Controlling the Workload Mix using TASM in an Autonomous World

Douglas Brown, Technical Innovation Office (TIO)
Ruth Fenwick, Database Engineering

Agenda

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- **The future of Autonomics in TASM**
  - Artificial Intelligence
  - Machine Learning
- **Flex Throttle Review**
- **Arrival Rate Metering (ARM)**
- **Service Level Goals (SLG)**
- **Questions**

Autonomous Database

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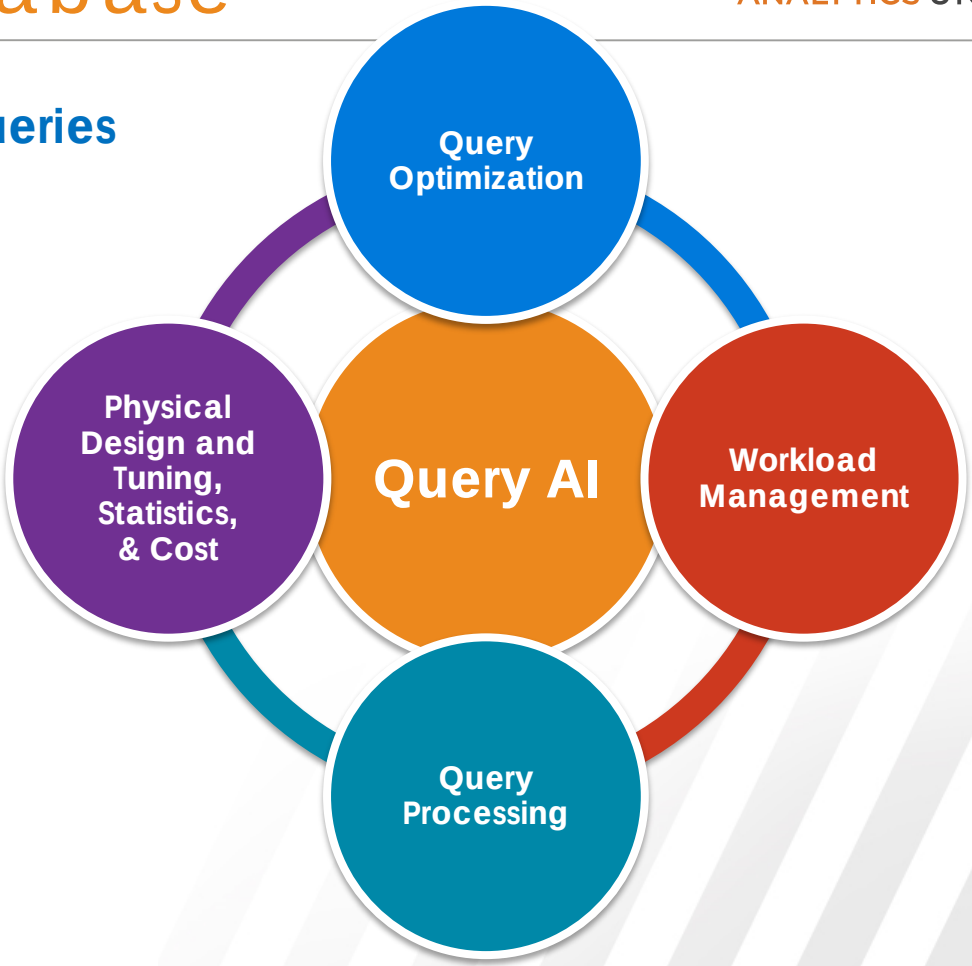
- **Artificial Intelligence for Queries**
  - Physical design and tuning
  - Statistics
  - Costing
  - Optimization
  - Workload Management
  - Query Processing
- **Learning at the Edge**
- **Focused ML Models**
- **Automation**
- **Closed loop**



AI Evolution

ARTIFICIAL INTELLIGENCE

Early theory and accomplishments stirs interest and excitement

1950s

MACHINE LEARNING

Predictive accuracy improves with more data

K-means clustering, Bayesian Networks, Support Vector Machines

mid 2000s

DEEP LEARNING

Allows more-complex problems to be tackled, and others to be solved with higher accuracy, with less cumbersome manual fine-tuning

Recurrent Neural Networks, Convolutional Deep Neural Networks, Generative Adversarial Network, Deep Feed Forward

mid 2010s

What makes Deep Learning so intriguing?

