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# **UTCAM-ENGINE™**

## **Accelerates Large Table Look-up Applications**

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# UTCAM Family

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- **UTMC Overview**
- **Introduction to CAMs**
- **Applications**
- **UTCAM-Engine™ Overview**
- **Future Directions**
- **Summary**

# UTMC Overview

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- **Located in Colorado Springs, CO**
- **Subsidiary of Aeroflex Corporation**
- **Founded in 1980**
- **Entered merchant market in 1985 focused on:**
  - **LAN ICs for Military Avionics**
  - **ICs for Satellite Communications and Control**
  - **ASICs for Space and Avionics applications**



**UTMC**

 **AEROFLEX** company

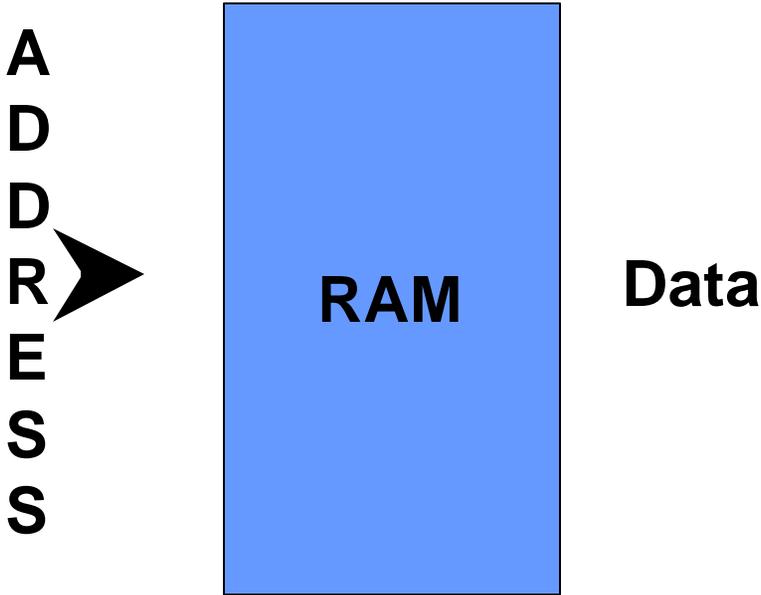
# Introduction to CAMs

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- **What is a Content Addressable Memory (CAM), also called an Associative Memory**
  - **Different from a conventional RAM (Random Access Memory) where you supply the address and get data back**
  - **You supply the data (key) and get the address back (the association)**

