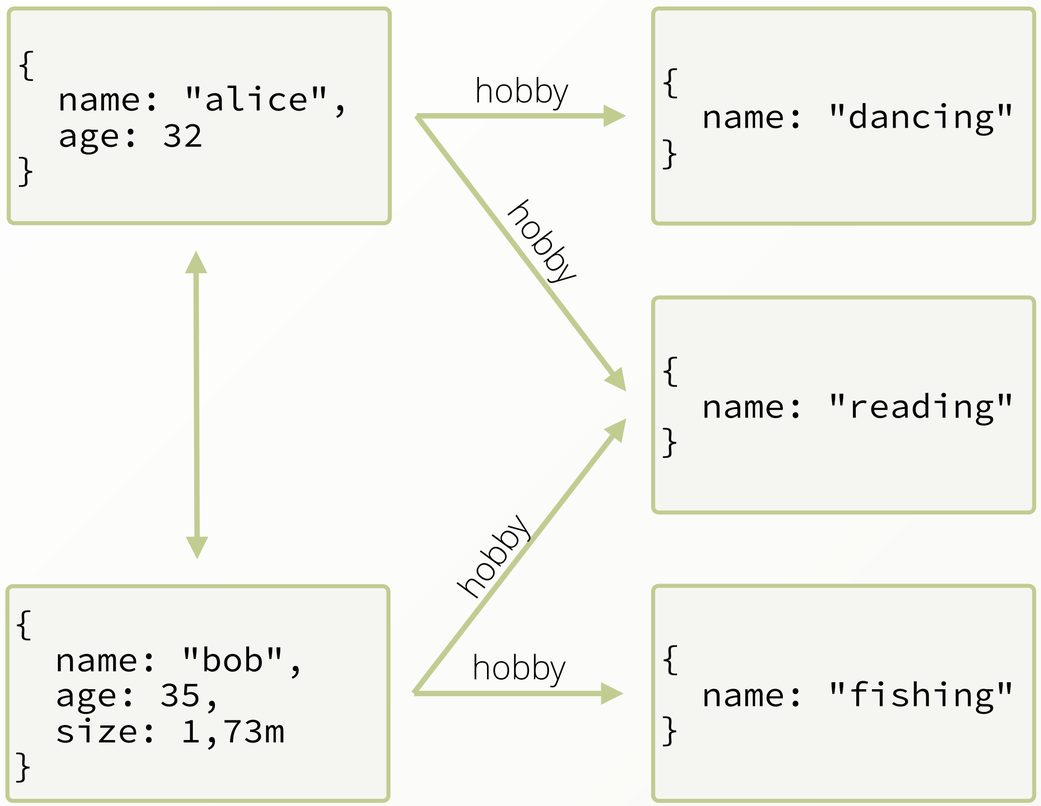
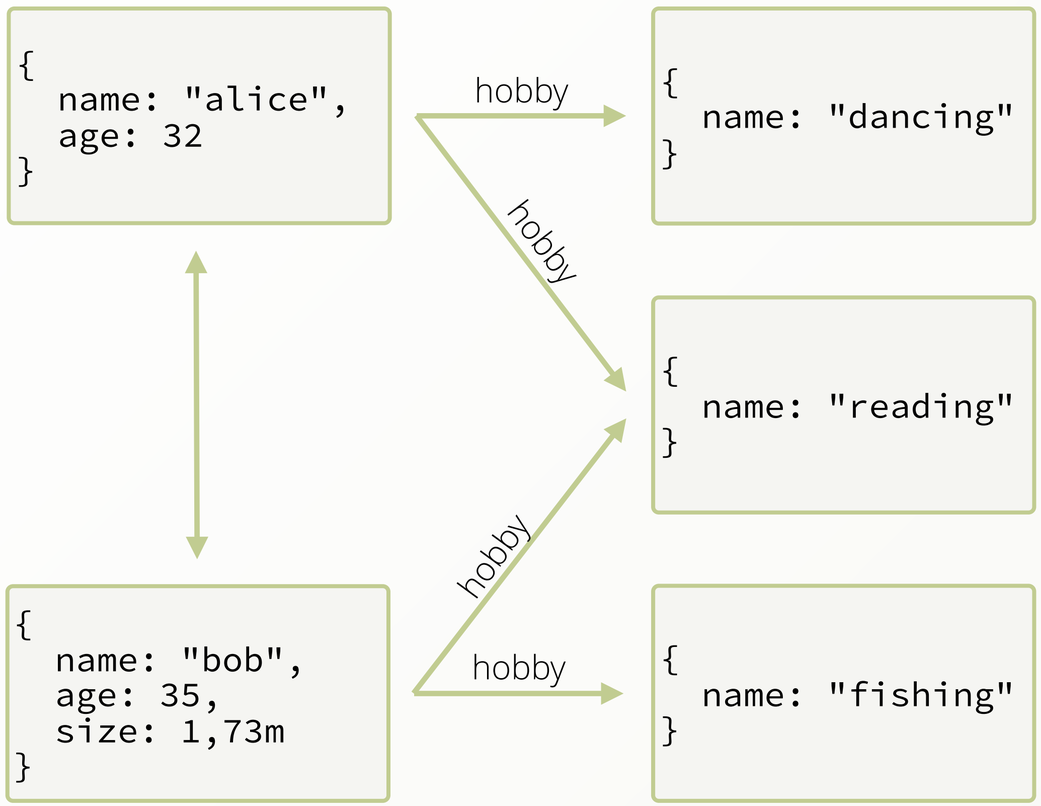
ArangoDB