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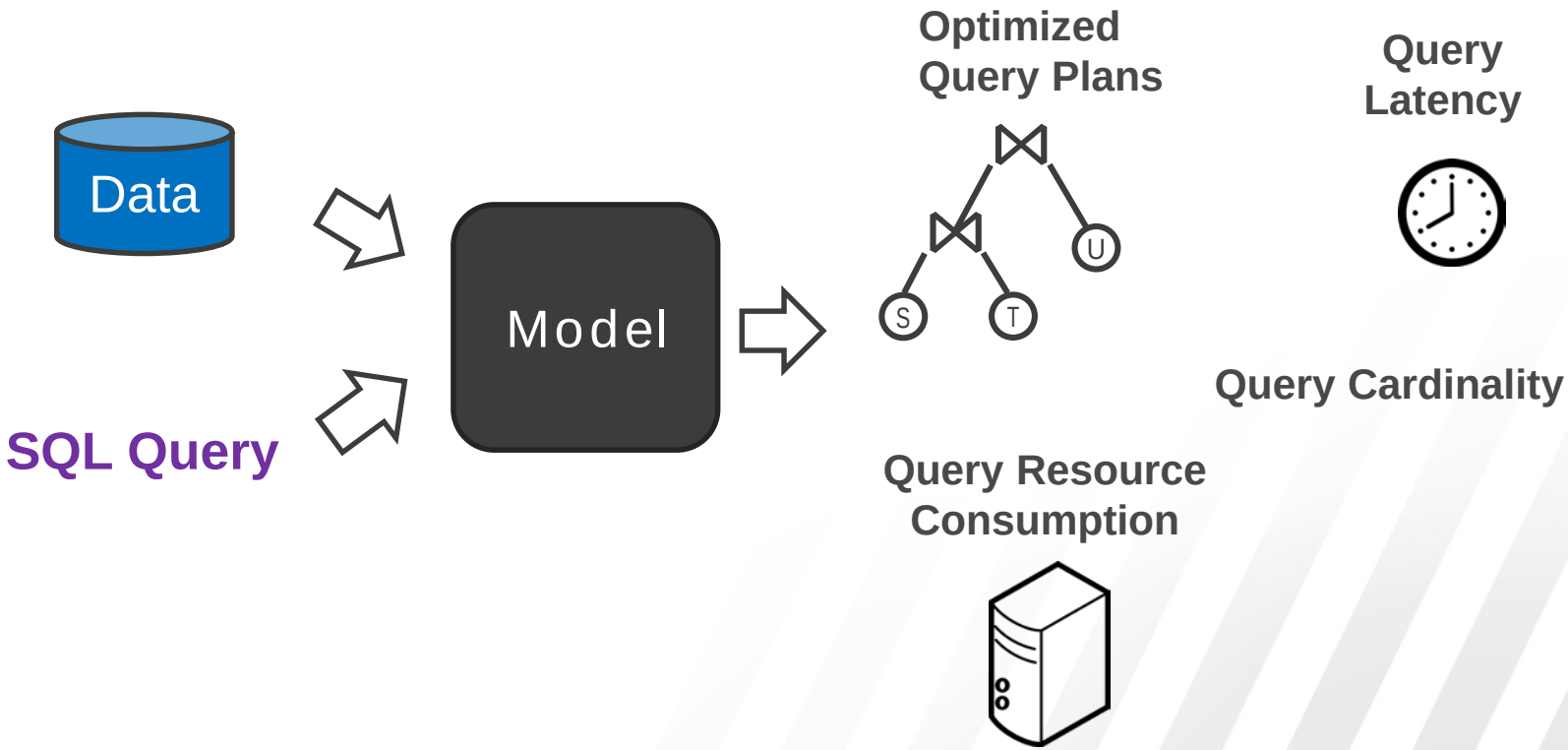
- Ability to create value with little or no domain knowledge required
- Ability to incorporate data from across multiple, seemingly unrelated sources
- Ability to tolerate very noisy data

Our Vision

Automate **workload management** in the context of **machine learning** and **deep learning**



What is stored in Database for Learning

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DBQL Log Tbl
- Contains detail query data (CPU, IO, Spool, etc.)
- One row / query

DBQL Obj Tbl
- One row per object referenced in query
- Identify unused / under-used objects.

DBQL Sql Tbl
- Contains full SQL text
- May record more than one row

DBQL Step Tbl
- Contains Plan and Actual Step data
- One row per query step

DBQL Explain Tbl
- Contains Full EXPLAIN text
- May record more than one row

DBQL XML Tbl
- Contains optimizer query plans, statistics recommendation as XML format

DBQL XML Lock Tbl
- Contains query lock contention as XML format

DBQL Param Tbl
- Contains values of the parameters for a parameterized query

Increasing level of detail

DBQL Summary Tbl*
- Populated by Summary or Threshold Logging
- Aggregated data for 10 minute time period

DBQL Utility Tbl *
- Contains for each individual utility job: jobname, utility name, user, queryband, LSN, timing by phases, rows/block count, CPU, IO, max AWT usage

Base and Perspective Views available in DBC

All Tables except * joined on Queryid

Machine Learning Models

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- **Why we need ML/AI models**

  - Throttle Analysis – How much should I throttle each request to guarantee optimal system performance?
    - Which workload(s) should I throttle?
    - Which type of throttle should I use: System, WD, Group, Flex, Arrival Rate Meters?
    - What is a recommended throttle setting?
    - Are my throttles under-performing?

  - SLG analysis – Will I meet my SLA?
    - How much budget does each query need?
    - Do I have enough capacity to meet my SLA?
    - How much does it cost to run my query?

