Using APEX 20KE CAM for Fast Search Applications

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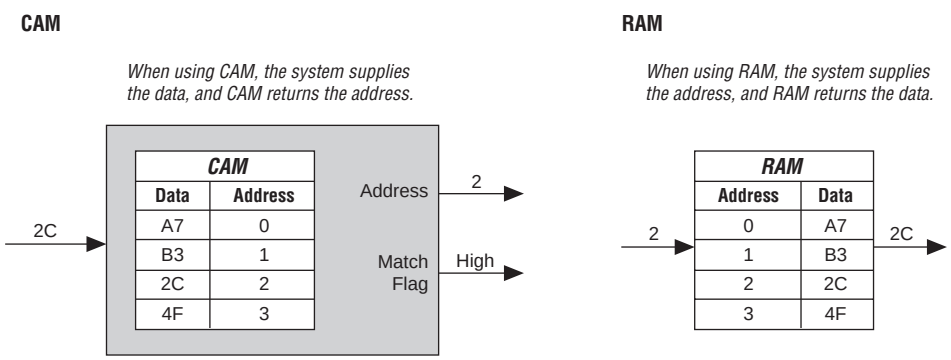
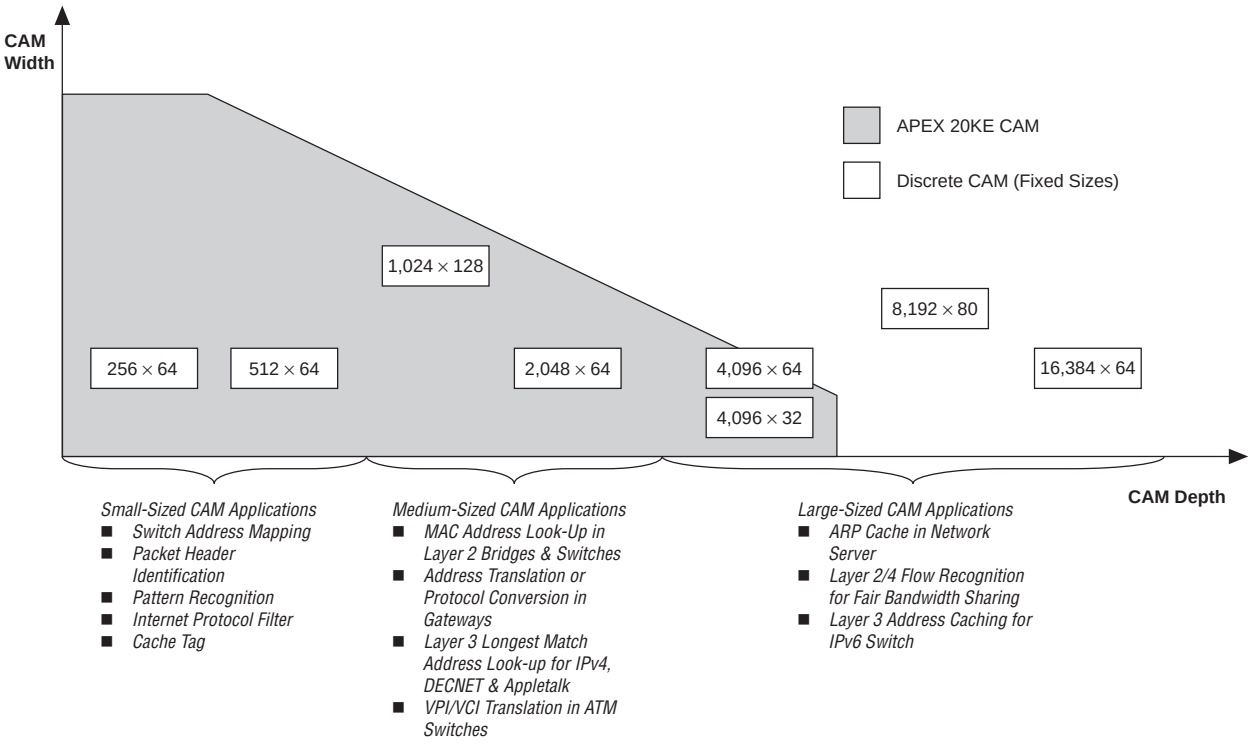
APEX™ 20KE embedded system blocks (ESBs) support content-addressable memory (CAM), a parallel processing memory that accelerates applications requiring fast searches through databases, lists, or patterns. CAM is memory technology developed from RAM. Most other memory devices store and retrieve data by addressing specific memory locations. However, in CAM, the system supplies the data and receives the data's address, as shown in Figure 1.

