Musify

IT INFRASTRUCTURE

THREE-YEAR COST ANALYSIS

EMIS 7352 – PROJECT I – GROUP 3
APOORVA JAIN

MUSIFY?

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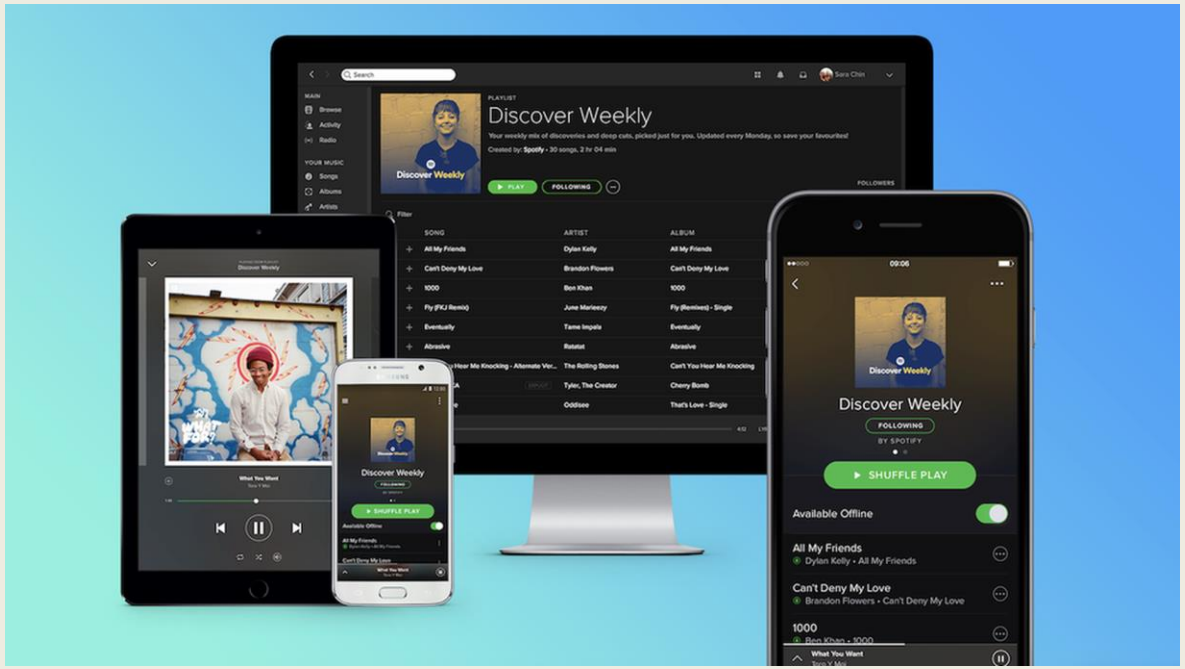
- Musify is a web-based, digital music service providing its subscribers with access to millions of songs.
- Songs can be digitally streamed at one of 3 bit-rates
  - Low: 112 kbps
  - Standard: 192 kbps
  - High: 240 kbps
- Songs can also be downloaded to the user's device for offline playback
- All songs are Data Rights Management (DRM)-protected (encrypted) to ensure that only authorized users are able to stream or download and play them
  - The System supports permission requests that provide users with the necessary DRM keys to play the songs.



PROJECT SCOPE

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- Group 3® , LLC was contracted by Musify to conduct an architectural and cost analysis for the build out of their IT infrastructure. That analysis includes the following:

- Assess Three-Year Costs for four (4) architectural options ("Scenarios")
  - 1. Implementing "General" compute servers; perform Data Rights Management (DRM) encryption on all streamed and downloaded songs
  - 2. Same as 1, except use "Dedicated Storage" solutions for stored data; (e.g., Storage Area Network (SAN) or Network Attached Storage (NAS))
  - 3. Same as 1, except incorporate Rate Adaptation (compressing to lower streaming bit rates)
  - 4. Same as 2, except incorporate Rate Adaptation

- Annualized Equipment Costs (servers, routers, racks)

- Annualized Operations Costs (power, labor, facility and other operating expenses)

BOTTOM LINE UP FRONT (BLUF)

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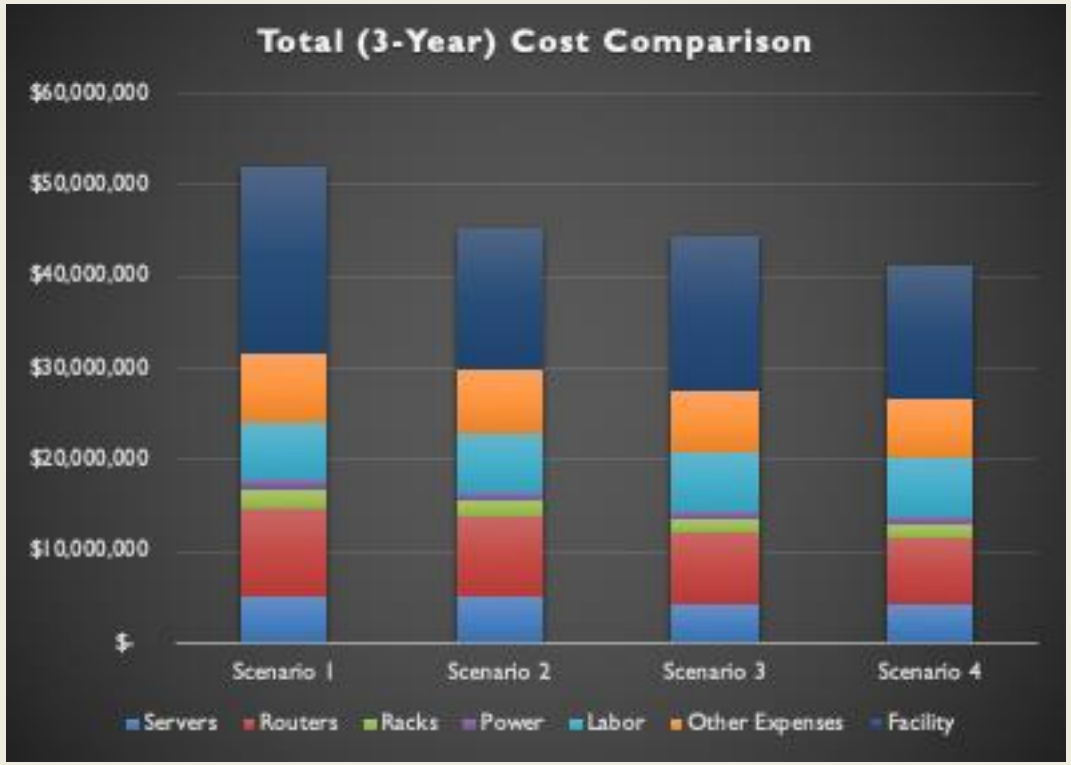

Scenario	Measure	Total	Scenario	Measure	Total
1	$ 52,021,925		3	$ 44,458,596	
(G, E)	Equipment Costs	$ 16,624,265	(G, E+R)	Equipment Costs	$ 13,475,627
	Servers	$ 5,177,265		Servers	$ 4,205,627
	Routers (Shelves	$ 9,622,000		Routers (Shelves	$ 7,800,000
	Racks	$ 1,825,000		Racks	$ 1,470,000
	Operations Cost	$ 35,397,659		Operations Cost	$ 30,982,970
	Power	$ 1,246,075		Power	$ 1,028,783
	Labor	$ 6,268,345		Labor	$ 6,268,345
	Other Expenses	$ 7,436,157		Expenses	$ 6,859,507
	Facility	$ 20,447,082		Facility	$ 16,826,335
2	$ 45,205,647		4	$ 41,232,978	
(G+D, E)	Equipment Costs	$ 15,585,437	(G+D, E+R)	Equipment Costs	$ 13,088,627
	Servers	$ 5,171,437		Servers	$ 4,205,627
	Routers (Shelves	$ 8,629,000		Routers (Shelves	$ 7,428,000
	Racks	$ 1,785,000		Racks	$ 1,455,000
	Operations Cost	$ 29,620,210		Operations Cost	$ 28,144,351
	Power	$ 889,139		Power	$ 827,919
	Labor	$ 6,268,345		Labor	$ 6,268,345
	Expenses	$ 6,986,855		Expenses	$ 6,494,523
	Facility	$ 15,475,871		Facility	$ 14,553,564