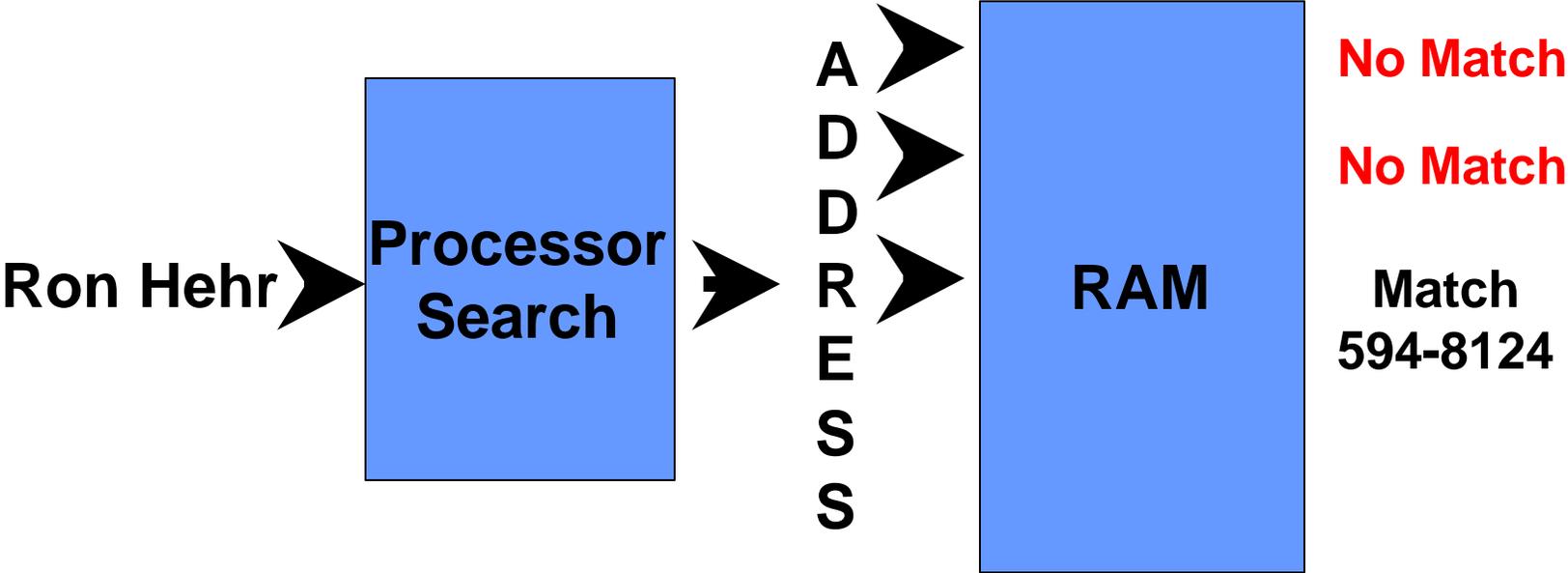
# Introduction to CAMs

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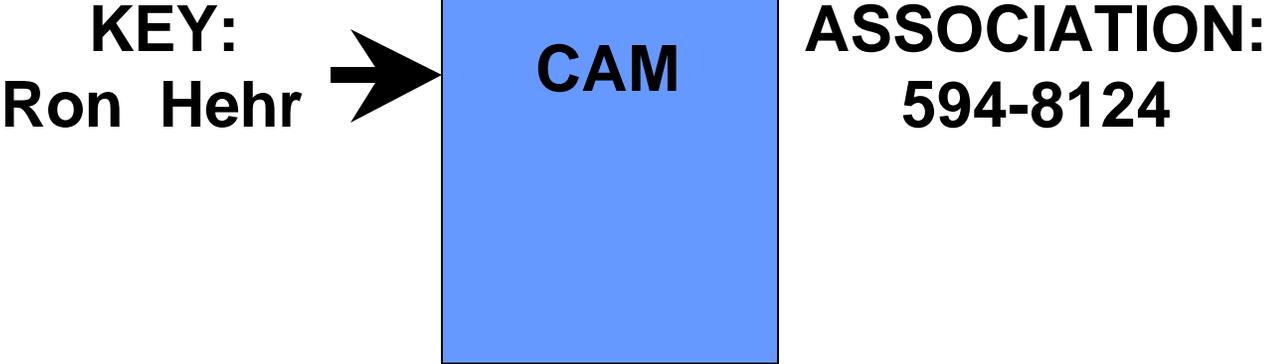
# Introduction to CAMs

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# Introduction to CAMs

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# UTCAM Family

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## Applications

- **Data Communications Equipment**
  - **Edge and Backbone Switches**
  - **Edge and Backbone Routers**
  - **Layer 3 (IPv4) Switches**
  - **Gigabit Ethernet Switches and Routers**
- **What are they used for**
  - **Large, Fast Look-up Tables**
  - **Address Resolution Logic**
  - **Packet Processing**
  - **Network Address Filtering**
  - **Firewalls**