TASM Background

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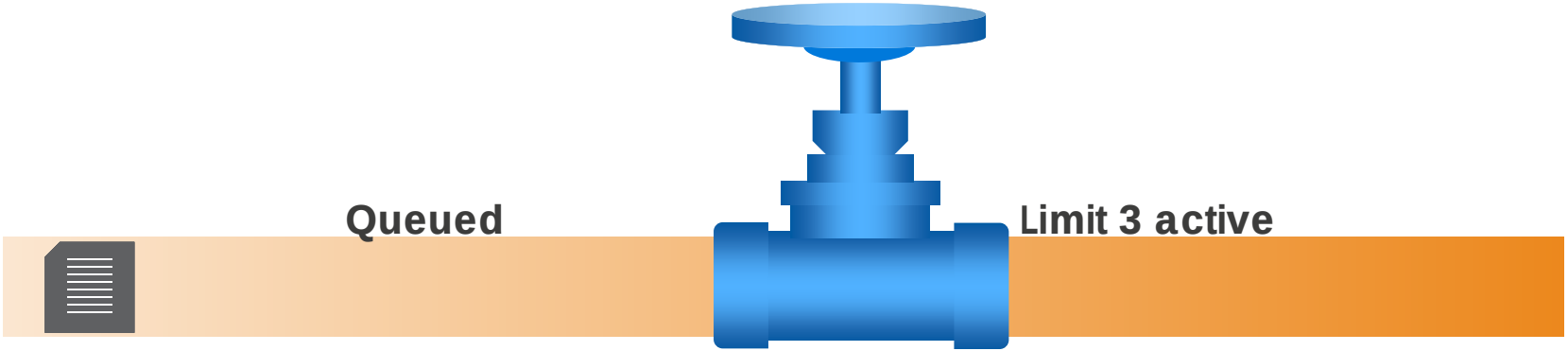
What is a Throttle?



TASM Flex Throttles

What Problem Do They Solve?

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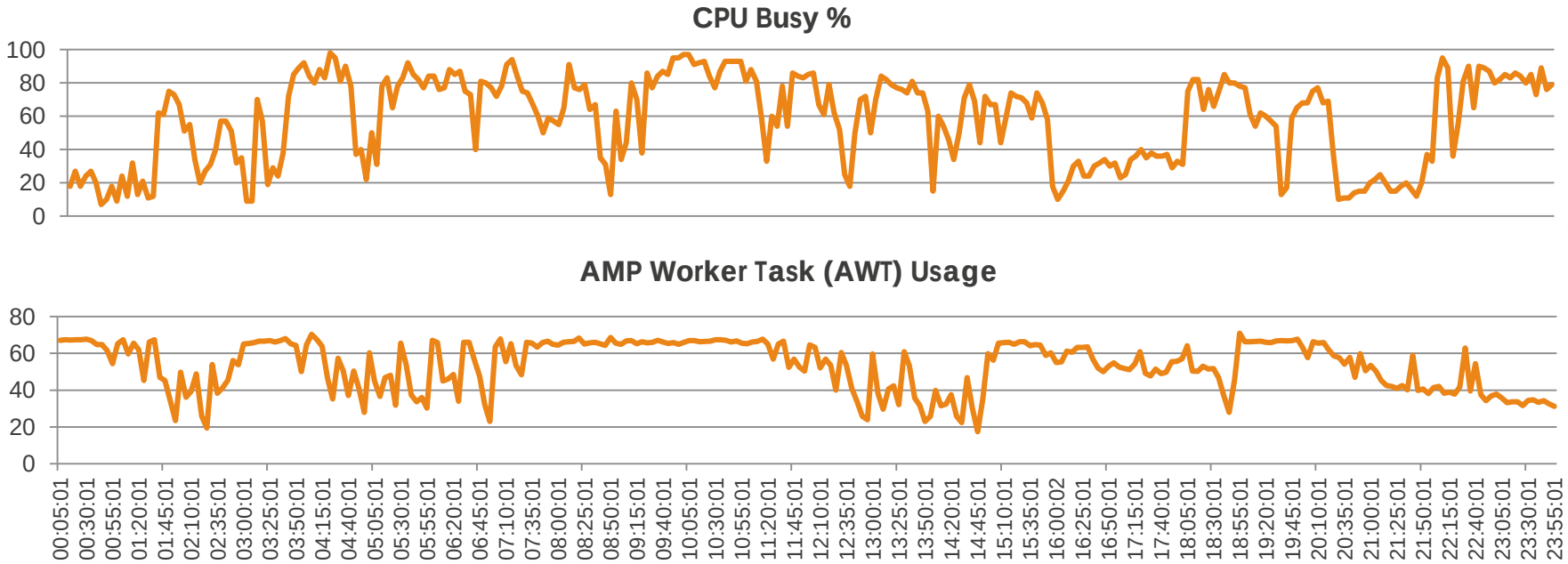