Group 3 recommends an architecture based on Scenario 4

- Lowest cost overall and lowest cost in each individual cost category (equipment, power, labor, operating expenses, and facility)
- Greatest opportunity for future expansion and scalability (use of highly-scalable, low operations cost Network Attached Storage)

FORECASTED USER BASE

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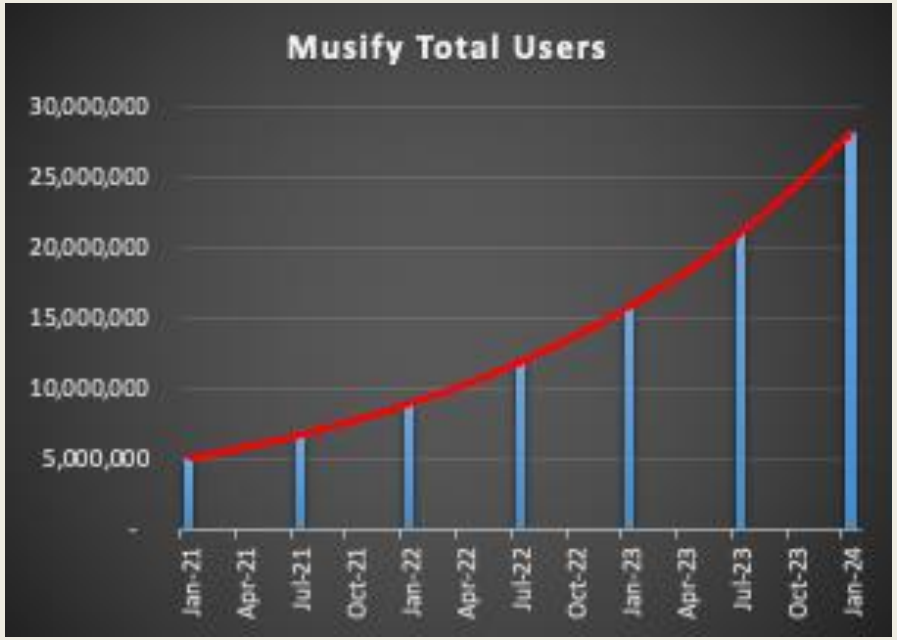

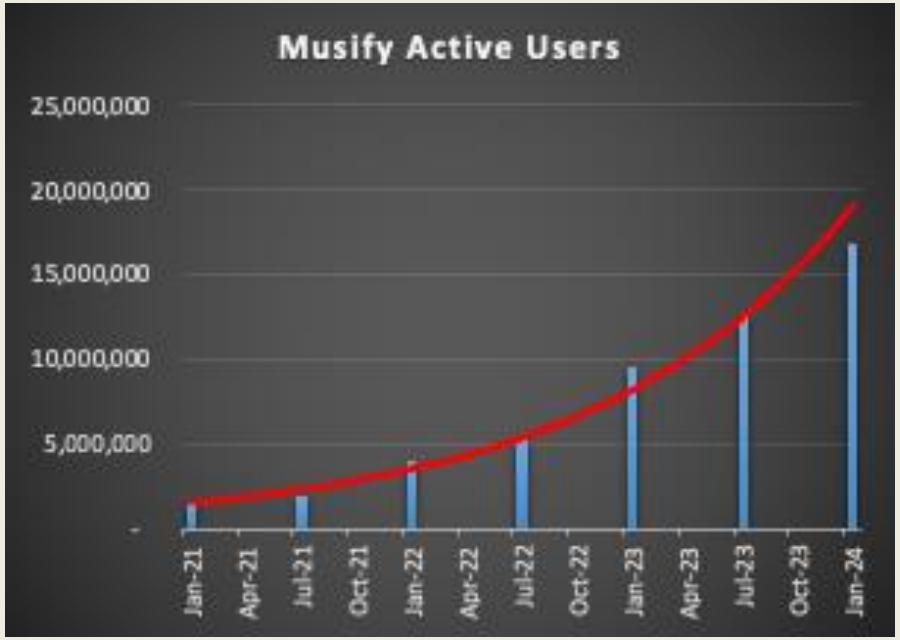

Period	Total Users	User Growth	User Growth Rate (%)	% Total Active Users	Average Active Users	Active User Growth	Active User Growth Rate (%)
Jan-21	5,000,000	-	-	30%	1,500,000		-
Jul-21	6,670,000	1,670,000	33.40%	30%	2,001,000	501,000	33.40%
Jan-22	8,890,000	2,220,000	33.28%	45%	4,000,500	1,999,500	99.93%
Jul-22	11,850,000	2,960,000	33.30%	45%	5,332,500	1,332,000	33.30%
Jan-23	15,800,000	3,950,000	33.33%	60%	9,480,000	4,147,500	77.78%
Jul-23	21,070,000	5,270,000	33.35%	60%	12,642,000	3,162,000	33.35%
Jan-24	28,090,000	7,020,000	33.32%	60%	16,854,000	4,212,000	33.32%

GENERAL APPROACH / ASSUMPTIONS

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- Data Center
  - Single Tier III Data Center
  - US Domain only;
    - Diurnal usage pattern (Peak-to-Average Ratio assessment)
    - Simplified Network / Internet Service Provider (ISP) cost analysis

- Annual Capacity Upgrades
  - Start-of-Year capacity supports end-of-year forecast
  - PROs: Extra capacity for higher-than-expected growth and in-house spares for failures; maximizes "lights-dim" data center philosophy (minimal staff, largely autonomous); time to assess and procure newer technology
  - CONs: Possible higher equipment and operational costs over more frequent/just-in-time installs; total system utilization may approach peak utilization capacity at year-end
    - Could be mitigated by turning some capacity off and "green" routers/switches (power savings)

GENERAL APPROACH / ASSUMPTIONS

Musify

- Song Library – 40,000,000 songs (remains steady over analysis period)
- Servers
  - Evaluated for each request type; all servers for a request type are homogenous (no mixing of L and XL servers)
  - The maximum number of servers required to support TPS, memory, storage or bandwidth were selected
- Routing
  - Assumed 9W/Gbps power consumption for cards (e.g., an OC-192 card with 4-10GbE ports would consume 360W)
  - Shelves configured with 20 GbE cards, 8 OC-48 cards and 4 OC-192 cards (for router-to-router interfaces
    - General servers have 1-GbE network interface cards (NICs)
    - NAS-based configs vary in scenarios 2 and 4 (NAS has 10GbE connections)
  - Full redundant connectivity (aligned with Tier III data center)
    - Protects against multi-port, multi-card and shelf-level failures

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  - Full redundant connectivity (aligned with Tier III data center)
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GENERAL APPROACH / ASSUMPTIONS

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- Racks
  - Assumed $5000 per fully-configured rack (dual PDUs, monitoring, cable runs, anchors, etc.), installed
  - Quantity determined by taking the maximum of RU-based vs kW-based calculations for servers and shelves
- Power and Cooling
  - Power and Cooling Costs based on "data sheet" specs at 80% CPU utilization
- Labor
  - Covers IT and Facilities management and maintenance, security, and custodial/grounds-keeping
  - Staffing M-F, 8-5, except Security (24x7)
  - Minimal staff in "lights-dim" Data Center configuration (minimal level access to maintain operations)
    - Monitoring performed remotely from Musify Operations Center

