Windows Azure

Architecting large scale Azure services

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Why Windows Azure SQL Database?

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Why do customers choose to use WA SQL Database?

Reason	Description
Capacity On-Demand	You can have a database in just a few minutes from the moment you decide you need it.
Automatic Features Pre-Configured	Automatic High-Availability, Patching, Backups, and other labor-intensive features are handled by default – no work required
It's a Service	Microsoft manages it for you and deals with hardware, upgrades, uptime, etc.

WA SQL DB Architectural Implications

- Fixed Size Machines
  - Use Scale-Out , not Scale-Up
- Commodity Hardware
  - Things fail more often, implying unplanned failovers
- Automatic Logic for Backups
- Multi-Tenancy
  - Variable performance when others are busy on same machine
- On-demand capacity
  - Grow and shrink as you need

Additional Architectural Implications - Cost

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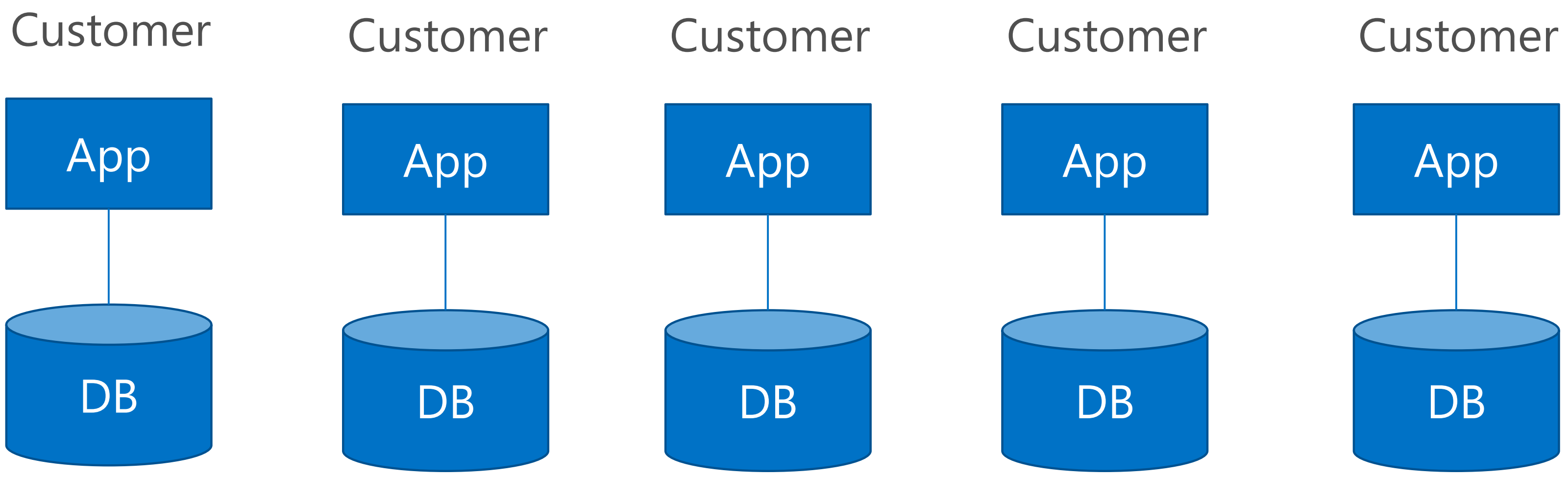
- Windows Azure has relatively cheap storage
- Often it makes more sense to store blobs or high-volume non-relational/non-transactional data on Windows Azure Storage
- Think through the choices
  - Blobs might just be easier to store in WA Storage
  - Logging data also makes sense
- This implies some differences in the application architecture

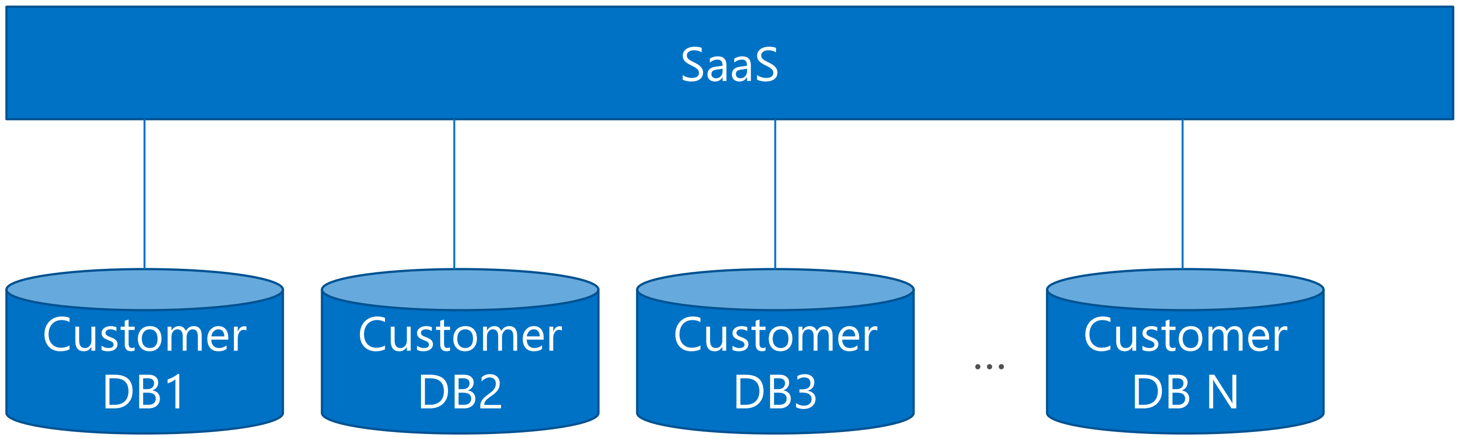
Common Scaling Patterns

- The largest WA SQL Database customers we have today are ISVs
- Build a DB App, sell it to a customer and they run it on their hardware
- Sell lots of copies, make lots of money



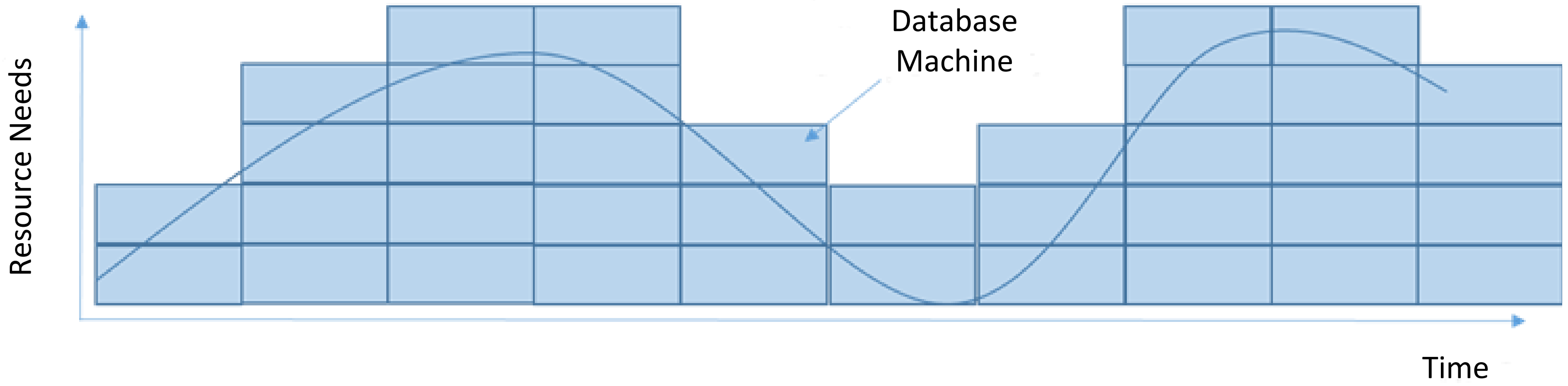
Software as a Service (SaaS) ISVs

- SaaS ISVs run their code as a layer
- Code is usually shared across many customers
- Sometimes databases are shared too
- When they have more customers, they often have more databases



Big Application Architectural Game Plan

- Find a way to get our database application to run over many machines
- Even better – make it adjust based on the resource needs for the database!
- Scale-out is natural in a Web Tier or App Tier
  - The same model can work in a Data Tier with a bit of work
- So - How can we split up a database and spread it over machines?



Data Model Sharding

- Typical OLTP databases look something like this picture
- Everything goes into a single database, but you usually only query for individual customers at a time (example: customer places an order)
- Reports run on the same database or are moved to a secondary replica to avoid contention on locks, resources

Customers

CustID	First Name	Last Name
1	Bob	Smith
2	Larry	Miller
3	Sue	Carter

Orders

OrderID	CustId	Date
1	1	1-Jan-2012
2	1	2-May-2012
3	1	5-May-2012
4	2	3-Feb-2012
5	3	21-Nov-2012
6	3	5-Dec-2012

OrderDetails

OrderDetailsID	OrderId	ItemId	Qty
1	1	12345	1
2	1	3125	5
3	2	88743	2
4	3	3532	1
5	4	99134	1
6	4	12345	1
7	5	92342	4
8	6	874	2