Flex Throttle Example

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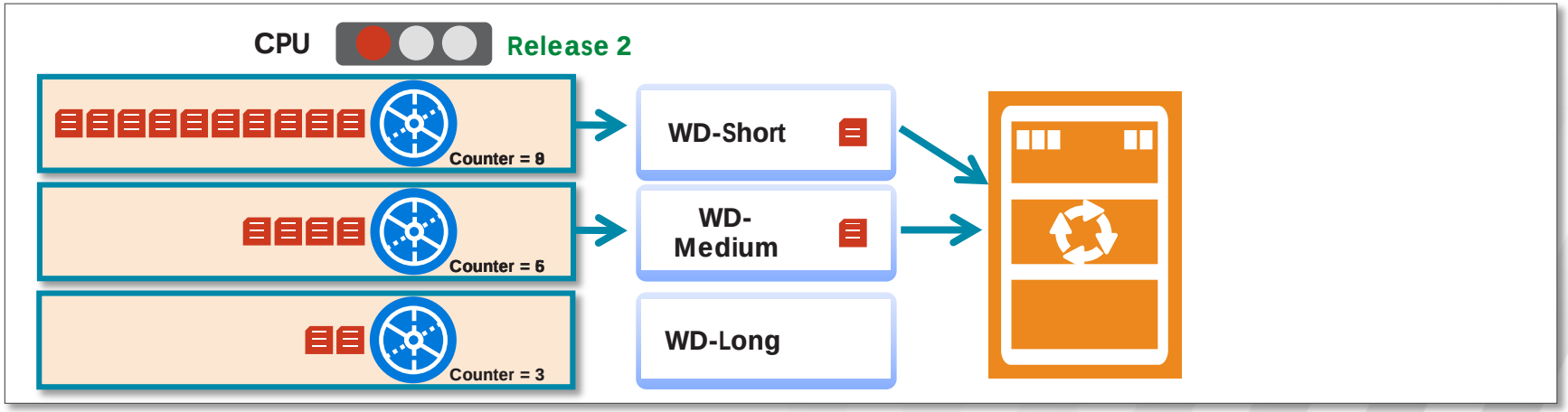
Workload Throttles	Flex ON/OFF	Workload Priority	Throttle Limit	Throttle Counter
WD-Short	ON	High	8	9
WD-Medium	ON	Medium	5	6
WD-Long	OFF	Low	3	3



Arrival Rate Meter

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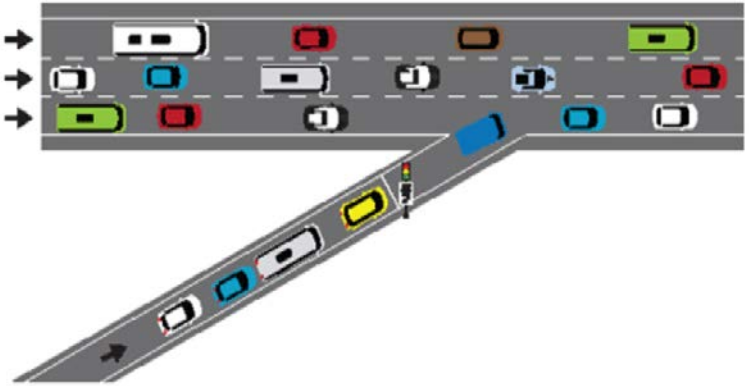
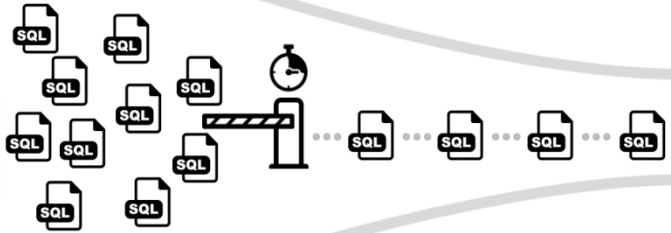
- New TASM rule type
- Regulate the flow of SQL requests being admitted by TASM
- Specify maximum rate during a specific time unit.
- Example: 3 queries per hour for queries with estimated processing time of more than 1 hour.

Freeway with Ramp Metering



TASM Arrival Rate Meter



Arrival Rate Meter - Processing

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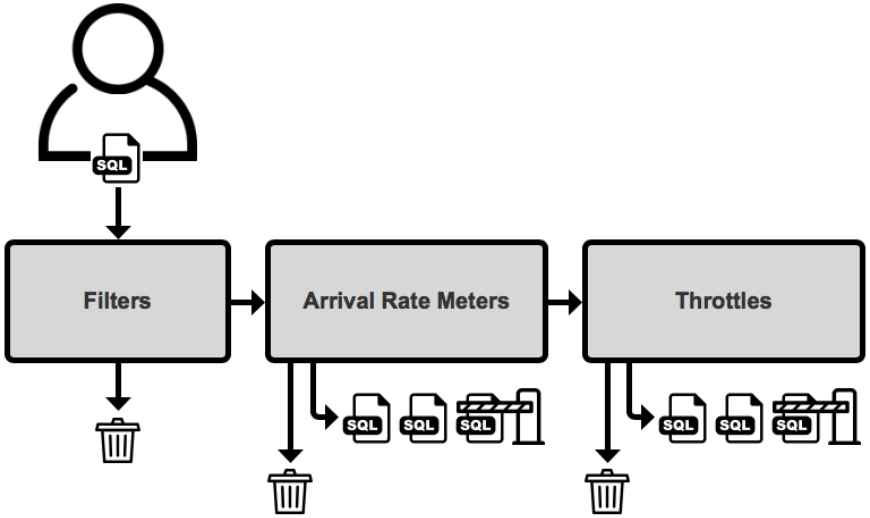
Order of processing:

1. Filters
2. Arrival Rate Meters (Defer Queue)
3. Throttles (Delay Queue)



Arrival Rate Meter – Use case 1

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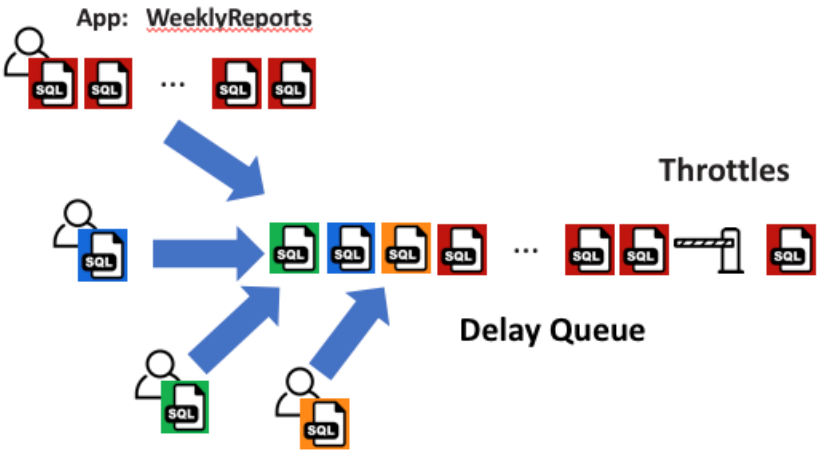
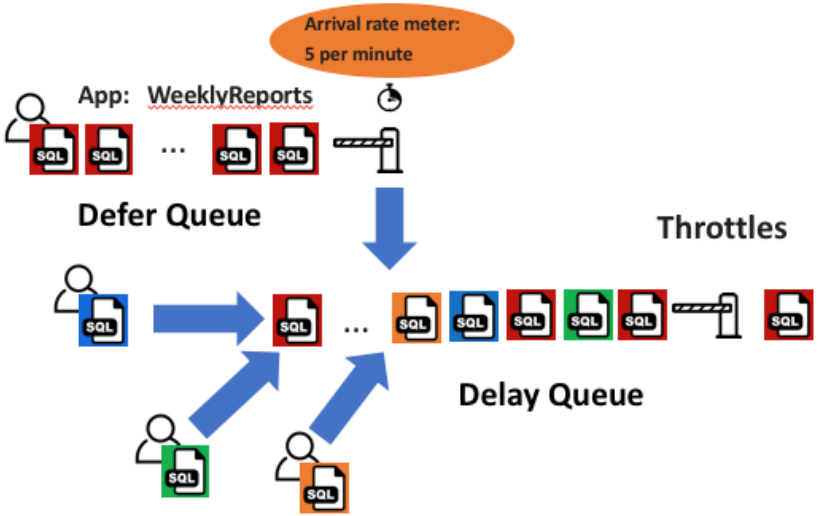
Problem: **Flood of requests from specific application monopolizing the front of the throttle delay queue.**

Solution: **Create an arrival rate meter for this application so that other requests can get in between each time unit.**





Arrival Rate Meter – Use case 2

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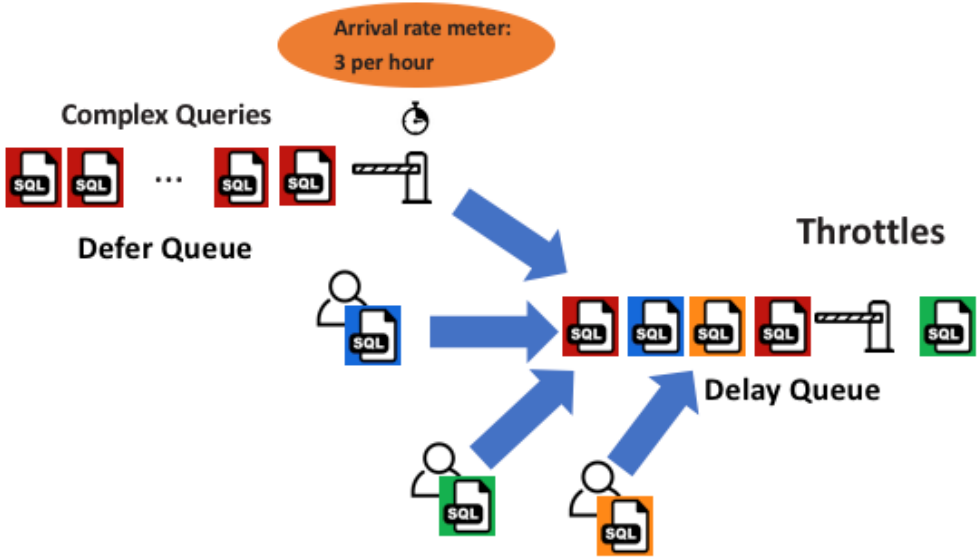
Problem: **Complex queries use too much resources.**

Solution: **Create an arrival rate meter for complex queries to limit resource usage.**



Service Level Goals (SLGs)

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- Purpose:
  - Increase consistency and predictability
  - Make it easier to keep important jobs higher priority
  - Easier configuration
- Replace the current methodology of having to create Tier WDs and assign specific shares.
- User defines response time goal and DBS executes query to meet that goal.
- TASM determines the rate needed to execute to meet SLG.

Inaccurate Predictions Bigger Problems!

Current Query Optimizer's Cost Estimates

↓

Poor Prediction of CPU & I/O Usage

↓

Poor Budget Estimations

↓

Poor Scheduling Decisions | Poor Capacity Planning

↓

Service Level Goal (SLG) Violations

SLG Tiers

Workloads | SLG Summary | Evaluation Order | Virtual Partitions | Partition Resources | Workload Distribution | Console Utilities

Specify the allocation of resources for each workload in the context of a virtual partition in each planned environment.