GENERAL APPROACH / ASSUMPTIONS

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- Annual Operations Costs
  - Energy Consumption, Labor, Internet Transit (ISP) Costs, Hardware Vendor Warranty Support, Data Center Property Taxes (assumed 1%/year of land and construction costs)
  - Power and Labor costs segregated in estimates
- Facility (Capital) Costs
  - Includes Land (assumed 5 acres), Construction Costs (incl. Architecture/Engineering Fees, interest on funds, etc.), "Last-Mile" Fiber Optic Cable runs (to ISP Point of Presence), Internal Cabling, Fire Suppression
  - Based on Tier III data center specifications (for reliability and availability)
  - All costs incurred in 1st year

EXCLUSIONS

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- Development, maintenance and sustainment of application software; including development and test equipment and facilities
- Business services (program management, supply chain, customer service, quality, engineering, finance, marketing, artist compensation, etc.)
- Other services and capabilities a system like this would likely provide and support:
  - User accounts and subscriptions (paid services)
  - Advertising
  - User profiles, playlists, preferences,
  - Data analytics (customized user experience based on historical usage patterns and preferences)
  - Other media (video, podcasts, etc.)
  - Client/App download and updates
  - Album Cover images

USAGE PATTERNS

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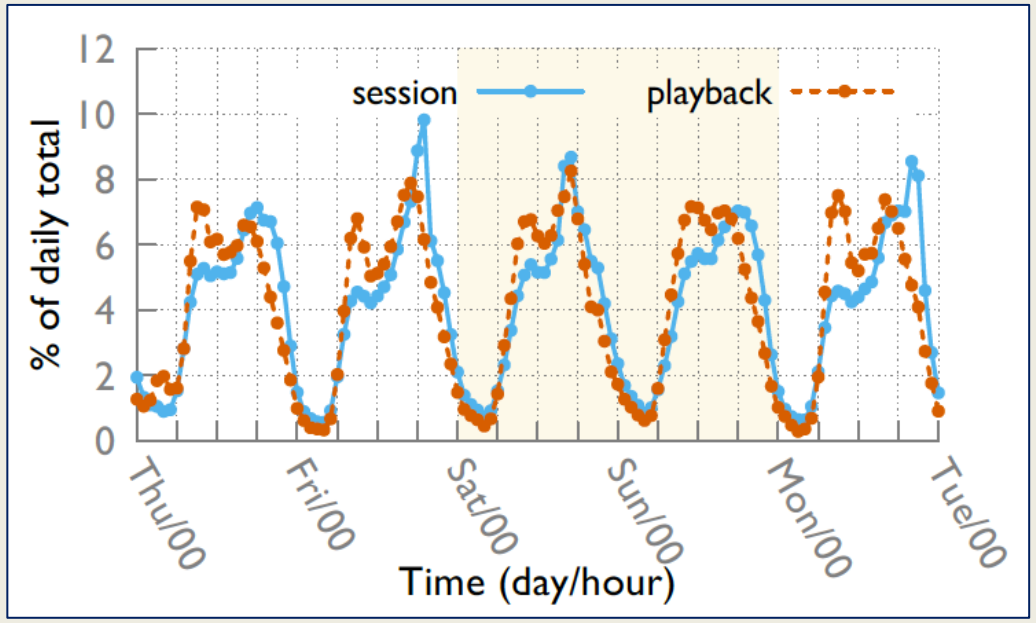
- Active Users follow a common diurnal pattern
  - Peak during the daylight; rapid ramp-up in morning, ramp down at night; minimal activity overnight
- Four (4) peak hours per day identified: 7-9am, 8-10pm
- Peak-to-Average Ratio (PAR) : 1.75:1
- Equivalent Peak Hours: 7.55



SYSTEM WORKLOAD

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- Request Rates (per Active User per Hour)

Streaming	Downloads	Permission Reqs	Total
24	4	16	44

- Assume 1 compute transaction per request (no weighting of request types)
- Transactions per second (TPS)

Period	Active Users	Streaming	Download	Permission	Total
Jan-21	1,500,000	3,143.75	523.96	2,095.83	5,763.54
Jul-21	2,001,000	4,193.76	698.96	2,795.84	7,688.56
Jan-22	4,000,500	8,384.38	1,397.40	5,589.59	15,371.37
Jul-22	5,332,500	11,176.03	1,862.67	7,450.69	20,489.39
Jan-23	9,480,000	19,868.50	3,311.42	13,245.67	36,425.58
Jul-23	12,642,000	26,495.53	4,415.92	17,663.68	48,575.13
Jan-24	16,854,000	35,323.18	5,887.20	23,548.78	64,759.15

CAPACITY NEEDS

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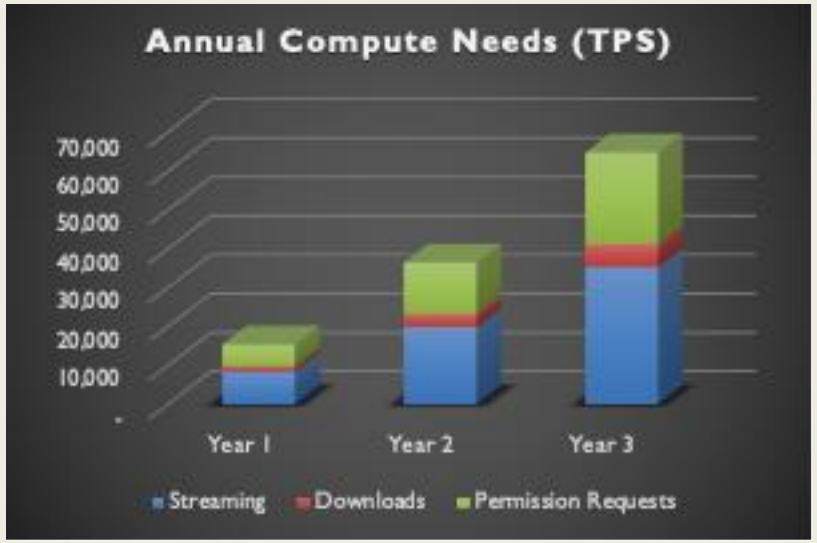