Data Model Transaction Boundary

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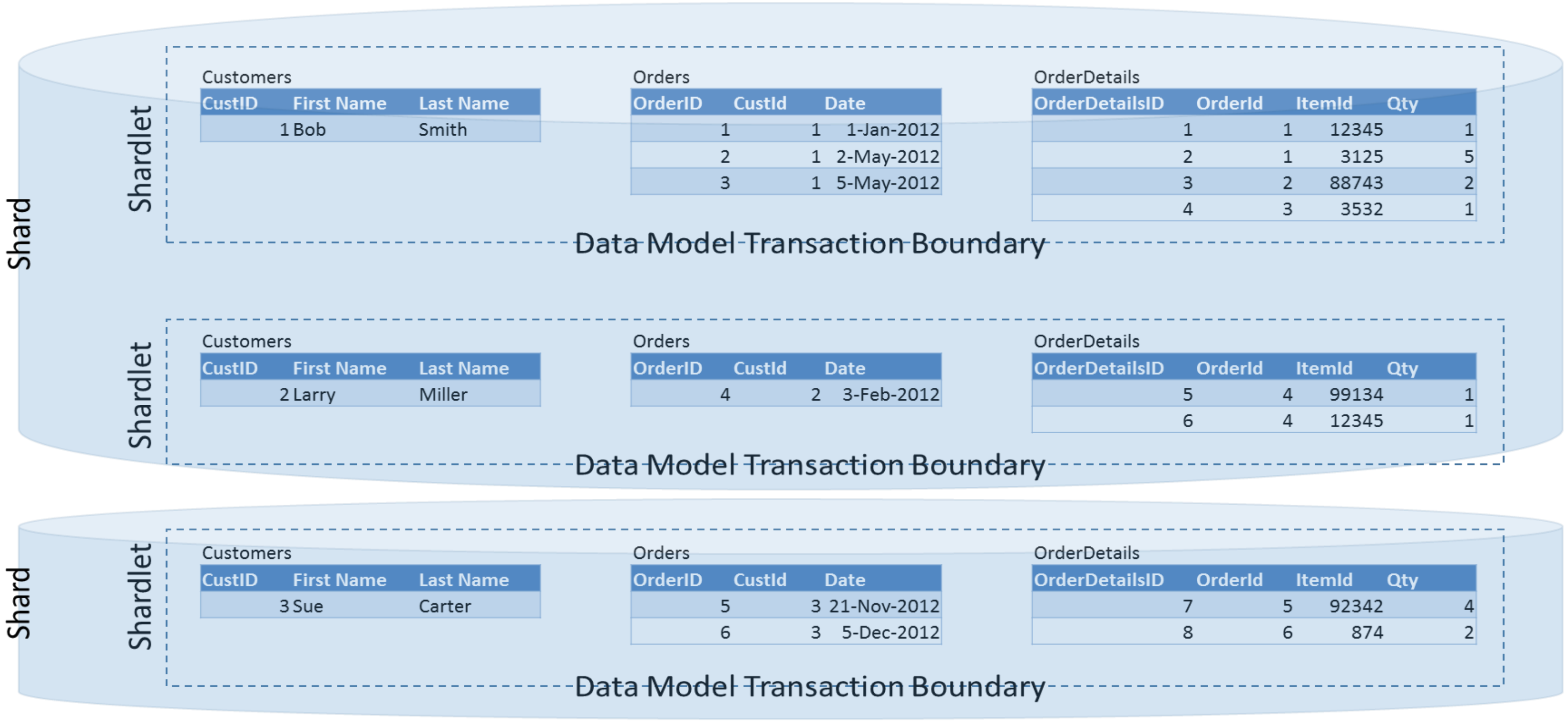
Sharded Model

- Sharded Models split the data across multiple databases that each have the same schema
- All data about one customer is located within a single database – OLTP operations work fine
- Cross-database operations do not work at all (without manual work)
- Data is automatically spread across many machines in a cluster, not just one



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OrderDetails

OrderDetailsID	OrderId	ItemId	Qty
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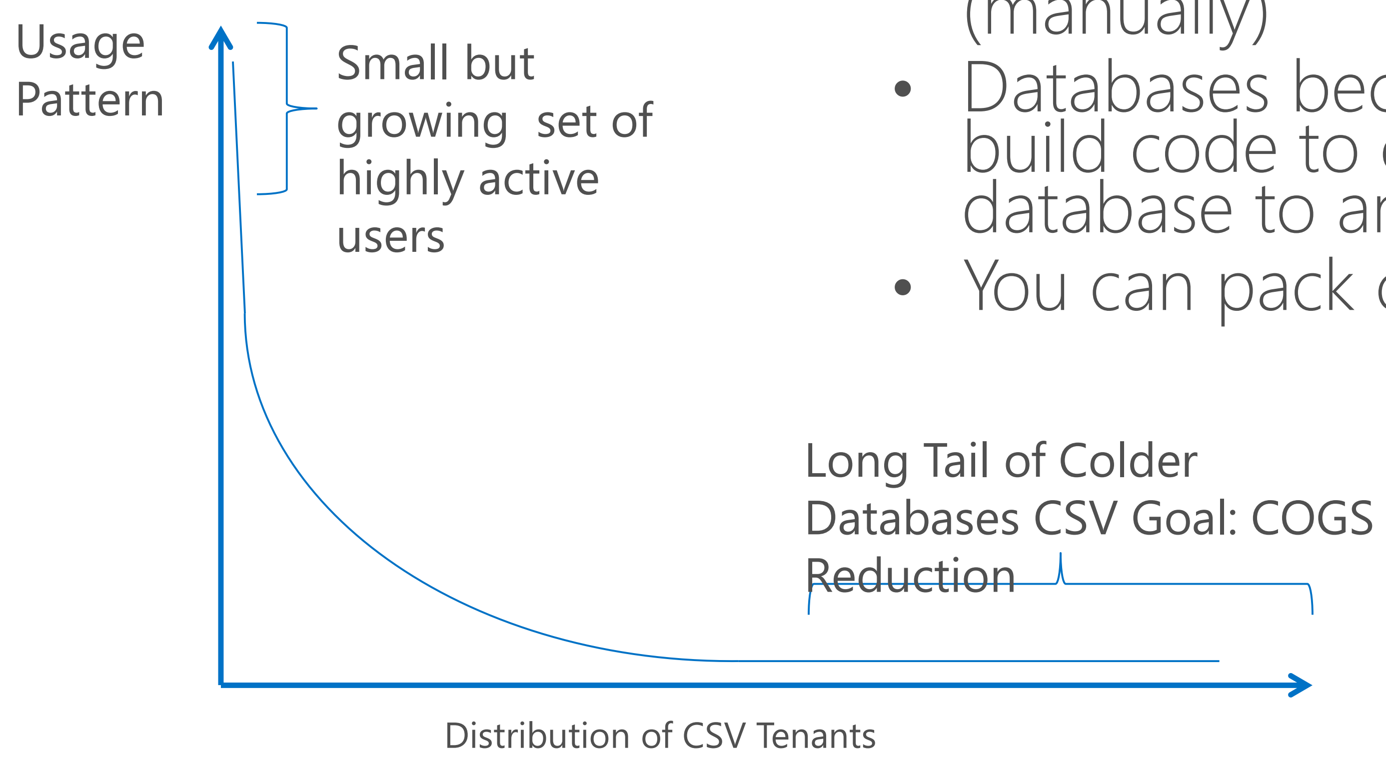
Capacity Balancing

- SQL Azure will
  - Auto-place different databases on different machines in a cluster
  - Adjust to load over time and move databases around
- We can add/remove machines under the cover as well and this pattern still works just fine
- This capability is difficult to do on normal SQL Server
  - You can try to do readable secondaries, but you still have only one master and that machine must be at least big enough for your write load
  - You can try to move files around, but then you need to set up the HA once you move around databases to adjust for load
- We do this over hundreds of machines and thousands of databases all day, every day.

Multi-Tenancy

- Single-tenancy case (1 customer = 1 database) is easy
- It is also possible to do multi-tenant cases (manually)
- Databases become containers and you build code to copy customer data from one database to another
- You can pack cold tenants to save money



Central Metadata Databases

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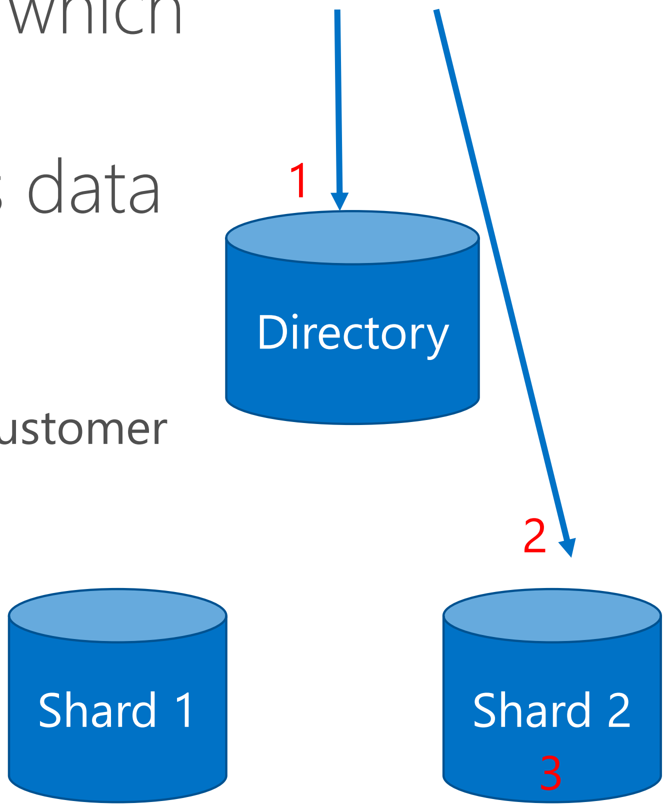
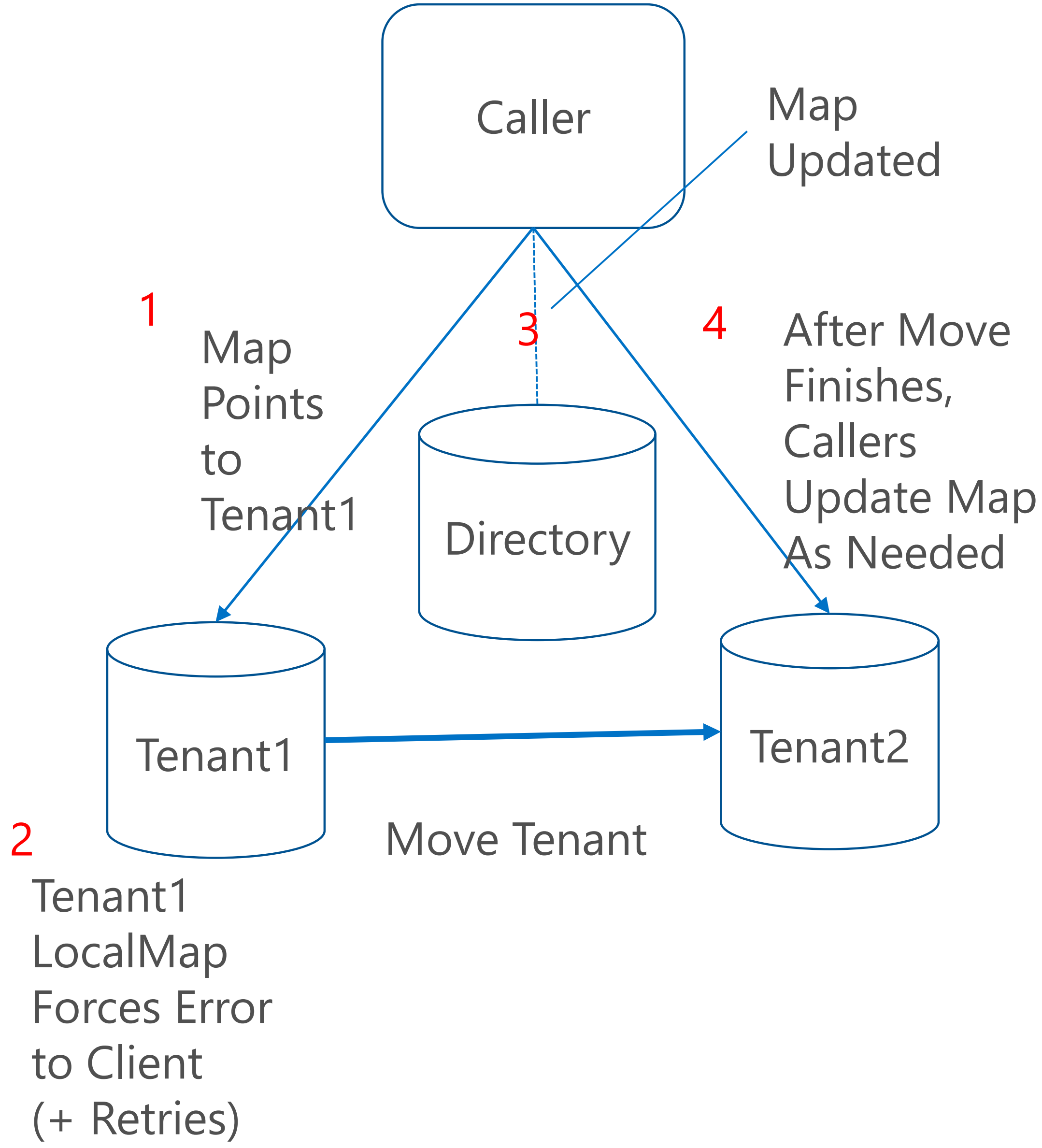
- If you have a whole bunch of databases, you need a directory to keep track of which Customers are in each database
- A "Directory" database stores this data
- General Login Path
    1. Connect to Root Database, find tenant
    2. Connect to Right Client Database for this Customer
    3. Perform Work on per-customer data