Handling Billions Of Edges in a Graph Database

Michael Hackstein
@mchacki



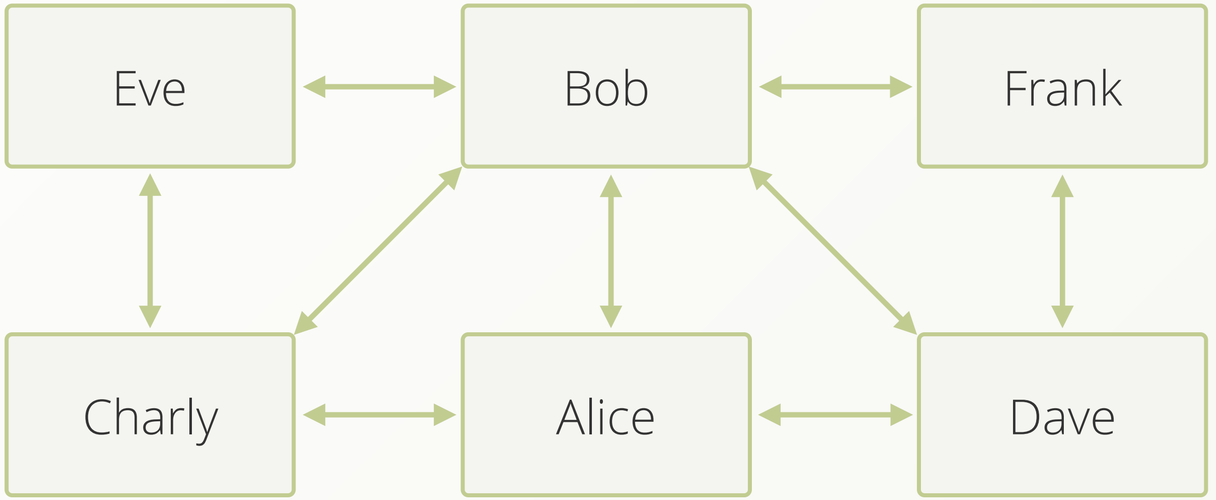
- Schema-free Objects (Vertices)
- Relations between them (Edges)
- Edges have a direction



- Schema-free Objects (Vertices)
- Relations between them (Edges)
- Edges have a direction

- Edges can be queried in both directions
- Easily query a range of edges (2 to 5)
- Undefined number of edges (1 to *)
- Shortest Path between two vertices

