Spectrum Scale Memory Usage

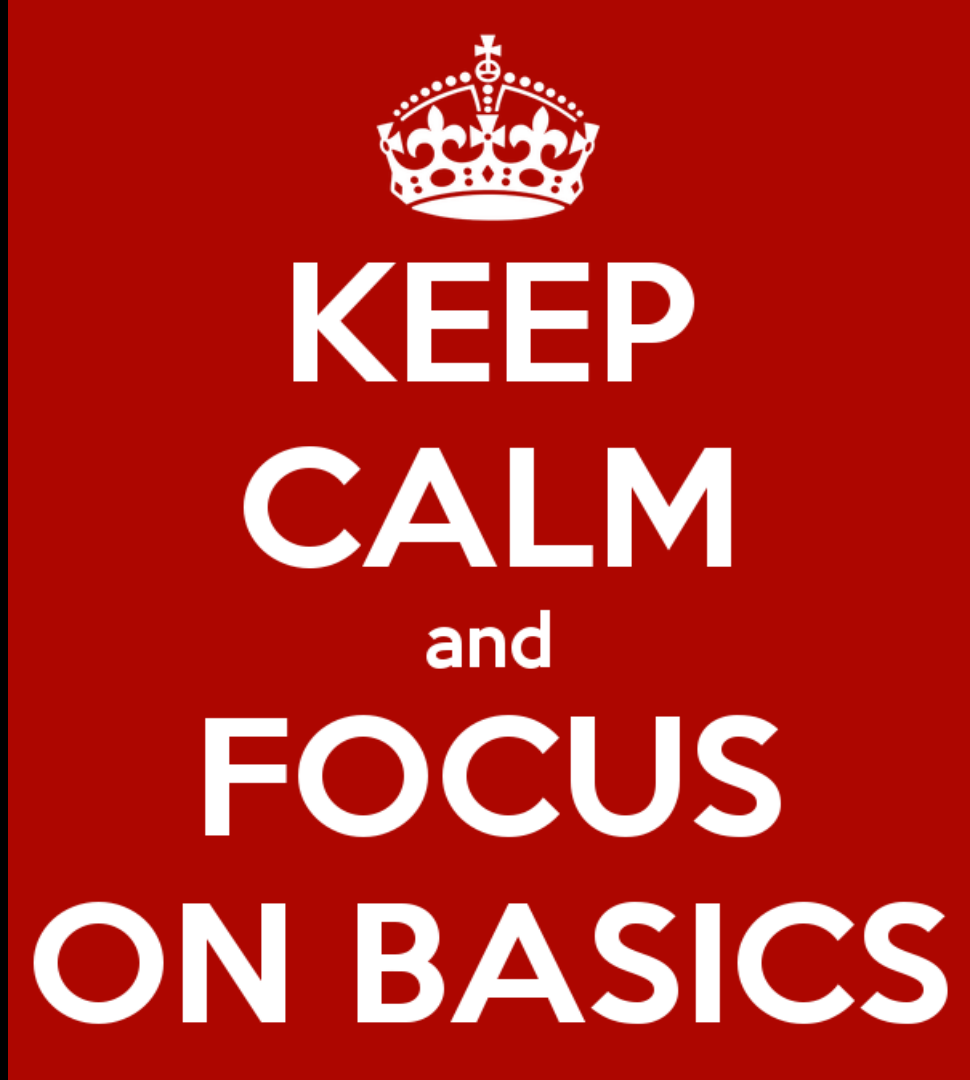
Tomer Perry
Spectrum Scale Development
<tomp@il.ibm.com>

Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?
- Others

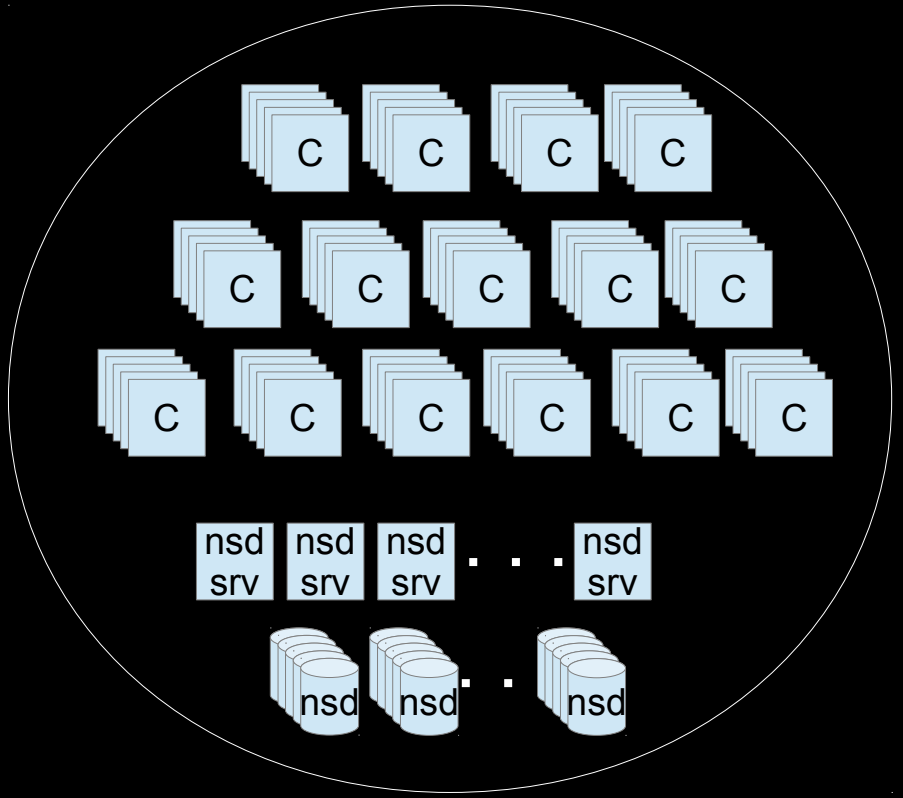
Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?
- Others



Some relevant Scale Basics
”The Cluster”

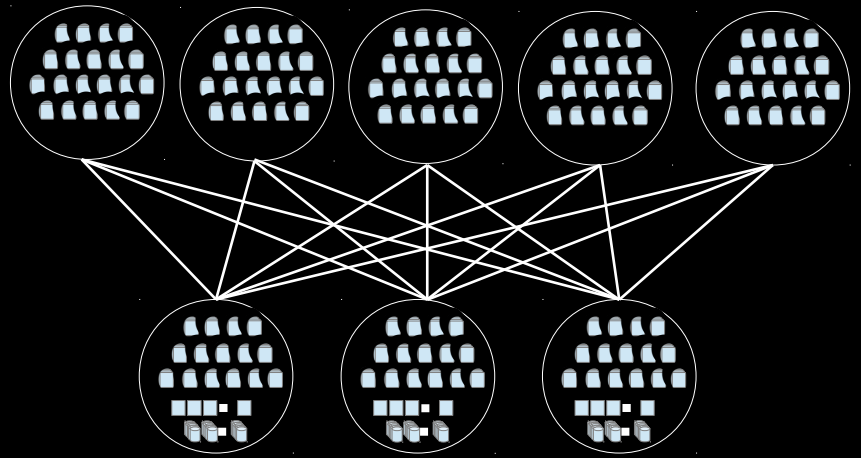
- **Cluster** – A group of operating system instances, or **nodes**, on which an instance of Spectrum Scale is deployed
- **Network Shared Disk** - Any block storage (disk, partition, or LUN) given to Spectrum Scale for its use
- **NSD server** – A node making an NSD available to other nodes over the network
- **GPFS filesystem –** Combination of data and metadata which is deployed over NSDs and managed by the cluster
- **Client –** A node running Scale Software accessing a filesystem



IBM

Some relevant Scale Basics
MultiCluster

- A Cluster can share some or all of its filesystems with other clusters
- Such cluster can be referred to as “Storage Cluster”
- A cluster that don’t have any local filesystems can be referred to as “Client Cluster”
- A Client cluster can connect to 31 clusters (outbound)
- A Storage cluster can be mounted by unlimited number of client clusters (Inbound) – 16383 really.
- Client cluster nodes “joins” the storage cluster upon mount



IBM

Some relevant Scale Basics
Node Roles

- While the general concept in Scale is “all nodes were made equal” some has special roles

