End to end performance of WebSphere environments with Linux on System z

Session 9291

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Agenda

• WebSphere Base Environment
• Network (LPAR)
• Network (z/VM)
• Java setup
• Database
• Tuning Results
  • Dynamic Cache
  • Database Setup
• 31-bit versus 64-bit
• Cryptographic hardware support
Performance tuning at all layers

• “Optimize your stack from the top to the bottom”
  
  • Application design
  
  • Application setup
  
  • Database
  • Application server
  
  • Operating system
  
  • Virtualization system
  
  • Hardware
Trade workload

• By IBM - is designed to cover the programming model and performance technologies with WebSphere Application Server.
• Supports environments with DB2 and Oracle databases
• Supports newest J2EE programming models (WAS releases)
• Models an electronic stock brokerage providing Web based online securities trading
• Provides a real world business application mix of operations
• Client / server scenario
Trade workload (2)
workload

• The Trade application models an online brokerage firm providing web based services such as login, buy, sell, get quote and more.
WebSphere base environment (LPAR)

- let's start with a simple setup
- when increasing the load, the first bottleneck was the single shared network connection
Network constraints – base environment

- first tuning step: separate the connection to the database (2\textsuperscript{nd} OSA card)  
  improvement +10%

- second step: use Hipersockets for connection 2  
  improvement +33%
Network constraints - monitoring

- monitor with `sar -n DEV [interval] [count]`
- Some maximum values observed with benchmark workloads with OSA express2 cards and Hipersockets

<table>
<thead>
<tr>
<th></th>
<th>small requests</th>
<th>large requests</th>
<th>Throughput for large packages in one direction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pkg/seg recv or send</td>
<td>pkg/seg recv or send</td>
<td>MTU 32K</td>
</tr>
<tr>
<td>1GEth</td>
<td>35,000</td>
<td>82,000</td>
<td>--</td>
</tr>
<tr>
<td>10GEth</td>
<td>40,000</td>
<td>85,000</td>
<td>--</td>
</tr>
<tr>
<td>Hipersockets</td>
<td>120,000</td>
<td>107,000</td>
<td>1 GByte/sec</td>
</tr>
</tbody>
</table>

- The scenario described before would exceed 50,000 packages/sec when sharing a single OSA card
  - the traffic from all systems using the card needs to be added!
Network constraints – setup changes

- Choose your MTU size carefully!
  - Avoid fragmentation, lots of small packages can drive up CPU utilization
  - Use the largest MTU size supported in the path, and verify it using
    ```bash
    ping -M do system15.ibm.com -s 8000 -c3
    PING system15.ibm.com 8000(8028) bytes of data.
    From dyn-9-152-198-41.ibm.com icmp_seq=0 Frag needed and DF set (mtu = 1500)
    ```

- For really busy network devices consider to
  - Increase the number of inbound buffers in the qeth driver (default 16)
    - Device has to be offline
      ```bash
      echo <number> >
      /sys/bus/ccwgroup/drivers/qeth/<device_bus_id>/buffer_count
      ```
    - or for a SUSE distribution:
      ```bash
      add following line to /etc/sysconfig/hardware/hwcfg-qeth-bus-
      ccw-0.0.<nnnn>
      QETH_OPTIONS="buffer_count=128 checksumming=hw_checksumming"
      ```
    - Consumes memory!
      - 64KB per buffer, maximum 128 buffer = 8 MB per device
      - for tuning purpose, start with a large value, monitor the impact and then iterative reduce the number of buffers until throughput drops down

- Use channel bonding
WebSphere typical environment

- The application server needs to be protected with a DMZ
- Easy to implement under z/VM using a guest LAN
  - this environment could also be extended to a cluster
Networking – Connection types