Figure 1. APEX Integrated CAM vs. RAM



APEX 20KE CAM offers an ideal solution for high-performance applications such as data compression, network switches, Internet protocol filters, and peripheral component interconnect (PCI) functions. In addition to performance advantages, integrated CAM in APEX 20KE devices provides flexible CAM sizes. Figure 2 illustrates typical applications using various CAM block sizes.

Figure 2. APEX CAM Offers Flexible Block Sizes



CAM vs. RAM in Memory Search Applications

Memory applications, which often involve searching, have previously been implemented in programmable logic devices (PLDs) using RAM. Searching for an item in RAM can take many clock cycles. The latency of the search depends on the depth of the RAM block; a 64-word × 32-bit RAM block requires up to 64 clock cycles to find the data.

Identifying an item stored in memory by its data content rather than its address can be more efficient. CAM works this way, making it ideal for high-speed search applications. CAM simultaneously compares the data requested against a list of entries, providing an order of magnitude reduction in search time over RAM. Other memory algorithms, such as binary- or tree-based searches, or look-aside tag buffers, perform a multi-cycle search through the memory space and are much slower than CAM.

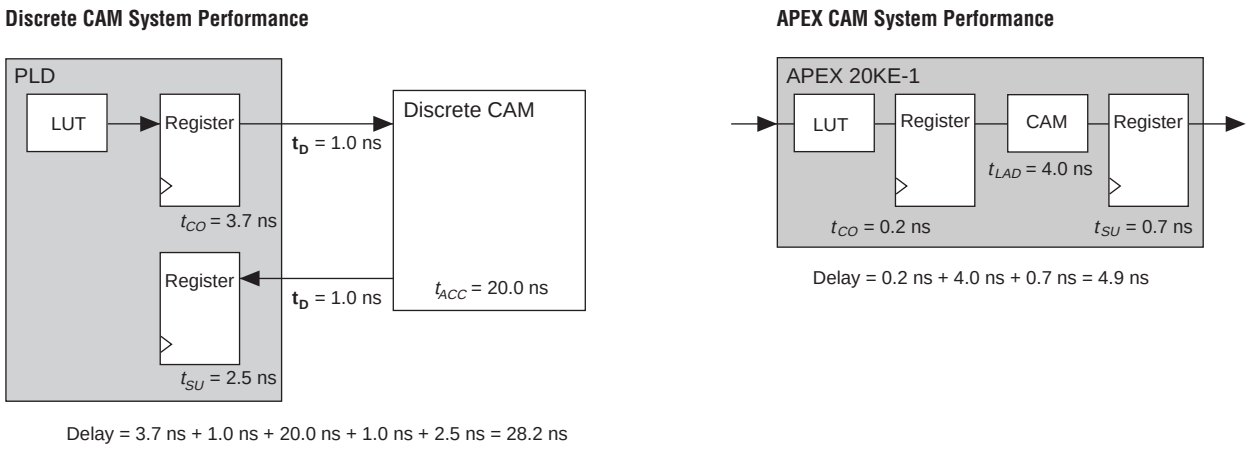
To better understand the performance advantages of CAM, compare the total time required to search an item using both RAM and CAM implementations. Locating an item in a 32-word × 32-bit RAM block running at 125 MHz requires up to 256 ns (32 clock cycles × 8-ns clock cycle). In contrast, the total time required to find an item in a similar-sized CAM block is 4 ns (1 cycle × 4-ns clock cycle). CAM is up to 98% faster than RAM and has a latency of one clock cycle compared to a maximum of 32 cycles for RAM.

