3. Computer Buses

- Introduction
- Electrical Considerations
- Data Transfer Synchronization
- Parallel and Serial Buses
- Bus Arbitration
- PCI Bus
- PCI Express Bus
- Other Serial Buses
- VME Bus

VME Bus

- VME Bus
  - VME Bus Overview
  - Parallel VME Bus Variants
  - VXS Bus
  - VPX Bus

VME Bus Overview (1)

- VME (*Versa Module Eurocard*)
- Originates from VERSAbus (*Motorola*)
- VERSAbus has been adapted for the double Eurocard form factor (6U, 267×160 mm)
  - VMEbus, rev. A
- The VME specifications have been updated (revisions B, C, C.1)
- IEC, IEEE, and ANSI/VITA standards (VITA - *VME International Trade Association*, vita.com)

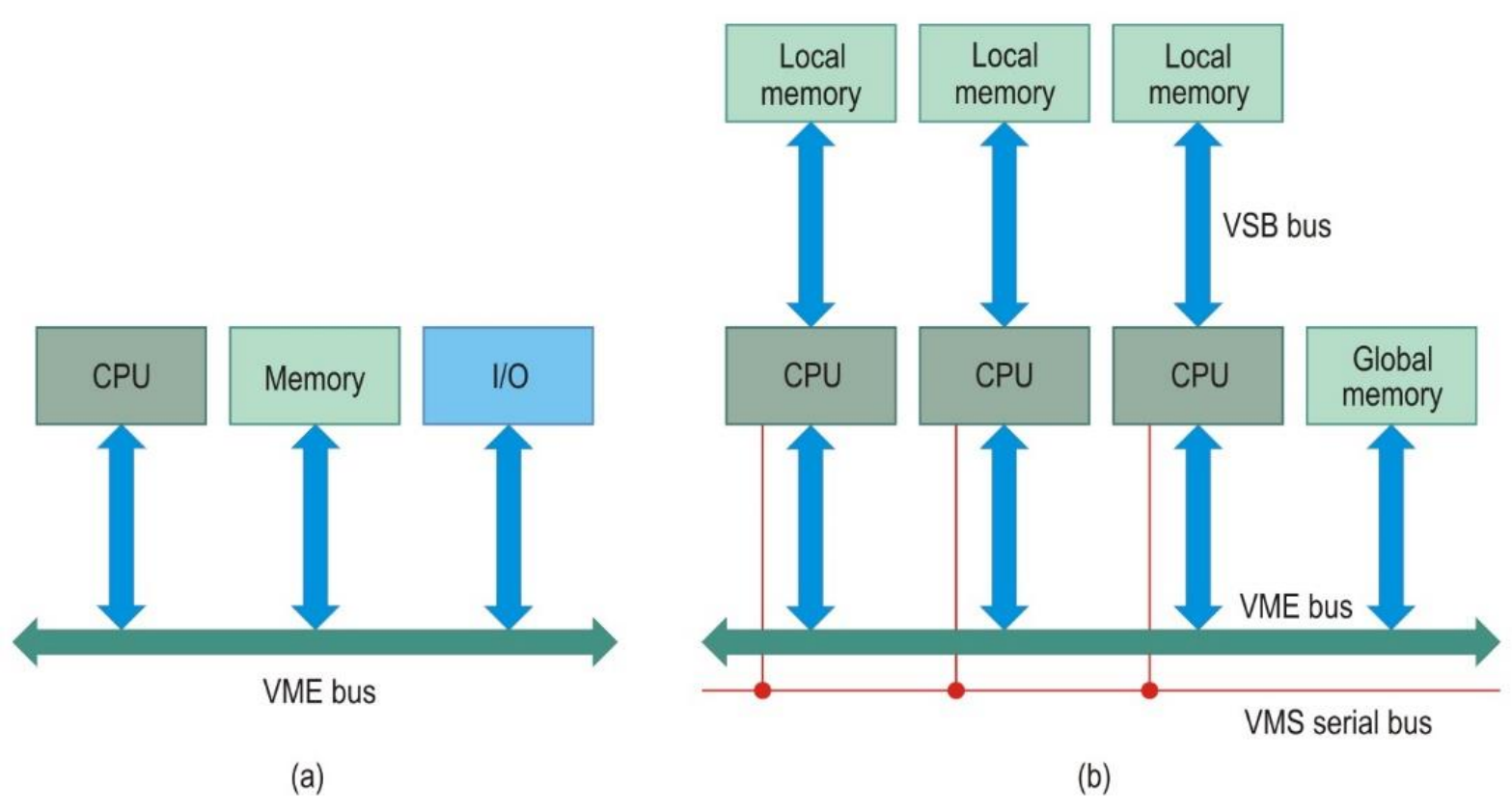
VME Bus Overview (2)

- Parallel bus
  - Used for industrial and embedded systems
- Asynchronous bus
  - Allows various components to operate at a speed appropriate to the technology used
- There are no proprietary rights
- The reliability of the bus is ensured by:
  - Mechanical design → connectors with metallic pins
  - Logical protocol

VME Bus Overview (3)

- Family of three buses
  - VME: main bus
  - VSB: secondary bus
    - Bus for memory extension
    - Allows to increase performance by reducing the overall traffic on the main VME bus
  - VMS: serial bus
    - Used for communication and synchronization between multiple processors

VME Bus Overview (4)



