Fluxo: Simple Service Compiler

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Architecting Internet Services

- Difficult challenges and requirements
  - 24x7 availability
  - Over 1000 request/sec
    - CNN on election day: 276M page views
    - Akamai on election day: 12M req/sec
  - Manage many terabytes or petabytes of data
  - Latency requirements <100ms

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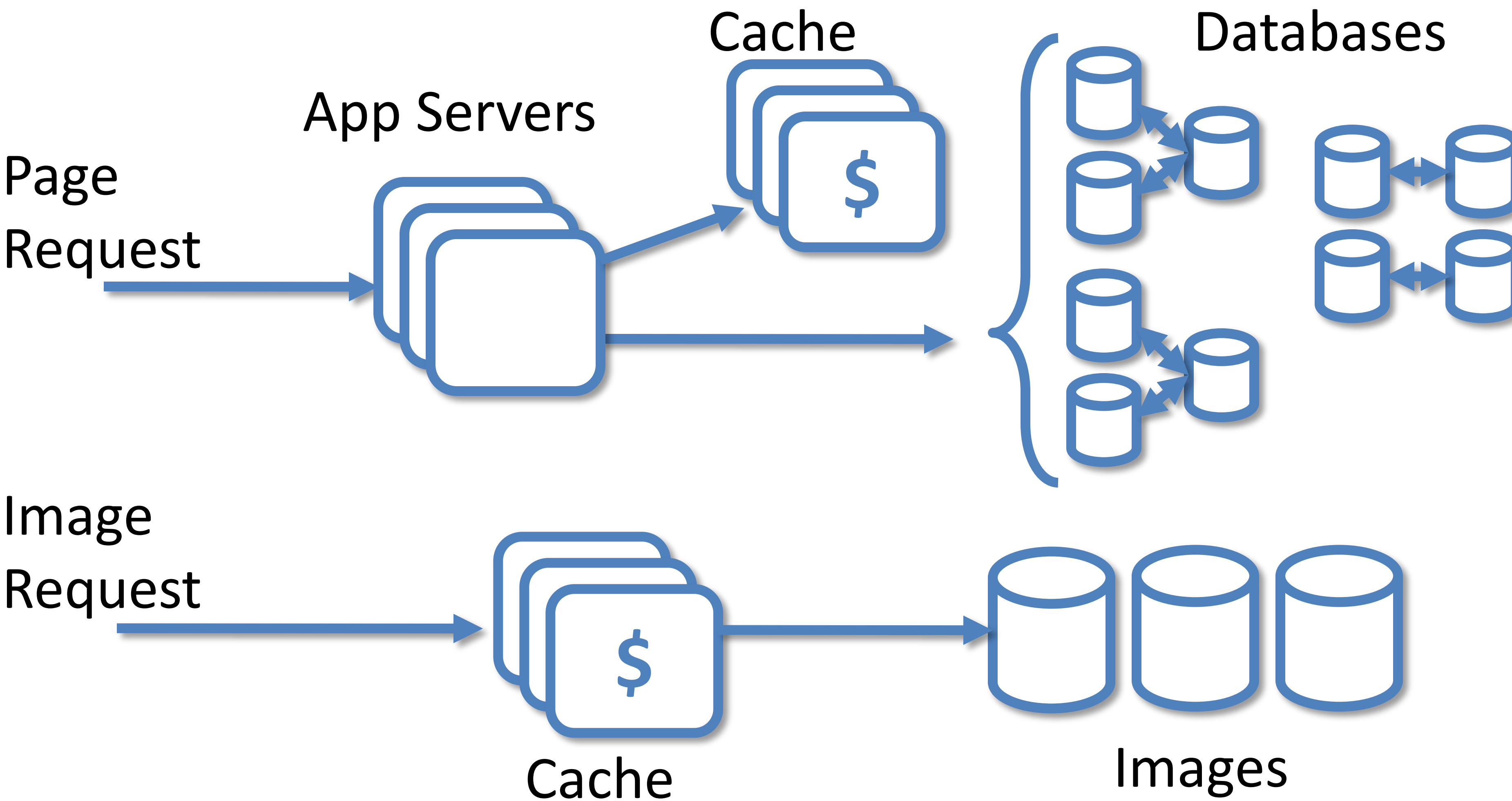

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Common Architectural Patterns

(In no particular order)

- **Tiering:** simplifies through separation
- **Partitioning:** aids scale-out
- **Replication:** redundancy and fail-over
- **Data duplication & de-normalization:** improve locality and perf for common-case queries
- **Queue or batch long-running tasks**

Everyone does it differently!

- Many caching schemes
  – Client-side, front-end, backend, step-aside, CDN
- Many partitioning techniques
  – Partition based on range, hash, lookup
- Data de-normalization and duplication
  – Secondary indices, materialized view, or multiple copies
- Tiering
  – 3-tier (presentation/app-logic/database)
  – 3-tier (app-layer / cache / db)
  – 2-tier (app-layer / db)

