Cloud + Data + ML
Opportunities and Challenges

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The world is changing
... Data & AI is powering the change
Knowledge in Action: World Graph

Search queries, views, click throughs, ...

World graph
- People
- Places
- Things
- Actions

2B+ entities
130B+ Web pages
50B+ facts

Web pages, Web documents, Images, ...
Bing—Intelligent Local Queries

- Trained Deep Semantic Model to encode local query and local entity

- Extended ANN to support location based search. New distance: Semantic Similarity with Physical Distance
Content Optimization
Content Recommendation on Web Portals

Observe  Learn  Improve

Estimate $P(\text{response} \mid \text{user, item, context})$
Modeling Overview

**Offline Modeling**
- Exploratory data analysis
- Regression, feature selection, collaborative filtering (factorization)
- Seed online models & explore/exploit methods at good initial points
- Reduce the set of candidate items

**Online Learning**
- Online regression models, time-series models
- Model the temporal dynamics
- Provide fast learning for per-item models

**Explore/Exploit**
- Multi-armed bandits
- Find the best way of collecting real-time user feedback (for new items)

Large amount of historical data (user event streams)

Near real-time user feedback
The Epochs of Microsoft’s Big Data Journey

1. Collect the data first
   - New design patterns based on abundant & cheap storage
   - We could not have predicted the scenarios or the value we derived ahead of time

2. The Power of Sharing
   - A unified platform with a consistent security model to shape, join, aggregate, and share data across the enterprise
   - Guidelines, monitoring, and policies for maintaining high utilization and minimizing waste

3. Data Virality
   - Data is the basis for intelligent action
   - High-value datasets bootstrap enterprise-wide usage, generating many value-added derivative datasets, thereby attracting more usage—the virtuous cycle of a data-centric enterprise

4. Data Governance
   - **Data Vault**: Secure, flexible, permission-based sharing and billing
   - **Data Map**: Ever growing needs for Auditing, Compliance with data use and sharing policies, Data Lineage, Regulatory requirements
Microsoft’s Big Data Service

Microsoft’s internal data lake

- A data lake for all teams @Microsoft
- Good developer tools
- Batch, Interactive, Streaming, ML
- Used across Office, Xbox, Azure, Windows, Ads, Bing, Skype, ...
- Production jobs and experimentation

By the numbers

- Exabytes of data, billions of files
- 100Ks of physical servers
- Millions of interactive queries
- Huge streaming pipelines
- 100Ks of daily batch jobs
- 15K+ developers
- 100s of teams

Enabling business growth:
- Office productivity revenue (45%YoY)*
- Intelligent Cloud (100% YoY)*
- Bing search share doubles

Azure Data Lake
A data lake for everyone

- Microsoft’s serverless Big Data platform
- Fully aligned with Hadoop ecosystem and standards, with full support for Hadoop tools and engines as well as unique Microsoft capabilities
- Migration from Cosmos to ADL is already underway
- External customers on the same service as internal customers

By the numbers

- Exabytes of data, billions of files
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Azure Data and Analytics

For Business Intelligence
- Power BI

For data Ingestion
- Azure Data Factory

For data preparation
- Azure Databricks
- Azure HDI

For querying curated data
- Azure SQL DW

For building and training AI models
- Azure ML

Business Analysts
Low/no code

Data Scientists
Low to high code
Governed Intelligence
Responsible Data Use and Governance

- Security
  - Authenticated role-based access
  - Policy-based permissible use
    - E.g., privacy policies
  - Regulatory compliance
    - E.g., GDPR

How can we support ML over data inside a DBMS?
What is a database management system?

Access control, governance

- Reporting, BI, Tooling
- Querying / Updates

State management
- Tiered caching
- Transaction management
- Recovery

Storage and indexing
Before

Attribute Selection Tool
C++/R

Segmentation Tool
C++/R

After

SQL Server

Attribute Selection
sp_execute_external_script
'R code'

Segmentation
sp_execute_external_script
'R code'

Scoring
sp_execute_external_script
'R code'

Data tables
Today’s data landscape: Silos

- Relational data
  - OLTP

- Warehouse data
  - DW, OLAP

- Data Lake
  - Files, docs, videos, telemetry, graphs

Different workload characteristics
Different requirements
Different DB systems

There isn’t one database system that can do it all well
10 Million Images @ Scale
Governance is Getting Harder