• Which connectivity to use:
  • inside z/VM use for guest to guest communication
    • VSWITCH without an OSA card
    • Guest LAN (no layer 2 support)
  • to another LPAR inside the same System z
    • use Hipersockets
      Hipersockets are completely driven by CPU
  • External connectivity:
    • Use new 10 GbE cards with MTU 8992
    • VSWITCH with an OSA card
    • Attach OSA directly to Linux guest image
Networking under z/VM: guest LAN

Network type and Maximal Frame Size for Hipersockets

- guest LAN type Hipersockets with a MFS of 24K can be recommended because of higher throughput at lower latencies
Java setup - general

- Assure that the JIT is enabled (java -version)

- increase the heap size
  - Setting heap size: -Xms(minimal), -Xmx(maximal), use min=max, avoids fragmentation
  - Larger heap size implies better performance
  - Avoid swapping!

- Special consideration for 31 bit distributions
  - to define a heap inside the memory up to 1.2 GB in 31bit SLES8, SLES9 use:
    echo 268435456 >/proc/<pid>/mapped_base
  - In 31bit RHEL4 environments use flex-mmap mechanism to get a larger heap size, but watch out for prelinked applications!
    - modify /etc/sysconfig/prelink
      set PRELINKING=no prelink -ua
    - run /etc/cron.daily/prelink
    - reboot
WebSphere / Java evolution

WebSphere Application Server 6.1 got a 20% improvement

Use the latest WebSphere / Java combination if possible!

WebSphere Application Server 6.0.2 with JDK 1.4.2

WebSphere Application Server 6.1 with JDK 1.5
Networking – connection to the database

• Use recent versions of database connectors
  • Type 4 JDBC connectors have a performance advantage of about 10% compared to JDBC type 2 over DB2 Connect

• Monitor the connection pool (number of physical connections to the database). Set the “Maximum pool size” of to a value that there are always some inactive connections

• Keep the latencies in the network communication between the WebSphere server and the database short
  • Use a fast network connection which can handle easily the traffic
  • low number of network hops between the application server and database
**Networking – DB2 database on z/OS**

- Set the right maximum number of physical connections in the database
  - Set the DSNZPARM parameter `CONDBAT` to the sum of the “maximum pool size” of all the WebSphere Application servers you use with the database and all other applications.
  - Set the DSNZPARM parameter `MDBAT` to the maximum acceptable number of active DBATs (= active connections).
  - Monitor with `-dis ddf`
    ```
    DSNL080I  -DB91  DSNLTDDF DISPLAY DDF REPORT FOLLOW:
    DSNL082I  ISTATUS=STARTE  DSNL082I LOCATION  LUNAME GENERICLU
    DSNL084I  DB91ZOS USIBMT6.BB91ZOS  -NONE  DSNL084I  TCPPORT=446
    SECPORT=0  RESPORT=447  IPNAME=-NONE  DSNL085I
    IPADDR=:9.12.22.95  DSNL086I  SQL
    DOMAIN=India3.pdl.pok.ibm.com  DSNL086I  RESYNC
    DSNL090I  DT=I  CONDBAT=10000
    MDBAT=1000  DSNL092I  ADBAT=198  QUEDBAT=0  INADBAT=0
    CONQUED=0  DSNL093I  DSCDBAT=85  INACONN=320  DSNL099I
    DSNLTDDF DISPLAY DDF REPORT COMPLETE
    ```

- when `ADBAT` exceeds `MDBAT` then new or inactive connections must be queued
Database on z/OS

On z/OS define proper WLM policies

- **SYSSTC** Built in service class. Used for DB91IRLM. High priority service class. Only ‘SYSTEM’ service class is higher.

- **DB2ADDRS** Service class for DB91MSTR, DB91DBM1, and DB91DIST.
  - Uses importance=1, velocity=80. Slightly lower than the IRLM address space.