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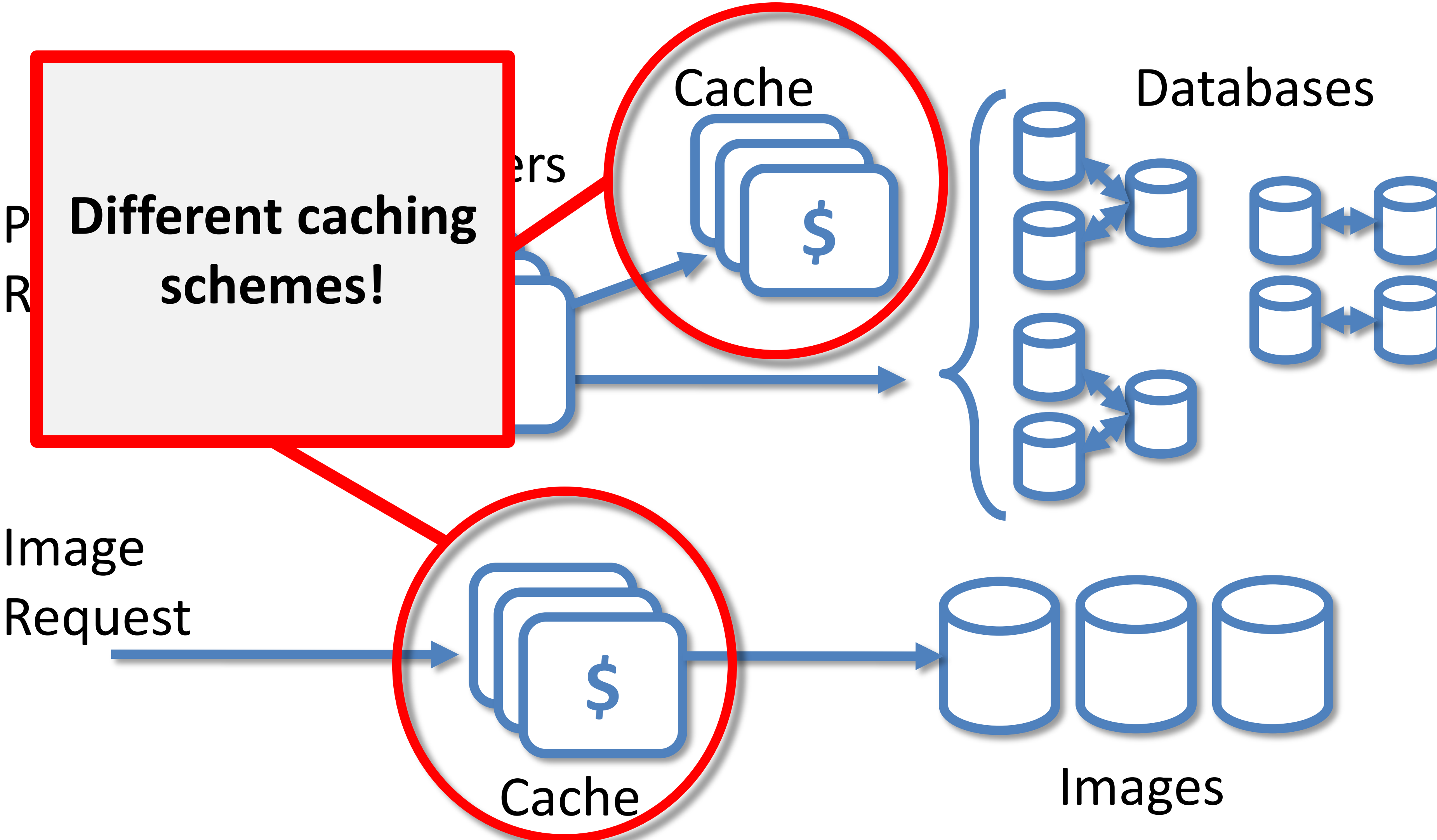

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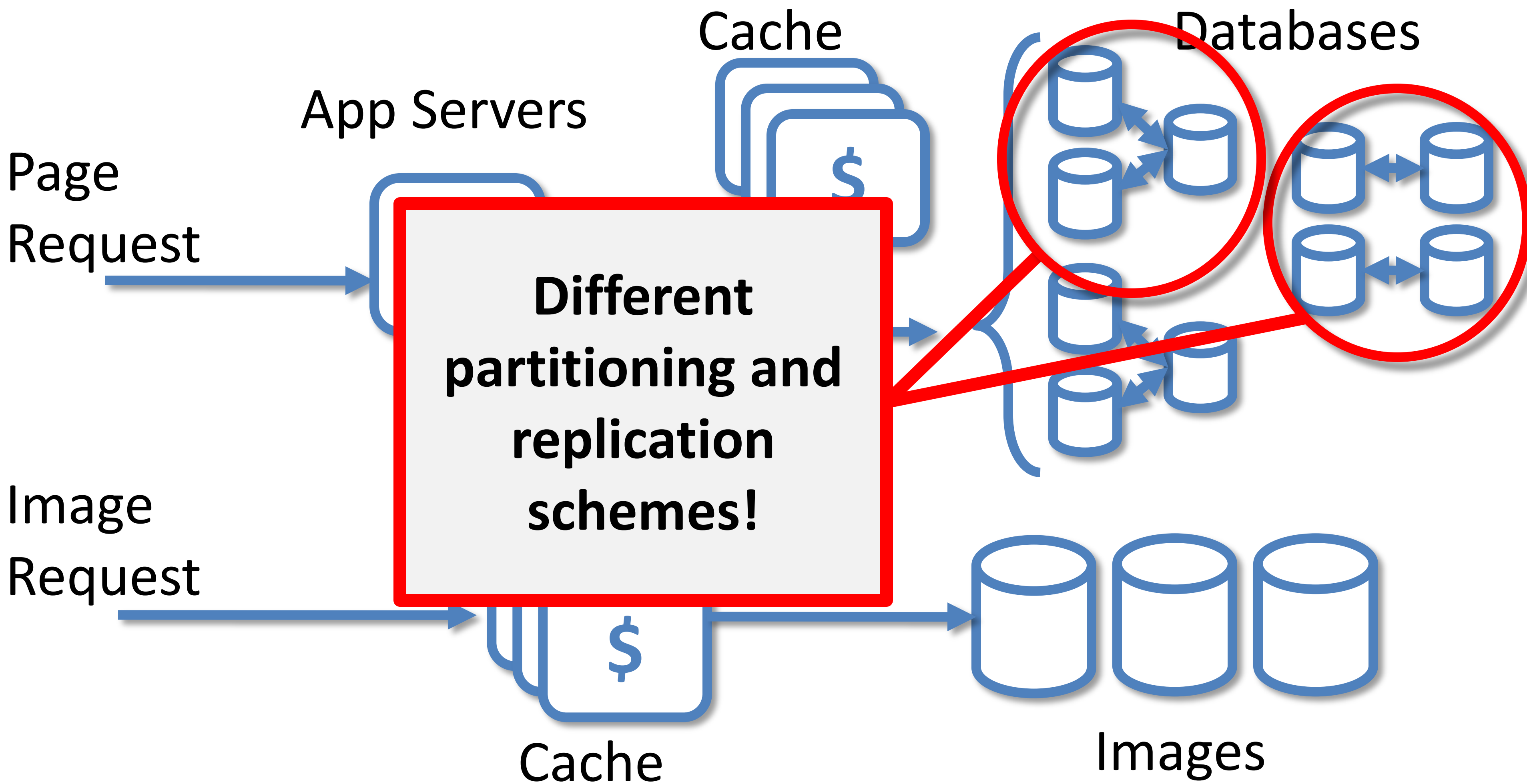

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Differences for good reason

- Choices depend on many things
  - Component performance and resource requirements
  - Workload distribution
  - Persistent data distribution
  - Read/write rates
  - Intermediate data sizes
  - Consistency requirements

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Except this one!