System Workload Report

Planned Environment: ALWAYS — Virtual Partition: STANDARD — 100% of system

Tactical

- CallCenter

SLG Tiers

Tier 1

- Dashboard 15%
- ... 10%
- ... 10%
- 65% remaining

Tier 2

- CustOffer 30%
- ExecReports 20%
- 50% remaining

Tier 3

- MktgQry 40%
- QuickDrill 30%
- 30% remaining

Timeshare

Top	High	Medium	Low
Adhoc-High	BI-Tools	Adhoc-Medium	DataLab
Admin	ETL-Loads	Appl-Loads	Forecasting
T-WD	H-WD	WD-Default	L-WD
		M-WD	

SLG Tier Reporting

System Workload Report

View workload resource allocations across all virtual partitions. Translation of workload allocations to system resource percentages does not consider workload hard limits. To sort on a second column, hold the Control/Command key.

Planned Environment: **Always**

Virtual Partitions

Standard	90%
Ne...	10%

Workloads

WORKLOAD	VIRTUAL PARTI.	TIER	% OF TIER	% OF SYSTEM	% OF SYSTEM
slg1	NewVP	Tier 1	13.6	1.4	
slg2	NewVP	Tier 2	26	2.2	
ts-top	NewVP	TS1 Timeshare Top		2.2	
ts-top2	NewVP	TS1 Timeshare Top		2.2	
ts-high	NewVP	TS2 Timeshare High		1.1	
ts-med	NewVP	TS3 Timeshare Medium		0.6	
ts-low	NewVP	TS4 Timeshare Low		0.3	
webApp1	Standard	Tier 1	10	9	
webApp2	Standard	Tier 1	10	9	
dashboard	Standard	Tier 1	15	13.5	
CustOffer	Standard	Tier 2	30	17.6	
ExecRpts	Standard	Tier 2	20	11.7	
MktQry	Standard	Tier 3	40	11.7	
QuickDrill	Standard	Tier 3	30	8.8	
SLGapp1	Standard	Tier 4	5	0.4	
SLG5app1	Standard	Tier 5	5	0.4	
T-WD	Standard	TS1 Timeshare Top		2.9	
wd1	Standard	TS2 Timeshare High		1.4	

23 rows total

Close

Profiling Service Level Goals

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Response Time Distribution	• Needs DBQL Data • Shows the distribution of queries by time
ResUsage	• Needs ResUsage Data • Shows CPU, IO, AWT
SLG	• Need TASM Data with SLGs defined • Shows # of queries met/not met SLG

Deployed as Jupyter Python Notebook @ hub

Response Time Distribution

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"Response Time Distribution" View

- For a customer with no SLA, this helps in setting up SLG and Service Level Percentage(SLP)
- Each TASM planned environment has a different graph.
- Lets you know how RT behaved for same WD in different environments.

What does this view have?

Input: Time Window, WD

Output: % of queries in each bin of response time

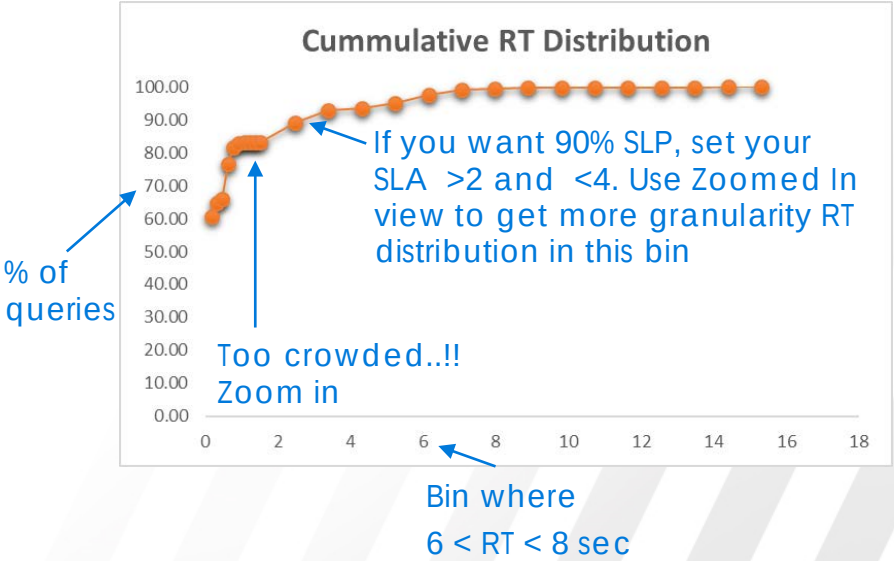
X-Axis: Response time

Y-Axis: % queries in that bin.

Additional Information in table:

- How many queries in that bin met SLA.
- how many % met with exception and without exception.
- how many WD each tier had and how many had SLA defined.

How graph looks like?