Token Manager/s

- Multiple per filesystem
- Each manage portion of tokens for each filesystem based on inode number

Config Servers

- Holds cluster configuration files
- 4.1 onward supports CCR - quorum
- Not in the data path

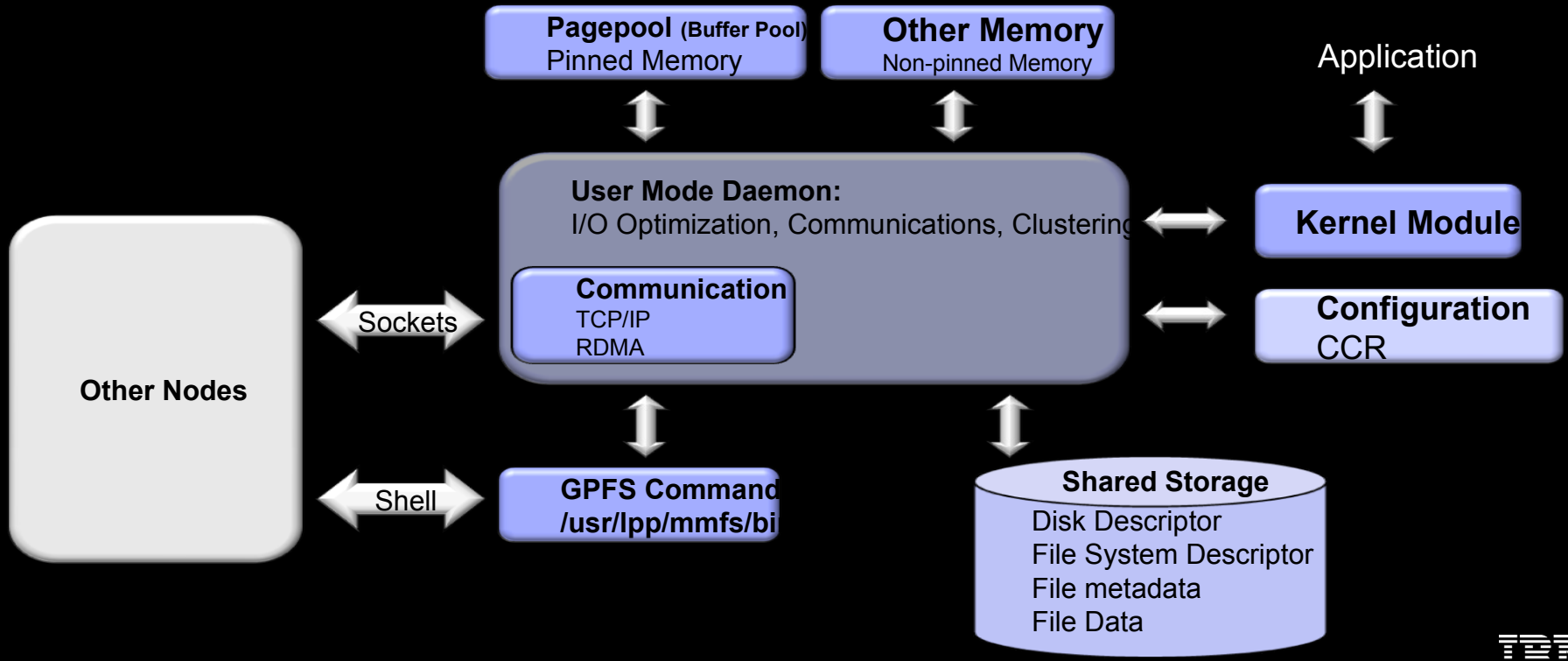
Cluster Manager

- One of the quorum nodes
- Manage leases, failures and recoveries
- Selects filesystem managers
- mm*mgr -c

