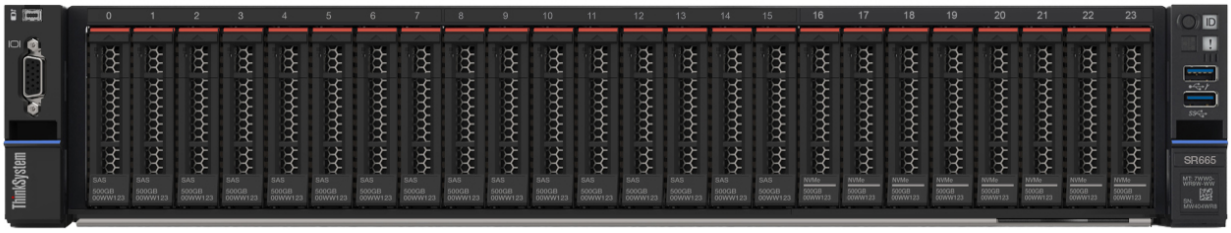
Tier B (Database Server)



ThinkSystem SR665

There is one database server in this TPC-E configuration. This document describes how it should be setup and configured.

Hardware

- Before connecting the server to AC power, install the hardware components so you have:
  - Processors- 2 x 2.45GHz
  - Memory- 32 x 64GB DIMMs (populated as 2 DIMMs per channel)
  - Internal RAID- 1 x ThinkSystem RAID 940-16i in PCI-e slot 3
  - Internal Storage-
    - 2 x 480GB SATA SSDs in drive bays 0 & 15
    - 14 x 800GB Mainstream SAS SSDs in drive bays 1- 14
  - Networking-
    - 1 x Broadcom NX-E dual-port 10Gb Ethernet adapters in PCI-e slot 6
    - 1 x Onboard quad-port 10Gb Ethernet OCP adapter
  - Power- 2 x 1800W power supplies
  - Do not install any other hardware into the system yet.
- Now connect the server to AC power
- System Settings:
  - Boot the server and press F1 when prompted to drop into UEFI setup. Once there:
    - Load default settings
    - Set the correct date and time
    - Set a static IP address & mask for the BMC so it is on your lab network
    - Select the "Maximum Performance" Operating Mode
    - Save settings
    - Select the "Custom" Operating Mode, then change these settings:
      - Disable SOC P-States
      - Disable Memory Power Down
      - Set NUMA Nodes per Socket to NPS2
    - Under System Settings → Processors
      - Disable DF C-States
      - Disable L1 & L2 Prefetchers
      - Set xGMI Maximum Link Width = 1
    - Under System Settings → Memory
      - Disable DRAM Scrub Time
    - Save settings
  - Power the server off
- Management network:
  - Connect the server's System Management Ethernet port to the lab network
  - Another system, such as the driver, on the lab network can now manage the server via a web browser pointed at the static BMC address entered above
- Update the server's code levels:

- Download the latest system code levels for this server from lenovo.com:
  - XCC (BMC)
  - UEFI
  - LXPM
- Connect to the BMC via a web browser. After logging in, click on "Firmware Update" and then "Update Firmware" and follow the onscreen directions.
- When the BMC update is done, restart the BMC and wait until you can log back into it.
- Now use the same BMC firmware update interface to update the server's UEFI and LXPM code levels.

OS

Create the Internal Arrays:

- Boot the system. Press F1 when prompted to go into UEFI setup.
- On the Advanced page, select the RAID 940-16i adapter
- Select Main Menu → Controller Management
- Under "Advanced Controller Management ":
  - Select "Set Factory Defaults", Confirm, and Yes. OK.
  - Under "Schedule Consistency Check", set "Consistency Check Frequency" to Disable. Apply Changes. OK.
- Under "Advanced Controller Properties":
  - Under Patrol Read:
    - Set Mode to Disabled
    - Set "Setting for Unconfigured Space" to Disabled
    - Apply Changes. OK.
  - Set SMART Polling to 65535
  - Apply Changes. OK.
- ESC back one menu level

- Create the OS Array:
  - Select "Configuration Management" → "Create Virtual Drive – Advanced"
  - RAID-1
  - "Select Drives"
    - Select the two 480GB drives in drive bays 0 and 15
    - Apply Changes. OK.
  - "Virtual Drive Name" = "OS"
  - Leave default 64K stripe, No Read Ahead, Write Through, Direct, Read/Write, Drive Cache disabled
  - Set "Default Initialization" to Full
  - Save Configuration. Confirm. Yes. OK.
  - The OS array now gets initialized. Wait until it is done, which will be several minutes.