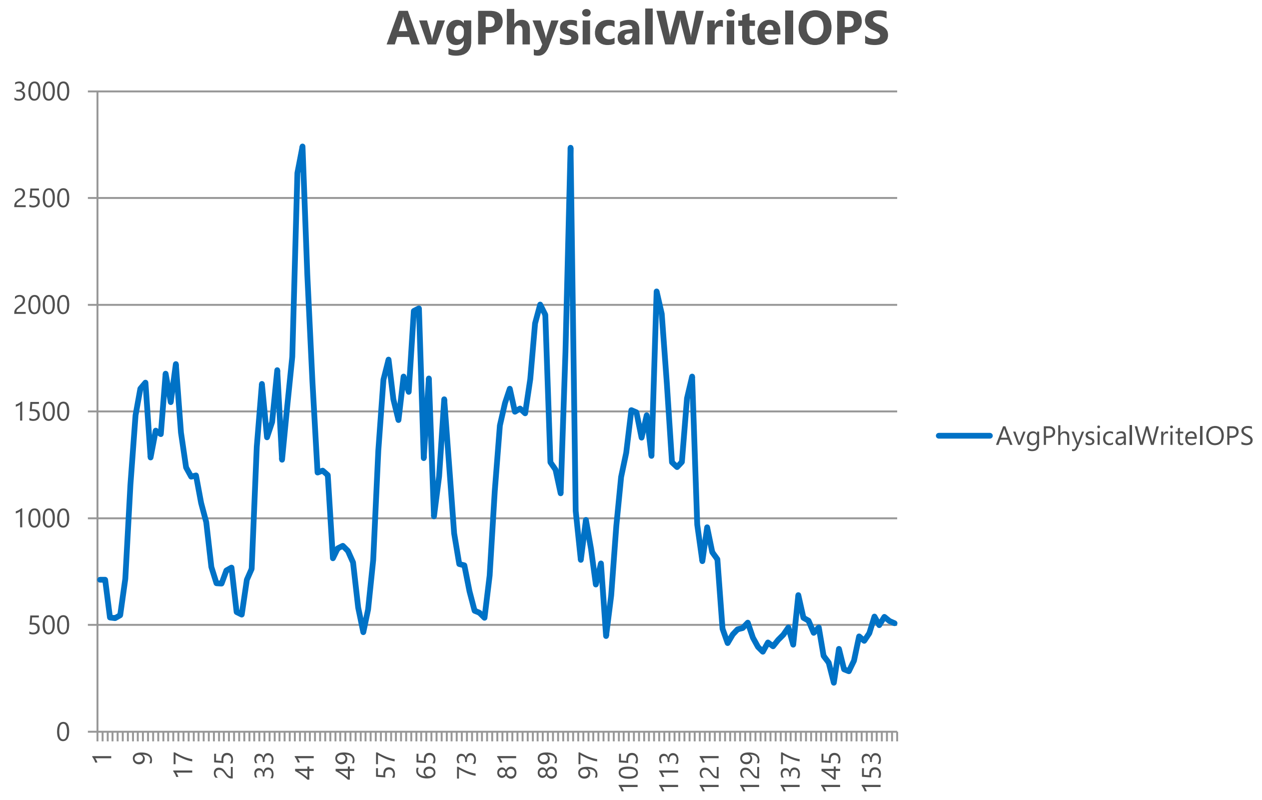
Offline Move Tenant

- You can move tenants to adjust for load/space/capacity in a SaaS ISV
- Mark per-tenant data offline in directory (often both global and local copies)
- Then copy from src->dest
- Then we mark it online again
- Client code must check for availability when connecting each time
- Online Tenant Move is possible but requires careful app planning



Telemetry

- This is an example from one SaaS ISV
- Weekly data on Physical Writes
- Thousands of Databases
- Regular weekly growth
- We spend time tuning the various jobs to even out the load and avoid spikes



Another Example

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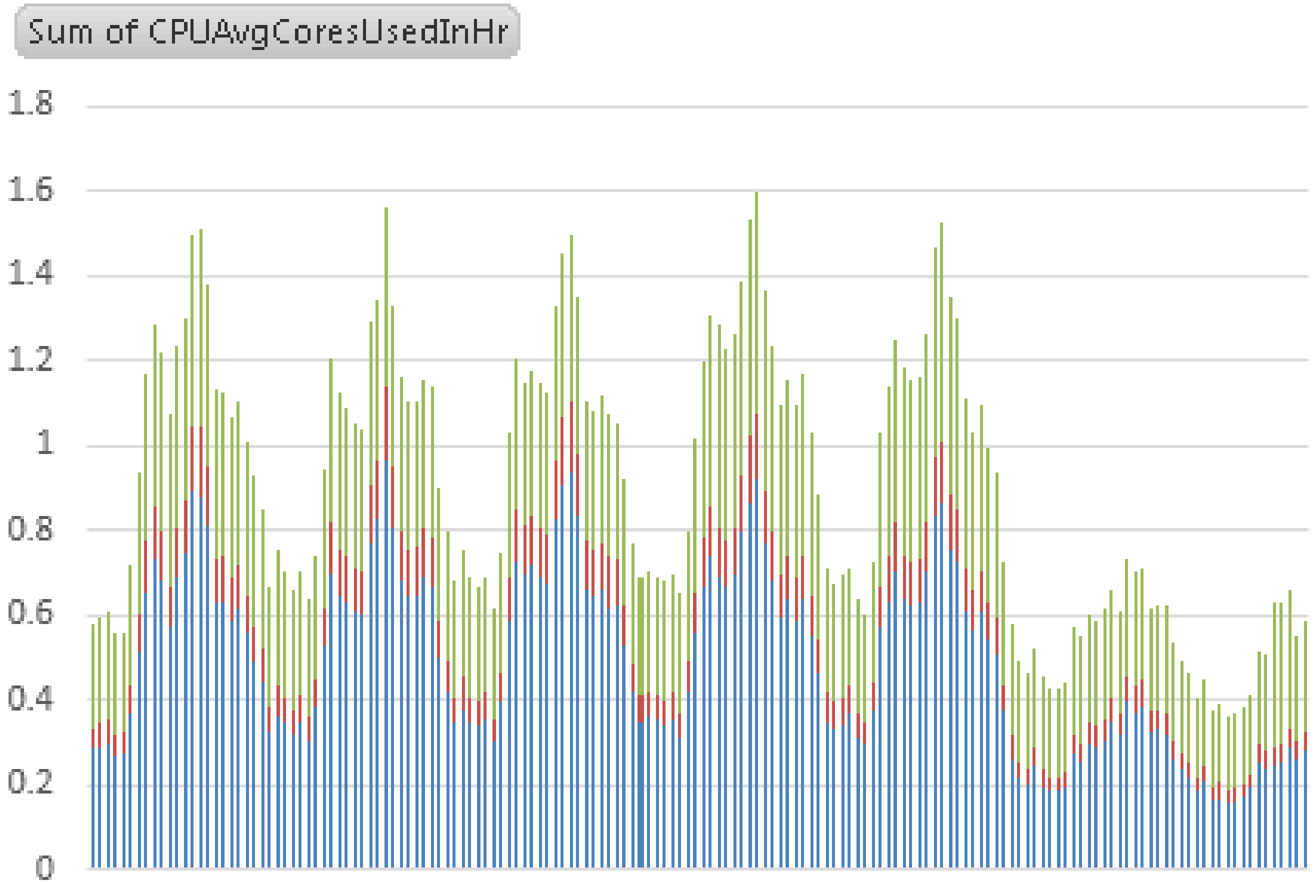
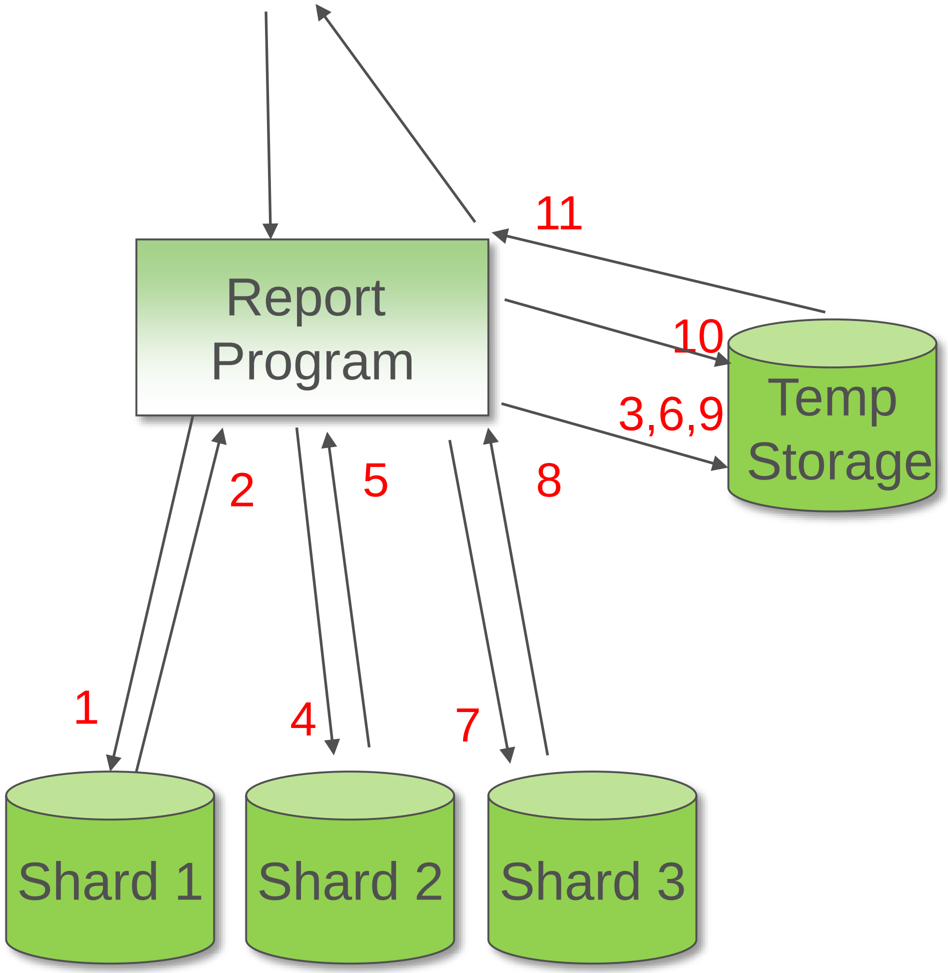
- Weekly CPU Data over 3 special databases
- We are helping this customer split out their load from a monolithic single "directory" database
- Once we finish we'll be able to grow their load 10x-100x without further changes



