Search Engine

For SVFIG

Dr. C. H. Ting
Offete Enterprises

December 16, 2006

Summary

- Early Search Engine Design
- Challenges of Search Engines
- Complete Search Engine Design
- Components of Search Engine
- Implementation
- Conclusion

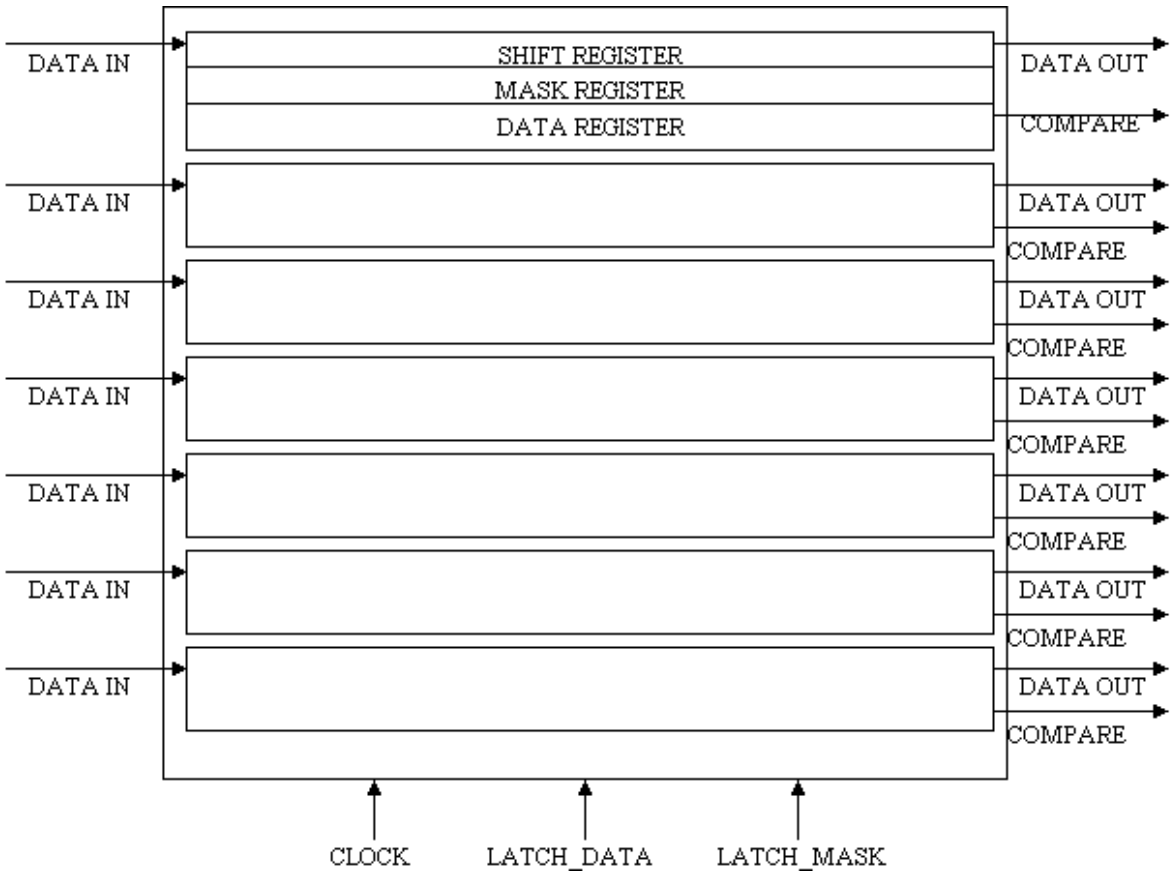
Early Search Engine Design

- **DC7 Search Engine**
  - **Seven 70-bit pipelined comparators for parallel data searching, prototyped by Orbit Semiconductor.**
- **Logic Equation**