APEX CAM Integration Enhances Performance

Traditionally, search applications use discrete CAM, where CAM is implemented as a separate device. A designer must add an individual CAM device to the printed circuit board (PCB), which increases design time and reduces the amount of usable PCB space. Discrete CAM also reduces system performance because it introduces additional on- and off-chip delays.

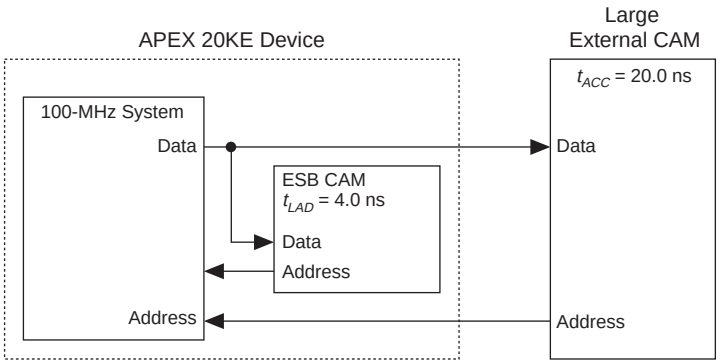
APEX CAM provides higher performance than discrete CAM by eliminating on- and off-chip and PCB board delays. Also, APEX CAM—which is manufactured on a 0.18-µm process—has a much faster access time (4 ns) than typical discrete CAM, which is generally manufactured on older processes, resulting in a slower access time (20 ns). Figure 3 illustrates the system performance advantages of APEX CAM over discrete CAM.

Figure 3. APEX Integrated CAM Provides Superior Performance



In applications that require a CAM block larger than what is available in an APEX 20KE device, you can use the embedded APEX CAM to cache a larger, discrete CAM block. This implementation of APEX 20KE CAM accelerates large CAM applications, as shown in Figure 4. If the APEX CAM that interfaces with the system finds a match in one clock cycle, the system immediately proceeds. Otherwise, the system waits two or three clock cycles for the external CAM to find a match, and then proceeds.

Figure 4. APEX CAM as Cache for Large, Discrete CAM



APEX CAM Provides Flexibility

APEX CAM offers variable CAM sizes. One APEX ESB can be configured as a 32-word × 32-bit CAM block, and multiple ESBs can be cascaded together to implement wider and deeper CAM blocks. You can create any CAM depth or width as long as there are additional unused ESBs. For example, if all ESBs in an EP20K1500E device are used for CAM, you can create a 228-Kbit CAM block with varying widths or depths (e.g., 7,296 words × 32 bits or 3,648 words × 64 bits). Table 1 lists the APEX ESB resources available.

Table 1. APEX Device Densities & ESB Resources

Feature	EP20K60E	EP20K100E	EP20K160E	EP20K200E	EP20K300E	EP20K400E	EP20K600E	EP20K1000E	EP20K1500E
Maximum System Gates	162,000	263,000	404,000	526,000	728,000	1,052,000	1,537,000	1,772,000	2,524,000
Logic Elements	2,560	4,160	6,400	8,320	11,520	16,640	24,320	38,400	54,720
ESBs	16	26	40	52	72	104	152	160	228
Maximum CAM Bits	16,384	26,624	40,960	53,248	73,728	106,496	155,648	163,840	233,472

Conclusion

The APEX family is the first to offer integrated CAM in a PLD. This advanced feature provides system performance benefits to designers by simplifying functions that require searches through lists or data tables. With the additional benefits of enhanced system performance, effective resource utilization, and inherent configuration flexibility, APEX devices offer a spectrum of CAM block sizes, providing superior integration benefits over competing devices.

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