Reporting "Queries"

- How do you run a monthly report over all customers?
  - Iterate over each DB
  - Collect intermediate results in a single database
  - Finish query over intermediate results
- Key Details
  - Not transactionally consistent
  - Intermediate results needs to fit in one database (150GB limit)
  - Some operations may fail; re-run pieces that fail
  - On huge systems, it can take hours to run



SaaS ISV Scaling

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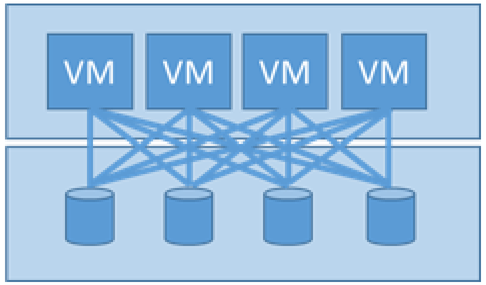
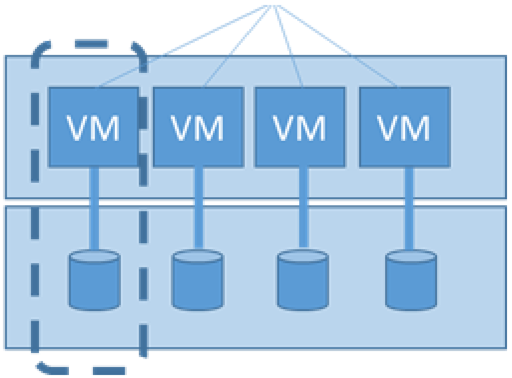
- So, what happens when you keep adding connections to a regular SQL Server instance???
  - Eventually you hit the 32K sessions cap per SQL Server instance
- WA SQL Database limits connections at far lower levels (hundreds)
- WA lets you scale each service somewhat independently
- This usually works, but it has some trouble with state-full services

State-full Scale-Out Applications on Azure

- When you Scale-Out Multiple Tiers with SQL,..
  - You can cause connections to grow at N*M instead of linearly



- Scale-Out Should *Align* Data Access Across Tiers to avoid this issue
  Front-End Routing Web Role that understands partitioning
  Separate App Tier Deployments
  Affinity with Databases



Availability

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- WA SQL DB SLA is 3 "9s" or 99.9% availability of each database
- WASD also performs automatic mechanisms that fail over databases if
  - Load is too high on one machine (load balancing across cluster)
  - A machine dies
  - We are rolling out a patch to the service
- These usually manifest as small outages when SQL fails over from one replica to another
- Like SQL Server failovers, this can cause small outages (several seconds, usually) as we move the database from one copy to another as primary

Programming for Availability Issues

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- Basic Guidance
  - Make each operation atomic (avoid lots of session state) so you can reconnect and continue
  - Make 1 Batch == 1 Transaction
  - Understand Idempotency Needs

Disaster Recovery

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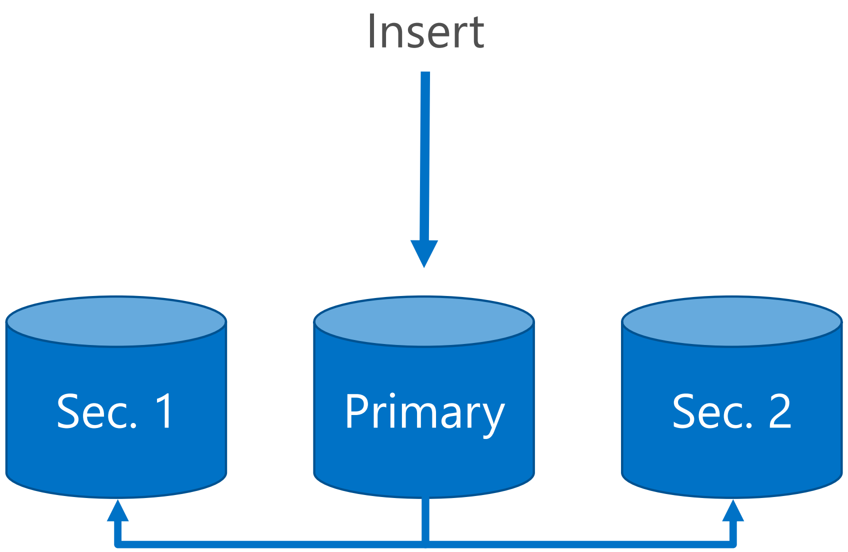
- WA SQL Database maintains 3 copies of each database in the system
- When a database is changed, the transaction commits only if a quorum "ack"s the change
- This protects you against individual machine failures and rack failures
- It does not protect you against
  - Data Center failures
  - Yourself ("Oops" scenarios)
- Failover times are usually well under 30 seconds



Changes automatically pushed before transaction commit completes

Throttling

- WA SQL DB has defined limits on various resources you can use (connections, worker threads, memory, etc.)
  - These are smaller than a dedicated SQL Server Instance (service is multi-tenant)
- WA SQL DB also defines min and max capabilities for each resource
  - You are guaranteed to get the minimum
  - You are guaranteed not to get more than the maximum
- We also measure the average experience and are improving user isolation over time (in each service release, we improve performance isolation)
- There are times when everyone on a node gets busy at once…
- WA SQL Database will sometimes throttle connections until it can rebalance the system across the cluster
  - Soft throttling will just tell you to retry
  - Hard throttling will kill your connection and force you to reconnect
  - More details in "Windows Azure SQL Database Performance and Elasticity Guide"

Designing for Unavailability

- Program “defensively” to allow for outages
- Cache data more aggressively instead of always calling DB
- Especially important for key databases (Central Metadata DB)
- Separate each part of Internet-facing Services
  - Core OLTP separated from Billing and Account Management and …
  - This allows each part to be offline separately
  - It also allows for you to upgrade each part separately
- Key Lesson: At larger scales, everything fails – you can determine how it fails in your design to minimize customer pain

Telemetry Pipelines/Dashboards

- Traditional SQL Server debugging is a hands-on affair
  - Ad-hoc tracing
  - Querying DMVs
  - Performance Counters
  - …
- With 1 Server, this is ok
  - With 5 Servers, it starts to be painful
  - With thousands of servers, it is impossible
- Debugging in Windows Azure is driven by Logging systems
- It is also critical to separate Time-To-Resolution from Root-Cause-Analysis
  - Engineers like RCA
  - Customers like Time-to-Resolution first

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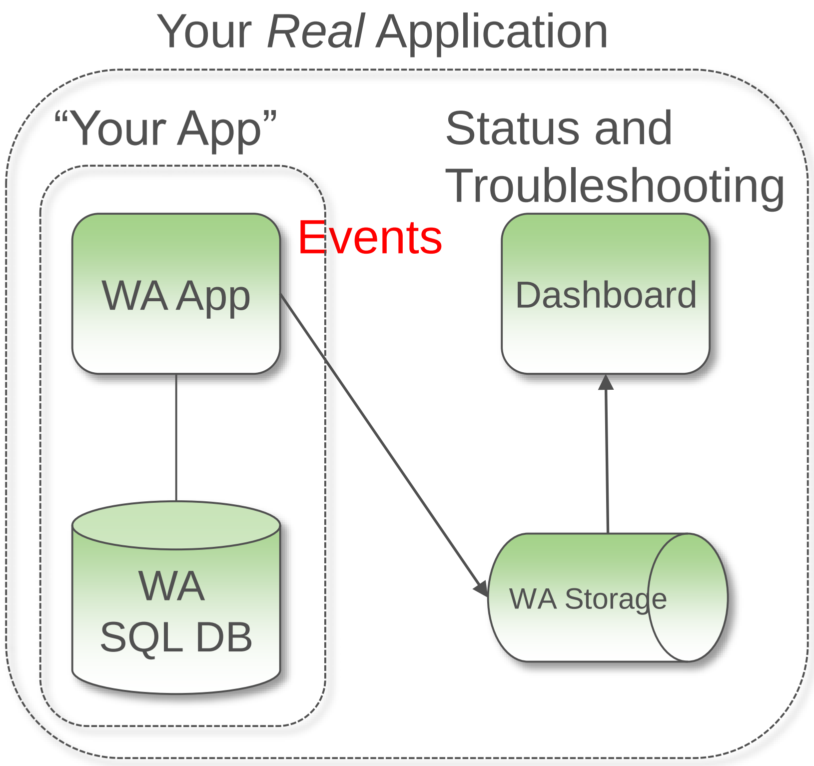
Common Telemetry Architectures

- Most "Big" Apps write events from each scaled-out instance
- Multi-Tenant Systems can not be taken "offline" to do debugging
- WA Blob/Table Storage gives higher write throughput
- Automated Log Processing used to
  - Visualize Trends
  - Spot common patterns
  - Build Alerting Systems
- Goal: Continuously automate common patterns + solutions, avoid labor costs, achieve massive scales



Upgrades?

