## Gambit HMMU

The Gambit HMMU (Hash Memory Management Unit) manages translation of 42-bit virtual addresses to 29-bit physical addresses. A hash table is used to perform translations. Two hashes are generated for each virtual address. Each hash acts as an index into a hash table full of page table entry groups. Each page table entry group contains eight page-table entries. This allows up to sixteen hash collisions for a given translation. The PTE group for the first hash is searched first for a translation. If not found by the first hash, then a second hash is used to search a different PTE group. If the translation is not found by either hash then a HMMU fault is raised to allow software to resolve the translation.

There are 8192, 64kB pages mapped in the system. For a total of 512MB. Although there are 8192k pages to map the translation table supports 64k entries. The translation table simply translates addresses, it does not offer protection. Read, write and execute protection are provided in the segment register. These accessibility rights apply to all pages in the segment.

### Hash Function1

The low order 16 bits of the virtual address are xor’d with the page index.

### Hash Function2

This hash function is the ones complement of Hash Function1

## Page Table Entry Group

Page table entries are grouped together in groups of eight. Eight 64-bit PTE’s occupy a 512-bit cache line. A 16-bit hash is shifted right three times to generate a 13-bit index into the page table entry group table. There are 8192, 512-bit entries in the PTEG Table. All eight PTE’s are searched simultaneously for a match.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |
| PTE7 | PTE6 | PTE5 | PTE4 | PTE3 | PTE2 | PTE1 | PTE0 |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 63 | 62 | 61 | 60 | 59 | 58 | 57 32 | 31 19 | 18 0 |
| P | A | D | F | U | V | VADR41..16 | Page Number13 | Protection Key19 |

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Word | Bit |  |  |  |  |
| 0 | 0 to 18 |  | PK | Protection Key |  |
| 19 to 31 |  | PPN | physical page number |  |
| 32 to 57 |  | VADR | virtual address |  |
| 58 |  | V | Valid | 1 = translation valid |
| 59 |  | U | undefined usage | available for use by OS |
| 60 |  | F | Hash Function | 0 = primary, 1 = secondary hash used |
| 61 |  | D | Dirty | 1 = page was written to |
| 62 |  | A | Accessed | 1 = accessed |
| 63 |  | P | Present | 1 = present in memory |

## ATC – The Address Translation Cache

Address translations are cached in a 4-way association cache.