- Create the database log array:
  - Select "Configuration Management"->"Create Virtual Drive – Advanced"
  - RAID-1
  - "Select Drives"
    - Select the eight 800GB drives in drive bays 1-4 & 11-14
    - Apply Changes. OK.
  - "Virtual Drive Name" = "LOG"
  - Leave default 64K stripe, No Read Ahead, Write Through, Direct, Read/Write, Drive Cache disabled
  - Set "Default Initialization" to Full
  - Save Configuration. Confirm. Yes. OK.
  - The log array now gets initialized. Wait until it is done, which will be several minutes.

- Create the database tempdb array:
    - Select "Configuration Management"->"Create Virtual Drive – Advanced"
    - RAID-1
    - "Select Drives"
        - Select the six remaining 800GB drives in drive bays 5-10
        - Apply Changes. OK.
    - "Virtual Drive Name" = "TEMPDB"
    - Leave default 64K stripe, No Read Ahead, Write Through, Direct, Read/Write, Drive Cache disabled
    - Set "Default Initialization" to Full
    - Save Configuration. Confirm. Yes. OK.
    - The tempdb array now gets initialized. Wait until it is done, which will be several minutes.

<u>Install the OS:</u>
- Be sure the system date and time are correct in F1 setup
- Insert the Windows Server 2019 installation DVD into the system (or mount its ISO image via the BMC) and boot from it
- Install Windows
    - Language to install = English
    - Time and currency format = English (United States)
    - Keyboard or input method = US [Next]
- Select "Install Now"
- Enter product key [Next]
- Choose "Windows Server 2019 Standard (Desktop Experience)" [Next]
- Accept the license terms [Next]
- Select "Custom" installation type
- Select to install Windows to "Disk X Unallocated Space" that is the 480GB OS array [Next]
- Windows will now install. This will take several minutes, and the system will reboot more than once. No user interaction is needed.
- Set the new Administrator password and log in.
- You are now brought to the Windows desktop. Windows is installed. You can remove/unmount the installation DVD now.

<u>Configure the OS:</u>
- Server Manager→ Local Server:
    - Enter the computer description, name, and workgroup
    - Turn off Windows Firewall for domain, public, and private networks
    - Turn off Windows Defender
    - Set diagnostics to Basic and turn off feedback
    - Turn off IE enhanced security
    - Set the time zone and the date and time; turn off internet time synchronization
- Setup the lab network (IP address)
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- From the Start Menu, select the settings icon:
    - System
        - Display
            - Set the display resolution as appropriate
        - Power & Sleep
            - Set screen to turn off after 4 hours
            - Additional Power Settings
                - Pick "High performance" plan
    - Devices→AutoPlay
        - Turn off AutoPlay
    - Network & Internet
        - Windows Firewall
            - Turn off Windows Firewall for all networks

- Personalization→ TaskBar
    - Use small taskbar buttons
- Time & language
    - Turn off "Set time automatically"
    - Turn off "Set timezone automatically"
    - Set the time zone
    - Set the time
- Privacy → Diagnostics & feedback
    - Set "Diagnostic Data" to Basic
      Set "Windows should ask for my feedback" to Never

- Control Panel (view by small icons):
    - User Accounts
        - Change UAC to Never Notify
    - System → Advanced System Settings
        - Computer Name
            - Set the computer name and workgroup
        - Advanced→ Performance
            - Visual Effects
                - Choose "Adjust for best performance"
                - Choose "Show window contents while dragging"
            - Advanced
                - Choose "Background services"
                - Set custom size page file on C: = 8192-16384
            - Data Execution Prevention
                - Set DEP for essential Windows programs and services only
        - Advanced→Startup and Recovery
            - Don't automatically restart on a system failure
            - Automatic memory dump
        - Remote
            - Allow remote desktop connections, from any level client
    - File Explorer Options→View→Advanced Settings
        - Always show menus
        - Do not hide any files and folders
    - Administrative Tools
        - Local Security Policy
            - Account Policies → Password Policy
                - Set "Maximum password age" to zero
                - Set "Password must meet complexity requirements" to disabled
            - Press CTRL-ALT-DEL and change OS password to a simpler one. Use the same password that you used on the database server.
            - Local Policies → User Rights Assignment
                - Select "Lock Pages In Memory"
                - Add the group "Administrators"
        - Event Viewer
            - Right click on each "Windows Logs" type →Properties
                - Set "Maximum log size" to 256,000