These are all measurable in real systems!

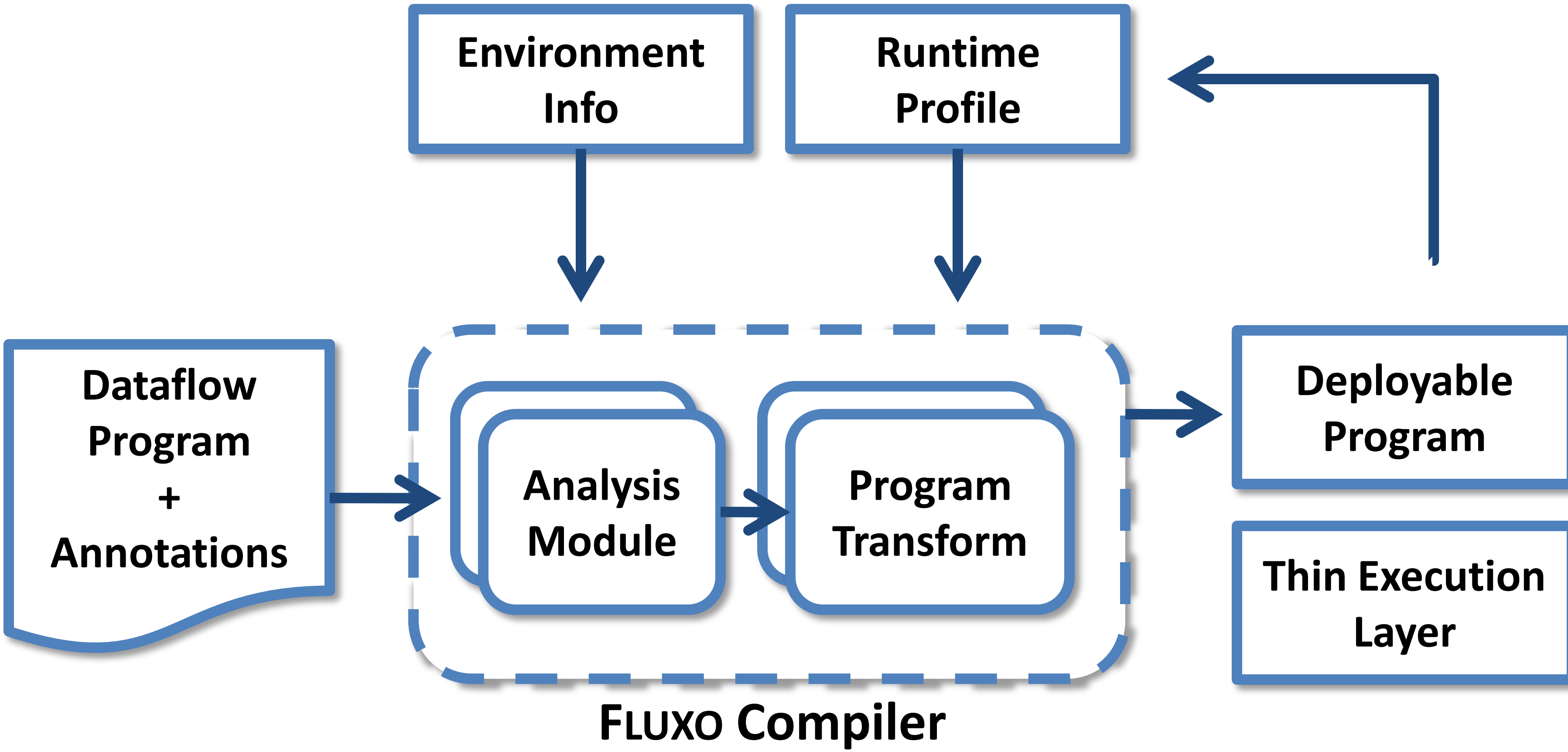
FLUXO

- Goal: Separate service's logical programming from necessary architectural choices
  - E.g., Caching, partitioning, replication, …