- **DDFWORK** Service class for DDF.
  - Uses importance=2, velocity=80. Slightly lower priority than the DB2 address spaces.
Identify bottlenecks in the environment

**WebSphere Server Chain**

**CPU utilization**

- Tuning should start with the bottleneck
  - WebSphere application server and UDB server in the example environment
  - don't run the WebSphere Application Server permanently over 90% CPU utilization
The caches of WebSphere servers

- Caching Proxy Cache for static content
  - ServerConnPool value ON allows reuse of existing sockets
  - ServerConnTimeout is used to limit the network idle time

- Dynamic Cache services of the application server and ESI cache can be used for dynamic content
Caching modes (Trade benchmark)

Scaling Trade caching modes

Transaction throughput

<table>
<thead>
<tr>
<th>Mode</th>
<th>2 CPUs</th>
<th>4 CPUs</th>
</tr>
</thead>
<tbody>
<tr>
<td>No cache</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>Command caching</td>
<td>250%</td>
<td>350%</td>
</tr>
<tr>
<td>Distributed Map caching</td>
<td>200%</td>
<td>300%</td>
</tr>
</tbody>
</table>

- Significant performance gains are achieved when caching technology can be used
- Application support required (cache usage, data consistency !)
Varying dynamic cache size

- Best results seen in our experiment with 10,000 cached statements
- Default cache size is only 2,000 statements

<table>
<thead>
<tr>
<th>Dynamic cache size [statements]</th>
<th>Normalized transaction throughput</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>100%</td>
</tr>
<tr>
<td>6000</td>
<td>100%</td>
</tr>
<tr>
<td>10,000</td>
<td>140%</td>
</tr>
</tbody>
</table>
Database tuning effects (application layout)

- DB optimization is a key!
- Database optimization steps improve throughput by 12% in this example of optimization on database layout

![Normalized transaction throughput diagram](chart.png)
31-bit versus 64-bit

- 64-bit WebSphere and Java is production ready today!
- The 64-bit WAS environment needs additional CPU cycles and memory resources
- If running 64-bit define 20% to 30% more JVM heap to get the equivalent Java garbage collection behavior as seen with 31-bit
- If the application does not need the additional memory size and heap then the use of 31-bit is recommended
  - You can run 31-bit WebSphere in the 31-bit emulation layer of 64-bit distributions (RHEL5, SLES10)
  - There may be constraints like supported configuration, local 64-bit database connection
There are two types of crypto hardware support on System z:

- Crypto cards used for encryption related with authentication (userid +password/certificates)
  - Asymmetric or 'public key' crypto used for SSL handshake to establish SSL session & create session key
  - System z PCI crypto cards (PCICC, PCICA, PCIXCC, CEX2) can accelerate asymmetric crypto operations for Linux on System z

- CPACF (system z processor feature) used for data encryption
  - Symmetric or 'private key' crypto used to encrypt/decrypt data - uses session key
  - The CP assist for Cryptographic Functions (CPACF) offers a set of symmetric cryptographic functions that enhance the encryption/decryption performance of clear key operations
Cryptographic hardware support another WebSphere environment – using WebSEAL

- WebSEAL provides an authentication and authorization mechanism
  - based on Tivoli Access Manager
  - enables an end-to-end Single Sign On (SSO) solution for secure transactions for WebSphere application servers residing on z/OS.

Candidates for encryption

System z9

- z/OS - LPAR
- z/VM - LPAR
- Firewalls 1 and 2
- WebSeal Proxy Server
- WebSphere Application Server
- DB2 UDB - z/VM guest
- Tivoli Access Manager/IBM Tivoli Directory Server + DB2 Client

Clients
- Linux on System x
- Internet

1 Gbit Ethernet connection via Hipersockets
WebSEAL – page size with SSL access

- the connection from client to WebSEAL server runs encrypted using SSL (AES-128)
- increase the size of the requested page
- uses mostly the CPACF feature from the processor

Improvement up to factor 2.4x!