- Other settings:
    - Set desktop to use Small Icons
    - Pin frequently used programs to the taskbar

- Run gpedit.msc
    - Choose Computer Configuration→Administrative Templates→System
        - In the right pane, near the bottom, open "Display Shutdown Event Tracker"

        - Select “Disabled” [OK]

- Run “control userpasswords2”
    - Uncheck “Users must enter a user name and password to use this computer” [OK]
    - Enter your account password twice [OK]

- Reboot the computer to apply all those settings

Additional Hardware

Install Additional Hardware:

- Remove AC power from the server.
- Install the ThinkSystem RAID 930-8e adapters into PCI-e slots 1, 2, 4, 5, 7, & 8
- Reapply AC power and boot the system

Install Device Drivers:

There are Windows-compatible versions for most of these code updates. Download these versions from Lenovo.com, copy them over to the server, run the EXE there, and choose to do the update immediately, rather than extracting the files for later.

- Chipset INF:
    - Download the latest chipset INF software for this system
    - Install it
- Networking:
    - Broadcom NX-E Adapters (OCP and PCI-e):
        - Download the latest NX-E networking drivers for this system
        - Install the Ethernet device drivers
- RAID:
    - Download the latest ThinkSystem RAID 930 controller driver for this system
    - Download the latest ThinkSystem RAID 930 controller firmware
    - Install the controller driver
    - Install the controller firmware updates
- Video:
    - Download the latest video driver for this system
    - Install it
- Drive firmware:
    - Download the latest SAS/SATA hard drive update program
    - Run the program to update the firmware on any down-level drives
- Reboot

Additional OS Settings

Configure IP Addresses & Network Connections

- One of the server’s onboard Ethernet ports will be used for the lab network. Connect the left-most onboard Ethernet port (OCP port 1) to a Gb Ethernet switch that will create the lab network, linking the database server, client, driver, and any other needed systems. This network is used to copy files between the systems, synchronize system times, manage the systems, etc..

- There are four dedicated 10Gb Ethernet crossover connections between the client and the database server. These are attached to the following ports on the database server:
    - Onboard Ethernet adapter, inside-right port (OCP port 3)
    - Onboard Ethernet adapter, right-most port (OCP port 4)
    - Slot 6 PCI-e Ethernet adapter, left port
    - Slot 6 PCI-e Ethernet adapter, right port

    These network connections are used during the benchmark run.

- IP addresses:
  - Onboard adapter, port 1: Set IP address as needed for your lab network
  - Onboard adapter, port 3: Set static address 10.10.1.1 / 255.255.255.0
  - Onboard adapter, port 4: Set static address 10.20.1.1 / 255.255.255.0
  - Slot 6, left port: Set static address 10.30.1.1 / 255.255.255.0
  - Slot 6, right port: Set static address 10.40.1.1 / 255.255.255.0

- Make these connections, using crossover cables:
  - Database server OCP, port 3 → client slot 1, left port
  - Database server OCP, port 4 → client slot 1, right port
  - Database server slot 6, left port → client slot 5, left port
  - Database server slot 6, right port → client slot 5, right port

- Test each network connection using ping.

Miscellaneous OS Setup:
- Copy TPC-E kit files to the server. See the kit documentation for details.
- Place a BAT file, synctime.bat, into the startup folder to synchronize the time with another server every time the system is rebooted. The driver, server, and client will have this same BAT file in their startup folders, and they all sync their times off of the same system. The systems are rebooted before a run of TPC-E and this insures that all of the system clocks will be synchronized. Test the BAT file to be sure it works.

SQL Server

Installation:
- We will install SQL Server 2019 Enterprise x64 Edition.
- Run setup.exe
- SQL Server Installation Center
  - choose "Installation" on the left
  - choose "New SQL Server stand-alone installation…"
- Product Key. Evaluation [Next >]
- License Terms. Accept the terms [Next >]
- Microsoft Update [Next >]
- Product Updates [Next >]
- Feature Selection, check
  - Instance Features
    - Database Engine Services
  - Shared Features
    - Client Tools Connectivity
  - [Next >]
- Instance Configuration. Use the default instance. [Next >]
- Server Configuration
  - Service Accounts tab
    - Change "SQL Server Database Engine" service from automatic startup type to manual
    - For all enabled services, change the Account Name to "Administrator" and enter the Administrator password
  - Collation tab
    - [Customize…]
      - Select "Windows collation designator and sort order"
      - Select Collation Designator = "Latin1_General"
      - Select Binary sort order
    - [OK]
  - [Next >]
- Database Engine Configuration

