Chapter Objectives

• Different memory technologies
• How to plan for a memory installation or upgrade
• To install and remove memory chips
• How to optimize memory for Windows platforms
• Best practices for troubleshooting memory problems
• The benefits of teamwork
801-1.2: Differentiate between motherboard components, their purposes, and properties.
801-1.3: Compare and contrast RAM types and features.
801-1.5: Install and configure storage devices and use appropriate media.
801-3.1: Install and configure laptop hardware and components.
802-1.1: Compare and contrast the features and requirements of various Microsoft operating systems.
802-1.4: Given a scenario, use appropriate operating system features and tools.
802-1.5: Given a scenario, use Control Panel utilities.
802-3.1: Explain the basic features of mobile operating systems.
802-4.2: Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU, and power with appropriate tools.
802-4.6: Given a scenario, troubleshoot operating system problems with appropriate tools.
# Computer Memory

<table>
<thead>
<tr>
<th>RAM vs. ROM</th>
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</thead>
<tbody>
<tr>
<td><strong>RAM (random access memory)</strong></td>
<td><strong>ROM (read only memory)</strong></td>
</tr>
<tr>
<td>Video Adapter</td>
<td>Framework adapter</td>
</tr>
<tr>
<td>Found on adapters</td>
<td>Found on adapters</td>
</tr>
<tr>
<td>Change</td>
<td>Change</td>
</tr>
<tr>
<td>Can be changed</td>
<td>Cannot be changed</td>
</tr>
<tr>
<td>Volatile (data goes away when power is removed)</td>
<td></td>
</tr>
<tr>
<td>Holds actively running applications</td>
<td></td>
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<tr>
<td>Found on motherboards</td>
<td></td>
</tr>
<tr>
<td>Stores part of the running operating system</td>
<td></td>
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</tbody>
</table>

- **RAM** (Random Access Memory)
- **ROM** (Read Only Memory)
Memory Technologies
Magnetic-core memory

- Predominant form of random-access computer memory for 20 years (circa 1955-75).
- Magnetic toroids (rings), the *cores*, through which wires are threaded to write and read information.
- Magnetized in two different ways (clockwise or counterclockwise) to represent bits (0,1)
A 32 x 32 core memory plane storing 1024 bits of data.
SRAM (Static RAM)
DRAM (Dynamic RAM)
RIMM (Rambus Inline Memory Module)
SIMM (Single Inline Memory Module)
DIMM (Dual Inline Memory Module)
SO-DIMM (Small-Outline DIMM)
Random access memory (RAM)
- Holds data and instructions used by CPU
- Static RAM (SRAM) and dynamic RAM (DRAM)
- Both volatile memory

RAM on motherboards today is stored on DIMMs
Memory Technologies

- Random access memory (RAM)
  - SRAM (Static RAM):
    - Holds data as long as there is power
    - Use circuits (flip flop) that have two stable states (0, 1)
  - DRAM (Dynamic RAM):
    - Stores each bit of data in a separate capacitor
    - Capacitor can be either discharged or charged (0, 1)
    - Capacitors leak charge, loses data quickly, and eventually must be refreshed
Memory Technologies

• Versions
  • SIMM (outdated): Single Inline Memory Module
  • RIMM: older RAM by Rambus, Inc.
  • DIMM: Dual Inline Memory Module
    • small outline DIMM (SO-DIMM) : Laptops, routers
    • microDIMMs: smaller than SO-DIMM: subnotebooks
Memory Technologies

• Differences among DIMM, RIMM, SIMM modules
  • Data path widths: e.g. 64 bit(8B), 128 bit(16B)
  • How data moves from system bus to module
• Memory Controller
  • digital circuit which manages the flow of data going to and from the main memory.
  • Also called a Memory Chip Controller (MCC).
Memory Technologies