# UTCAM Family

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## Applications

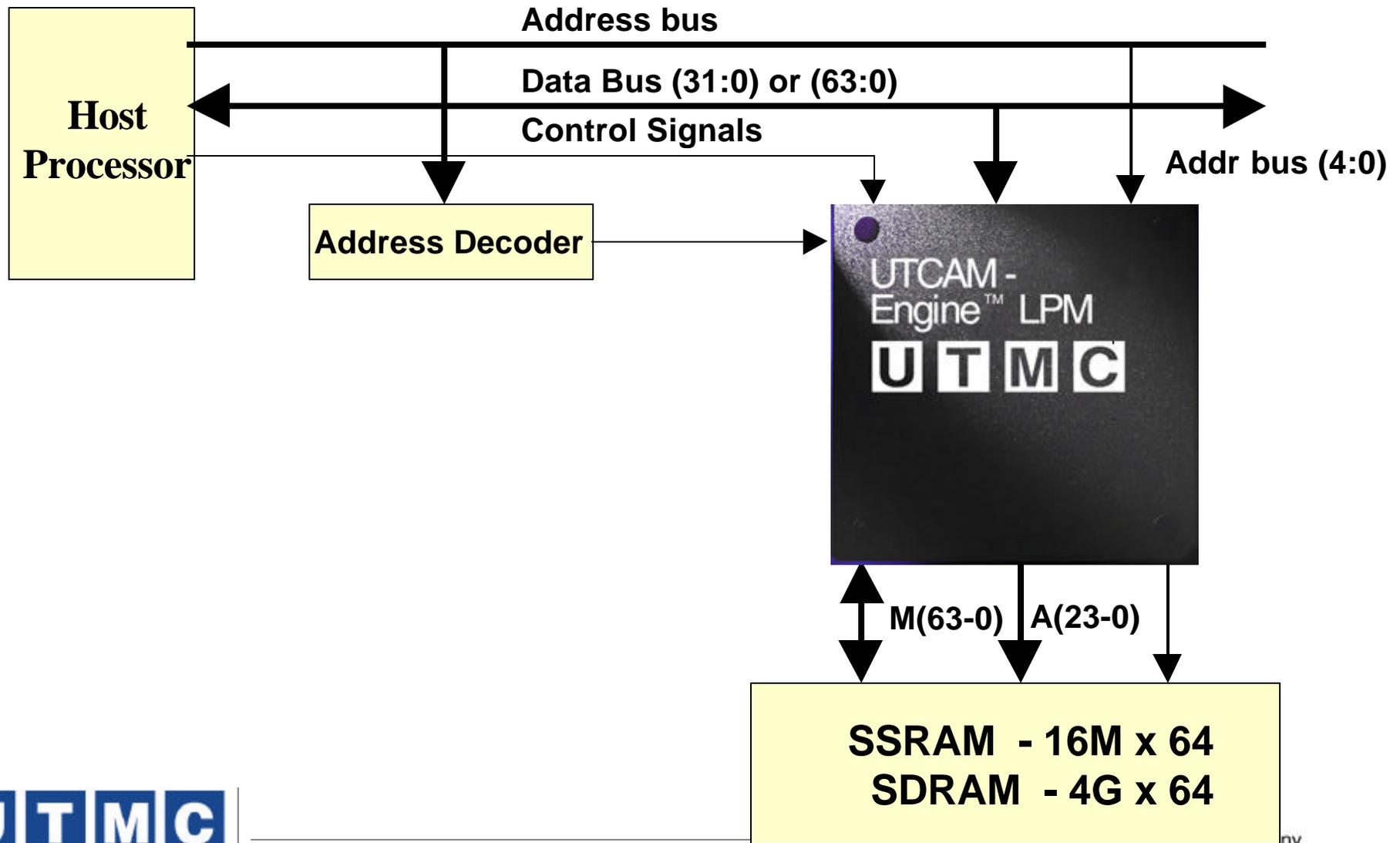
- **Image Processing**
- **Pattern Recognition**
- **Artificial Intelligence Learning Systems**
- **Database Accelerators**
- **Compression/Decompression Engines**
- **Encryption/Decryption Engines**

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- **UTCAM-Engine**
  - **Transforms conventional SRAM or SDRAM into CAM**
  - **Significant cost advantage for large tables**
    - **CAM - \$50/Mb**
    - **SSRAM - \$4/Mb + Engine**
    - **SDRAM - \$0.25/Mb + Engine**