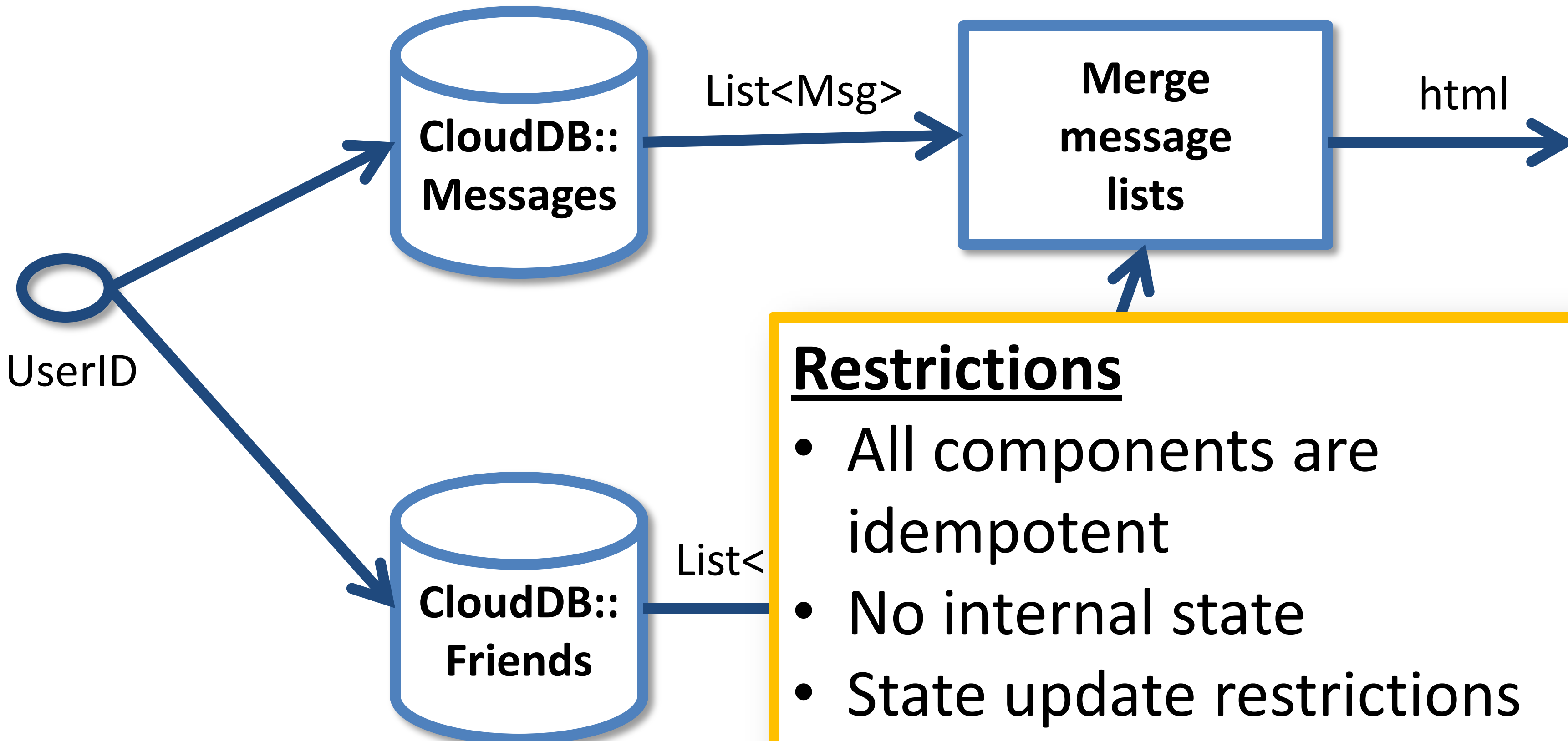
<u>Techniques</u>:

1. **Restricted programming model**
   - Coarse-grained dataflow with annotations
2. **Runtime request tracing**
   - Resource usage, performance and workload distributions
3. **Analyze runtime behavior -> determine best choice**
   - Simulations, numerical or queuing models, heuristics…