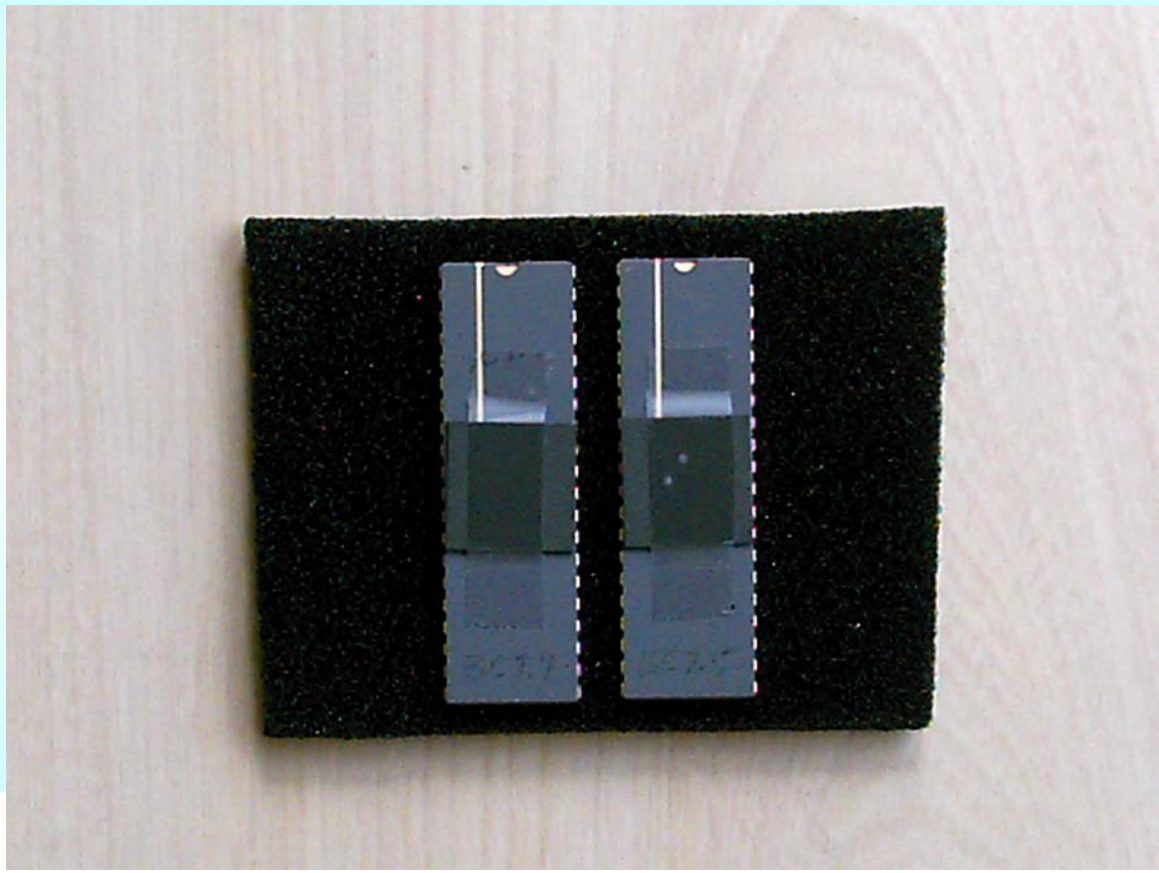
  Compare <= ‘1’ when

  ((shifter xor data) and mask) = 0 else ‘1’;