# UTCAM-Engine™ LPM System Block Diagram



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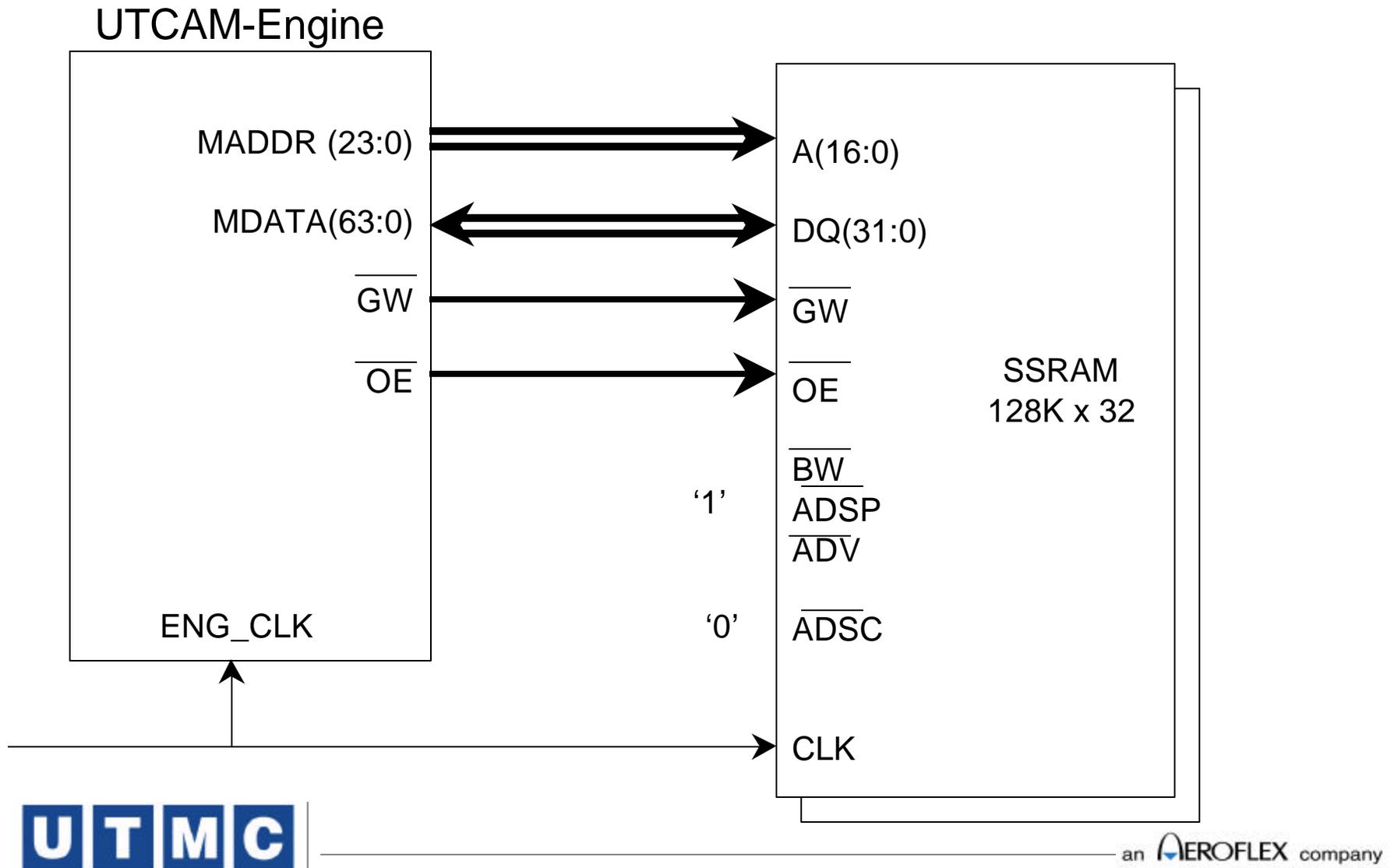
- **UTCAM-Engine**
  - **Drives up to 32 gigabytes of memory**
  - **Multiple Tables**
  - **Multiple Key Widths**
  - **Programmable Association Widths**
  - **Fast Match Time Characteristics**
  - **Longest Prefix Match (32 Bit)**
  - **Hierarchical Search Capability**
  - **100 MHz operation**