- Server Configuration tab
  - Select Mixed Mode
  - Enter password, same as used for Administrator account
  - [Add Current User]
- TempDB tab
  - Set "Number of Files" to 1
- [Next >]

- Ready To Install [Install]
- Complete [Close]
- Close the SQL Server Installation Center

- Download the latest SQL Server 2019 Cumulative Update from Microsoft. Install it.
- Download the latest SQL Server Management Studio (SSMS) from Microsoft. Install it.

Configuration:

- To configure the softNUMA nodes, merge the included file SoftNuma_2P7763.reg into the registry.

- To bind networking ports to softNUMA nodes, start the SQL Server Configuration Manager
  - On the left, expand "SQL Server Network Configuration"
    - Highlight "Protocols for MSSQLSERVER"
      - On the right, double click on "TCP/IP"
        - Protocol tab
          - Set "Enabled" to "Yes"
          - Set "Listen All" to "No"
        - IP Addresses tab
          - Find and enable each of these IP addresses, and set "TCP Port" to the string shown:

IP Address	TCP Port String
10.10.1.1	1400, 1410[0x1], 1411[0x1], 1412[0x1], 1413[0x1]
10.20.1.1	1420[0x2], 1421[0x2], 1422[0x2], 1423[0x2]
10.30.1.1	1430[0x4], 1431[0x4], 1432[0x4], 1433[0x4]
10.40.1.1	1440[0x8], 1441[0x8], 1442[0x8], 1443[0x8]

[OK] [OK]

  - Close SQL Server Configuration Manager

- To turn on large page allocation for SQL Server, merge the included file LargePageDLLs_SQL2019.reg into the registry

- Configure SQL Server options:
  - Open SQL Server Management Studio. Load and execute the included file SQLconfig.sql. It will configure SQL Server for this workload on this system.
  - When done, close the SQL Server Management Studio and restart SQL Server

- Configure SQL Server startup flags (see included file StartSQL.bat):
  - Use the following flags to start SQL Server from now on
    - -c start SQL independent of the service control manager
    - -x disable performance statistics
    - -T3502 display checkpoint messages in the SQL errorlog
    - -T834 use large page allocations for the buffer pool
    - -T661 disable the ghost record removal process
    - -T8744 disallow prefetch for ranges
    - -T652 disable page prefetch scans

- -T3979 disable forced flush feature
- -T8040 disable rm operations
- -T8095 disable page exclusion bitmap
- -T8099 disable exponential spinlock backoff
- -T8077 disable HT-aware automatic softNUMA
- -T8088 disable log stats
- -T9038 disable multiple log writers
- -T9044 disable LC lock backoff
- -T8101 reduce spins for spinlocks

Storage

Hardware Connections:

- Turn off the server
- Mount the drive enclosures into the racks.
- Install the drives into the enclosures and connect the enclosures to RAID adapters:

  Database Data and Run-Time tempdb (Priced):

  - Put (21) 800GB SAS SSDs into each of six Lenovo Storage D1224 enclosures. These 126 drives will be used for database data.
  - For each one of these enclosures, connect it directly to one ThinkSystem RAID 930-8e adapter using two SAS cables. So there will be six enclosures in total with each attached to its own RAID adapter.

  At this point, all six of the server's ThinkSystem RAID 930-8e adapters have drives and enclosures attached to both ports of each RAID adapter. This comprises all of the external priced storage.

  Backup, Flat File, and Load-Time Temp Space (Measured):

  - Put (24) 1200GB 10K SAS HDDs into each of four Lenovo Storage D1224 enclosures. These 96 drives will be used to hold database backup & load files.
  - Put (24) 900GB 10K SAS HDDs into each of two Lenovo Storage D1224 enclosures. These 48 drives will be used to hold database backup & load files.
  - For each one of these enclosures, connect it directly to one of the database data enclosures described above, using two SAS cables. So there will now be twelve enclosures in total, two per RAID adapter. Each RAID adapter will be connected to one enclosure holding database data and one enclosure holding backup & load file storage.