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- Downtime is not usually an option for most services
- Upgrades should be split into small pieces
- Example
  - Roll out schema changes first (no code behavior changes)
  - Then roll out side-by-side stored procedures (old, new)
  - Roll out Application Tier changes (draining old, starting to use new)
  - Eventually, remove “old” stored procedures in clean up step
- Functionally Partition Service into different components
  - Do upgrades for each service independently (if needed)
- Primary Goal: Avoid ALL downtime

Conclusion

- We have customers running at large scales (thousands to tens of thousands of databases) across multiple geographies
  - Thousands to hundreds of thousands of end-users.
- This pattern enables building Internet-facing web sites and services
  - …that can scale almost arbitrarily
- Over time, we hope to make it easier and faster for customers to make applications in this model.

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Designing data tiers for the cloud

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Principal Program Manager
Windows Azure Customer Advisory Team

Microsoft

Agenda

- Windows Azure Storage Options
  - Windows Azure Storage
  - SQL Server in Azure VMs
  - Azure SQL DB
- Azure SQL DB Performance/Scaling
  - Sizing databases
  - Cost Optimization
  - Techniques to minimize peak load
- Functional Partitioning
- Sharding Trigger Points
- Application Tier Caching

Azure Storage Options

Platform as a Service

- Azure SQL Database (managed databases)

- It's not SQL Server!
- Publish and run
- Shared environment

Infrastructure as a Service

- SQL Server running in a Windows Azure VM

- It's SQL Server!
- Full control / insight
- More administrative effort

Azure Storage

- Tables
- Blobs
- Queues

- No relational
- Cheap storage
- Optimized for density

Azure Storage Tables

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Schema-less / NoSQL abstraction on Azure Storage (video – slides - paper)
No relational capabilities, limited query-ability
Works great for append-only workloads, range (partition key) lookups

Density
• Use appropriate partition keys to co-locate data
• Use appropriate partition keys to break data up into more partitions
• Implement retry logic with back-off for 503 (service unavailable) errors
• Avoid use of table storage for applications requiring non-trivial aggregation or function projection
Scale
• Leverage partitioning multiple storage accounts (not multiple tables) to increase operations/second

Table Limits	Limit
Max operations / second per partition	2,000
Max row size (names + data)	1 MB
Max column size (byte[] or string)	64 KB
Maximum number of rows	N/A (up to storage account size limit)
Scale-out unit	Table partition
Scale-out impedance	Low

SQL Server in Windows Azure VMs

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More transparency, control and tuning options

- Application compatibility, works with any traditional workload
- Storage layout flexibility, trace flags, etc.
- Windows Azure Blobs exposed as NTFS volumes

Multiple VM sizes available

- Up to 8 cores, 56 Gb of RAM and up to 16 Data Disks (up to 1TB each, 16 x 500 IOPS)

Can be deployed in HA/DR configurations leveraging AlwaysON

- Require a proper maintenance plan and cloud ‘infrastructure design’ (no single VM deployment in production)

Can scale up to the biggest size available

- Require adequate planning for scale out scenario (can leveage AlwaysON readable secondaries)
- Require additional efforts if full elasticity is needed (e.g. optimize running costs based on peaks management)
- With careful design (DIP communication) can minimize latency, but still exceeds co-located on-premise

Azure SQL Database

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Multi-tenant environment with shared resources

- Worker threads, Memory, Log, IO subsystem
- Resource governance
- HA configuration out of the box (3-copies replica set)
- Self provisioning, limited maintenance required

Works great with OLTP workloads

- Point lookup, fully relational
- Less for DW and analytical queries, no parallelism
- Cloud client access approaches (batch, minimize round trips) to improve latency and avoid resource throttling

Scale out approach (not just db size but computing resources)

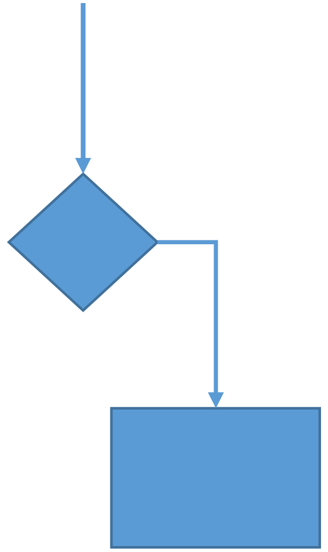
- Adding more databases gets you more performance
- Microsoft balances load over time

Soft and hard throttling to protect system stability

- Requires retry logic and restartability

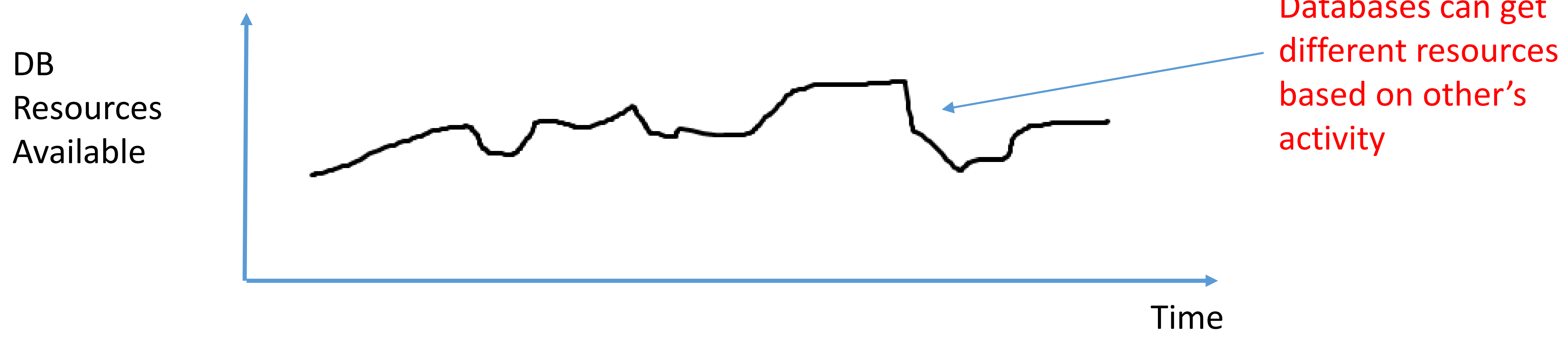
Decision Points

- Common Data going to WA Storage
  - Telemetry Logs
  - Blobs for WA SQL DB (lower costs, reduce DB size under 150GB limit)
  - Things where cost is the driving factor
- Commonly going to SQL Server in VM
  - Existing SQL Server applications (they get hosting)
  - Applications needing more performance (IOPS usually) – light DW workloads
  - Applications needing features not in SQL DB (example: Fulltext)
- Commonly going to SQL DB
  - Applications who do not want to manage their databases
  - Applications that need massive horizontal scale (Internet-facing SaaS ISVs)
  - SQL Server applications where the customer is willing to do some rearchitecting



SQL DB Web/Business Performance Variance

- Web/Business Editions provide no performance guarantees
- We host hundreds of customers on a single machine
- Performance of your DB will vary based on what others are doing
- SQL DB contains logic to move DBs around to balance load across each cluster to maximize average resources



Premium Edition

- Not all applications work well in shared environments
- Premium Edition was introduced for customers who need dedicated resources.
- Common customer attributes:
  - High throughput requirements
  - Low latency requirements
  - Low performance variance requirements
- Premium Edition details
  - Dedicated resources (min=max) to avoid performance variance
  - Different sizes (P1-P2) allow adjustment based on resource needs
  - Currently in Public Preview

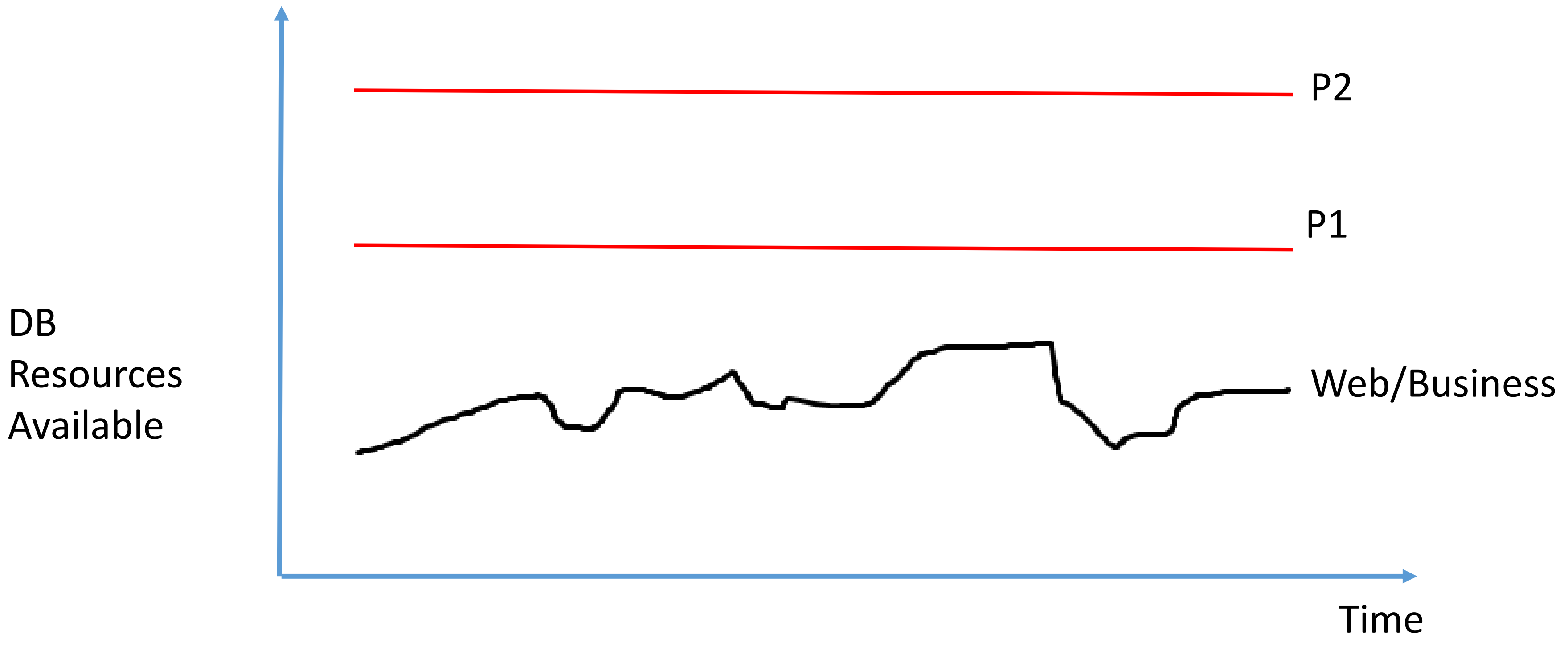
Premium Edition Reservation Sizes

- Reservations are done separately for each database
  - Capacity is limited during public preview
  - Customers can get 1-2 reservations based on availability
- Monthly Price is USD $930 for P1 at GA. P2 is 2x