DC7 Search Engine



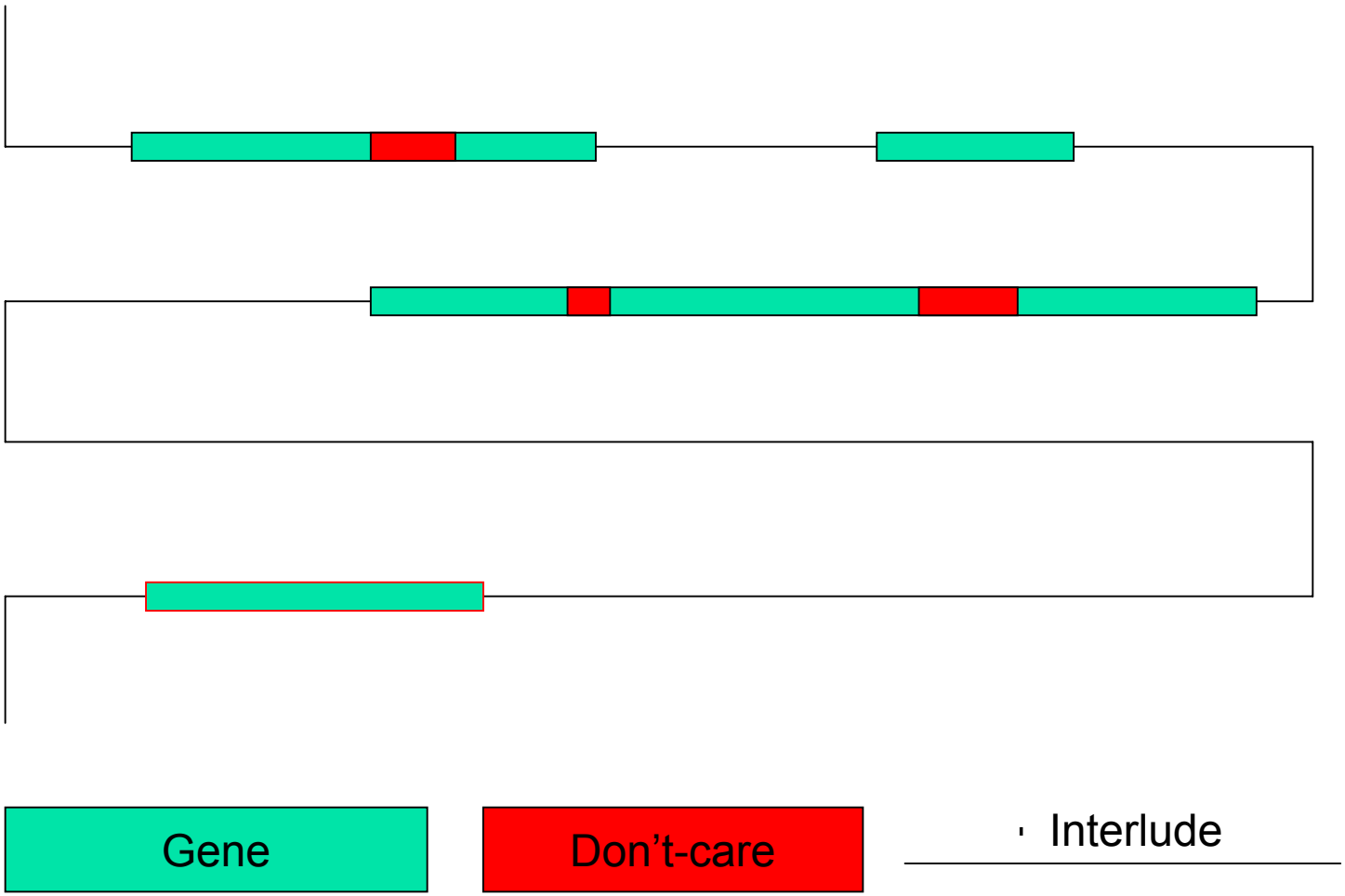
DC7 Search Engine



Challenges of a Modern Search Engine

- Many keywords—AND relation
- Keywords may contain don't-care characters—Maskable characters
- Keywords may have spatial relationships—Variable interludes
- Keywords may have alternatives—OR relation