Filesystem Manager

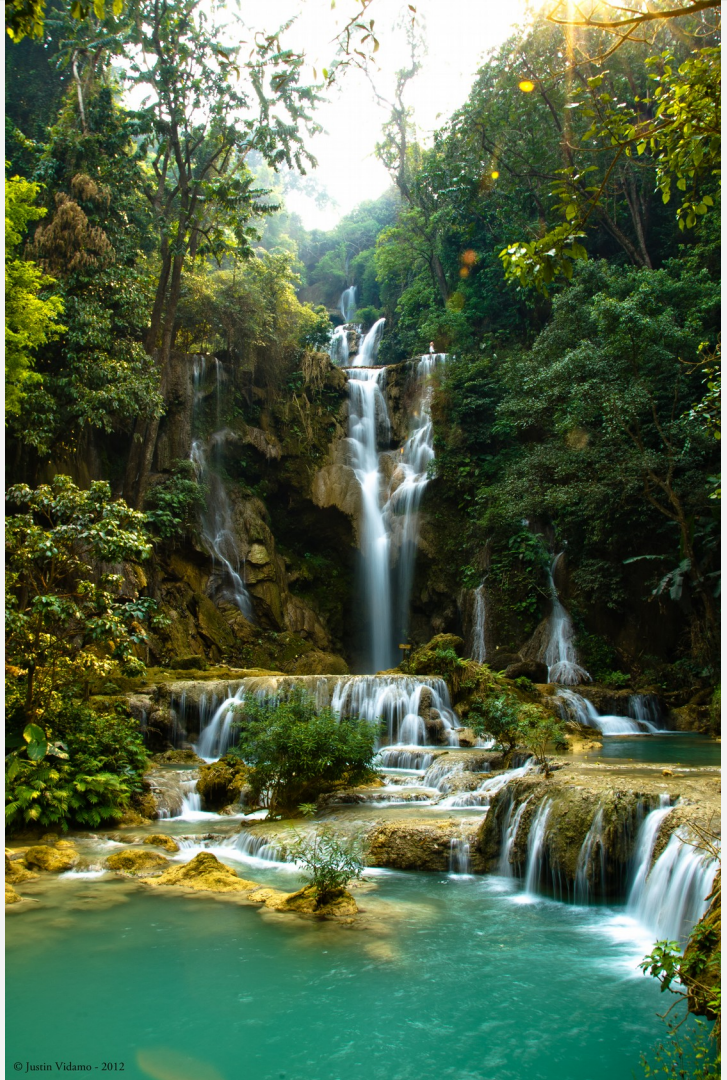
- One of the “manager” nodes
- One per filesystem
- Manage filesystem configurations (disks)
- Space allocation
- Quota management

Some relevant Scale Basics
Node Internal Structure



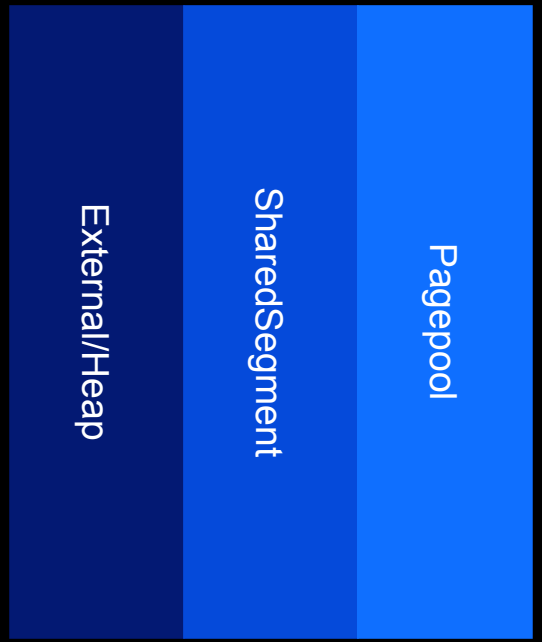
Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?
- Others