- Power on the enclosures, then the server and boot the OS.
- Update the ThinkSystem RAID 930-8e adapters:
  - Download the latest firmware for these adapters from Lenovo.com
  - Update the firmware
  - Reboot the system when done
- Update the drives:
  - Download the latest SAS/SATA hard drive update program from Lenovo.com
  - Run the program and update the firmware on any down-level drives.
  - Reboot the system when done.
- Update the enclosures:
  - Download the latest D1224 firmware package from Lenovo.com
  - Follow the directions to update the firmware on any down-level external enclosures.
- Install LSA:
  - Download the latest version of LSI Storage Authority (LSA) from Lenovo.com
  - Install it

Controller Settings:

- Reboot the system. During POST press F1 when prompted to go into UEFI setup.

- Go to System Settings → Storage.
- For each 930-8e adapter:
    - Select Main Menu → Controller Management
    - Under "Advanced Controller Management ":
        - Select "Set Factory Defaults", Confirm, and Yes. OK.
        - Under "Schedule Consistency Check", set "Consistency Check Frequency" to Disable. Apply Changes. OK.
    - Under "Advanced Controller Properties":
        - Under Patrol Read:
            - Set Mode to Disabled
            - Set "Setting for Unconfigured Space" to Disabled
            - Apply Changes. OK.
        - Set SMART Polling to 65535
            - Apply Changes.

<u>Create Arrays:</u>

- Boot the OS and run LSA.

- Create all the external arrays.
  Using LSA, create each of these arrays on each of the six RAID 930-8e adapters:

    - <u>Data Arrays (6 total, one per RAID adapter):</u>
        - Under Actions for the controller, select Configure → Advanced Configuration
        - Choose RAID 5 [Next]
        - [Add Physical Drives]
        - Find the 21 SSDs in the priced D1224 enclosure meant for database data.
        - Place a checkmark next to each of those SSDs
        - [Add Physical Drives]
        - [Add Virtual Drives]
        - Use the following settings:
            - Virtual Drive Name = "data ***X***", where ***X*** is an incrementing number , 1-6
            - Strip size = 64KB
            - Initialization State = "Full initialization"
            - Read Policy = "No Read Ahead"
            - Write Policy = "Write Through"
            - I/O Policy = "Direct IO"
            - Disk Cache Policy = "Disabled"
        - [Add Virtual Drives]
        - [Finish]
        - The array will now be created and initialized, which will take several minutes.
        - [Close]

    - <u>Backup & Load Arrays (6 total, one per RAID adapter):</u>
      Follow the same procedure as for the data arrays, but name them "backup ***X***" instead of "data ***X***". These HDDs are in the measured (vs priced) enclosures. This will create six 24-drive arrays, RAID-5.

  Wait for all the arrays to complete initialization.

- <u>Configure Arrays:</u>
  Now add the arrays into Windows:
    - Open Windows Disk Management.
    - You will be asked to initialize the new disks.
        - Be sure all the new arrays are selected

        - Choose GPT as the style
        - [OK]
    - You should now see the new data, tempdb, backup, and log arrays on the display. Now we will create the partitions.
        - Find the array created for the database log.
            - Create one partition on it, 2,100,000MB in size, and make it drive E:. Don't format it.
            - Create a second partition on it, 700,000MB in size, and make it drive G:. Don't format it.
            - Using the rest of the free space on this array, create another partition and make it drive F:. Quick-format it NTFS.

        - Find the array created for the database run-time tempdb.
            - Create one partition on it, using all the space, and make it drive T:. Quick-format it NTFS.

        - The rest of the new arrays will be for database data, flat files, and database backup space. They will be accessed via mount points.
            - Create mount points in the folder c:\mp. See the included files rc6.bat and rc.bat. These files will create:
                - six mount point folders for each of the four database data arrays: fx***Y***, gw***Y***, and xt***Y***, where ***Y*** is an integer (1-6).
                    - fx mount points are for fixed database data (1 per array)
                    - gw mount points are for growing database data (1 per array)
                    - xt mount points are extra space (1 per array)

                - one mount point folder, bk***Z***, for each of the 12 backup partitions, where ***Z*** is an integer (1-12). Each of the six backup arrays will be split in half as two backup partitions (12 total).

            - Create the required partitions on each data and backup drive and assign them to the mount points. See the included file Diskpart_CPX4P_Create.txt for details.

            - Quick-format and label all of the backup and extra partitions. See the included file formt.bat.

    - The arrays should now look like the included screenshot files WindowsDiskLayout_x.JPG.

- The storage arrays have now been created. The next step is to load the TPC-E database. Follow the directions in the TPC-E kit.