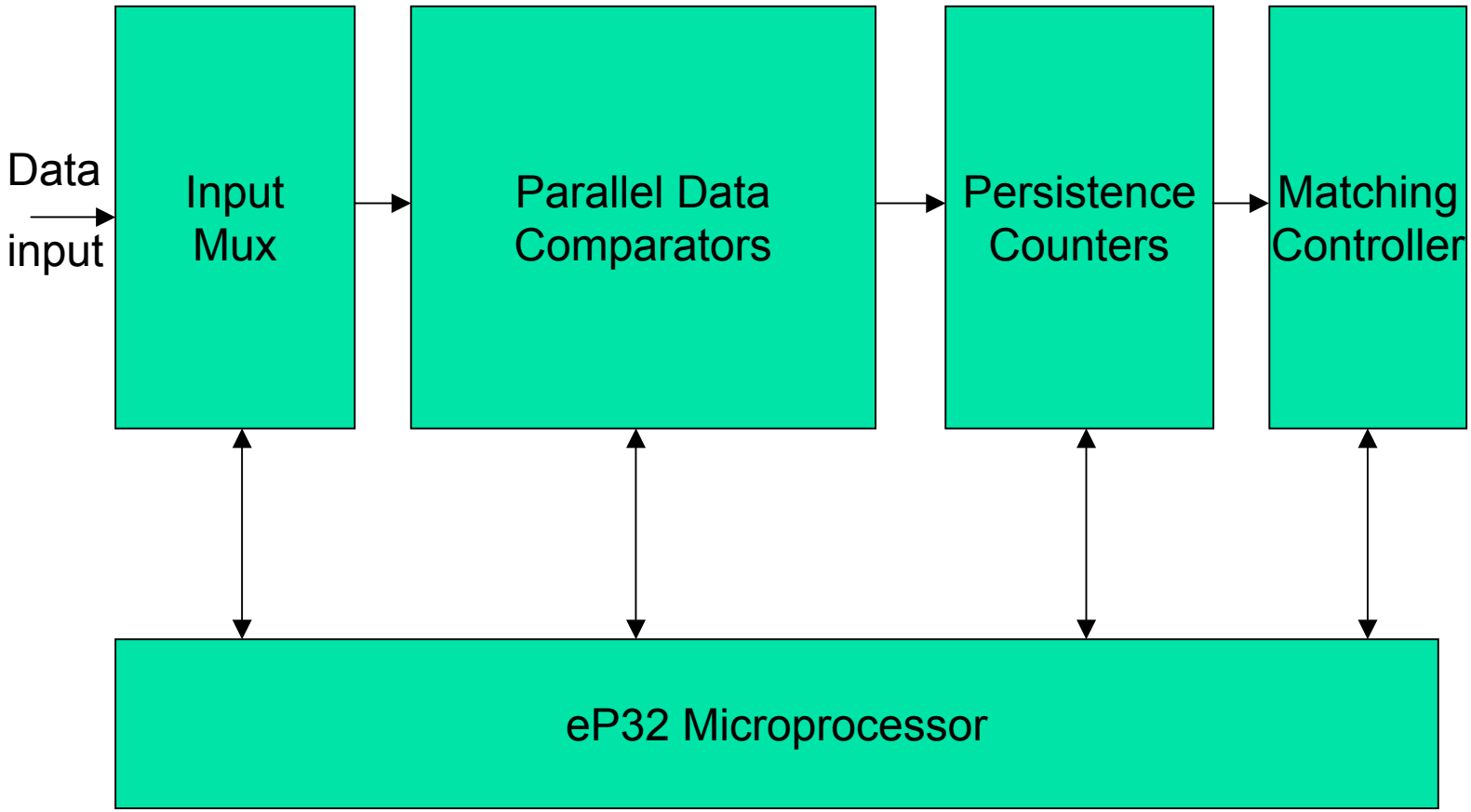
Challenges of a Gene Search Engine



Complete Search Engine Design

- Input Multiplexers
- Data Comparators
- Persistence Counters
- Matching Controller
- eP32 Microprocessor

Components of Search Engine



Input Multiplexers

- 32x32 Crossbar Input Multiplexers
- Any input bit stream can be directed to any Data Comparator
- Parallel input streams are used to load Data and Mask Registers
- A single serial input stream is used to distribute input data to all comparators

Data Comparators

- 32 200-bit Shifters with matching Data Registers and Mask Registers
- Controlling Signals
  - Master Clock
  - SHIFT
  - LOAD_DATA
  - LOAD_MASK
- COMPARE output

Persistence Counters

- **32 Persistence Counters to stretch the COMPARE signals from each comparator**
- **Persistence allows matching of several data segments with variable interludes among them**

Matching Controller

- Flexible OR-AND structure allowing persistent compare signals to be OR'ed and AND'ed together
- OR'ed compare signals are AND'ed to produce final HIT signal
- Locations of 16 Final HIT signals are logged for software analysis

