadvantages:** Wider data can mean that more space taken by the same data, which might be seen as a major disadvantage of the x64 architecture and 64 bit microprocessors in general. i.e a numbers that only requires nine bits to store, if stored in a 32-bit integer as is done by the x64 processor, may lead to the wastage of unused bits, causing bloat and high system usage for fairly simple tasks. So, without retooling, a simple recompile to 64 bit can yield faster, but slightly more bloated software.

Another problem might be seen as backwards compatibility. Although the x64 architecture is mostly backwards compatible with x86 systems of 32-bit, some older programs will not work in a 64-bit system, and furthermore, x64 is totally incompatible to any older 16 bit and lesser architectures, which may cause inconvenience to some.

**64-bit Architecture:** The 64 bit or x64 architecture is backwards-compatible to x86 - meaning that this x64 architecture provides a separate legacy 32-bit mode which may provide support to older x86 programs and software to run on newer machines. Although first introduced by AMD in the commercial market, the x64 instruction set is identical for 64-bit Intel processors too.

x64 extends x86's existing general-purpose registers to be 64-bit – these registers are 8 in number, adding a further 8 new 64-bit registers. The naming convention of the 64 bit registers and their corresponding 32-bit register parts is given in the table below.

|  |  |  |  |
| --- | --- | --- | --- |
| 64-bit register | Lower 32 bits | Lower 16 bits | Lower 8 bits |
| rax | eax | ax | al |
| rbx | ebx | bx | bl |
| rcx | ecx | cx | cl |
| rdx | edx | dx | dl |
| rsi | esi | si | sil |
| rdi | edi | di | dil |
| rbp | ebp | bp | bpl |
| rsp | esp | sp | spl |
| r8 | r8d | r8w | r8b |
| r9 | r9d | r9w | r9b |
| r10 | r10d | r10w | r10b |
| r11 | r11d | r11w | r11b |
| r12 | r12d | r12w | r12b |
| r13 | r13d | r13w | r13b |
| r14 | r14d | r14w | r14b |
| r15 | r15d | r15w | r15b |

Table: Naming convention for 64-bit registers

As shown in the above table, even the lower bits of every individual register is directly accessible in the x64 architecture, unlike the 32-bit architecture where certain registers like si and di did not allow for this liberty to the programmer. Further, those 32 bit smaller registers can again be used as two 16 bit ones, which can be further used as 2 8 bit registers and so on. (We have to keep in mind that the higher order i.e. ah, bh, and so on for these 8 bit registers are still addressable, but can’t be used for all types of operands present in the x64 architecture.) This applies to all the 16 64 bit registers in the x64 architecture. Even the instruction registers as well as the flags have been extended to be of 64 bit in this architecture, allowing for more complex instructions as well as more flexible approach to programming.

In addition to this, processors using the x64 architecture also provide floating-point registers as:   
8 80-bit x87 registers, 8 64-bit MMX registers that overlap with the x87 registers and may be dynamically used in conjunction. The 32-bit architecture had 8 128-bit SSE registers, which is extended in the x64 architecture to be 16 in number as well.

### Addressing Modes: The addressing modes for 64 bit systems is very similar to that of the 32 bit systems, and the following are some of its features:

* In a 64-bit processor, instructions that refer to 64-bit registers are performed with 64-bit precision. (For example: **mov rax, [rbx]** moves 8 bytes beginning at **rbx** into **rax**.)
* A special form of the **mov** instruction has been added for 64-bit immediate constants or constant addresses. For all other instructions, immediate constants or constant addresses are still 32 bits.
* A new relative addressing mode(rip) is provided in x64. i.e. Instructions that refer to a single constant address are encoded as offsets from **rip**. For example, the **mov rax, [**addr**]** instruction moves 8 bytes beginning at addr + **rip** to **rax**.
* Instructions, such as **jmp**, **call**, **push**, and **pop**, that implicitly refer to the instruction pointer and the stack pointer treat them as 64 bits registers on x64.

Hence, this is the general outline of the architecture and features of a 64-bit processor; which have become integral parts of our lives nowadays.