(a) Minimal system; (b) Multiprocessor system

VME Bus Overview (5)

- Applications:
  - Industrial control
  - Military: radars, communications, avionics
  - Aerospace: spacecraft control, satellites
  - Transportation: railway control
  - Telecommunications: cellular telephone base stations, telephone switches
  - Medical: computed tomography scan, nuclear magnetic resonance imaging
  - High-energy physics: particle accelerators

VME Bus

- VME Bus
  - VME Bus Overview
  - Parallel VME Bus Variants
  - VXS Bus
  - VPX Bus

Parallel VME Bus Variants (1)

- Original VME Bus
  - Non-multiplexed data and address lines
  - Data size: 8 .. 32 bits
  - Address size: 16 .. 32 bits
  - Multiprocessing capability: M/S architecture
  - Centralized arbitration by daisy-chaining
  - A number of 7 interrupt request lines
  - Connectors with 3 rows x 32 pins (96 pins)
  - Up to 21 expansion boards in a backplane

Parallel VME Bus Variants (2)

- VME64 Bus
  - 64-bit data (double Eurocard)
  - 64-bit addresses (double Eurocard)
  - 32-bit or 40-bit addresses (single Eurocard)
  - Lower-noise connectors
  - “Plug and Play” features → ROM memory
- VME64x Bus
  - 3.3-V power supply pins
  - 141 user-defined I/O pins

Parallel VME Bus Variants (3)

- New connectors: 5 rows x 32 pins (160 pins)
  - Compatible with the 3-row connectors
- Additional 95-pin connector (5 rows x 19)
- Higher bandwidth (up to 160 MB/s)
- Modified protocol for data transfer cycles → 2eVME (*Double-edge* VME)
- Live-insertion (hot-swap) capability: insertion of modules during operation
- Front panels with guiding pins

Parallel VME Bus Variants (4)

- VME320 Bus (VME 2eSST)
  - Bandwidths of over 320 MB/s (peak bandwidths of over 500 MB/s)
  - Star-interconnection method
    - All the interconnections are joined together at the middle slot of the backplane
  - A new protocol → 2eSST (*Double-edge Source Synchronous Transfer*)
    - During the data phases, it is a source-synchronous protocol

VME Bus

- VME Bus
  - VME Bus Overview
  - Parallel VME Bus Variants
  - VXS Bus
  - VPX Bus

VXS Bus (1)

- VXS – *VMEbus Switched Serial*
- Combines the parallel VME bus with high-speed switched serial interconnects
- ANSI/VITA standards
  - ANSI/VITA 41.0: Base specification
  - ANSI/VITA 41.1: InfiniBand technology
  - ANSI/VITA 41.2: Serial RapidIO technology
  - ANSI/VITA 41.3: Gigabit Ethernet technology
  - ANSI/VITA 41.4: PCI Express technology (4x)

VXS Bus (2)

- Switched serial interconnect
  - Point-to-point links between modules
  - Clock and data signals are combined into a single serial bitstream
  - Data rates of 3.125 or 6.25 Gbits/s
    - With 8b/10b encoding: 312.5 or 625 MB/s
    - With 64b/66b encoding: 378 or 756 MB/s
  - Switch boards (1-2): contain an active switch
  - Regular (payload) boards (up to 18): other boards that connect to the switch boards

VME Bus

- VME Bus
  - VME Bus Overview
  - Parallel VME Bus Variants
  - VXS Bus
  - VPX Bus

VPX Bus (1)

- VPX – *Virtual Path Cross-Connect*
- Replaces the parallel VME bus with point-to-point serial interconnects
- ANSI/VITA 46 standard
  - ANSI/VITA 46.0: Base specification
  - ANSI/VITA 46.1: VMEbus signal mapping
  - ANSI/VITA 46.3: Serial RapidIO technology
  - ANSI/VITA 46.4: PCI Express technology
  - ANSI/VITA 46.7: 10 Gigabit Ethernet technology

VPX Bus (2)

- VPX generations
  - Gen 1 VPX: data rates of 2.5 .. 3.125 Gbits/s
  - Gen 2 VPX: 5 .. 6.25 Gbits/s
  - Gen 3 VPX: 8 .. 10.3 Gbits/s
  - Gen 4 VPX: 16 Gbits/s
  - Gen 5 VPX: 25 Gbits/s and higher
- VPX REDI (*Ruggedized Enhanced Design Implementation*)
  - ANSI/VITA 48 standard
  - Defines designs for enhanced cooling

VPX Bus (3)

- ANSI/VITA 66 standard
  - Specifies fiber optic interconnects for VPX modules
- ANSI/VITA 67 standard
  - Specifies analog coaxial interconnects with VPX modules for radio-frequency (RF) signals
- Applications of VPX-based systems
  - Military and aerospace
- Advantages: high performance; high reliability; scalability; resilience to shocks

Summary

- The VME bus is one of the most successful interconnect technologies
  - Mechanical, electrical, and software compatibility is ensured with all existing VME boards
  - The parallel VME bus has been significantly improved, but it has reached its limits
  - The VXS bus ensures the transition to high-speed serial interconnects
  - The VPX bus uses only serial interconnects
    - It has partially replaced the parallel bus

Concepts, Knowledge (2)

- Family of VME buses
- Original VME bus features
- VME64x bus features
- VME320 bus features
- VXS bus features
- VPX bus features