Matching Controller

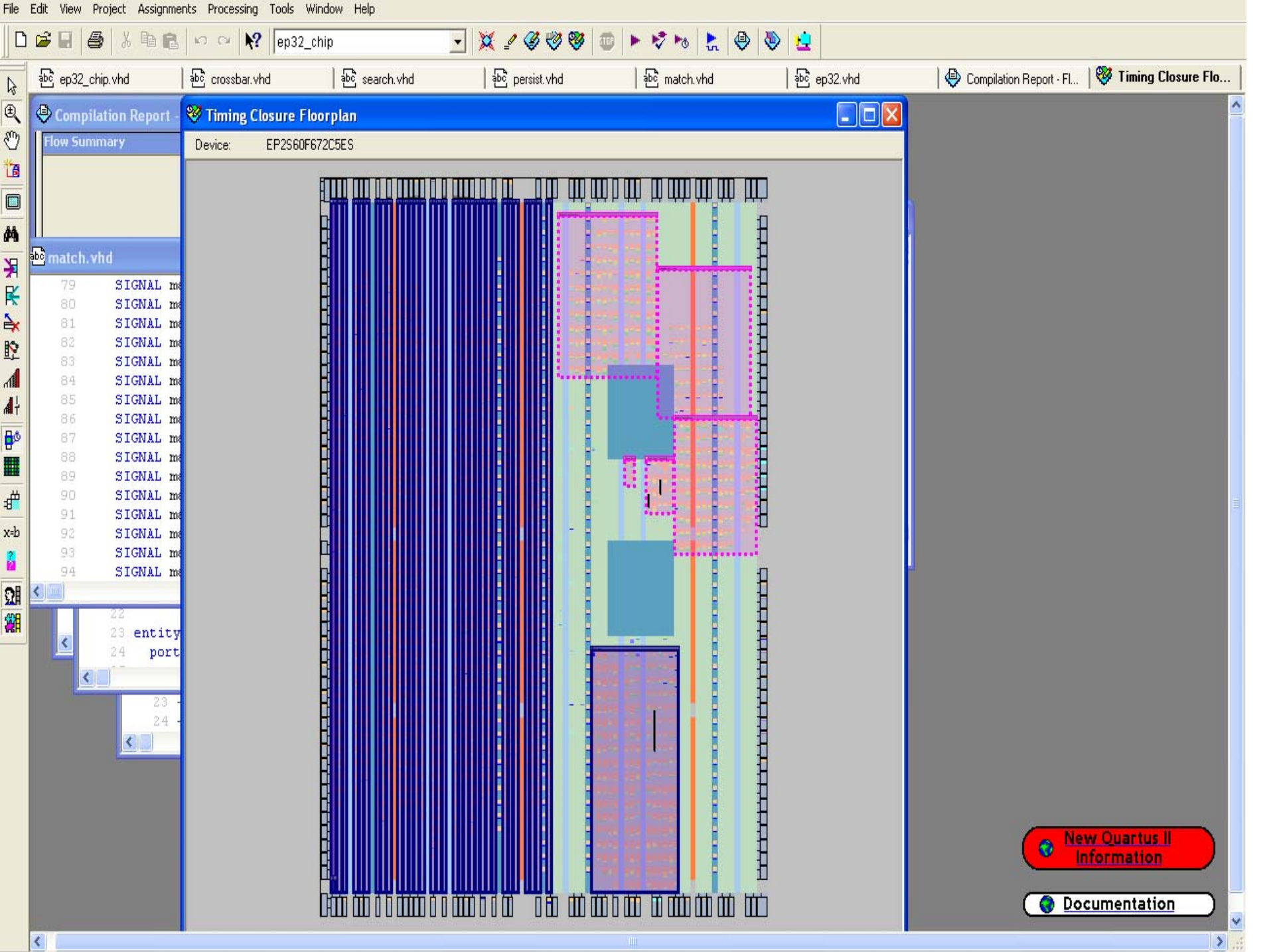
- **Match_Command Register issues SHIFT, LOAD_DATA and LOAD_MASK commands to Data Comparator**
- **Match_Parallel Register routes data to Input Mux in parallel**
- **Match_Serial Register routes data to Input Mux in a series of 32 clocks**

eP32 Microprocessor

- Initialize Input Mux, Persistence Counters, and Match registers
- Write Match_Parallel Register to set up Data and Mask Registers in Data Comparator
- Write Match_Serial Register to run comparison
- Read Match_Counters to examine the searching hits

Implementation of Search Engine

- Implemented on Altera Stratix II FPGA chip
- Synthesized using Quartus II tools
- Tested on NIOS II Evaluation Board
- Resource Utilization:
  - 27728 ALUT (57%)
  - 24363 total registers
  - 786432 memory bits (31%)
  - 34:41 synthesis time