Architecture



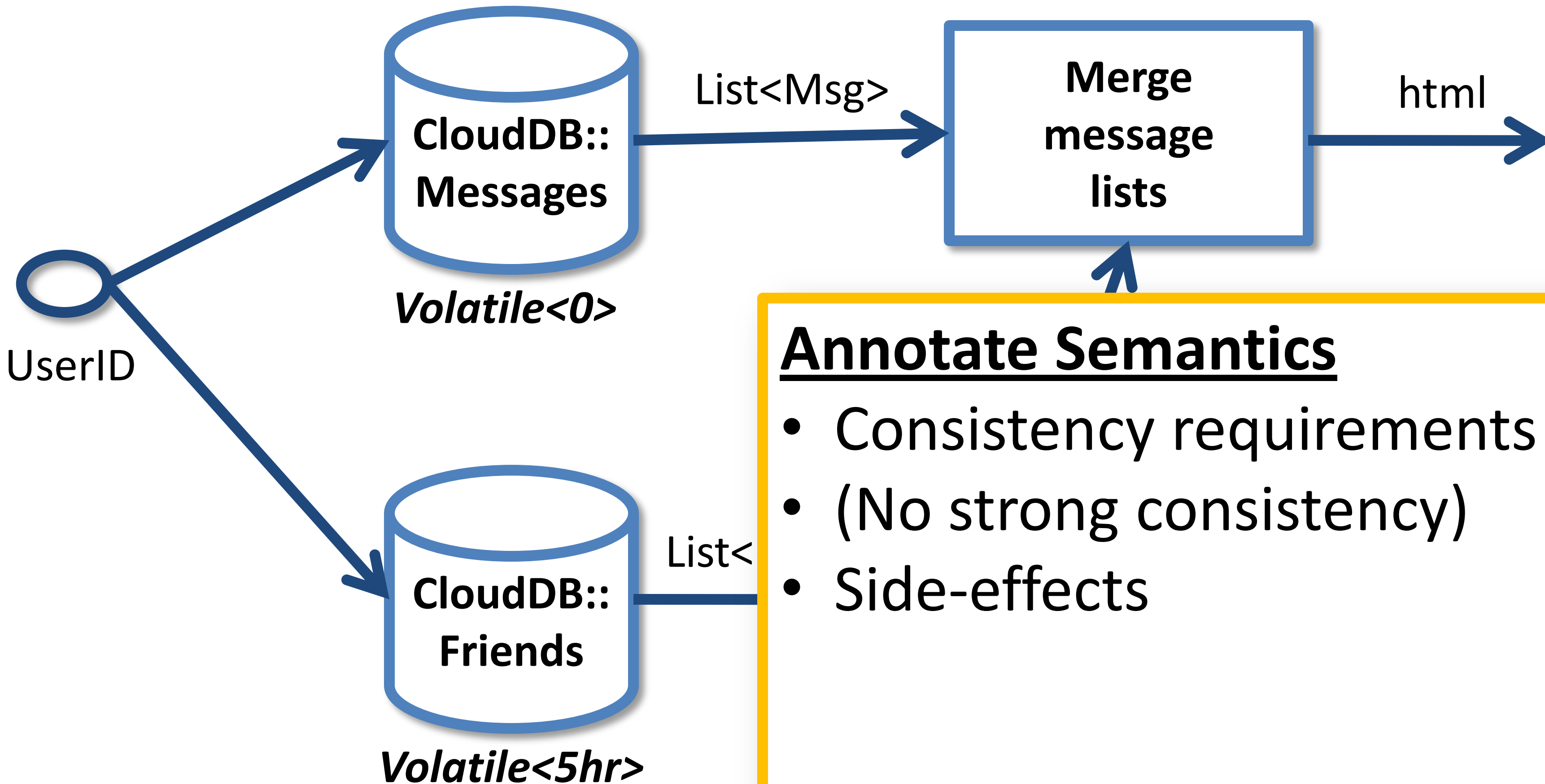
Dataflow Program



<u>Restrictions</u>

- All components are idempotent
- No internal state
- State update restrictions

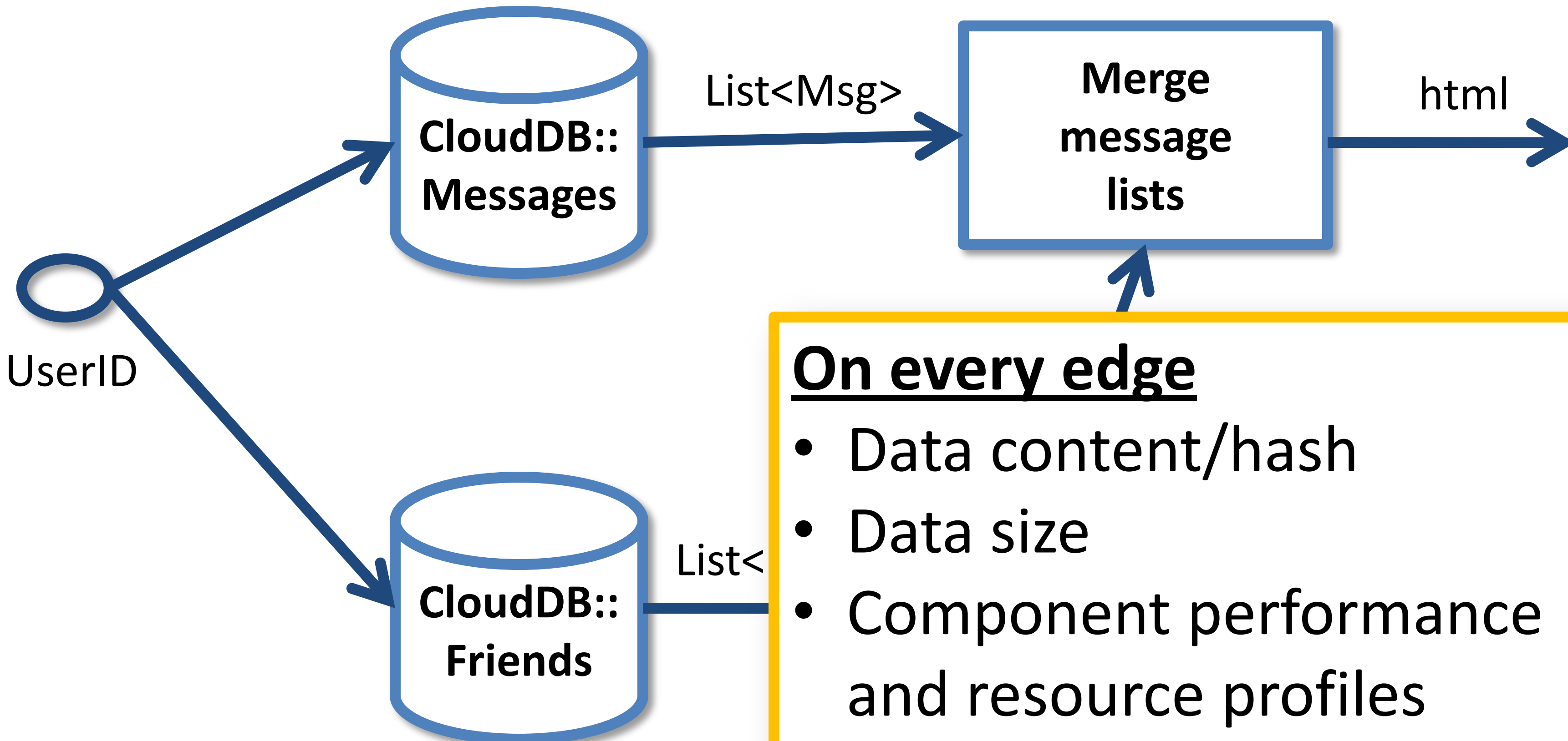
What do We Annotate?