Size	CPU Cores	Worker Threads	Active Sessions	Disk IO (IOPS)	Memory (GB)
P1	1	200	2000	150	8
P2	2	400	4000	300	16

Edition Comparison

- Premium has reserved resources
- You can upgrade or downgrade a database
- You should decide sizing based on your resource needs



Scale up comes with a cost

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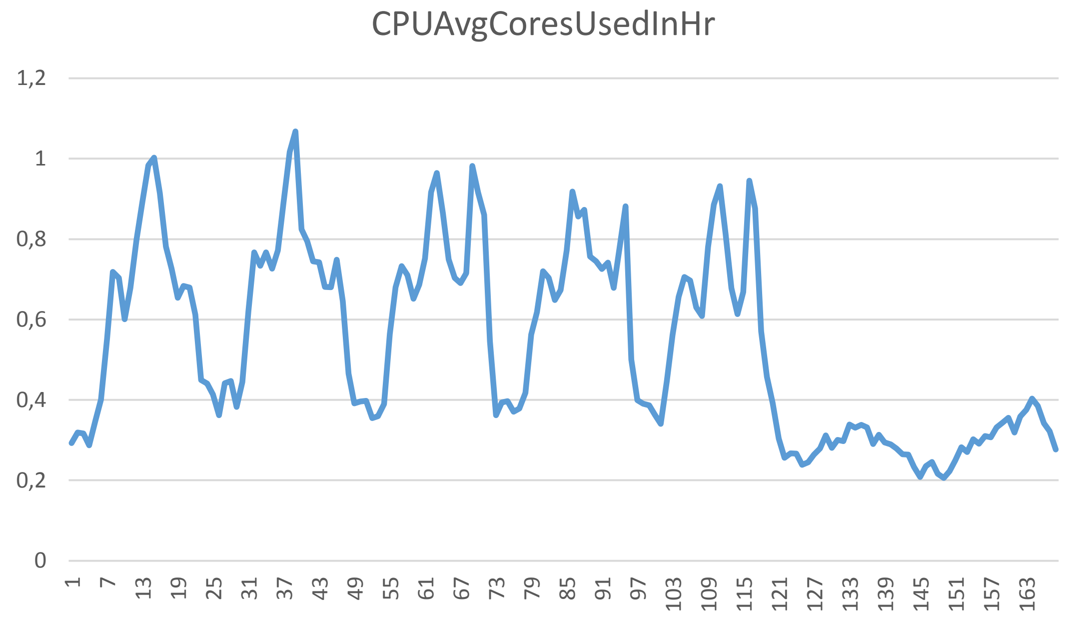
SQL Premium DB Size	SQL Premium GA Monthly Cost	SQL VM Monthly Cost	SQL VM Size (Enterprise Edition)
P1 (M) 1 CPU Core 8GB RAM 150 IOPS	$930	$1,629	S (A1) 1 CPU Core 1.75GB RAM 2x500 IOPS
P2 (L) 2 CPU Cores 16GB RAM 300 IOPS	$1860	$1696	M (A2) 2 CPU Cores 3.5GB RAM 4x500 IOPS
		$1,830	L (A3) 4 CPU Cores 7GB RAM 8x500 IOPS
		$2,321	A6 4 CPU Cores 28GB RAM 8x500 IOPS
		$3,660	XL (A4) 8 CPU Cores 14GB RAM 16x500 IOPS
		$4,642	A7 8 CPU Cores 56GB RAM 16x500 IOPS

- SQL DB resources are dedicated to that database workload only, SQL VM resources will be used to run the entire VM (OS + SQL + all databases)
- A single SQL VM does not provide any availability SLA. You'll need 2 instances and AlwaysOn
- Premium will offer more than just performance predictability

Sizing Databases

- For a SINGLE database…
  - Find largest resource consumer
  - Measure peak load over time period
  - Choose appropriate reservation size to handle peak load
- Workload Type matters
  - Batch processing – aim to achieve avg throughput over time (not size for peak)
  - Interactive applications need to size for the peak to preserve response times



Capacity planning

- Use *sys.resource_stats* in master db to determine your application resource needs:

```sql
SELECT * FROM
sys.resource_stats
WHERE  database_name =
'MyTestDB' AND start_time >
DATEADD(day, -7, GETDATE())
```

	start_time	end_time	database_name	sku	usage_in_seconds	storage_in_megabytes	avg_cpu_cores_used	avg_physical_read_iops	avg_physical_write_iops	active_memory_used_kb	active_session_count	active_worker_count
1	2013-09-27 09:10:00.00	2013-09-27 09:15:00.00	MyTestDB	Web	0	1.57	0.0000000	0.0000	0.0867	0	0	0
2	2013-09-27 09:15:00.00	2013-09-27 09:20:00.00	MyTestDB	Web	0	1.57	0.0005733	0.0033	0.0033	0	2	0
3	2013-09-27 09:20:00.00	2013-09-27 09:25:00.00	MyTestDB	Web	0	1.59	0.0000000	0.0000	0.0033	0	2	0
4	2013-09-27 09:25:00.00	2013-09-27 09:30:00.00	MyTestDB	Web	0	1.59	0.0000000	0.0000	0.0033	0	2	0
5	2013-09-27 09:30:00.00	2013-09-27 09:35:00.00	MyTestDB	Web	25	9.46	0.0844000	0.0267	1.1933	0	102	98
6	2013-09-27 09:35:00.00	2013-09-27 09:40:00.00	MyTestDB	Web	23	9.46	0.0789833	0.0000	1.1933	0	102	100
7	2013-09-27 09:40:00.00	2013-09-27 09:45:00.00	MyTestDB	Web	7	20.15	0.0245567	0.0000	0.4600	0	2	0
8	2013-09-27 09:45:00.00	2013-09-27 09:50:00.00	MyTestDB	Web	0	20.15	0.0000000	0.0000	0.0033	0	1	0

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Investigating resource usage

Avg and Max resource usage

```
SELECT
    avg(avg_cpu_cores_used) AS 'Average CPU Cores Used',
    max(avg_cpu_cores_used) AS 'Maximum CPU Cores Used',
    avg(avg_physical_read_iops + avg_physical_write_iops)
AS 'Average Physical IOPS',
    max(avg_physical_read_iops + avg_physical_write_iops)
AS 'Maximum Physical IOPS',
    avg(active_memory_used_kb / (1024.0 * 1024.0)) AS
'Average Memory Used in GB',
    max(active_memory_used_kb / (1024.0 * 1024.0)) AS
'Maximum Memory Used in GB',
    avg(active_session_count) AS 'Average # of Sessions',
    max(active_session_count) AS 'Maximum # of Sessions',
    avg(active_worker_count) AS 'Average # of Workers',
    max(active_worker_count) AS 'Maximum # of Workers'
FROM sys.resource_stats
WHERE  database_name = 'MyTestDB' AND start_time >
DATEADD(day, -7, GETDATE())
```

Percentage of time using more than 1 core

```
SELECT
(SELECT
    SUM(DATEDIFF(minute, start_time, end_time))
    FROM sys.resource_stats
    WHERE database_name = 'MyTestDB' AND
          start_time > DATEADD(day, -7, GETDATE()) AND
          avg_cpu_cores_used > 1.0) * 1.0 /
SUM(DATEDIFF(minute, start_time, end_time)
) AS percenage_more_than_1_core
FROM sys.resource_stats
WHERE database_name = 'MyTestDB' AND start_time > DATEADD(day,
-7, GETDATE())
```

	percenage_more_than_1_core
1	NULL

	Average CPU Cores Used	Maximum CPU Cores Used	Average Physical IOPS	Maximum Physical IOPS	Average Memory Used in GB	Maximum Memory Used in GB	Average # of Sessions	Maximum # of Sessions	Average # of Workers	Maximum # of Workers
1	0.0235641	0.0844000	0.372062	1.2200	0.000000000000	0.000000000000	26	102	24	100

Cost Optimization

- Two paths to improve your cloud service
  - Spend more money (purchase more capacity)
  - Optimize/Tune (more operations in capacity you have)
- The Cloud model let you choose
  - If you have development resources available, you might choose to ‘tune’
  - If you are on a time deadline, you might just choose to spend more instead
- This model also works great for seasonal demand changes
  - Example: Add capacity before the holiday sales season, remove after

Managing Peak Load

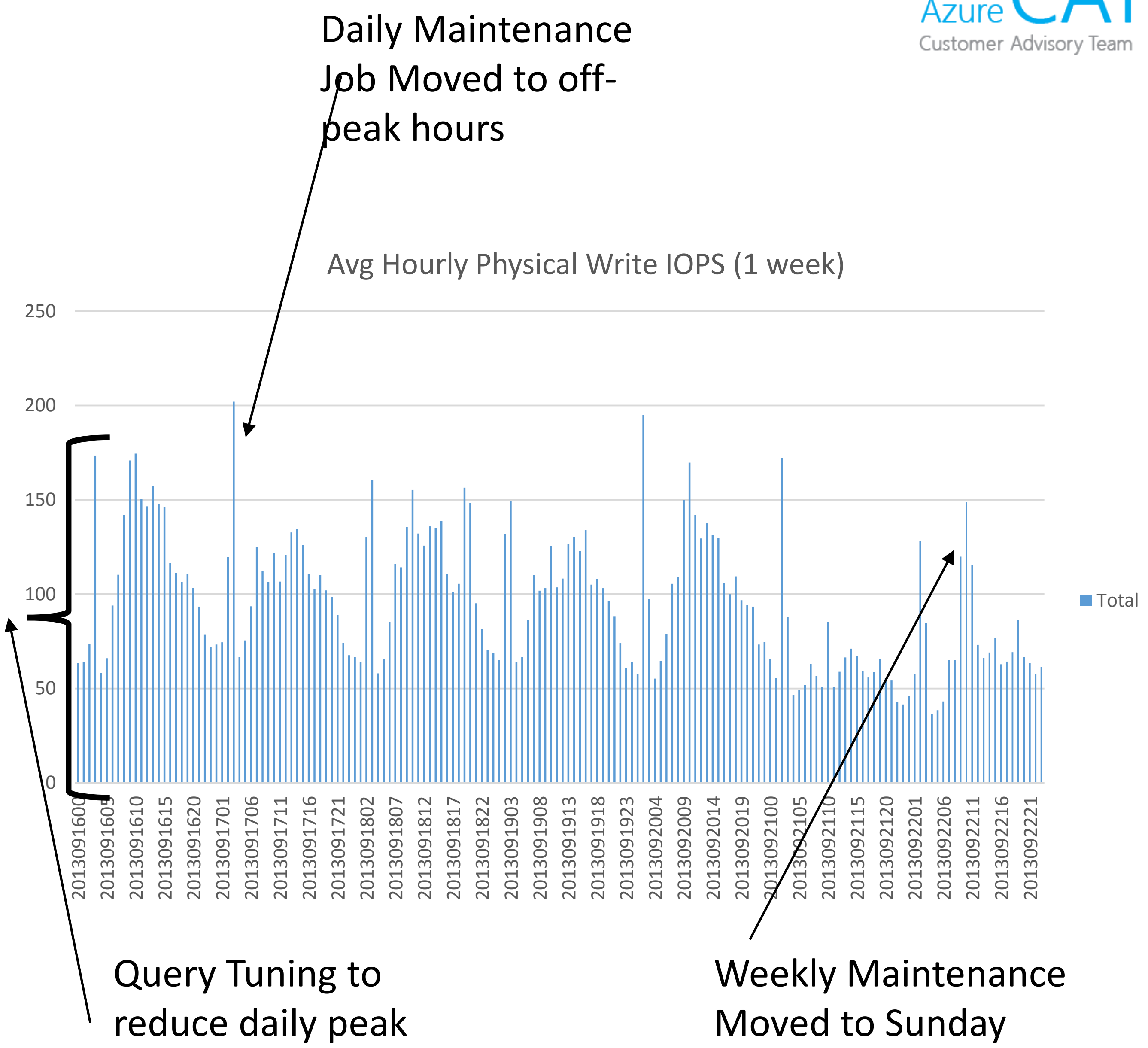
- Normal Box Capacity Planning happens rarely (usually once)
  - You buy a box bigger than you hope you will ever need
  - You tune as needed to make things work well in that box
  - If things are really bad, buy a bigger box
- Cloud planning is more-or-less continuous
- When you want to not spend more money, you tune
- Some tuning is just like normal SQL Server (tune queries, etc.)
- Other tuning is completely different…