ResUsage Metric Graph

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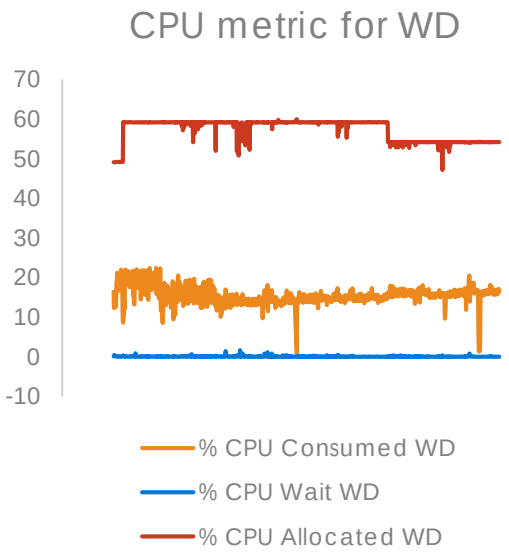
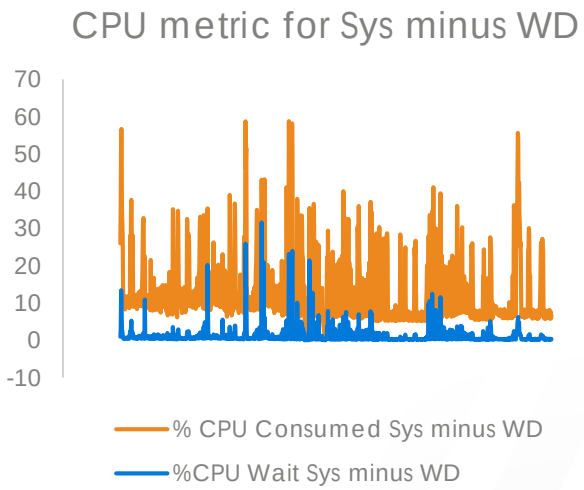
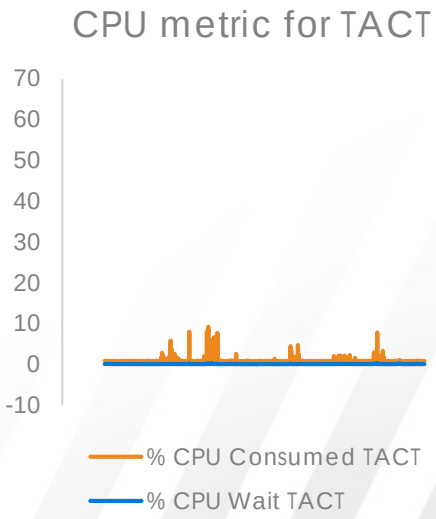
Two Reasons:

- SLA behavior
- Resources Consumed

- What resources correspond to the SLG behavior reported
- Helps in analysis of queries if missed SLG - what was the load on system resources.







ResUsage metric graph

X-Axis: Time

Y-Axis: Metric value(each graph has different Y axis)

SLG by Tiers

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Why "Tier Wise" view?

- Top level view
- Simplified aggregated information for all tiers
- User can identify which Tier is bad
- Not to overwhelm user with all existing WDs
- Drill down more with other views to identify bad WD

What does this view have?

Input: Time Window

Output: Per Tier %queries met/not met SLA

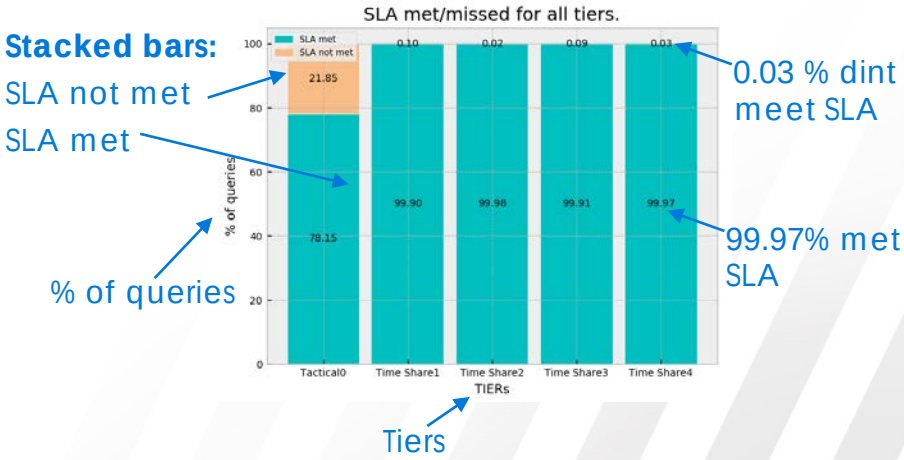
X-Axis: Tiers (not time)

Y-Axis: % queries met/not met SLA.

Additional Information in table:

- how many % met with exception and without exception.
- how many WD each tier had and how many had SLA defined.

Graph by Tiers



SLG by WD

"Specific Workload" view?

- Lowest level view
- To identify bad environment/settings for the WD
- Give two sides of information:
  - SLG met/not met by Planned Environment
  - ResUsage Information as discussed above

What does this view have?

Input: Time Window, WD

Output: Per WD setting, %queries met/not met SLA

X-Axis: set of WD settings (not time)

Y-Axis: % queries met/not met SLA.

Additional Information in table:

- Setting information like planned env name, SLA, CPU rel share etc.