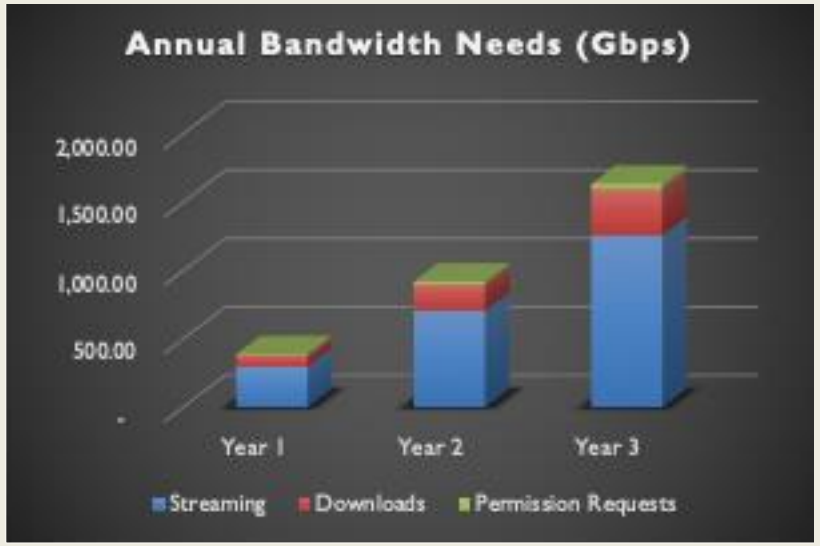

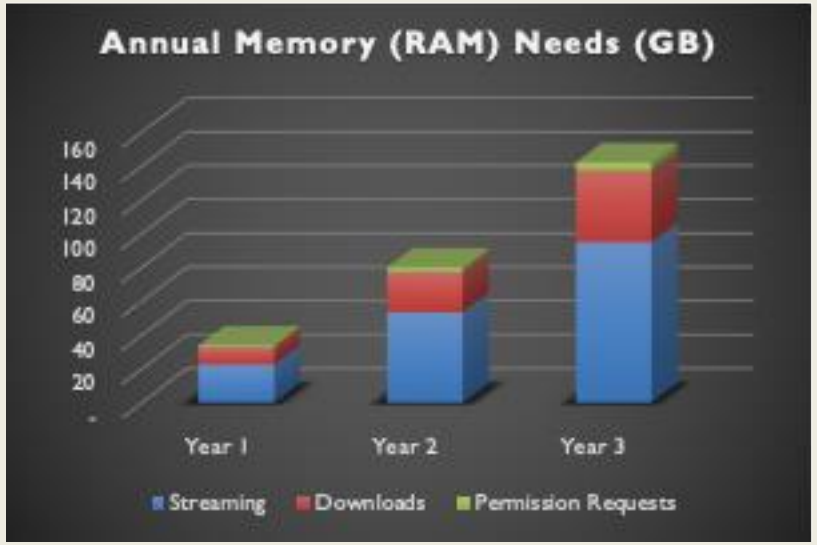

- These are based on total capacities needed to support end-of-year active user forecasts
- Allocation of these across servers in architecture varies by scenario
- Storage not provided; capacity varies by scenario

BASE PHYSICAL ARCHITECTURE

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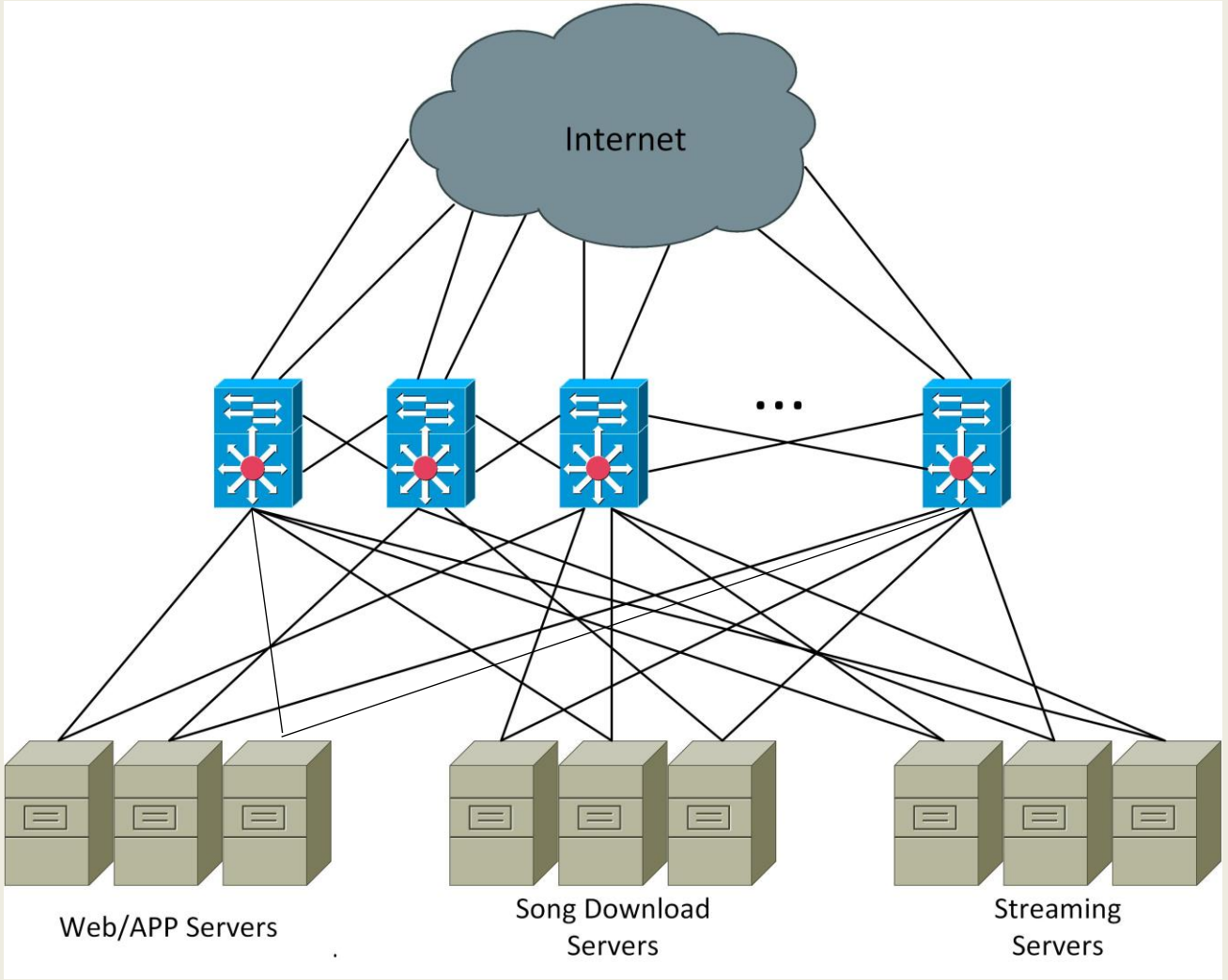
- Single Layer 2/3 tier routing provides access, aggregation, distribution and core routing and switching
  - Also assumed to provide load-balancing, server cluster mgmt, access control, etc.
- Full cross-connect redundancy in router-to-server and router-to-internet connections
- Router shelves cross-connected in "ring"-like approach
- Dedicated server "clusters" for each back-end service



SCENARIO 1 - OVERVIEW

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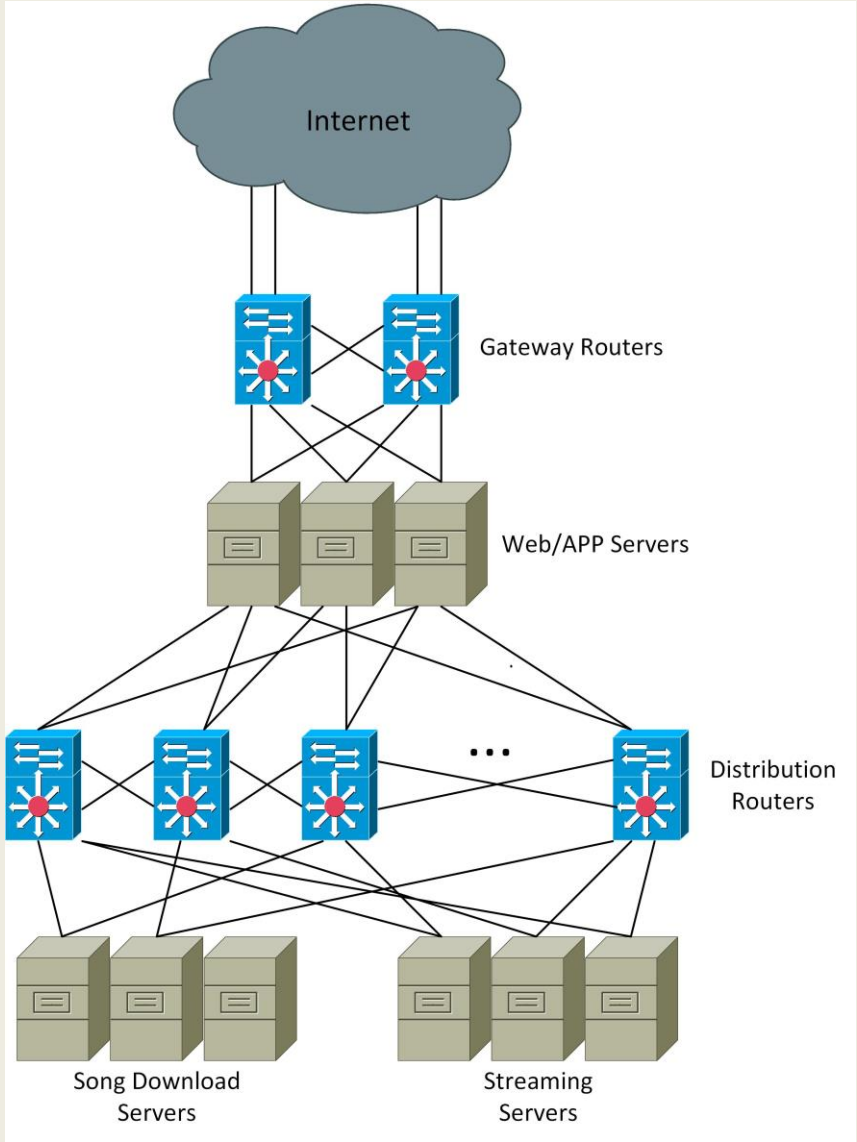
- No Rate Adaptation necessitates all bit-rate versions of all songs be stored (low, standard, and high streaming bit rates) and download-sized songs
- Backend Storage Servers satisfying streaming and download transactions also perform encryption on the fly
  - Servers estimated at 50% user capacity
- All requests process through the Web/App Servers and then routed to allocated back-end storage servers for song distribution
  - Web/App Servers also handle all permission requests directly
  - Servers estimated at 50% user capacity
- Perfect load-balancing and efficient routing assumed to equally distribute workload across all available servers