Annotate Semantics

- Consistency requirements
- (No strong consistency)
- Side-effects

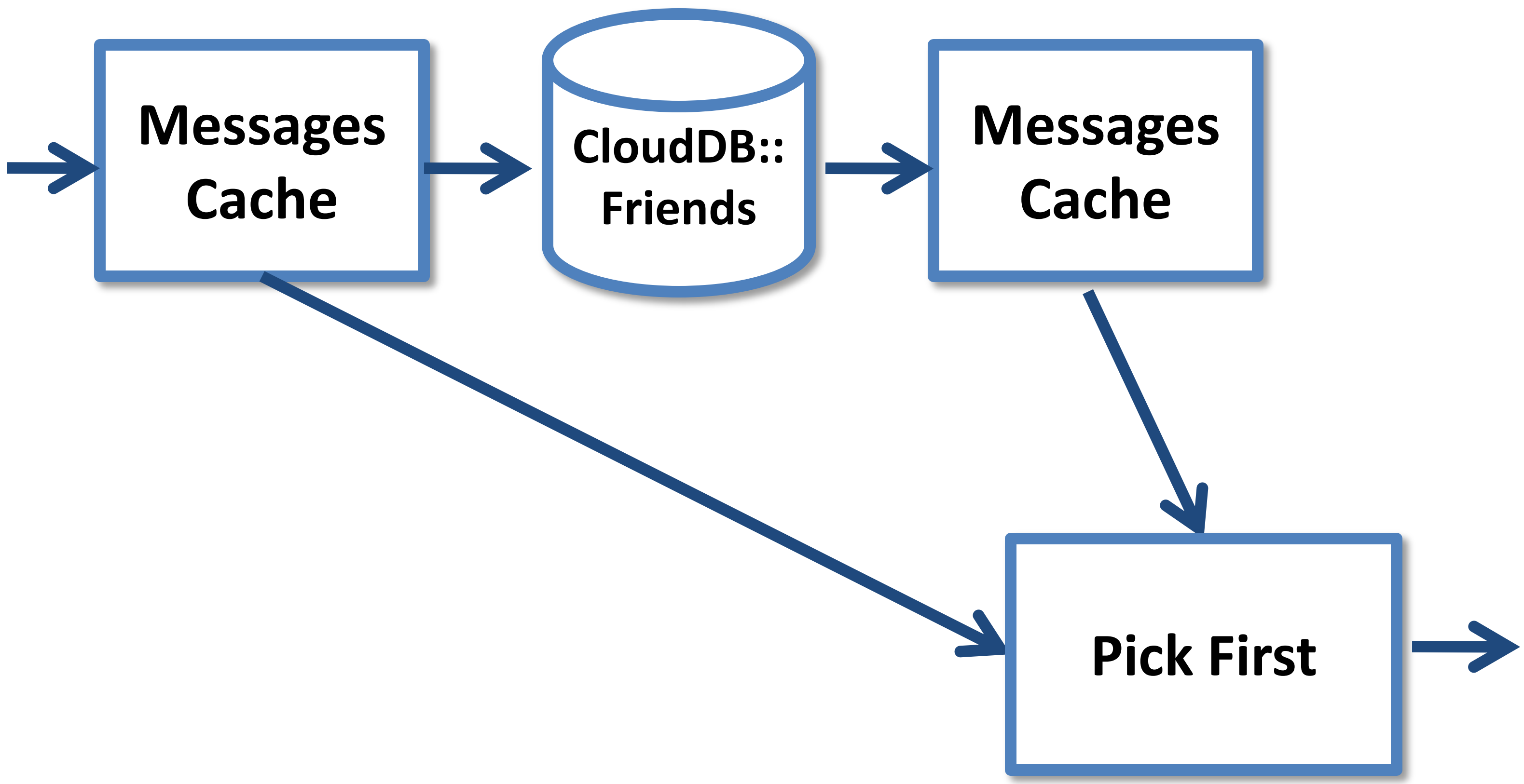
What do We Measure?



<u>On every edge</u>

- Data content/hash
- Data size
- Component performance and resource profiles
- Queue info

How do we transform? Caching



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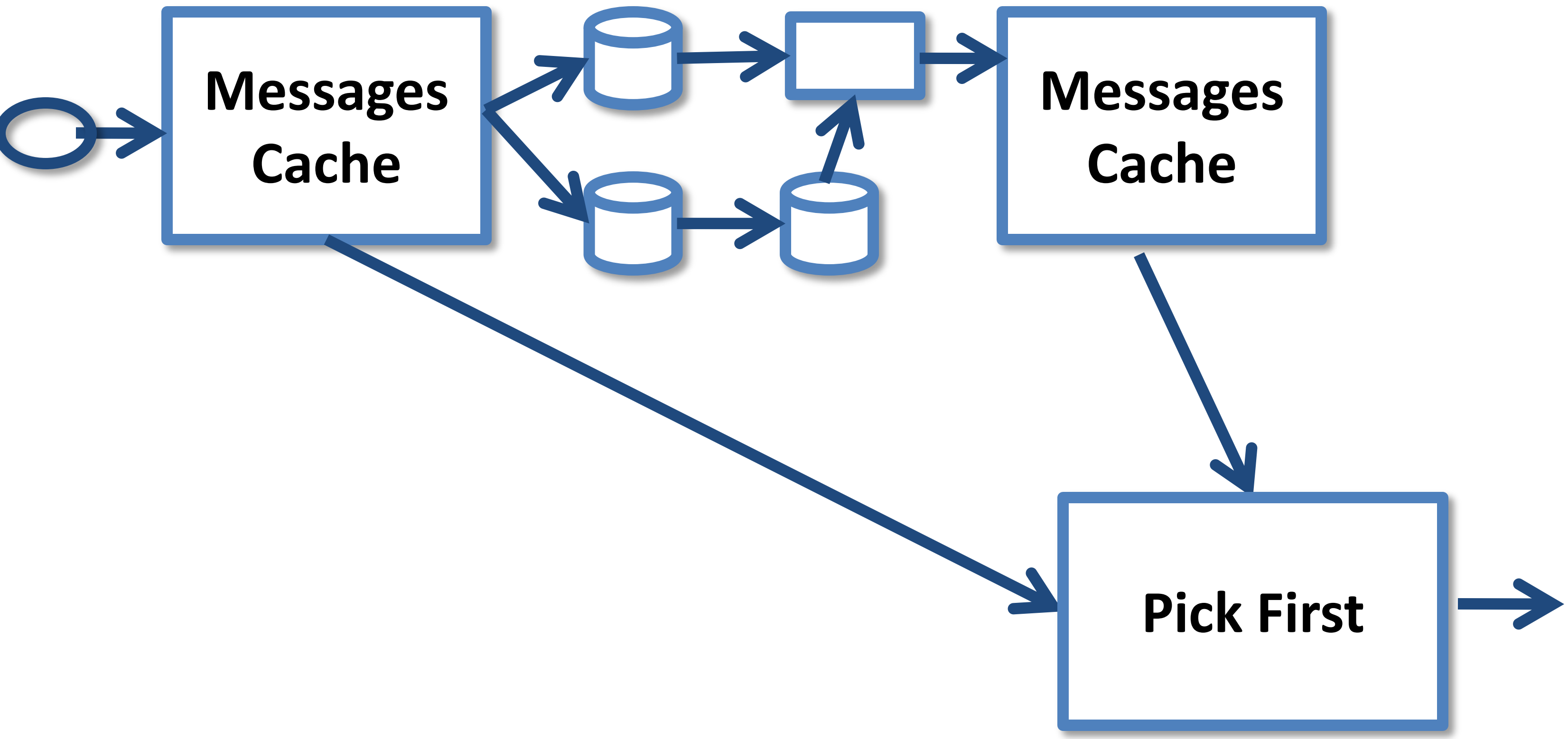
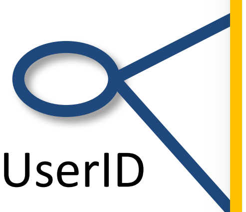


So, where do we put a cache?