Timeline of memory technologies
DIMM Technologies

- **DDR SDRAM (DDR1) DIMMs** - DIMMs based on Double Data Rate (DDR) DRAM
  - PC1600 = 200 MHz
  - PC2100 = 266 MHz
  - PC2700 = 333 MHz
  - PC3200 = 400 MHz
- PCrating = Speed(MHz) * DataPath(Bytes)
  - A measure of total bandwidth of data moving between the module and the CPU
DIMM Technologies

• DIMM Speed
  • Measured in MHz or PC rating

• DDR SDRAM (DDR1) DIMMs - DIMMs based on Double Data Rate (DDR) DRAM
  • PC1600 = 200 MHz
  • PC2100 = 266 MHz
  • PC2700 = 333 MHz
  • PC3200 = 400 MHz
DIMM Technologies

• PC rating
  • Total bandwidth between module and CPU
    • PC1600 bandwidth: 1600MB/sec
  • MHz ≈ MB/sec divided by 8 Bytes
    • PC1600 = 200 MHz
    • PC2700 = 333 MHz
    • PC3200 = 400 MHz
• DDR2 PC rating
  • Usually labeled PC2
• DDR3 PC rating
  • Usually labeled PC3
DIMM Technologies

• Double Data Rate SDRAM
  • Also called DDR SDRAM, SDRAM II, DDR
    • Two times faster than SDRAM
  • DDR2 SDRAM
    • Faster than DDR and uses less power
  • DDR3 SDRAM
    • Faster than DDR2 and uses less power
• DDR2 and DDR3
  • Not compatible: use different notches
DIMM Technologies

• Factors that affect capacity, features, and performance
  • Quantity of RAM on a DIMM
  • Chip installation on Motherboard
  • Memory addressing
  • Number of channels used
  • Speed
  • Error-checking ability
  • Buffering
  • Access timing
DIMM Technologies

- Double-sided DIMM
  - Memory chips installed on both sides of module
- Memory bank
  - Memory processor addresses at one time
- 64 bits wide
  - DIMMs can always be installed as single DIMMs on a motherboard
DIMM Technologies

- Early single channel DIMMs
  - Memory controller accessed one DIMM at a time
- Dual channels
  - Memory controller communicates with two DIMMs at the same time
    - Doubles memory access speed
- Triple channels
  - Accesses three DIMMs at once
Motherboard Memory Slots

Single-channel memory

Channel A

Memory control hub

Dual-channel memory

Channel A

Channel B

Memory control hub
DIMM Technologies

• Setting up dual channeling
  • Pair of DIMMs in a channel must be equally matched
    • Size, speed, features
    • Use same manufacturer (recommendation)
• DDR, DDR2, DDR3 DIMMs use dual channels
• DDR3 DIMMs can also use triple channels
Three identical DDR3 DIMMs installed in a triple-channel configuration

- Setting up triple-channeling
  - Three DIMM slots populated with three matching DDR3 DIMMs
  - Notice 4th empty slot. If used, triple-channeling disabled

Three identical DDR3 DIMMs installed in a triple-channel configuration
Memory Features

- Parity
- Non-parity
- ECC (Error Correcting Code)
- Unbuffered Memory
- Registered Memory
- Fully Buffered Memory
- Single-sided Memory
- Double-sided Memory
Memory Features

• Error-correcting code (ECC)
  • Detects and corrects error in a single bit
• Parity
  • Error-checking based on an extra (ninth) bit
  • Odd parity
    • Parity bit set to make odd number of ones
  • Even parity
    • Parity bit set to make even number of ones
• Parity error
  • Number of bits conflicts with parity used
Memory Features

• Buffered and registered DIMMs
  • Buffers & Registers hold data and amplify signal before data is written
  • Registered DIMM
    • Uses registers
  • Unbuffered DIMM
    • No buffers or register support
  • Fully buffered DIMM (FB-DIMM)
    • Uses an advanced buffering technique
    • Allows servers to support a large number of DIMMs
Memory Features