SCENARIO 1 – RESULTS

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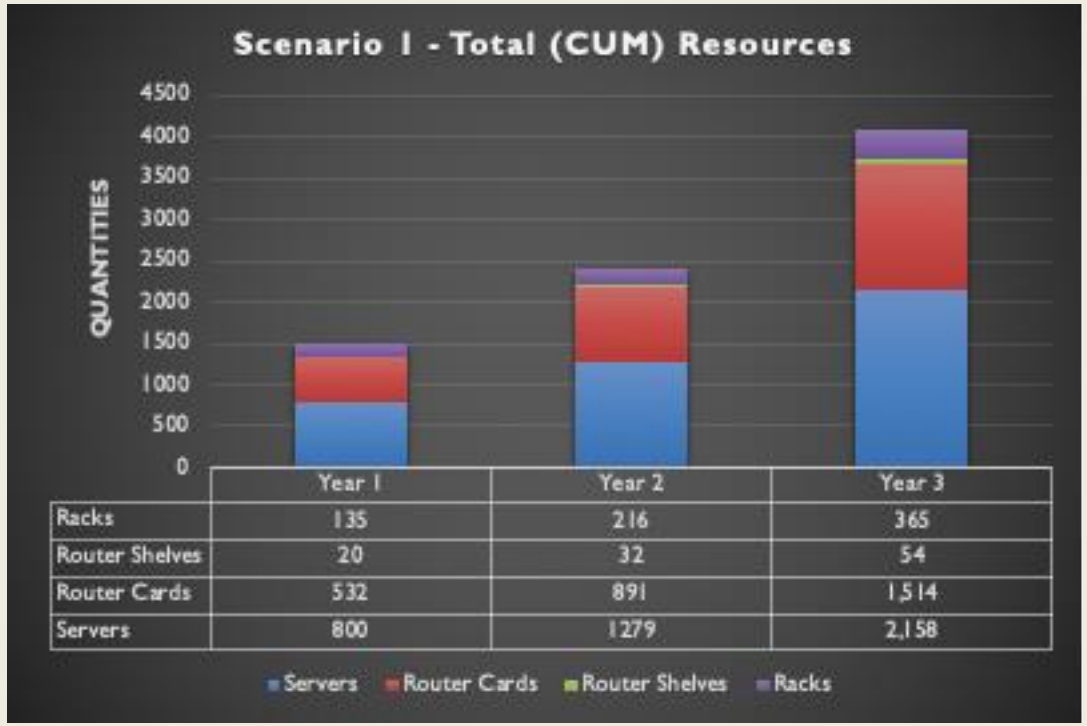

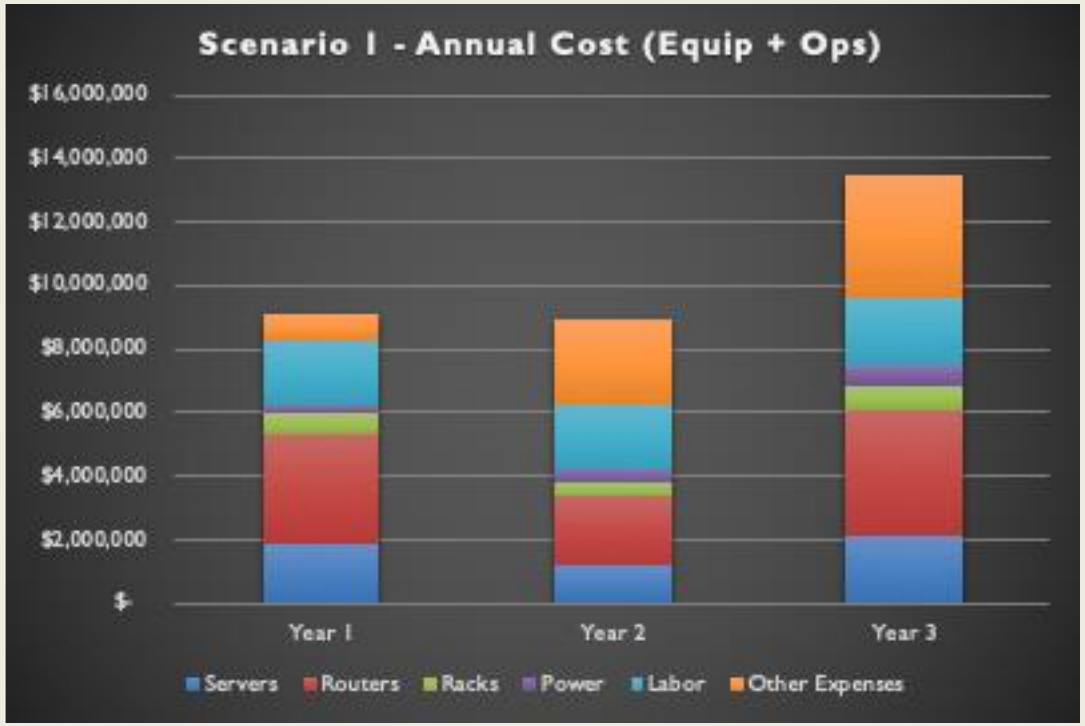

- Data Center: 23,360 total square feet, $20.45M in construction costs

Total (3-Year) Costs: $16.62M (Equip) + $14.95M (Ops) + $20.45M (Cap)