Managing DB Resource Growth

- Database size/resource growth need careful management in SQL DB
  - There are size limits on things and you can be broken if you hit them
- Assuming your application resources grow over time, you need a plan to deal with that growth
- Two architectural approaches to manage
  - "Scale-up" (limited): Web/Business -> P1 -> P2
  - "Scale-out": use more databases
- Partitioning data by function or by tenant allows you to adjust as needed to growth in resource usage
- Plan on actively monitoring/alerting telemetry about the resource use so you can adjust to growth before something breaks…

Peak Load Example

- Weekly IO chart of a large customer on WA SQL DB
- We **actively** work on the load each week
  - Query tuning
  - Moving maintenance jobs to off-peak hours
- We also do aggressive things
  - Split different functions out into different databases
  - Rate-meter background jobs to not impact core workloads



Scale-Up vs. Scale-Out

- P1-P2 supported during public preview period
- Additional sizes can be introduced by GA
- With a scale up approach you may lose some flexibility
  - E.g. require planning for worst case / peaks
  - Premium let you scale up/down between P1 and P2 max one time a day
- Scale up may not fit all costs/business models
  - Unpredictable workloads
  - Multiple database deployments

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Easyjet Seat Selection System

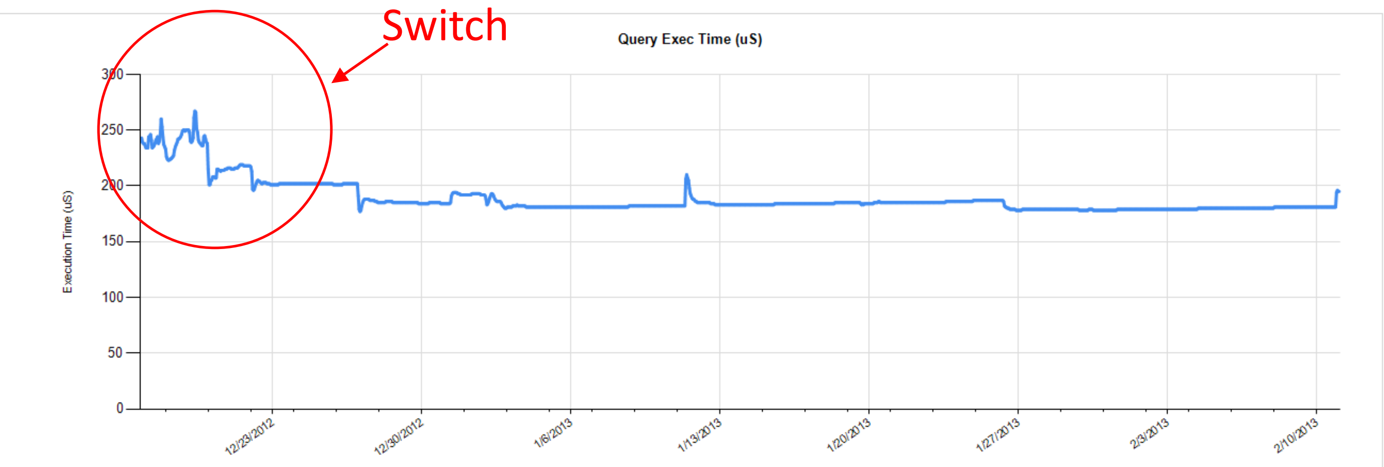
- 70/30 R/W workload, very efficient workload (<200mS max exec time)
- Majority of queries benefitted from switching
- Reduced and more stable response times for both reads and writes

SQL Database: Hourly Execution Time Stats

Return To Main Dashboard

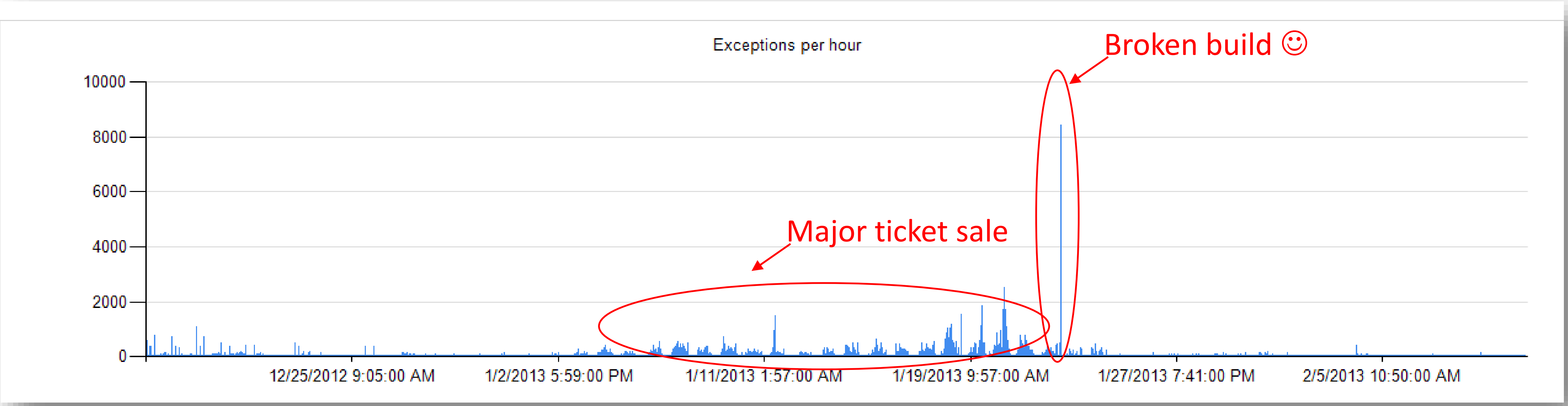
From: 12/1/2012 4:58:30 AM To: 2/11/2013 4:58:30 AM

Query text:	Avg Exec Time (uS):	Avg Elapsed (uS):	Avg Reads:	Avg Writes:	Count:	Last Execution Time:
SELECT s.FlightId, s.RowNumber, s.Letter, s.BlockNumber, s.SeatStatusId as Status, s.WithInfant, s.ReservedUntil, s.ReservationToken, s.ItineraryId, s.SeatAtGate, s.SsrNonPreferredSeat, s.[Timestamp] FROM dbo.Seat s WHERE s.FlightId = @FlightId ORDER BY s.rowNumber, s.Letter	181	227	5	0	24556022	2/11/2013 2:01 AM