- Notches on module indicate supported technologies

The positions of two notches on an SDRAM DIMM identify the type of DIMM and the voltage requirement. Prevents the wrong type from being installed on the motherboard.
• Direct Rambus DRAM
  • Also known as RDRAM, Direct RDRAM, Rambus
  • RIMM memory module
  • Expensive and slower than current DIMMs
  • RIMMs using 16-bit data bus: two notches, 184 pins
  • RIMMs using 32-bit data bus: single notch, 232 pins
A RIMM or C-RIMM must be installed in every RIMM slot on the motherboard.
<table>
<thead>
<tr>
<th>Description of Module</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>240-pin DDR3 DIMM is currently the fastest memory. It can support triple or dual</td>
<td><img src="image1.jpg" alt="Image" /></td>
</tr>
<tr>
<td>channels or be installed as a single DIMM. It has an offset notch farther from the</td>
<td><img src="image2.jpg" alt="Image" /></td>
</tr>
<tr>
<td>center than a DDR2 DIMM.</td>
<td></td>
</tr>
<tr>
<td>240-pin DDR2 DIMM can support dual channels or be installed as a single DIMM. Has</td>
<td><img src="image3.jpg" alt="Image" /></td>
</tr>
<tr>
<td>one notch near the center of the edge connector.</td>
<td></td>
</tr>
<tr>
<td>184-pin DDR DIMM can support dual channels or be installed as a single DIMM. Has</td>
<td><img src="image4.jpg" alt="Image" /></td>
</tr>
<tr>
<td>one offset notch.</td>
<td></td>
</tr>
<tr>
<td>168-pin SDRAM DIMM has two notches on the module. The positions of these notches</td>
<td><img src="image5.jpg" alt="Image" /></td>
</tr>
<tr>
<td>depend on the memory features the DIMM uses.</td>
<td></td>
</tr>
<tr>
<td>RIMM has 184 pins and two notches near the center of the edge connector.</td>
<td><img src="image6.jpg" alt="Image" /></td>
</tr>
<tr>
<td>72-pin SIMM must be installed two modules to a bank of memory.</td>
<td><img src="image7.jpg" alt="Image" /></td>
</tr>
<tr>
<td>30-pin SIMM must be installed four modules to a bank of memory.</td>
<td><img src="image8.jpg" alt="Image" /></td>
</tr>
</tbody>
</table>

Types of memory modules
Memory Technologies

- FPM (Fast Page Mode)
- EDO (Extended Data Out)
- BEDO (Burst EDO)
- SDRAM (Synchronous DRAM)
- DDR (Double Data Rate)
- DDR2
- DDR3
- DDR3L
- RDRAM (Rambus DRAM)
Flash Memory

- CompactFlash
- Secure Digital Cards
- MultiMediaCards (MMCs)
- xD Cards
- USB Flash Drives
Windows Disk Caching

- Virtual Memory
- Swap File
- Pages (4KB each)
Windows Disk Caching

- **Virtual Memory**
  - Hard drive space used as RAM

- **Swap File (Page/Paging File)**
  - Block of hard drive space used by apps like RAM
  - Set aside as much hard drive space as possible for swap file

- **Pages**
  - 4 KB blocks of RAM

- **Thrashing**
  - Too much swapping/paging!
Memory Technologies and Memory Performance

- Memory performance factors
  - Total RAM installed
  - Memory technology used
  - Speed of memory in MHz, PC rating, or ns
  - ECC/parity or non-ECC/nonparity
  - Single, dual, or triple channeling
- Connectors inside memory slots are tin or gold
  - Edge connectors on memory modules follow suit
  - Match connectors to prevent corrosive chemical reactions between metals
Before installing a memory module, power off the computer, disconnect the power cord from the back of the computer, and use proper antistatic procedures. Memory modules are especially susceptible to ESD. If ESD damages a memory module, a problem may not appear immediately and could be intermittent and hard to diagnose.
How to Upgrade Memory

• Basic technique
  • Add more RAM modules
• Problems solved
  • Slow performance
  • Applications refusing to load
  • An unstable system
  • Windows “Insufficient memory” error message
  • Bad memory module
How to Upgrade Memory (cont’d.)