Scale Memory Pools

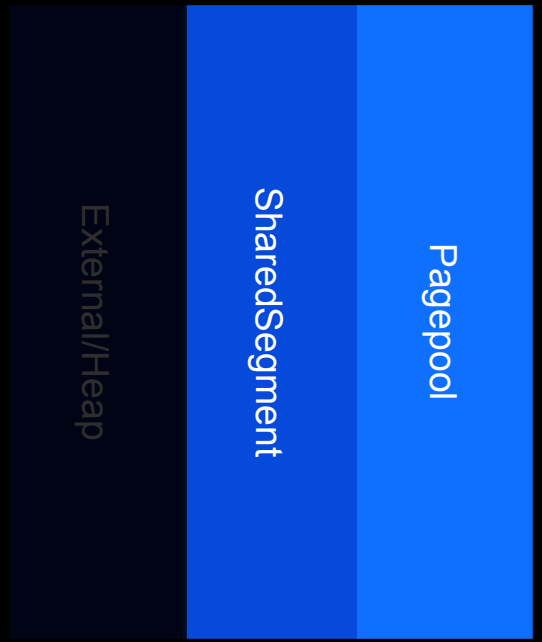
- At a high level, Scale is using several memory pools:
  - **Pagepool**
    data
  - **Shared Segment**
    “memory metadata”, shared (U+K)
  - **External/heap**
    Used by “external” parts of Scale (AFM queue, Ganesha, SAMBA etc.)



IBM

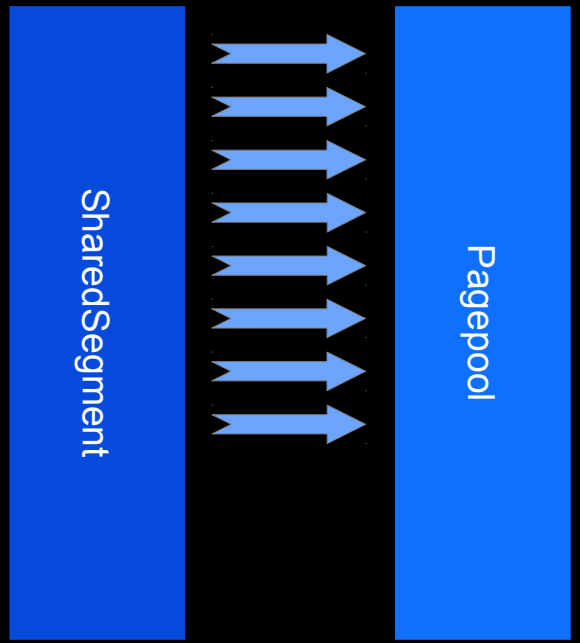
Scale Memory Pools

- At a high level, Scale is using several memory pools:
  - **Pagepool**
    data
  - **Shared Segment**
    “memory metadata”, shared (U+K)
  - **External/heap**
    Used by “external” parts of Scale (AFM queue, Ganesha, SAMBA etc.)



Scale Memory Pools
Pagepool

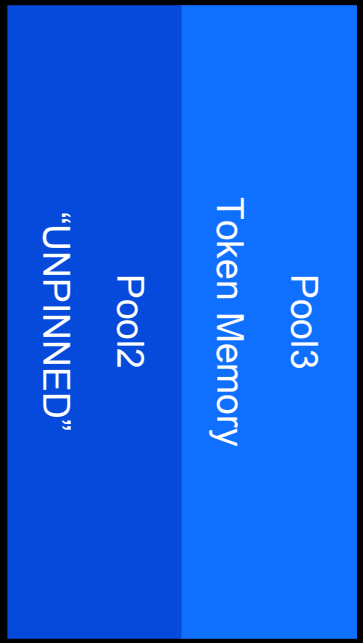
- Pagepool size is statically defined using the pagepool config option. It is allocated on daemon startup and can be changed using mmchconfig with the -i option (NUMA, fragmentation)
- Pagepool stores data only
- All pagepool content is referenced by the sharedSegment (data is worthless without metadata…)
- Not all the sharedSegment points to the pagepool



IBM

Scale Memory Pools
SharedSegment

- The shared segment has two major pools
  - Pool2 - “Shared Segment”
    - All references to data stored in the pagepool (bufferDesc, Openfiles, IndBlocks, CliTokens) etc.
    - Statcache (compactOpenfile)
  - Pool3 - “Token Memory”
    - Tokens on token servers
    - Some client tokens (BR)