# UTCAM Family

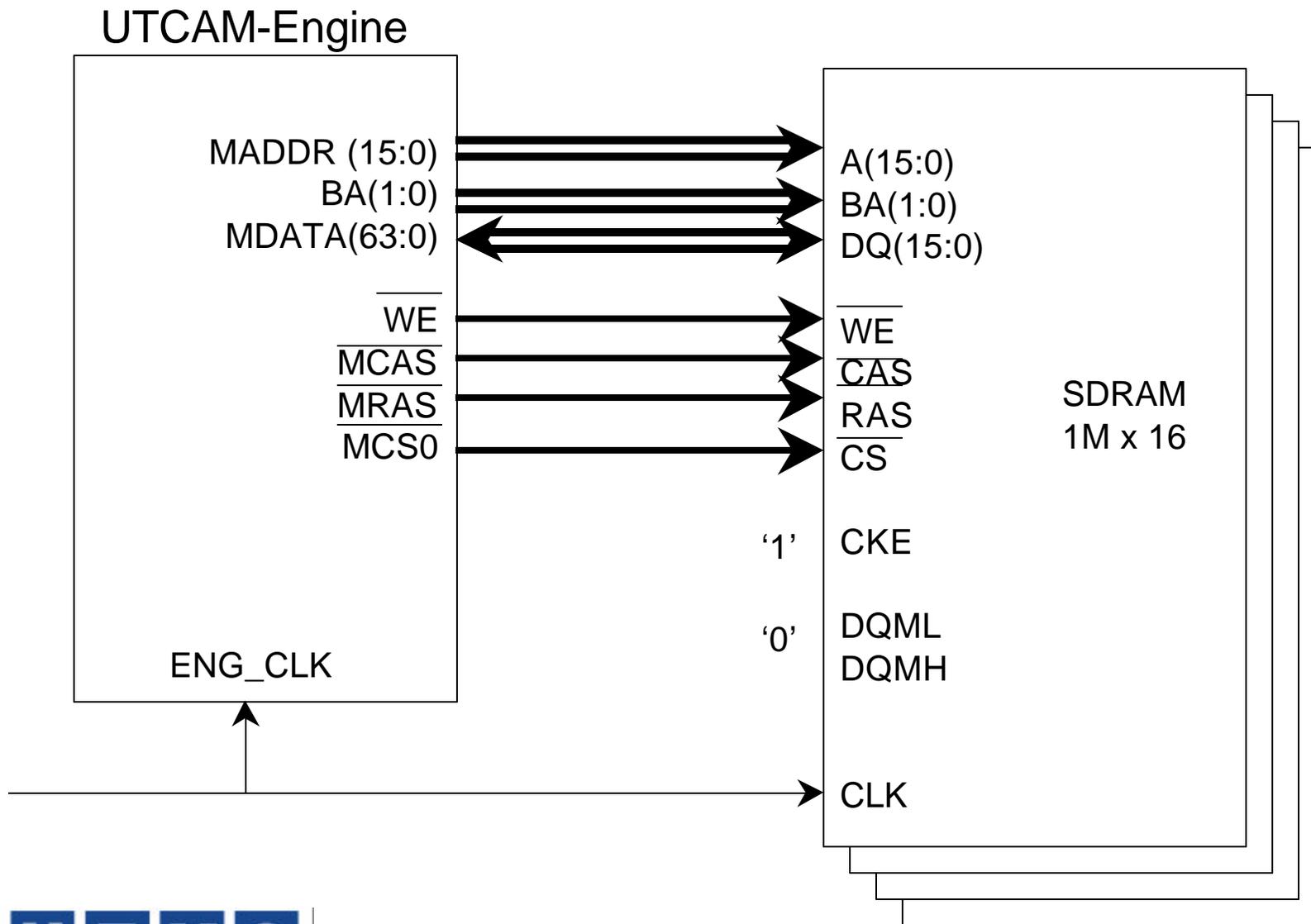
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- **UTCAM-Engine**
  - **Drives up to 32 Gigabytes of SDRAM memory**
    - **4G X 64 bit words**
  - **Drives up to 128 Megabytes of SSRAM**
    - **16M X 64 bit words**

# Interfacing the UTCAM-Engine to Synchronous SRAM



# Interfacing the UTCAM-Engine to Synchronous SDRAM



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- **UTCAM-Engine**
  - **Multiple Tables**
    - **Up to 8K tables can be configured within available memory**
    - **Table configuration information for first 64 tables on chip for fast context switching**
    - **Table depth can be from 512 to 64M records**
    - **For optimum performance size the table depth to 2X the number of records needed**

# UTCAM Family

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- **UTCAM-Engine**
  - **Multiple Key Widths**
    - **31 different widths configurable in byte increments**
    - **1 to 32 bytes (8 to 256 bits)**
    - **Set independently for each table**

# UTCAM Family

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- **UTCAM-Engine**
  - **Programmable Association Widths**
    - **Two types of tables**
      - » **Normal**
        - **Configurable from 0 to 32 bytes**
        - **0 bytes indicated a validation list, status bit set if key exists but no association is returned**
      - » **Extra Wide**
        - **Programmable from 1 to 8M bytes**
        - **Association storage is not allocated until record is added**
    - **Set independently for each table**