- Questions to ask
  - How much RAM do I need and how much is currently installed?
  - How many and what kind of memory modules are currently installed on my motherboard?
  - How many and what kind of modules can I fit on my motherboard?
  - How do I select and purchase the right modules for my upgrade?
  - How do I physically install the new modules?
How Much Memory Do I Need and How Much Is Currently Installed?

- Best answer: “All you can get”
- Windows XP requires at least 512 MB RAM
- Windows Vista needs at least 2 GB
- RAM limit for a 32-bit OS
  - 4 GB installed RAM
How Many and What Kind of Memory Modules Are Currently Installed?

• Open the case and look at memory slots
  • How many slots?
  • How many filled?
  • Review module imprint
• Examine module for physical size and notch position
• Read motherboard documentation
  • See if board supports dual channels or triple channels
• Last resort
  • Take motherboard and old memory modules to a good computer parts store for conformation
Look for the manufacturer and model of a motherboard imprinted somewhere on the board.
How Many and What Kind of Modules Can Fit on My Motherboard?

- Taking out and replacing small-capacity modules with larger-capacity modules:
  - Use type, size, speed the board designed to support
  - Discarding existing modules increases upgrade price
- Read motherboard documentation
  - Indicates how much memory motherboard can physically hold
- Select right number of DIMMs, RIMMs, SIMMs with right amount of memory on each module to fit memory banks on motherboard
How Many and What Kind of Modules Can Fit on My Motherboard?

DIMM modules
- DIMMs can be installed as single modules
  - Performance may suffer
- Motherboard supporting dual channeling
  - Install matching DIMMs in each channel for best performance
- DDR3 board supporting triple channeling
  - For best performance install three matching DIMMs in triple-channel slots
How Many and What Kind of Modules Can Fit on My Motherboard?

Motherboard using DDR3 triple-channel DIMMs

Four DDR3 slots on a motherboard
How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR3 triple-channel DIMMs (cont’d.)
  - Use three matching DIMMs in the three blue slots
    - If fourth slot populated, board reverts to single channeling
- Dual channeling:
  - Install two matching DIMMs in two blue slots farthest from processor
  - Leave other two slots empty
- For one installed DIMM:
  - Place it in the blue slot farthest position from processor
How Many and What Kind of Modules Can Fit on My Motherboard?

Motherboard using DDR DIMMs with dual channeling

Carefully push the cooler assembly clips into the retention mechanism on the motherboard until they snap into position.
How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR DIMMs with dual channeling (cont’d.)
  - Example: ASUS P4P800 (cont’d.)
    - Allows three different DDR DIMM speeds in one to four sockets, supports dual channeling
    - Two blue memory slots and two black slots
    - For dual channeling
      - Matching DIMMs must be installed in the two blue sockets
      - If two DIMMs installed in the two black sockets
        - They must match each other
How Many and What Kind of Modules Can Fit on My Motherboard?

- Motherboard using DDR DIMMs, single- or double-sided
  - Intel CC820 motherboard has two DIMM slots
  - Combination of single-sided and double-sided DIMMs

<table>
<thead>
<tr>
<th>Types of DIMMs to be Installed</th>
<th>Slot 0</th>
<th>Slot 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>One DIMM</td>
<td>DIMM</td>
<td>Empty</td>
</tr>
<tr>
<td>Two DIMMs - Same size, same number of sides (both single-sided or both double-sided)</td>
<td>Either DIMM</td>
<td>Either DIMM</td>
</tr>
<tr>
<td>Two DIMMs - Different sizes</td>
<td>Larger DIMM</td>
<td>Smaller DIMM</td>
</tr>
<tr>
<td>Two DIMMs - Same size, one is single-sided and one is double-sided</td>
<td>Single-sided DIMM</td>
<td>Double-sided DIMM</td>
</tr>
</tbody>
</table>

The Intel CC820 motherboard can use a combination of single-side and double-sided DIMMs
No matter how good you are at your job, you are still better to a company if you are part of a team than if you’re on your own.