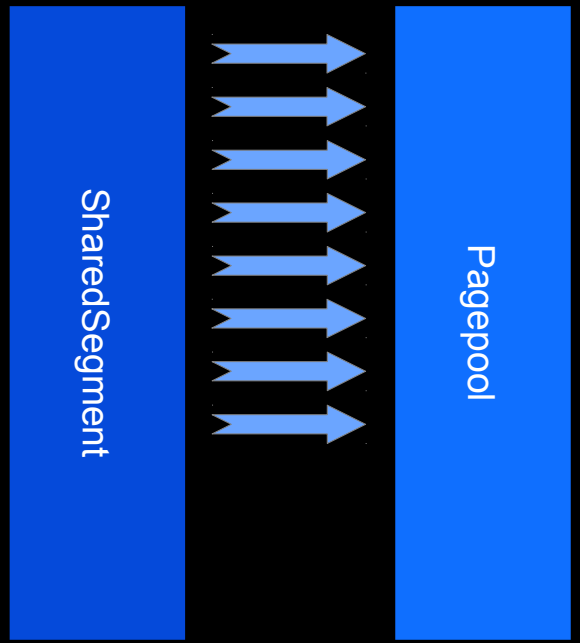


Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?
- Others

Memory Calculations
”So how much memory do I need?”

- Pagepool - ”it depends...”:
  How much DATA do you need to cache?
  How much RAM can you spend?
- Shared Segment - “it depends...”
  How many files do you need to cache?
  How many inodes do you need to cache?
  What is your access pattern (BR)



IBM

Memory Calculations
SharedSegment

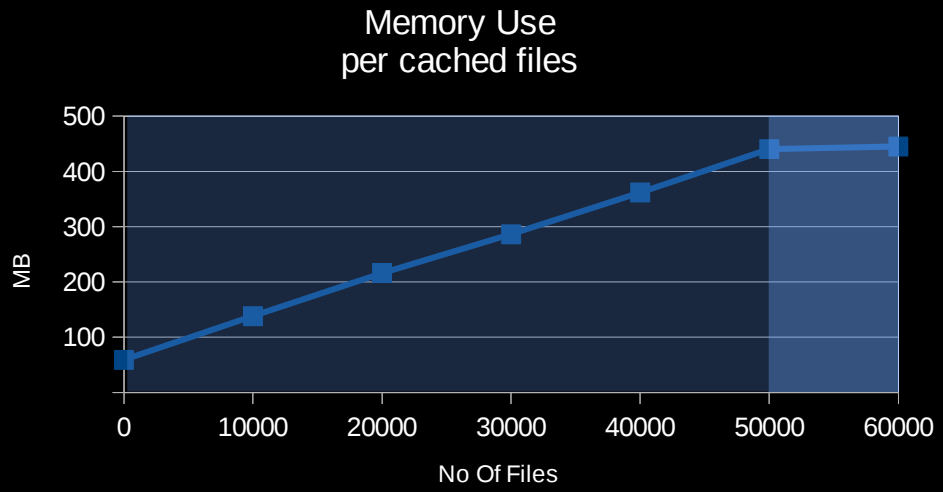
- Pool 2 - “Shared Segment”
  - **Scope:** Almost completely local (not much dependency on other nodes)
  - **Relevant parameters:**

    maxFilesToCache

    maxStatCache
  - **Cost:**

    Each MFTC =~ 10k

    Each MSC =~ 480b



For example, using MFTC of 50k and MSC of 20k and opening 60k files

Memory Calculations
SharedSegment

- Pool 3 - “Token Memory”
  - **Scope:** “Storage cluster” manager nodes
  - **Relevant parameters:**

    MFTC, MSC, number of nodes, “hot objects”
  - **Cost:**

    TokenMemPerFile ~= 464b, ServerBRTreeNode = 56b

    BasicTokenMem = (MFTC+MSC)*NoOfNodes*TokenMemPerFile

    ClusterBRTokens = NoOfHotBlocksRandomAccess * ServerBRTreeNode

    TotalTokenMemory = BasicTokenMem + ClusterBRTokens

    PerTokenServerMem = TotalTokenMemory / NoOfTokenServers

* The number of the byte range tokens, in the worse case scenario, would be one byte range per block for all the blocks being accessed randomly

Memory Calculations
SharedSegment

- Pool 3 - “Token Memory”
  - **Scope:** “Storage cluster” manager nodes
  - **Relevant parameters:**