$52,021,925

SCENARIO 2 - OVERVIEW

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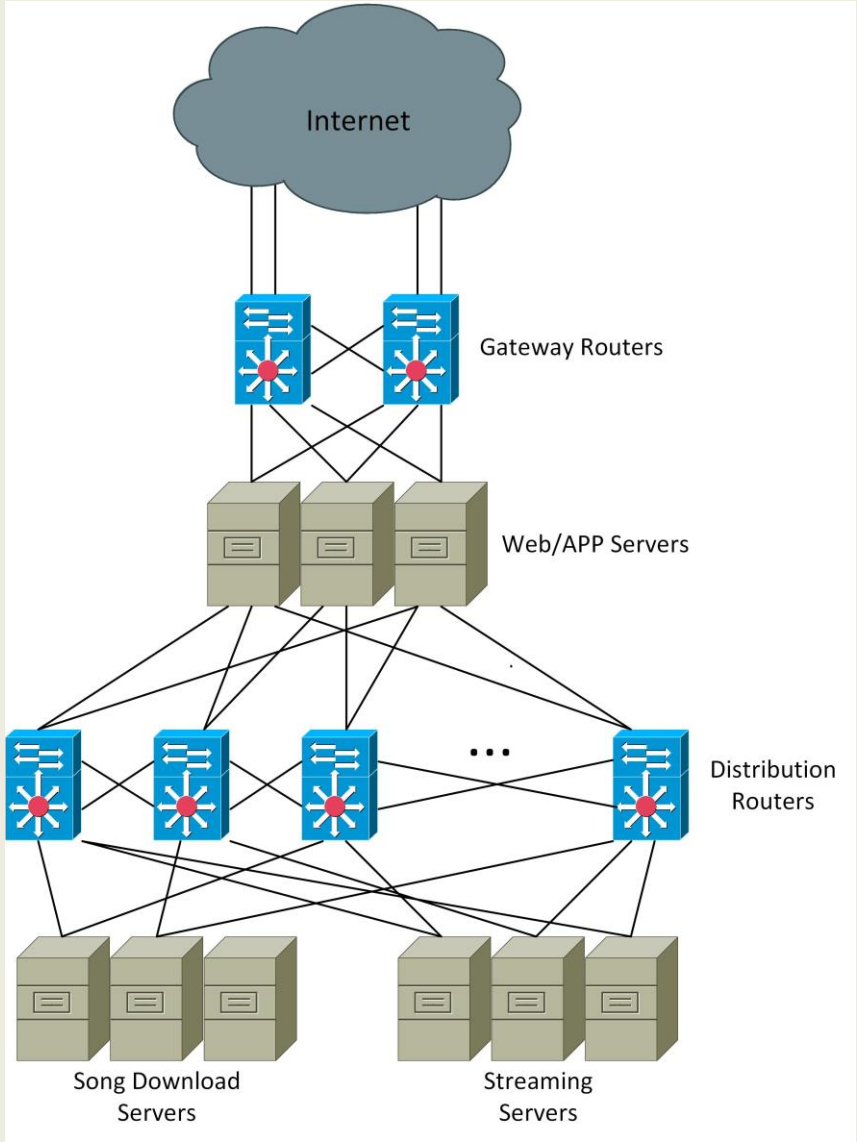
- Same approach as 1, except:
- Replace general servers with NAS for large storage needs
  - Streaming songs
  - Download songs
- NAS has no application (compute) capacity
  - Song encryption performed on the Web/App Servers
- Dell EMC Isilon Hybrid Scale H400 selected as basis of estimate
  - Up to 480 TB (used 120TB as basis for estimate, so lots of scalability for more songs and more users)
  - Up to 256GB memory
  - 8x 10GE (SFP+) network connections
  - $180K



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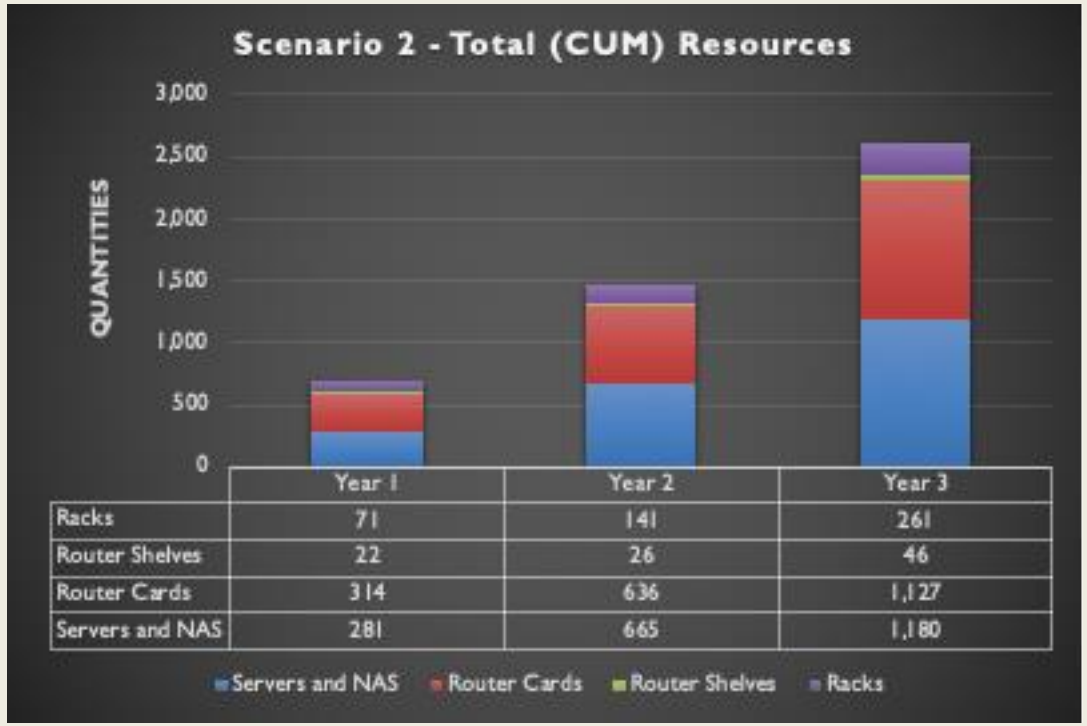

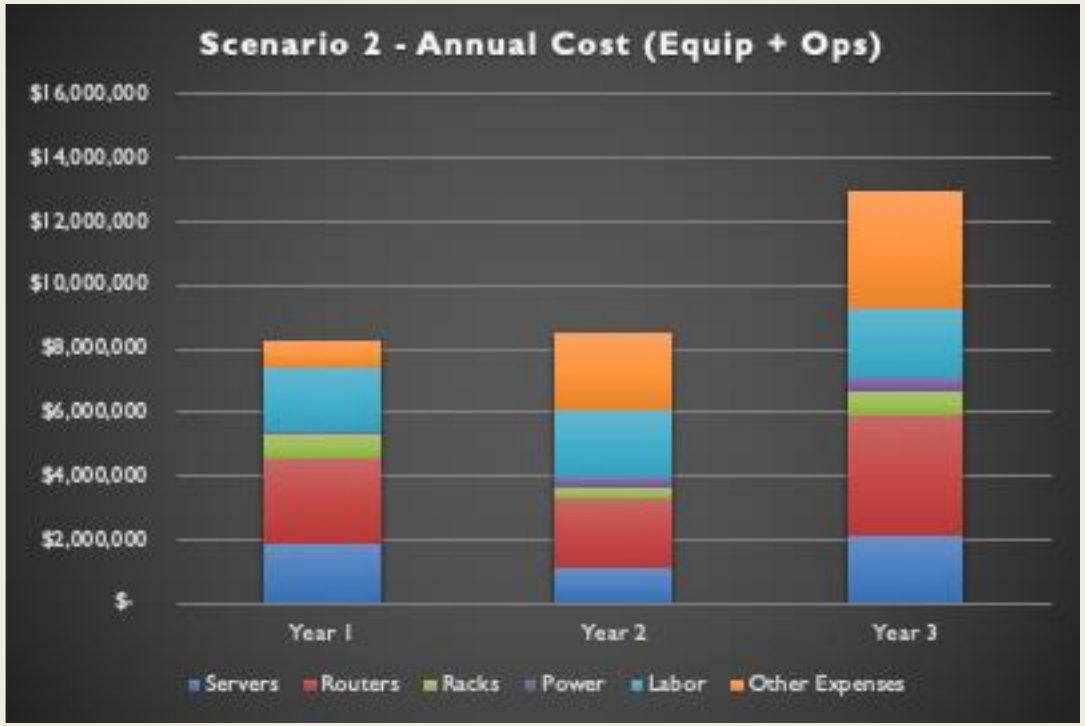

- Data Center: 16,704 total square feet, $20.45M in construction costs

Total (3-Year) Costs: $15.59M (Equip) + $14.14M (Ops) + $15.48M (Cap)