File Edit View Project Assignments Processing Tools Window Help
ep32_chip
ep32_chip.vhd
crossbar.vhd
search.vhd
persist.vhd
match.vhd
ep32.vhd
Compilation Report - Fl...
Timing Closure Flo...
Compilation Report
Flow Summary
Timing Closure Floorplan
Device: EP2S60F672C5ES
match.vhd
79 SIGNAL
80 SIGNAL
81 SIGNAL
82 SIGNAL
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84 SIGNAL
85 SIGNAL
86 SIGNAL
87 SIGNAL
88 SIGNAL
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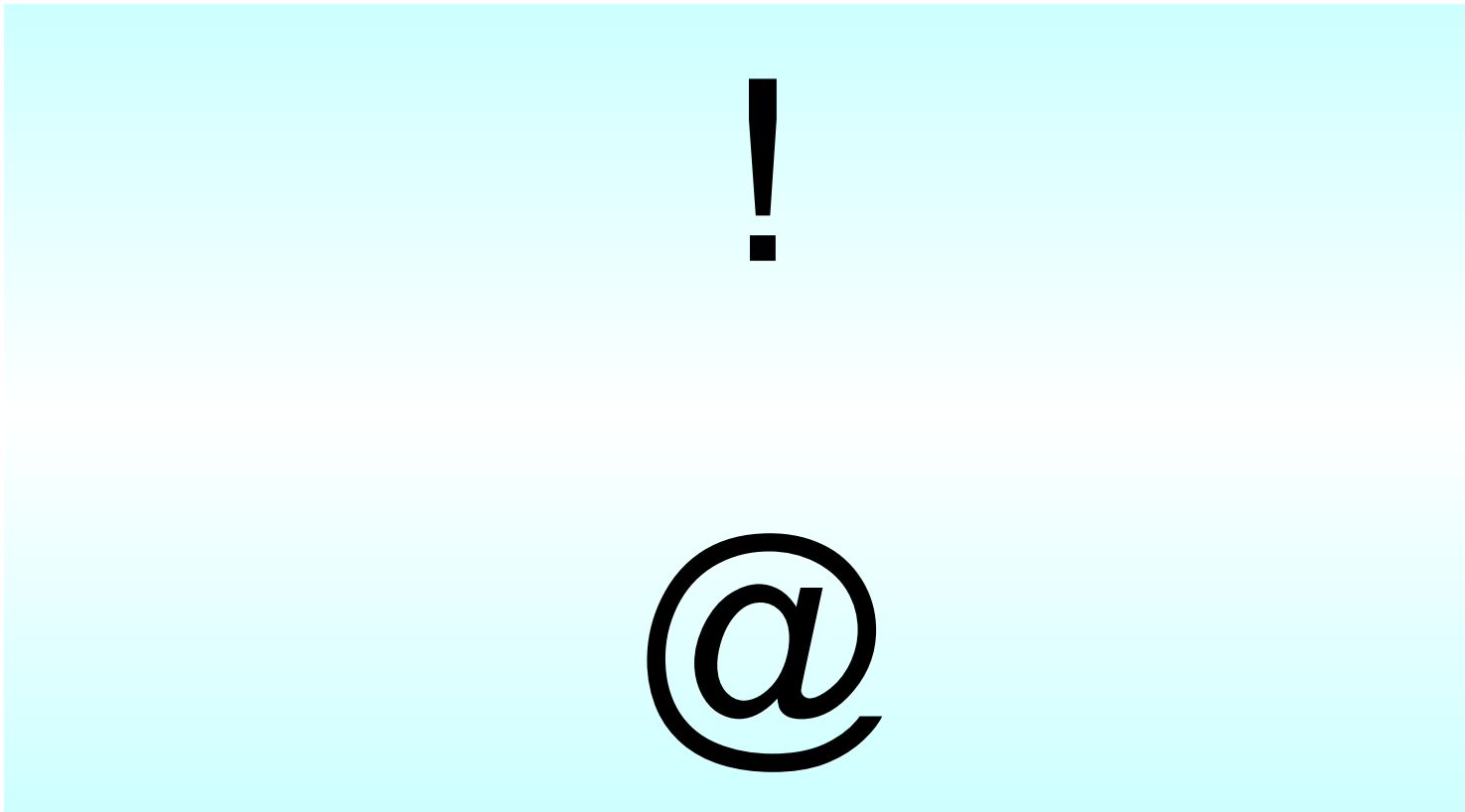
90 SIGNAL
91 SIGNAL
92 SIGNAL
93 SIGNAL
94 SIGNAL
23 entity
24 port
New Quartus II Information
Documentation

Where is the Software?



Concluding Remarks

- When you have your own CPU, everything is easy.
- This search engine is a good example of Hardware-Software Codesign. You can trade off hardware for software and time.

Thank you very much!