    MFTC, MSC, number of nodes, ... objects
  - **Cost:**

    TokenMemPerFile = 464b, ServerBRTreeNode = 56b

    BasicTokenMem = (MFTC+MSC)*NoOfNodes*TokenMemPerFile

    ClusterBRTokens = NoOfHotBlocksRandomAccess * ServerBRTreeNode

    TotalTokenMemory = BasicTokenMem + ClusterBRTokens

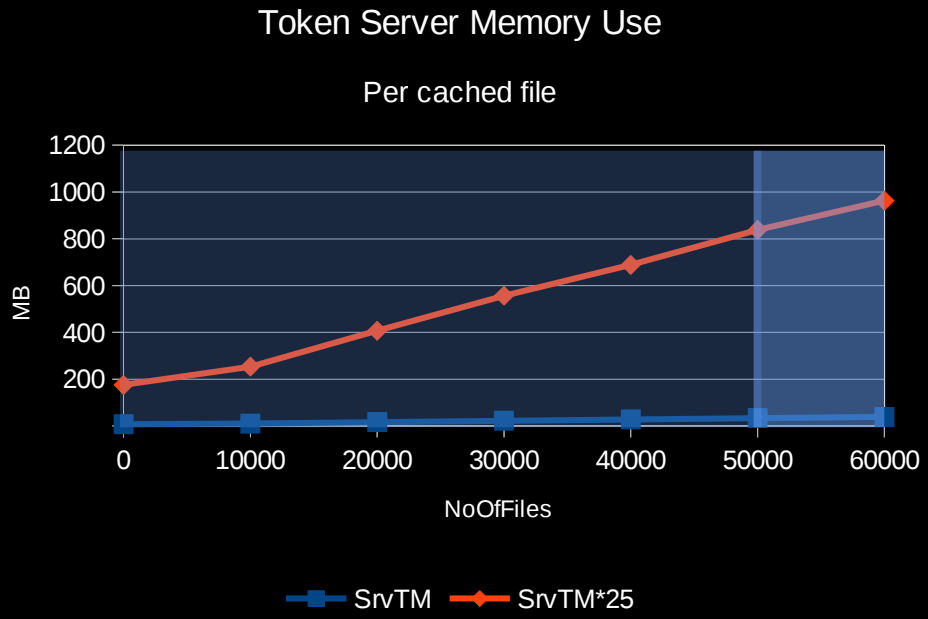
    PerTokenServerMem = TotalTokenMemory / NoOfTokenServers

Overall number of cached objects in the cluster
(different nodes might cache different numbers) * 0.5K
+ monitor token memory usage

* The number of the byte range tokens, in the worse case scenario, would be one byte range per block for all the blocks being accessed randomly.

Memory Calculations
SharedSegment

- Pool 3 - “Shared Segment”
  - As can be seen in the graph, single client don’t usually large memory foot print (blue line)
  - Using 25 clients, already brings us closer to 1G
  - There is no different between the “cost” of MFTC and MSC



For example, using MFTC of 50k and MSC of 20k and opening 60k files

Memory Calculations
SharedSegment

- But…where can we find those numbers?
  - Mmdiag is your friend

```
=== mmdiag: stats ===
Global resources:
  OpenFile counts: total created 50440 (in use 49313, free 1127)
    using 116347K memory
    cached 49313, dir 3, currently open 0+6, cache limit 50000 (min 10, max 50000), eff limit 50000
    stats: ins 65993 rem 16680 creat 50440 destr 0 free 67120 reuse 65993
           steals 0 (clean 0, dirty 0)
  StatCache counts: total created 10893 (in use 10692, dirs 0, free 201)
    using 3675K memory
    cache limit 19968
    stats: ins 16680 rem 5988 creat 10893 destr 0 free 5988 reuse 5787 hits 0 exp 5988 revk 0 steal 0 dirSteal 0 uses 5989
  OpenInstance counts: total created 1 (in use 0, free 1)
    using 0K memory
  BufferDesc counts: total created 11 (in use 11, free 0)
    using 7K memory
    cached 11 cache limit 500000 pseudo 0 prefetch 0
    stats: ins 11 rem 0 creat 11 destr 0 free 11 reuse 11
  indBlockDesc counts: total created 50640 (in use 49323, free 1317)
    using 20422K memory
    cached 49323 cache limit 50000 pseudo 49319
    stats: ins 66004 rem 16681 creat 50655 destr 15 free 67321 reuse 66004
```