$45,205,647

SCENARIO 3 - OVERVIEW

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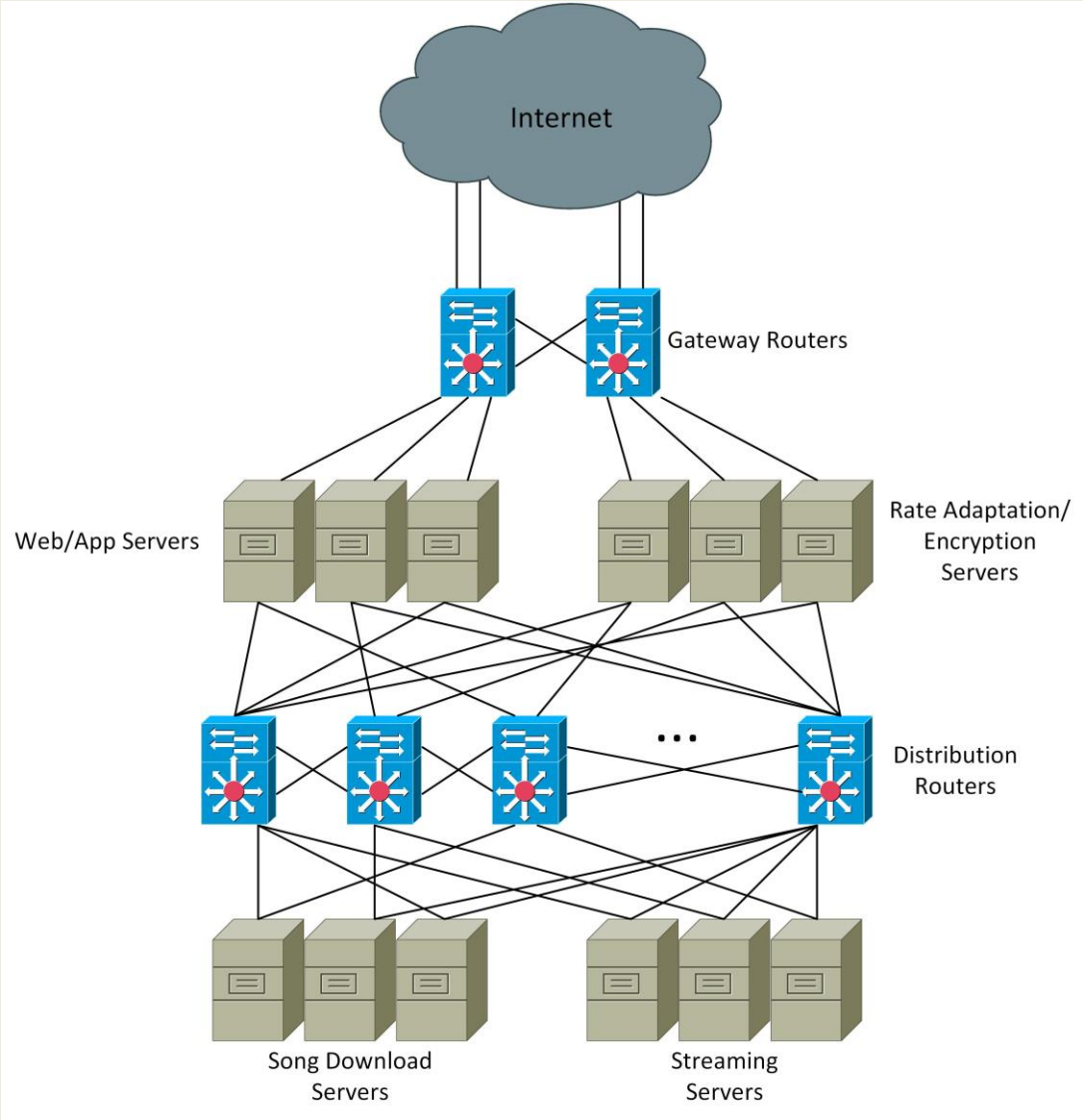
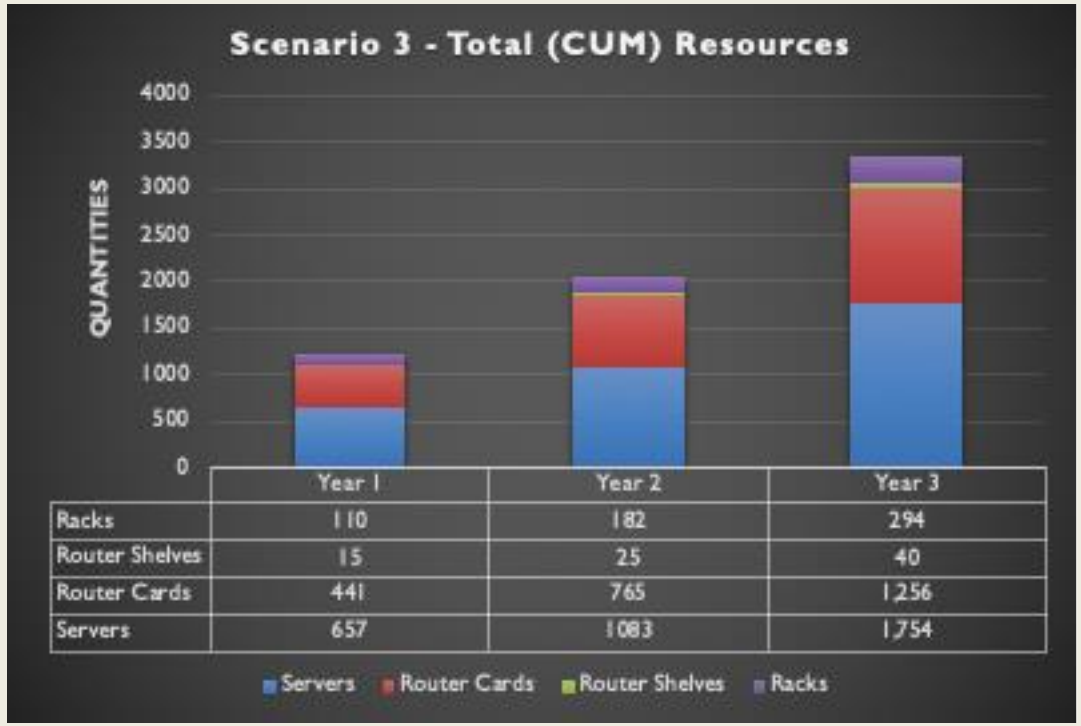
- Encryption AND Rate Adaptation On-the-Fly
  - Rate adaptation occurs before encryption
  - Download songs are only encrypted
  - Rate/Encryption Adapters stream/download songs to users
- Because of rate adaptation, no need to pre-store songs at different bit-rates
  - Only the highest bit-rate songs are stored and then compressed to low- or standard bit rates per request
  - High-bit rate song (20% of streaming requests) require no bit rate adaptation
- Servers performing rate adaptation and encryption do not need to process requests (transactions)
  - Assumption: server capacity is double that of standard user capacity
  - Allows same server to perform both rate adaptation AND encryption and normal specified user capacity



SCENARIO 3 – RESULTS

Musify



- Data Center: 18,816 total square feet, $16.83M in construction costs

Total (3-Year) Costs: $13.48M (Equip) + $14.16M (Ops) + $16.83M (Cap)