# UTCAM Family

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- **Longest Prefix Match**
  - Works on 32 bit words
  - Critical operation for IPv4 address processing
  - 32 bit words are loaded along with the number of bits that have significance
  - 32 bit keys are matched to find the association that matches the longest string of significant bits
  - Performance can be optimized based on the minimum significance length - 1, 8, or 16 bits
  - 95% of searches completed in less than 400 nsec, worst case search time 600 nsec.
  - Table maintenance operations completed in less than 1 usec

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- **Hierarchical Search**
  - **Supports hierarchical lookups on byte boundaries**
  - **Tables can be specified as having a specific child**
  - **Searches which fail to find a match automatically cascade to their child table**
    - **Key is “masked” to the length of the child table’s key**
    - **High Order Key Bytes are preserved**
    - **Keys must be on byte boundaries**

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- Proximity Match
  - Useful in pattern matching and image processing applications where “fuzzy” comparisons are used
  - Returns the association of the closest matching entry in a table
  - Processes the entire table at a rate of 50 million entries per second
  - 4, 8, 16, or 32 bit element boundaries can be selected
  - Either Manhattan or Euclidean distance formulas can be selected to compute the closeness
    - $a | E_n - T_n |$
    - $\sqrt{S} (E_n - T_n)^2$

# UTCAM Family

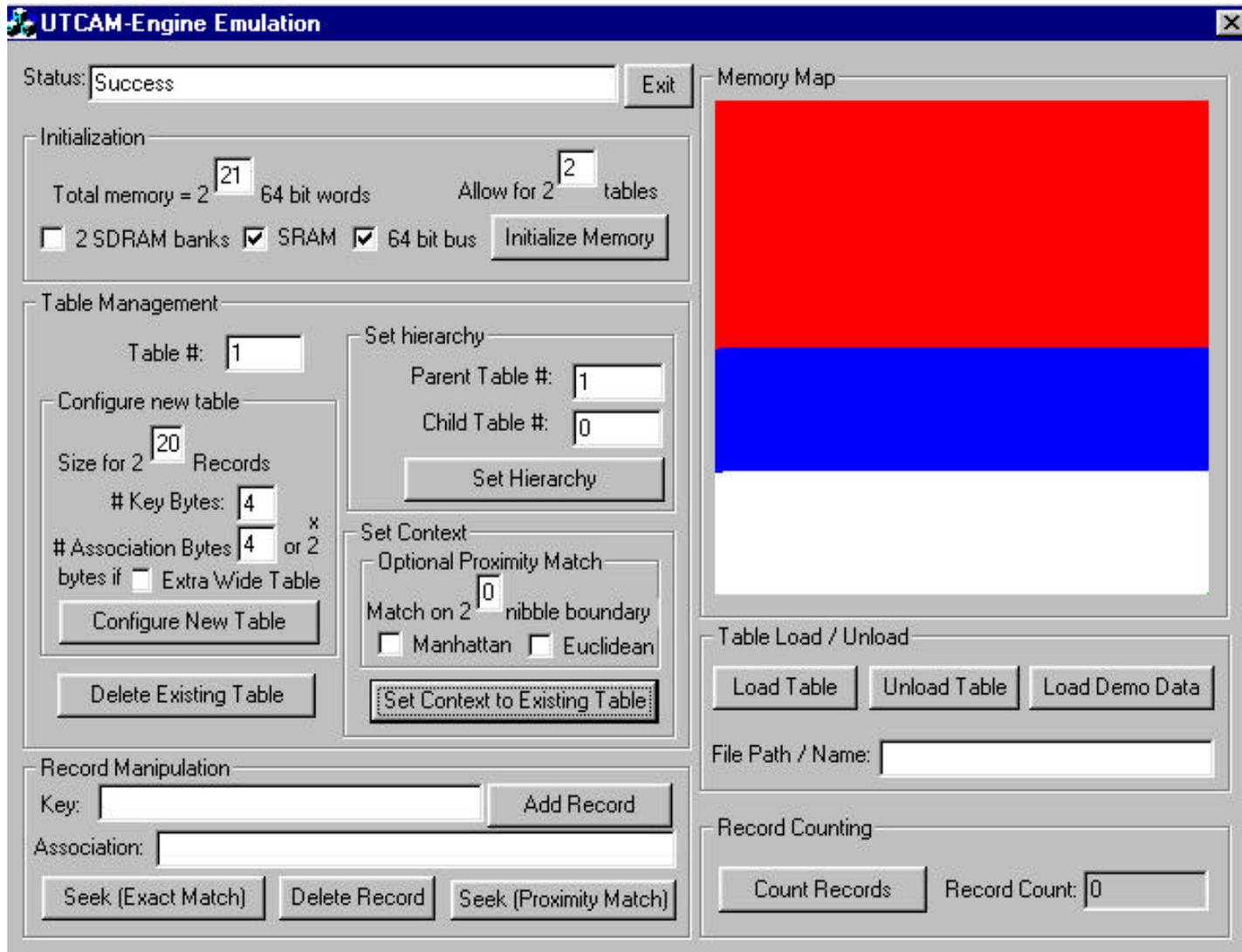
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- **UTCAM-Engine™**