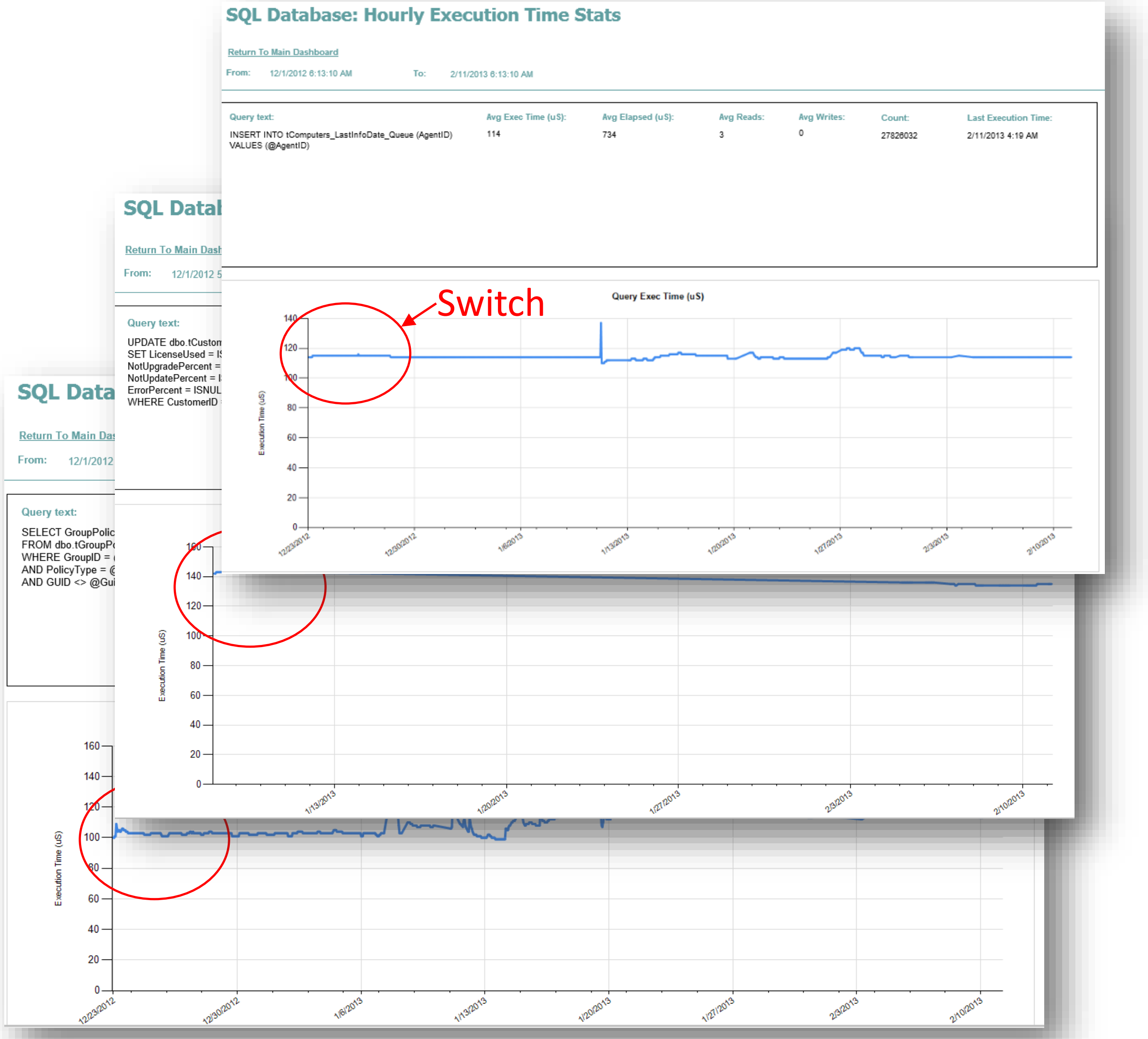
Customer experience: Easyjet

- Reduced impact of 40501, 10928 and 10929 errors
- Remaining exceptions have been mostly due to application issues



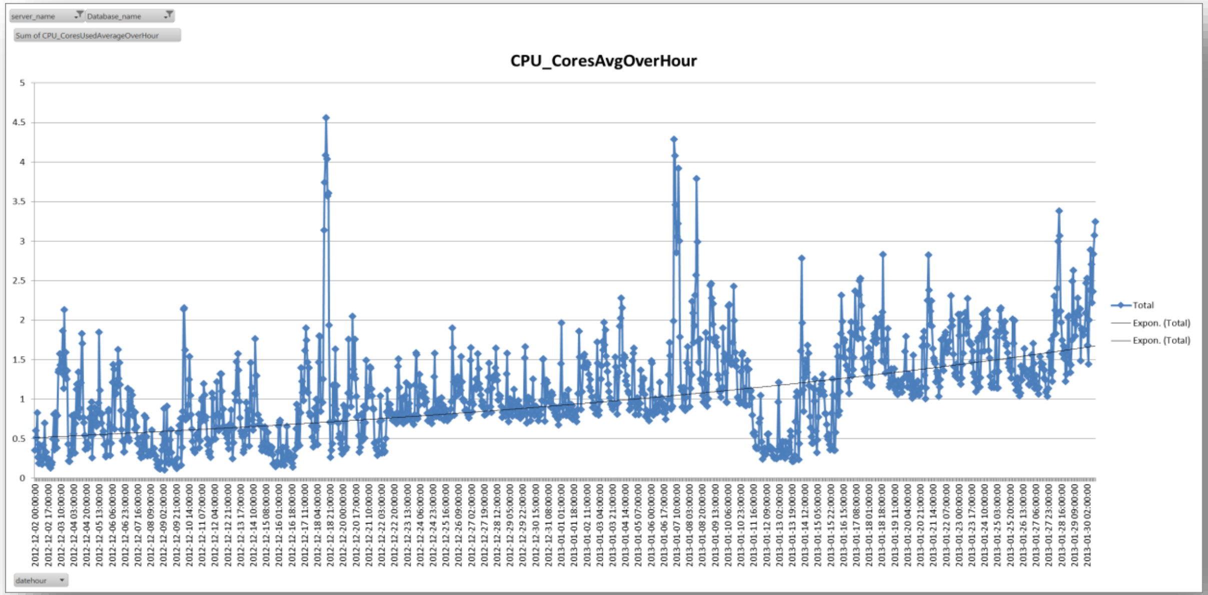
Customer experience: Panda Security

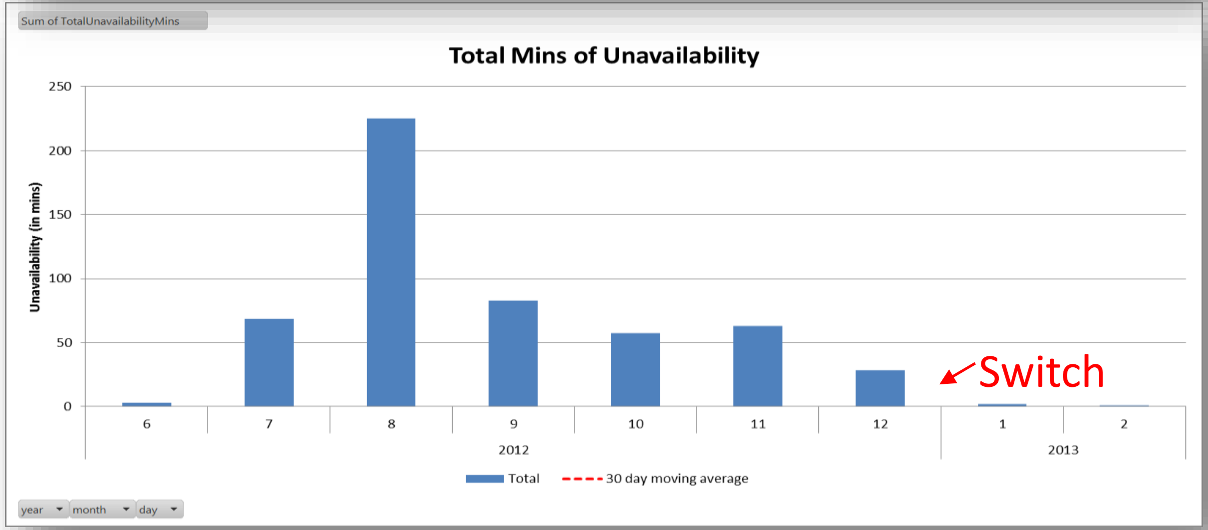
- 60/40 W/R workload
- Queue-like usage
- Have peaks of 50 active requests
- Many sub-optimized queries (indexing, blocking, etc)
- Most of the queries are stable, no big benefits after switch



Customer experience: Panda Security

- Availability has greatly improved after the switch (less than 2min x month)
- Growing trend in CPU usage
  - Around 2 on average, with spikes up to 5
- No major errors related to resource issues
- Sporadic throttling for High Log IO waits





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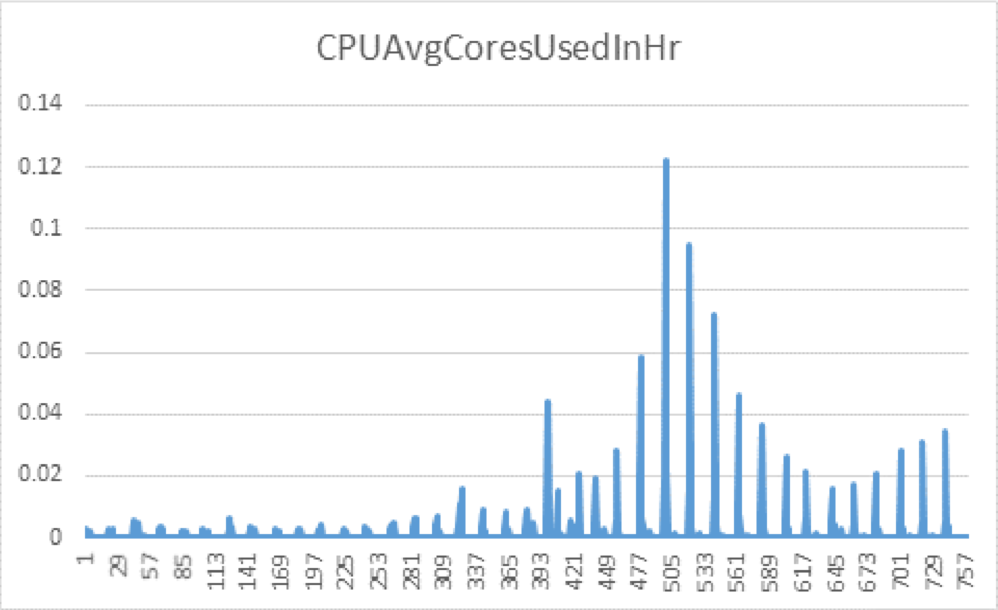
Application-Tier Caching

- App-tier caching is a very effective way to reduce data-tier load
- Azure has a several caching solutions available to you
- For load spikes, this can often significantly reduce peak load
- Example: Azure SQL DB was used in the last US Presidential Election
  - Few writes, massive reads all at once
  - Exponential decay distribution
  - App tier caching used to remove reads from the database

CPU graph for the core reporting DB

- 1st 10 seconds – 44K page views/second (est. ~450K DB calls/sec)
- Next 20 seconds – 10K page views/sec (est. ~100K DB calls/sec)

(DB calls mostly removed due to caching)



	Azure SQL DB	Azure SQL VM	Azure Storage Tables
Target Organizations	• Startup-mode dev organizations • Elasticity and flexibility, low friction	• Application compatibility • Existing enterprise customers • Traditional workloads	• Dev-oriented organizations • “Store and forget” • Limited query needs
Operations + Management	• Mostly auto-administered • Reduced surface for Insights	• Great single database • Requires effort for multi-db	• Storage analytics • 3rd party tooling
Availability	• 99.9% availability SLA • Requires development efforts if you need more	• (Almost) all the option of the box • Requires infrastructural effort for full HA	• Multiple copies of data • No “oops” recovery
Performance + Scalability	• Shared Resources • Requires scaling out	• Predictable performance • May be limited by hw resources	• Provided by partitioning • Throttling
Migration effort from on premises	• Limited application compatibility issues • May require effort in case of scaling out	• Mostly transparent • Can be more challenging to scale out if a single node is not enough	• May require rewrite of both data model and processing capabilities if coming from a relational app
Costs	• Optimized for low costs to buy and manage	• Licensing and VM costs could be not trivial	• Relatively cheap • May require additional computation resources

Resources

- Premium Preview for SQL Database Guidance (http://msdn.microsoft.com/en-us/library/jj853352.aspx)
- Azure SQL Database and SQL Server -- Performance and Scalability Compared and Contrasted (http://msdn.microsoft.com/en-us/library/windowsazure/jj879332.aspx)

Questions?

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