$44,458,596

SCENARIO 4 - OVERVIEW

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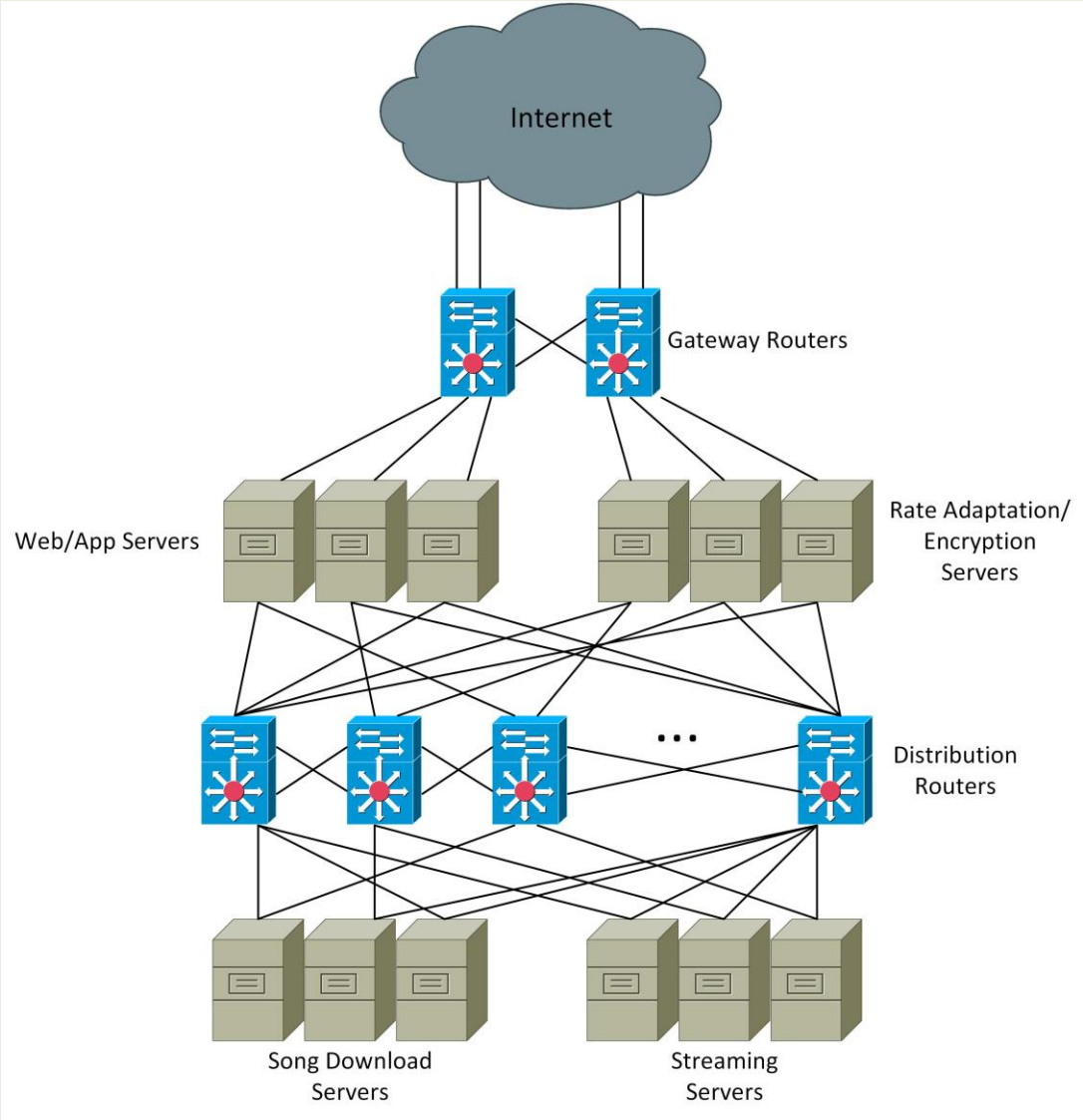
- Scenario 4 combines the assumptions of Scenarios 2 and 3
- NAS-based Storage
- Rate adaptation and encryption on separate (general) servers
  - NAS has no application (compute) capacity



SCENARIO 4 – RESULTS

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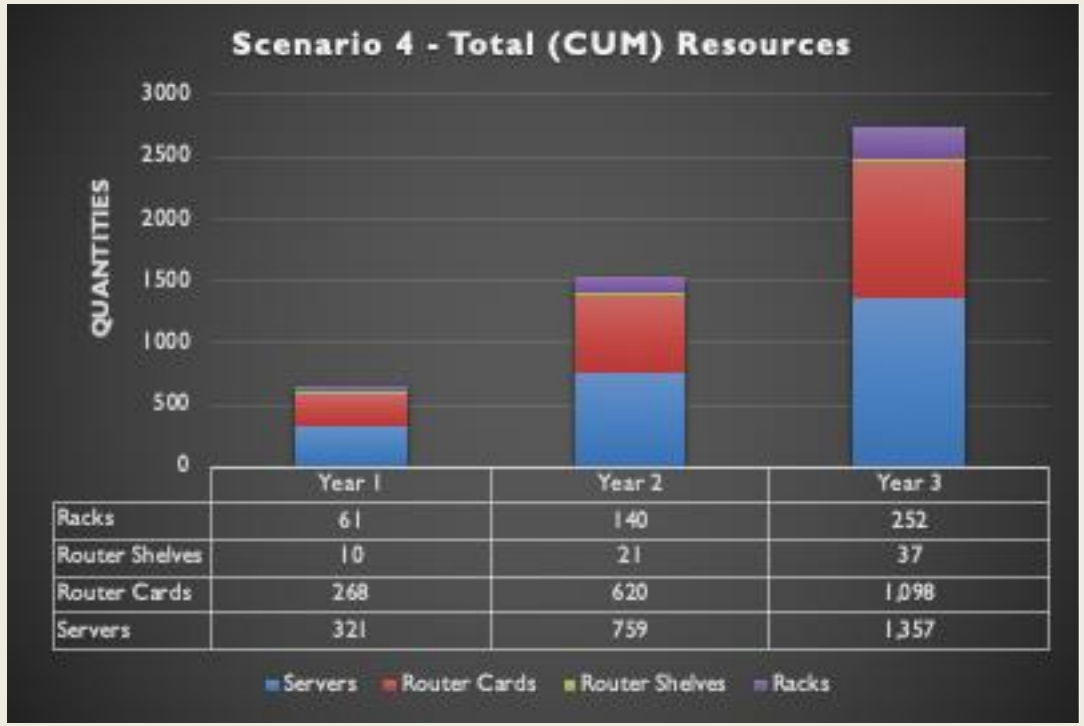

- Data Center: 16,128 total square feet, $14.55M in construction costs

Total (3-Year) Costs: $13.09M (Equip) + $13.59M (Ops) + $14.55M (Cap)

$41,232,978

OTHER CONSIDERATIONS

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- Costs could be reduced by making less conservative options regarding availability, reliability, etc.
  - Facility costs (square footage, infrastructure-related costs) significantly reduced if went with Tier II data center instead of Tier III
  - Router quantities and costs could be reduced by 25% or more if decided not to employ full 1:1 redundancy in router-to-internet and router-to-server connections
- Power costs assume all units powered on and processing 24x7 at normal capacities; could result in 50% or more reduction in power costs over a year
  - Given annual scale-up, unused capacity could be shut down at start of year and turned on over time as transactions increase
- Significant compute margin available in storage- and bandwidth-driven servers
  - Room to grow services and capability (and user base) without significant impact to resources
- Sensitivity Analysis may identify variables and assumptions to drive down costs
  - Example: 3kW rack power is VERY conservative today; many racks support 7kW or more for densely populated high-performance compute (HPC) servers
  - Denser racks means less square footage needed

RECOMMENDATION

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- Scenario 4 offers best all-around solution
  - Scalability: Through high-capacity, low-footprint, low power consumption Dell EMC Isilon NAS
    - Supports quick growth in song library and users
  - Full switch/routing redundancy
    - Reductions in redundancy from 100% can immediately grow capacity without additional equipment or facility upgrades (fiber) – increased risk of low-probability multiple failures.
  - Capacity margins support faster user growth curves
  - Lowest overall year-cost @ $41.2M
  - Tier III Data Center capability
  - Full routing redundancy

BACKUP

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