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Elastic Query Processing on Function as a Service Platforms

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Target Analytics Workloads

- Interactive ad-hoc analytics on cold data
  - Interactive – require query latencies in seconds
  - Ad-hoc
    - Every query is different
    - Infrequent query bursts
  - Cold data – infrequently accessed data
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‣ **Database systems need to adapt to them quickly**

Traditional Database Architectures

- Shared-everything
  - Limited compute scalability
  - Storage scalability via data tiering to larger/cheaper/slower storage until too slow
- Shared-nothing
  - Expensive data shuffles and loads on workload changes
  - Non-interactive performance during transition periods
- Shared-disk (with regular VMs)
  - Separate compute and storage resources, matching modern cloud infrastructures
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‣ **Current approaches do not scale fast enough and are prone to under- or over-provisioning**

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- Run user code on tiny, short-lived, and stateless workers
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  - **Combined performance high enough for large-scale query processing**
- Economically viable for users, when moderately utilized (2-8X the costs of VMs)

Challenges in FaaS-based Query Execution: Cloud Functions

1. Tight resource limits (2 vCPUs, 3GB RAM and 15min runtime)
2. Launch overheads (potentially 10s of seconds)
    - Invocation via web-based REST API
    - Initialization including host provisioning, worker placement and runtime setup
3. Observability for blackbox cloud function services
4. Fault tolerance via transparent re-execution
5. Indirect communication due to disabled inbound network connections

Challenges in FaaS-based Query Execution: Object Storage

6. Inefficiencies
   - High request latencies
   - Significant per-request costs

7. Weak data consistency guarantees
   - No read-your-own-write
   - No multi-key write

Challenges in Query Optimization for FaaS-based Execution

8. Cost-awareness
   - Cloud service pricing models
   - Cost-performance tradeoffs

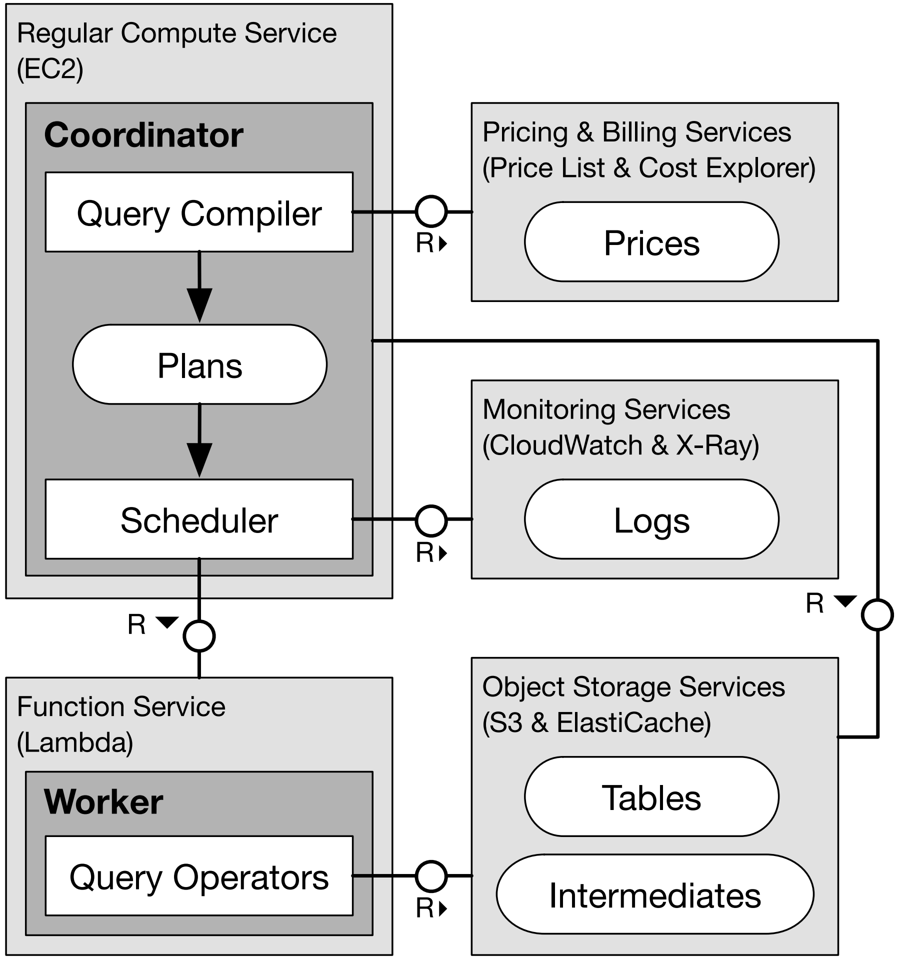
9. Parallel plans
   - Exploit parallelism of underlying platform
   - Avoid data shuffles

Cloud Data Analysis Systems

	Disaggregated Storage	FaaS-based Compute	Relational OLAP	Query Cost-Performance
FaaS-based Data Analysis Systems				
PyWren	✓	✓	✗	✗
Flint	✓	✓	✗	✗
Locus	✓	✓	✗	✓
Cloud-based OLAP Database Systems				
Amazon Redshift	✗	✗	✓	✗
Redshift Spectrum	✓	✗*	✓	✗
Snowflake	✓	✗	✓	✗
FaaS-based OLAP Database Systems				
Lambada	✓	✓	✓	✓
Starling	✓	✓	✓	✓
Skyrise	**✓**	**✓**	**✓**	**✓**

Skyrise Target Architecture

- FaaS-based, shared-disk architecture
- Coordinator compiles SQL queries to optimized plans
- Optimization incorporates statistics and prices
- Coordinator schedules operators on function service
- Coordinator observes operator execution
- Operators interact with storage service
- Build on AWS cloud services


Regular Compute Service (EC2)
Coordinator
Query Compiler
Plans
Scheduler
Pricing & Billing Services (Price List & Cost Explorer)
Prices
Monitoring Services (CloudWatch & X-Ray)
Logs
R
R
R
R
R
Function Service (Lambda)
Worker
Query Operators
Object Storage Services (S3 & ElastiCache)
Tables
Intermediates

Skyrise Query Engine

- Query operators
  - C++ for efficient resource management
  - Minimal deployment package for fast launches
  - Idempotence for correct behavior under failure

- Scheduler
  - Parallel function invocation
  - Function pre-warming

Skyrise Query Engine II

- Operator communication
  - Operator collocation
  - Interleaved and late materialization

- Access to Persistent and Intermediate Data
  - Columnar and compressed file formats
  - Statistics-based pruning
  - Wait for convergence of eventual consistent storage
  - Metadata layer for MVCC

Skyrise Query Optimizer

- FaaS-based execution: Limits and degrees of freedom
- Query cost-performance: Multi-objective optimization
- Parallel plans: Maximize parallelism and minize data exchange
- Parallel optimization: Cope with complex cost function and large search space

Conclusion

- Interactive ad-hoc analytics on cold data require elastic query processing capabilities
- Modern cloud infrastructure (i.e., FaaS platforms) represents a promising foundation
- We identify challenges of building a query processing system on FaaS platforms
- We propose approaches to address these challenges
- We report on our progress towards building these concepts into our research prototype
- We further provide an outlook of what is still planned in this thread of research

Thank you.
Questions?