- What data do we have?
  - How can we inventory our data to support GDPR compliance?
  - How can we keep my inventory up-to-date?
- Where is our data?
- Who is using the data and for what purpose?
  - What are the main business-related data flows?
- What data is this decision based on?
  - Explanations are more important when data is diverse and dirty
- How can we enforce data-use policies?
  - Are we compliant with regulations?
  - How can we evaluate our risk?
  - How can we automate alerts, track violations, gate actions, etc.?
Unified Information Management

Access control, Governance

- Relational data
  - OLTP

- Warehouse data
  - DW, OLAP

- Data Lake
  - Files, docs, videos, telemetry, graphs
What data, stored where

Who used, how

Provenance

Automated Tagging

Combination

Read Data A

Transform Data

Write Data H, I

Read Data G

Transform Data

Value Analysis

Flow Write Data H, I

Analysis

Analysis

Code

Analysis

Code

Analysis

Code

Analysis

Code

Analysis

Code

Analysis

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10+ Exabytes of data
2B+ Storage artifacts
100M+ Unique schema elements
60M+ Classification tags
150+ Policy specifications
Real-time enforcement, delete and export workflows, Offline audits, Daily dashboards, What-if analysis, and more...

All orgs, apps and services
5K+ users
60 FTE Common Infra
20 FTE DataMap Platform
Governed Database Ecosystem

- Data storage and state management separated from functional “heads”, and designed for interop
  - Extensible to new engines
- Governance (e.g., access control specification, policies, enforcement, discovery) cutting across all data and access patterns
  - Enforced natively for integrated stores, loose coupling elsewhere
The changing landscape of data

Cloud

Elastic compute

Network latency

Elastic storage

Data silos

Analytic complexity

- Scale
- Heterogeneity
- Many engines
- Many workloads

OLTP challenges

- Size-of-data operations are slow
- Long recovery times are painful
- Independently scale storage vs. compute costs
What is a database system?

Access control, governance

Compute

- Reporting, BI, Tooling
- Querying / Updates

Storage, Quorum

- Tiered caching
- Transaction management
- Recovery

Storage and indexing
Many database systems fit this pattern

OLTP
- Reporting, BI, Tooling
- Querying / Updates
- State management:
  - Tiered caching
  - Transaction management
  - Recovery
- Storage / Indexing

DW
- Reporting, BI, Tooling
- Querying / Updates
- State management:
  - Tiered caching
  - Transaction management
  - Recovery
- Storage / Indexing

Data Lake
- Reporting, BI, Tooling
- Querying / Updates
- State management:
  - Tiered caching
  - Transaction management
  - Recovery
- Storage / Indexing

NoSQL
- Reporting, BI, Tooling
- Querying / Updates
- State management:
  - Tiered caching
  - Transaction management
  - Recovery
- Storage / Indexing
Cloud-native design separates compute from storage + state management
Can we build on this, so other “heads” can directly access data?
SQL DB HyperScale Cloud Architecture

OLTP Application

- Read/write
- Primary
- SQL Server
- RBPEX

Fail-over target

- Read
- Scale-out read secondary
- SQL Server

Data and Transactional State

- Page Server #1
- Page Server #2
- Page Server #N
- RBPEX
- Azure Storage
- Checkpoint/Backup

Additional notes:

- SQL Data in Azure Data Lake Storage
- Flexible read replicas
- Hide cloud latencies
Sharing across applications using HyperScale

OLTP Application

Primary

SQL Server

RBPEX

Read/write

DW Application

Scale-out DW Compute

SQL Server

Data and Transactional State

Getting pages

Log Flush

Xlog Service

Log Apply

Page Server #1

Page Server #2

Page Server #N

Azure Storage

GetPage@LSN

Log Apply

Checkpoints/Backup

SQL Data in Azure Data Lake Storage

Readable by DW applications

No impact on OLTP workload
Storage, indexing and state management is still optimized for primary workload, but data is directly accessible by other engines.
Access control, Governance

OLTP
- Reporting, BI, Tooling
- Querying

DW
- Reporting, BI, Tooling
- Querying

Data Lake
- Reporting, BI, Tooling
- Querying

NoSQL
- Reporting, BI, Tooling
- Querying

Data and Transactional State
... across cloud, on-prem and edge!
Should we be thinking of “Database Ecosystems”?

- Data storage and state management separated from functional “heads”, and designed for interop
- Governance (e.g., access control specification, policies, enforcement, discovery) cutting across all data and access patterns
Questions?