1. **<u>Analyze Dataflow:</u>**
   Identify subgraphs with single input, single output

<u>2. Check Annotations:</u>

   Subgraphs should not contain nodes with side-effects; or volatile<0>

<u>3. Analyze measurements</u>

   Data size -> what fits in cache size?
   Content hash -> expected hit rate
   Subgraph perf -> expected benefit

Related Work

- **MapReduce/Dryad** – separates app from scalability/reliability architecture but only for batch
- **WaveScope** – uses dataflow and profiling for partitioning computation in sensor network
- **J2EE** – provides implementation of common patterns but developer still requires detailed knowledge
- **SEDA** – event driven system separates app from resource controllers

Conclusion

- **Q: Can we automate architectural decisions?**
- **Open Challenges:**
  - Ensuring correctness of transformations
  - Improving analysis techniques
- **Current Status:** In implementation
  - Experimenting with programming model restrictions and transformations
- If successful would enable easier development and improve agility

Extra Slides

Utility Computing Infrastructure

- On-demand compute and storage
  - Machines no longer bottleneck to scalability
- Spectrum of APIs and choices
  - Amazon EC2, Microsoft Azure, Google AppEngine
- Developer figures out how to use resources effectively
  - Though, AppEngine and Azure restrict programming model to reduce potential problems

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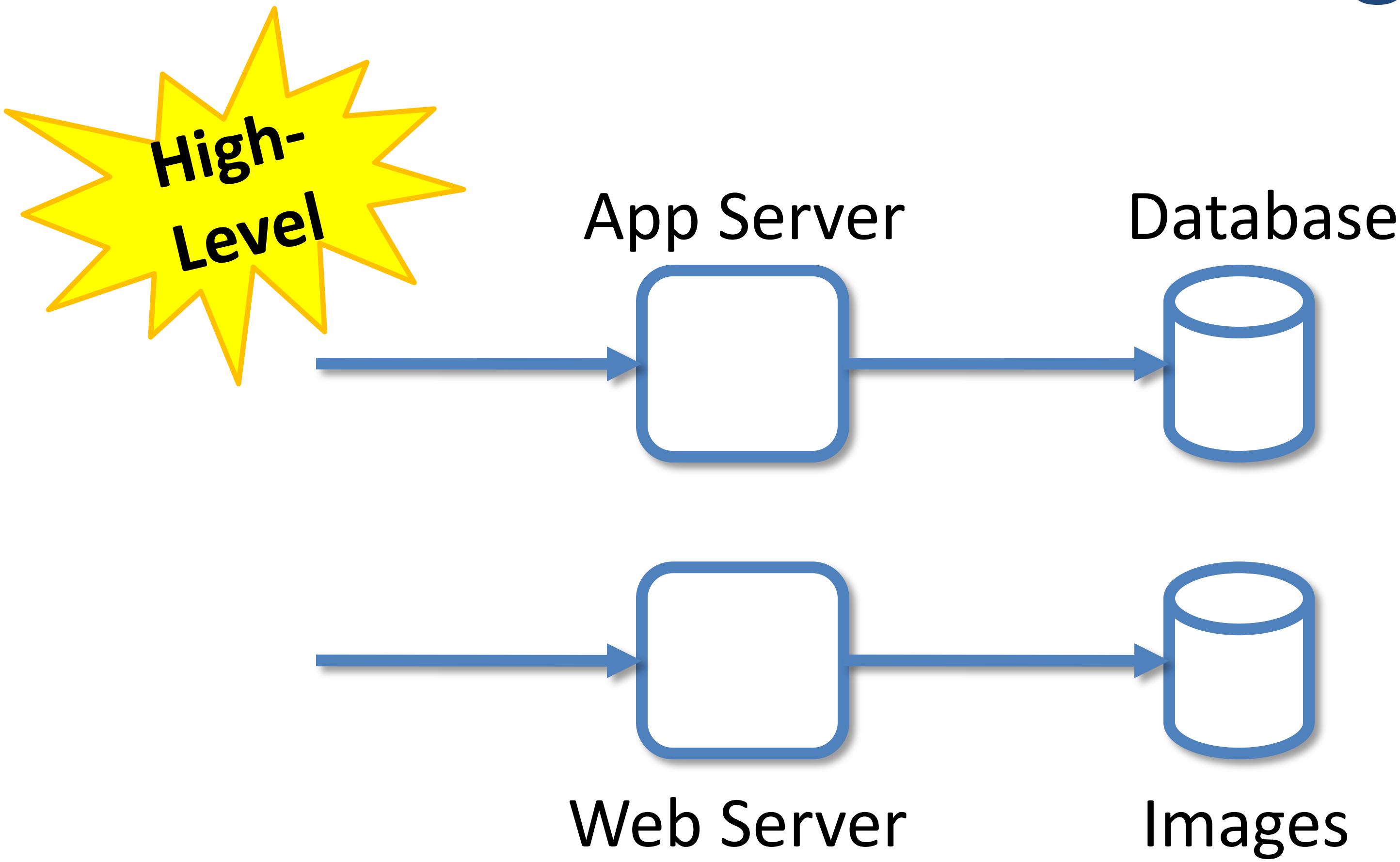