Improvement by hardware crypto support

<table>
<thead>
<tr>
<th>Throughput normalized to software encryption</th>
<th>0%</th>
<th>50%</th>
<th>100%</th>
<th>150%</th>
<th>200%</th>
<th>250%</th>
<th>300%</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.8KB</td>
<td></td>
<td></td>
<td>![BarGraph]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12KB</td>
<td></td>
<td></td>
<td>![BarGraph]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.9MB</td>
<td></td>
<td></td>
<td>![BarGraph]</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
WebSEAL – authentication workload

- access to very small pages (100 bytes) but authentication required
- the connection from client to WebSEAL server runs encrypted using SSL (AES-128)
- WebSEAL server with software encryption runs CPU constrained
  - both crypto facilities can be used
    - CPACF from processor
    - CEX2C crypto card
      - increases the throughput and
      - releases the CPU
  - total improvement up to factor 3x
Summary

• Setup of a WebSphere environment requires optimization on all levels
• first step is monitoring
• identify the resources which are utilized at its limit
  • do not run a WebSphere application server above 90% CPU utilization
  • one critical point is the network connection between WebSphere and the database
  • check the utilization of the whole network
  • Java heap size
  • always an item is the layout in the database (indexes, table structures)
  • consider using the crypto features available on System z for encrypting data
• Tuning activities are often not independent from each other
• Monitor performance critical environments at least periodically
Visit us!

- Linux on zSeries Tuning Hints and Tips
  - White Paper WebSphere Application Server
  - White Paper WebSEAL

- Linux-z/VM Performance Website
Questions
z/VM setup

- Size the CPUs appropriate (use benchmarks, prototyping, size390 / techline)

- Shares set for the Linux guests prioritize CPU resources
  - Use relative shares with a soft limit
  - Give production guests higher shares
  - “Infrastructure Servers” (e.g. DBMS) should be given even higher shares

- Define xstore because z/VM has evolved around to have a memory hierarchy (25 % xstore as a rule of thumb up to 4GB)

- Make sure there is sufficient central storage plus paging space in z/VM to back the virtual memory request of all your Linux guests

- Provide twice as much DASD paging space than the sum of the Linux guests' virtual storage sizes (fast entire volumes)

- Enable QUICKDSP only for production guests and guests which perform critical system functions (VM TCP/IP, routers)
Linux on System z setup on z/VM

- Use as few number of processors as possible
  - Start with a reasonable number of processors (from sizing or prototyping)
  - Then reduce the number for each guest regarding the consumption (use your favorite monitoring tool)
  - Do not define more virtual processors for the guest than are physical available to the z/VM LPAR

- You should always define a swap file. This could be a VDISK (15% -20% of the Linux guests virtual memory) or if memory constraint in z/VM use a full minidisk (MDC turned off)

- Size your Linux guest to have enough virtual memory to run without swapping excessively except for a short peak time

- “Surplus” virtual memory larger than the working set size is used by Linux for caches and buffers but will cause z/VM paging if over-committed
Data Access - Disk

• Hardware choices
  • Use SCSI instead of ECKD
  • Use FICON instead of ESCON
    • 4Gb FICON > 2Gb FICON > 1Gb FICON

• Utilize your hardware
  • Use “striped” logical volumes from different ranks
  • Consider using PAV
  • Carefully set up your storage system
    • ESS Caching modes (normal, inhibit or record)
WebSphere tuning

• JVM settings
  • Choose the proper maximum heap size for WebSphere and JVM
    • Leave a cushion of about 35% above normal high water mark
    • don't disable the JIT compiler

• Set the “Maximum pool size” of the connection pool (maximum number of physical connections to the database) accordingly to the sum of all data sources in this application server

• Static pages are best served via an HTTP server

• Check for bottlenecks in your server chain
  • Provide more resources to constraint servers
  • Various optimization actions are probably not independent

• Monitor the WebSphere Application Server dynamic cache size utilization
  • Use therefore the cache monitor application on the application server

• make sure to have no disk I/O constraints on the database