- **Design Status**

■ <b>Design Release</b>	<b>Complete</b>	<b>May 98</b>
■ <b>Silicon</b>	<b>Complete</b>	<b>June 98</b>
■ <b>Production</b>	<b>Complete</b>	<b>Oct 98</b>
■ <b>LPM Silicon (LPM, SDRAM)</b>	<b>Complete</b>	<b>June 99</b>
■ <b>LPM Production</b>		<b>July 99</b>

# UTCAM-Engine™ PC Demo Software



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- **Future Directions**
  - **UTCAM-Engine IP Core**
  - **UTCAM-Engine with embedded RAM**
    - **16 Megabit Embedded SDRAM**
    - **4 Megabit Embedded SRAM**
  - **Feature Enhancements**
    - **Support for IPv6 128 bit addresses**
    - **Auto Learning**
    - **Auto Aging**
    - **Multiple I/O Ports**
  - **Database Engines**

# UTCAM-Engine™

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- **Key Features**
  - **Drives standard cost effective RAM**, up to:
    - 16M X 64 of SSRAM
    - 4G X 64 of SDRAM
  - **Fast match times**
    - 10 Million Packets per Second for SEEKs
    - 4 Million packets per Second of LPM
  - **Real Time Table Maintenance**
  - **Configurable Memory Space**
    - Multiple Tables - up to 8k independent tables
    - Key widths - 2 to 32 bytes
    - Association width - 0 to 32 bytes or extended up to 8M
  - **32-bit or 64-bit I/O bus**
  - **Input and Output FIFOs** for pipelined operation
  - **32-bit Longest Prefix Match** function for IP address processing



# UTCAM-Engine™

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- **Applications:** High-Performance edge and backbone switches and routers, Layer 3 (IPv4) switches, any applications requiring **large look-up tables** - greater than 8K records
  - Example 1 - **32K X 64**
    - 3 chips - UTCAM-Engine™ and 2 128K X 32 SSRAMs
    - Cost ~ \$75
  - Example 2 - **64K X 64**
    - 3 chips - UTCAM-Engine™ and 2 2M X 32 SDRAMs
    - Cost ~ \$65
  
- **UTMC delivers significant size and cost benefits**

# UTCAM-Engine LPM

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- Advantages of UTCAM-Engine over KLSI LME
  - UTCAM-Engine supports unlimited table size (>256K entries)
    - KLSI LME limited to 8K entries
  - UTCAM-Engine supports multiple tables with independently configured key and association widths
    - KLSI LME supports single table
  - Longest Prefix Match Throughput
    - UTCAM-Engine 5 Mpps
    - KLSI LME 4.1 Mpps
  - Table Maintenance - Add/Delete
    - UTCAM-Engine <1  $\mu$ s
    - KLSI LME 1000  $\mu$ s

# UTCAM-Engine LPM

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- Advantages of UTCAM-Engine over MUSIC Routing CoProcessor (RCP)
  - UTCAM-Engine supports unlimited table size (>256K entries)
    - RCP limited to 8K entries per device - cascadable
  - UTCAM-Engine supports multiple tables with independently configured key and association widths
    - RCP supports single table with association determined by width of external RAM
  - Longest Prefix Match Throughput
    - UTCAM-Engine 5 Mpps
    - RCP 14.3 Mpps
  - Table Maintenance - Add/Delete
    - UTCAM-Engine <1  $\mu$ s
    - RCP - Longest prefix priority is determined by order in the CAM, changes require rewriting the entire table