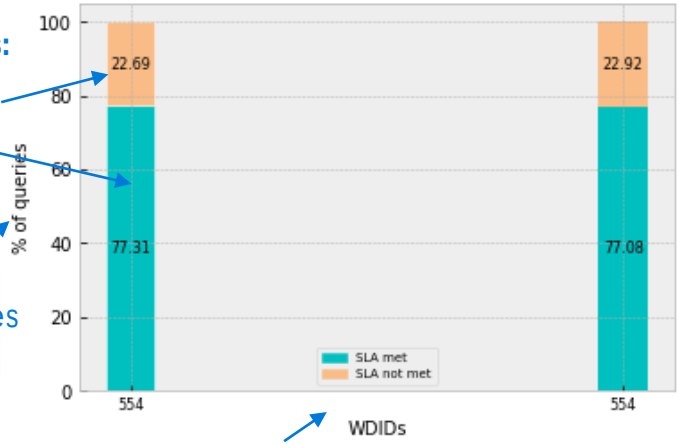
How graph looks like?

Stacked bars:

SLA not met

SLA met

% of queries



WDs

Thank You!

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Questions/Comments

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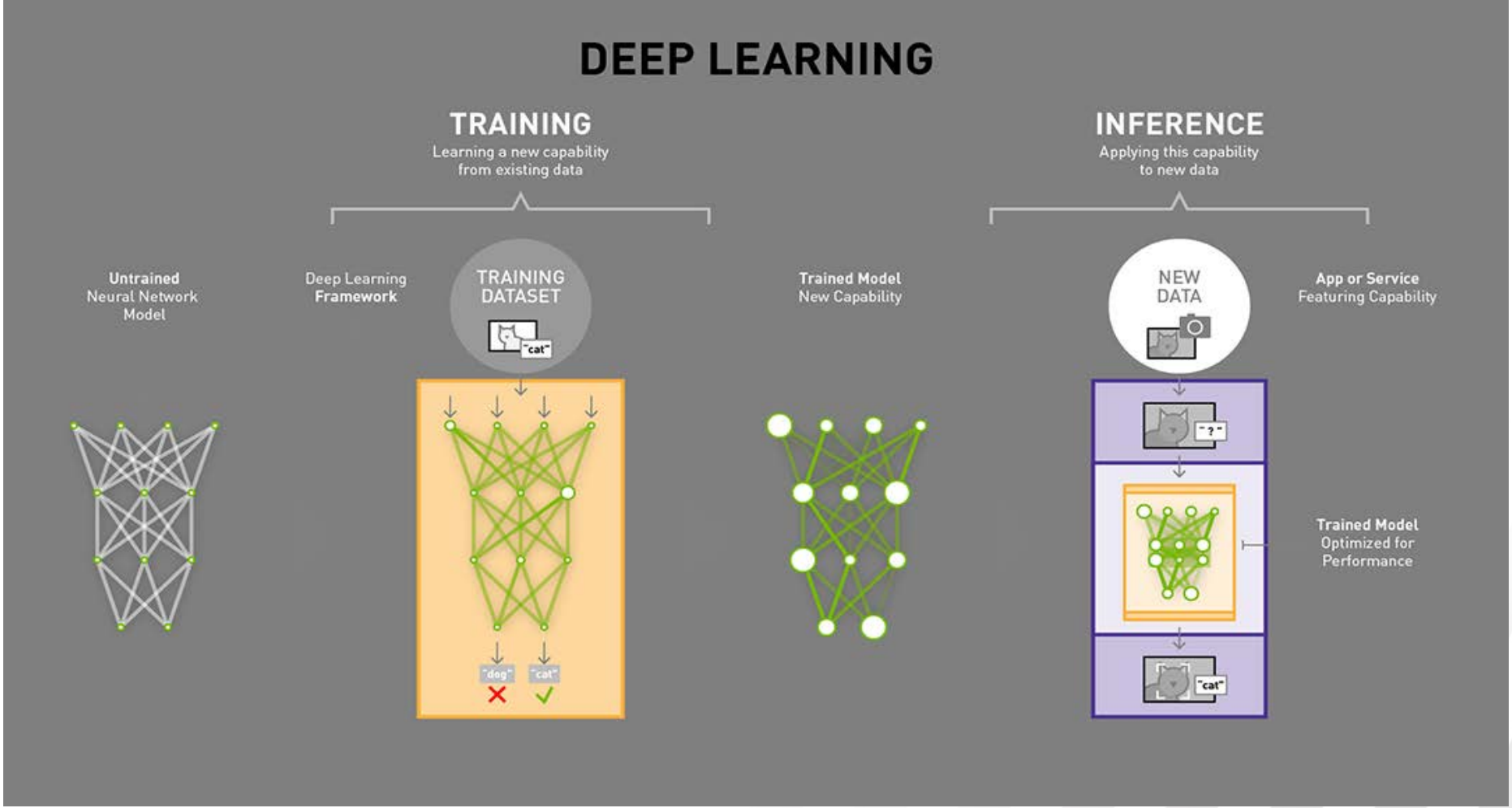
Bonus Material


DEEP LEARNING
TRAINING
Learning a new capability from existing data
INFERENCE
Applying this capability to new data
Untrained Neural Network Model
Deep Learning Framework
TRAINING DATASET
"cat"
"dog"
"cat"
Trained Model New Capability
NEW DATA
"?"
"cat"
App or Service Featuring Capability
Trained Model Optimized for Performance

Experimental Results