  - “The Command-Who-Must-Not-Be Named” can provide even more details (dump malloc)

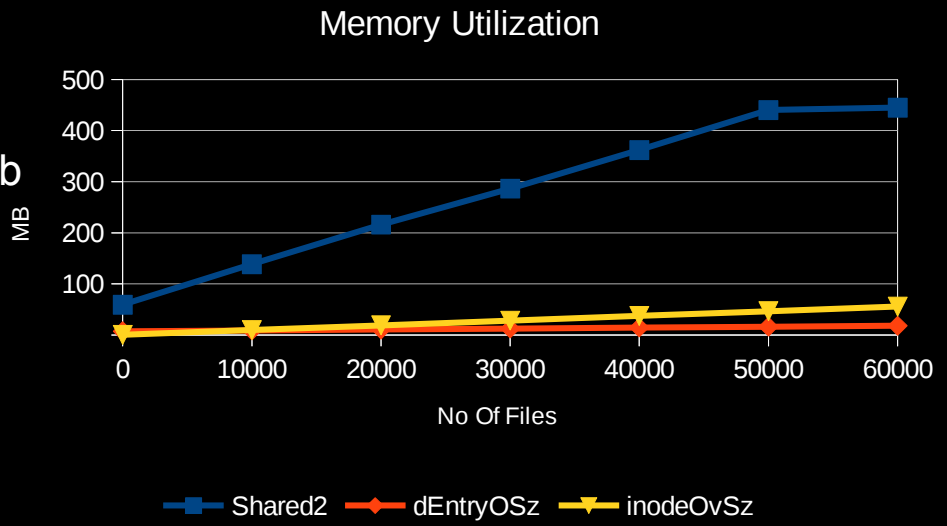
```
=== mmdiag: memory ===
mmfsd heap size: 999424 bytes


Statistics for MemoryPool id 1 ("Shared Segment (EPHEMERAL)")
          128 bytes in use
   71703796095 hard limit on memory usage
      1048576 bytes committed to regions
            1 number of regions
            3 allocations
            3 frees
            0 allocation failures


Statistics for MemoryPool id 2 ("Shared Segment")
    427530112 bytes in use
   71703796095 hard limit on memory usage
    452984832 bytes committed to regions
           18 number of regions
        51282 allocations
           28 frees
            0 allocation failures


Statistics for MemoryPool id 3 ("Token Manager")
      2099520 bytes in use
   71703796095 hard limit on memory usage
     16778240 bytes committed to regions
            1 number of regions
            4 allocations
            0 frees
            0 allocation failures
```

Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?
- Others

Is that all?
Related OS memory usage

- “Scale don’t use the operating system cache”...well...sort of
  - Directory Cache (a.k.a dcache) - ~192b
  - VFS inode cache - ~1K
- But is it really important? The SharedSeg takes much more memory




```
[root@sonascl23 memresults]# egrep -e "gpfs|dent| name" /proc/slabinfo
# name            <active_objs> <num_objs> <objsize> <objperslab> <pagesperslab> : tunables <limit> <batchcount> <sharedfactor> : slabdata <active_slabs> <num_slabs> <sharedavail>
gpfsInodeCache     60180  60180    960   34    8 : tunables    0    0    0 : slabdata   1770   1770      0
dentry            304286 304332    192   42    2 : tunables    0    0    0 : slabdata   7246   7246      0
```

Outline

- Relevant Scale Basics
- Scale Memory Pools
- Memory Calculations
- Is that all?(Linux memory)
- Others

Others
Out of scope here

- AFM queue memory
- Policy (and its affect on cached objects)
- Ganesha (YAIC)
- SAMBA
- Sysmon, zimon
- GUI
- TCT, Archive
- fsck, other maintenance commands

Others
Out of scope here

- AFM queue memory
- Policy (and its affect on cached objects)
- Ganesha (YAIC – Yet Another Inode Cache)
- SAMBA
- Sysmon, zimon
- GUI
- TCT, Archive
- fsck, other maintenance commands

Questions ?