Scaling Web Service

Capacity planning

- Q: How many requests can a machine handle?
  - Really depends on your application
  - Possible bottlenecks
    - Disk/DB IO: disk 100-500MB/sec, 5 - 10ms avg seek (or ~100K IOs for SSD)
    - Network: 1Gbps - 10Gbps
    - CPU/memory: 3Ghz
  - Estimation of workload capacity
    - Static content:
      - Q: 10KB per request, 100MB/s disk io, 1Gbps network, how many requests/sec?
        - Disk -> memory -> network diagram
        - Disk -> memory: sequential(~100MB/10KB) vs random (~1sec/10ms)
        - Memory -> network: (~100MB/10KB)
      - A high performance Web server can easily handle 5,000 req/sec/cpu
        - nginx, apache, ...
      - Main bottleneck is mostly disk/network io
    - Dynamic content:
      - Depends on the complexity of application
      - Rule of thumb: 10 request/sec/CPU
        - Assuming reasonably simple application logic
        - No SSL, no video/image encoding, ...
      - Cpu/context switch/io can be bottleneck
- Capacity planning
  - Characterize the workload:
    - Req/sec, res util/req
    - Measure resource utilization from your workload

  - Set your min acceptable service requirement
  - Remember: "premature optimization is the root of all evil" - Donald Knuth
    * Do not optimize based on your "guess"
    * Do not optimize unless you are sure it is important
    * **MEASURE from your workload** first!!!
- Tools for Profiling
  - CPU/process
    * `top`: load avg: # processes in running or runnable state
    * `ps`: common options: axl
    * `pstree`
  - Disk io
    * `iostat`
  - Network io
    * `netstat`: common options: -i or -s
  - Memory
    * `free -m`, `ps axl`, `vmstat`, `memstat`
  - DNS look up often causes lots of problem
    * Disable reverse DNS lookup if possible
  - Code profiling
    * A good first step to identify bottleneck
    * Node: Profiler built in since V4.4
    * Java: JProfiler, Eclipse TPTP (test & performance tools platform), ...
    * PHP: Xdebug profiler

Caching

- Q: Can we use caching to improve performance/scalability?
- Q: At what layer? Storage/DB? Application? HTTP?

Transport encryption (SSL)
HTTP server (apache/nginx)
Application server (tomcat/node)
Persistence/Storage layer (MySQL/Mongo)

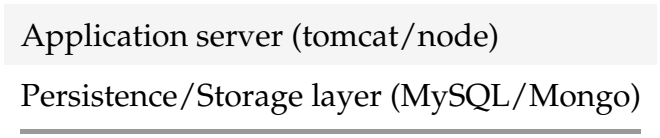
  - Caching files/disk blocks (disk cache)
  - Caching database objects
  - Caching dynamic web pages
  - Caching content close to the users
- Data object caching layer (memcached, redis)
  - All database access goes through caching layer
  - Minimize # requests hitting DB
  - memcached data model: (key, value) pair. Key-based lookup
  - Can use multiple machines for caching by partitioning the key w/
  - Special care on possible machine failure
- Dynamic page caching layer
  - Store generated HTML page as a static file
    - E.g., WordPress cache plugins
  - Q: What if a page contains a few user-specific content?
- Content distribution network (CDN)
  - Cache pages/images/videos close to users at the edge of the network
  - Users access cached object located close to them
    - Lower delay. Lower load on the main server
  - Q: How can a browser "know" the location of the cached objects that are close to them?
- How can we scale a Web site as it grows?
  - *Scale up*: buy a larger, more expensive server
  - *Scale out*: add more machines
  - Q: Pro/cons of scale up/out?

Scaling-out Web applications

- Typical Web server architecture

Transport encryption (SSL)

HTTP server (apache/nginx)



- **Q: How to scale out a Web site using cluster?**
  - **Q: Scaling out each layer?**
    - Encryption layer? http layer? application logic layer?
    - Persistence/database? more discussion later
  - Load balancer (TCP NAT request distributor)
    - Hardware: Foundary Network ServerIron, Cisco LocalDirector, ...
    - Software: nginx, ...
    - DNS round robin
- **Q: How can we scale database once the limit is reached?**
  - **Scenario 1**: Global read only data (online map, yellow pages)?
    - Q: 30 IOs/sec/machine. 3 read IOs/request. How many requests per machine?
    - Q: How can we scale if we get 20 requests/sec?
      - Remark: no DB synchronization problem
  - **Scenario 2**: Local read and write. All user data is local. No global sharing of data (Web mail, online bank, ...)?
    - Q: 30 IOs/sec/machine. 2 reads+1write IOs/sec/session How many sessions per machine?
    - Q: How can we scale to deal with 20 sessions? Does replication help?
      - Remark: again, no DB synchronization problem

  - **Scenario 3**: Global read/write. writes are globally visible (online auction, social network)
    * Q: 30 IOs/sec/machine. 2 reads+1write IOs/sec/session. How many sessions per machine?
    * Q: How can we scale to deal with 20 sessions? replication?
    * Q: Maximum # of sessions that can be supported using replication?
    * Q: partitioning?
    * Remark:
      - Eventually write requests saturate the DB
      - Scaling out DB is VERY CHALLENGING and requires careful analysis/design
      - Many companies buy larger machine to scale DB for critical data
- General remarks on scaling out
  - CPU is rarely a bottleneck and is very easy to scale
  - After reasonable optimization, DBMS/storage is often the main bottleneck
    * Two basic approaches for DB scaling: replication and partitioning
    * Design your database carefully
    * Identify early on how you will cache/replicate/partition your DBMS