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Fault Model

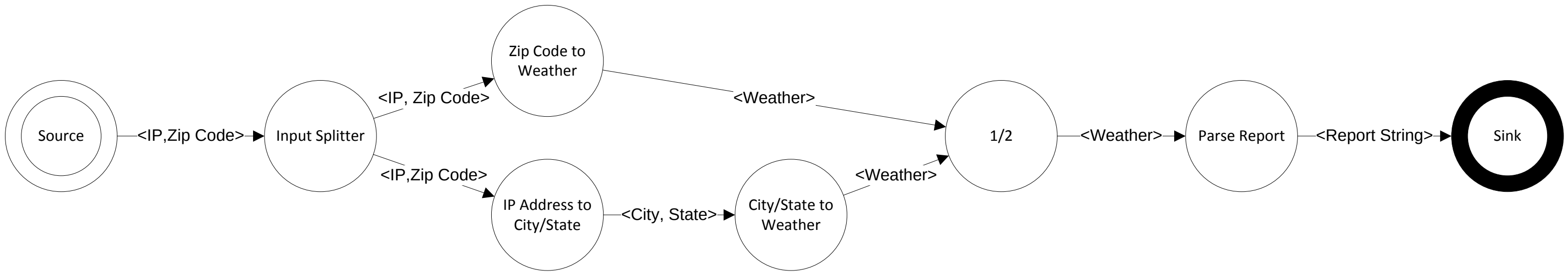
- Best-effort execution layer provides machines
  - On failure, new machine is allocated
- Deployed program must have redundancy to work through failures
- Responsibility of Fluxo compiler

Storage Model

- Store data in an “external” store
  - S3, Azure, Sql Data Services
  - may be persistent, session, soft, etc.
- Data written as delta-update
  - Try to make reconciliation after partition easier

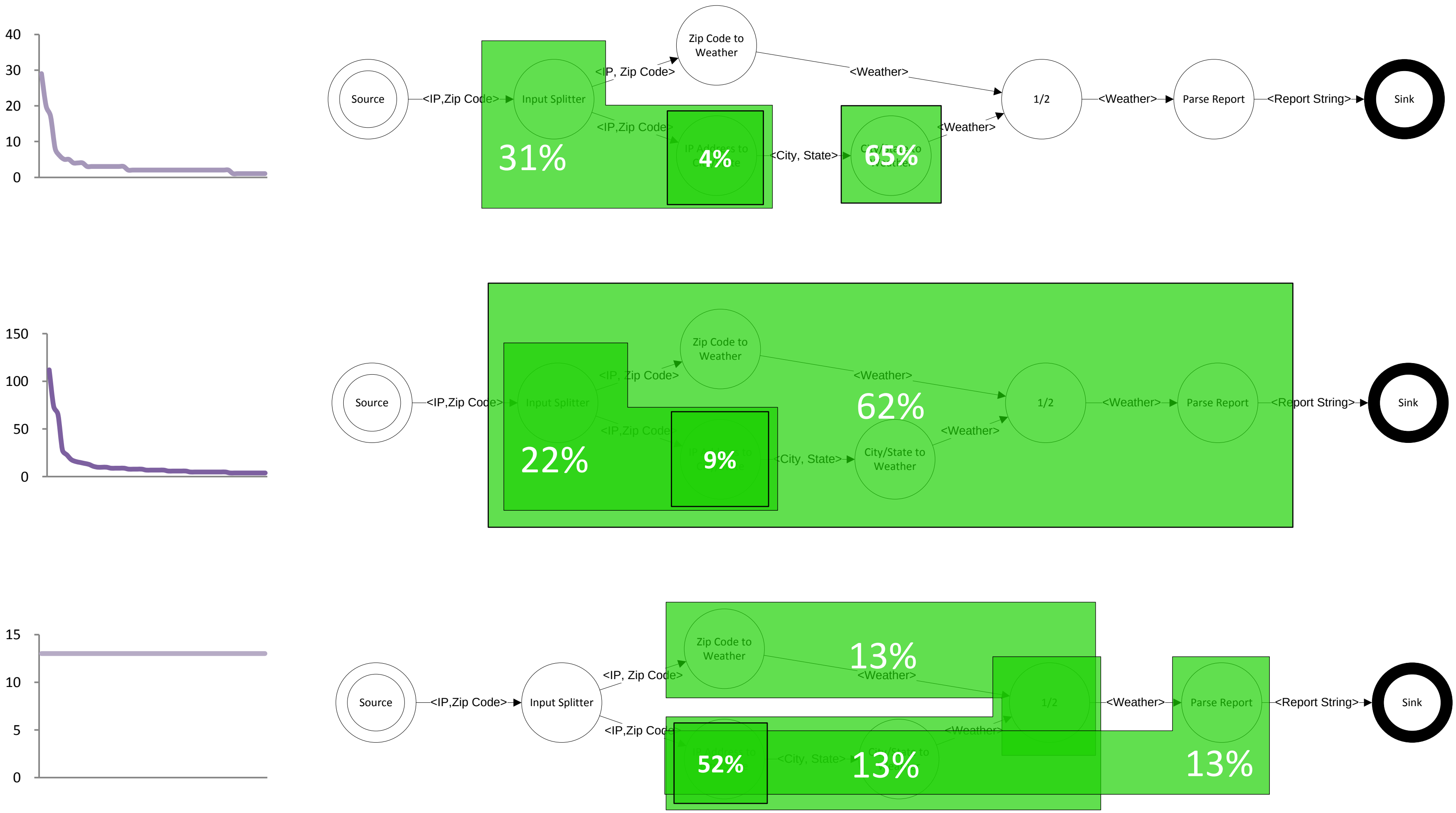
- Writes have deterministic ID for idempotency

Getting our feet wet…



- Built toy application: Weather service
  - Read-only service operating on volatile data
- Run application on workload traces from Popfly
  - Capture performance and intermediate workload distributions
- Built cache placement optimizer
  - Replays traces in simulator to test a cache placement
  - Simulated annealing to explore the space of choices

Caching choices vary by workload



Example #2: Pre/post compute