Technicians need to be good team players and see themselves as a reflection of their company when on the job.

Teamwork is part of the skill set that employers seek as much as they want you to have technical skills.
Review memory chips and modules right before the exam(s) in case you are asked to identify the memory type or DDRx name.

Review Windows operating system memory limitations, especially the Windows 7 and 32-bit Windows memory limitations.

Know how to calculate what memory is needed for an upgrade or a new install.

Be able to identify memory slots on a motherboard.

Know how to populate memory when dual- or triple-channeling is being implemented.

Be able to describe the difference between unbuffered and ECC memory.

Know that memory chips are especially susceptible to ESD and how to prevent ESD damage when installing or removing memory.

Review the troubleshooting symptoms and tips for the 220-802 exam.

Keep in mind that the following professionalism skills are part of the 220-801 exam: (1) maintain a positive attitude and (2) be on time (or, if late, contact the customer). You should not forget to review the professionalism skills.
Chapter Summary

- Memory on a motherboard is SDRAM, a type of RAM that is cheaper and slower than SRAM, the type of memory inside the CPU and processor housing.
- A DDR module fits in a DDR slot; so do DDR2 and DDR3 modules.
- RIMMs use RDRAM and were developed by Rambus, Inc. C-RIMMs are inserted into empty memory slots.
- Unbuffered memory is the memory normally installed in computers.
- ECC is used for error checking and is commonly found in high-end computers and servers. An older method of error checking was called parity.
- The CL rating or the timing sequence first number shows how fast the processor can access data in sequential memory locations. The lower the first number, the faster the access.
- SPD is a technology used so the memory module can communicate specifications to the BIOS.
Chapter Summary

- Double-sided memory is one module that acts like two modules (not that it has chips on both sides even though it most likely does). A motherboard must support using double-sided modules.

- Before installing memory, plan your strategy: read the manual to see the type of memory, determine the total amount of memory, determine if any memory is to be removed, determine the memory to purchase, and be mindful of getting the most out of your memory by implementing dual-, triple-, or even quadruple-channeling.

- When implementing dual-, triple-, or quadruple-channeling, buy matching memory modules.

- Any 32-bit operating system is limited to 4GB of memory.

- Particular versions of Windows have memory limitations. For example, Windows 7 Starter edition is limited to 2GB, but any of the other Windows 7 versions can go to 4GB for the 32-bit versions. 64-bit version limitations are as follows: XP is 128GB. Vista/7 Home Basic is 8GB. Vista/7 Home Premium is 16GB. Vista higher versions are limited to 128GB. Windows 7 higher versions are limited to 192GB.

- RAM is very susceptible to ESD events. Use proper antistatic handling procedures, including using an antistatic wrist strap.
• Before removing or installing memory, disconnect the power cord and remove the battery on a mobile device.

• Laptops and netbooks can sometimes be upgraded with SO-DIMMs. Tablets and smartphones can sometimes be upgraded and have additional storage using flash memory cards.

• Having as much RAM in the system as possible is an important performance factor; so is having free hard drive space because hard drive space is used as memory. This is called virtual memory, and the information stored temporarily on a hard drive is stored in an area known as a page file, paging file, or swap file. The swap file should be on the newest drive that has the most free storage.

• Use Task Manager to monitor memory performance.

• Use POST, motherboard LED/display output codes, BIOS diagnostics, and the Windows Memory Diagnostic Tool to diagnose memory problems.

• Flash media is used to provide memory or additional storage space for computing devices and includes USB flash drives, CF cards, and smaller cards, such as SD, microSD, miniSD, and xD.

• A technician is part of a business and should contribute to the team. A technician should professionally represent a company.