- Give me all friends of Alice



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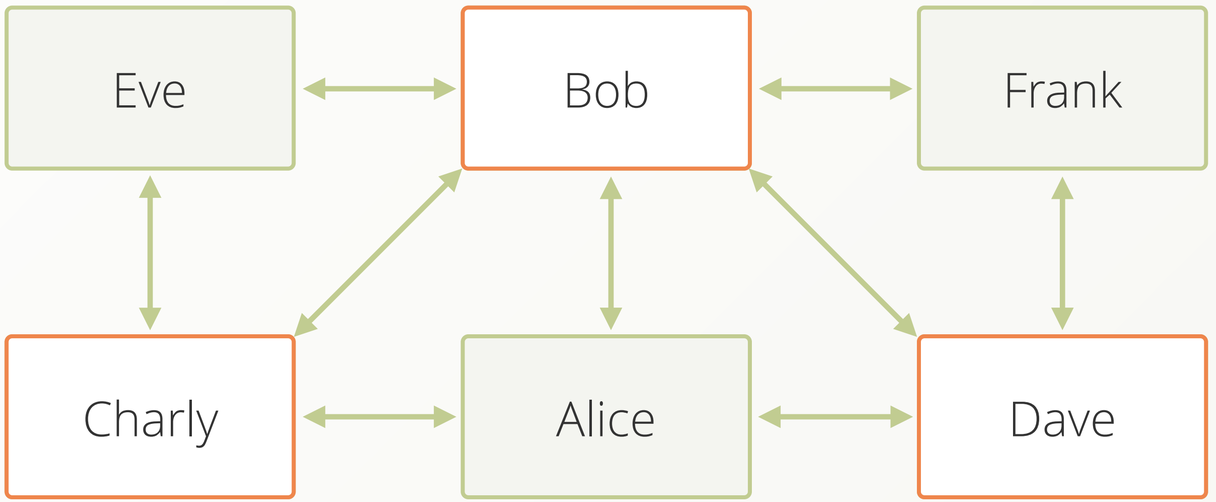
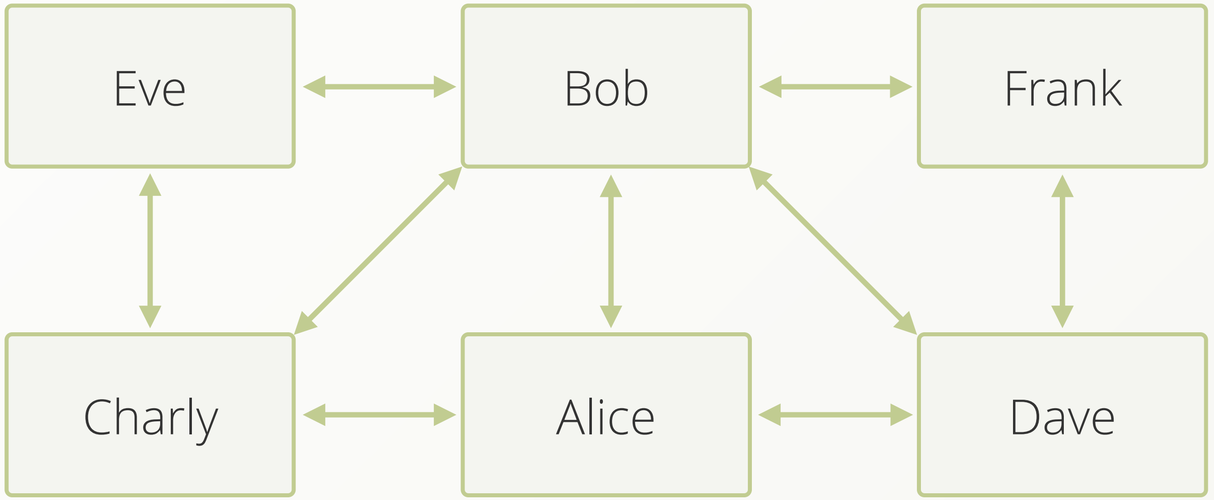


- Give me all friends-of-friends of Alice



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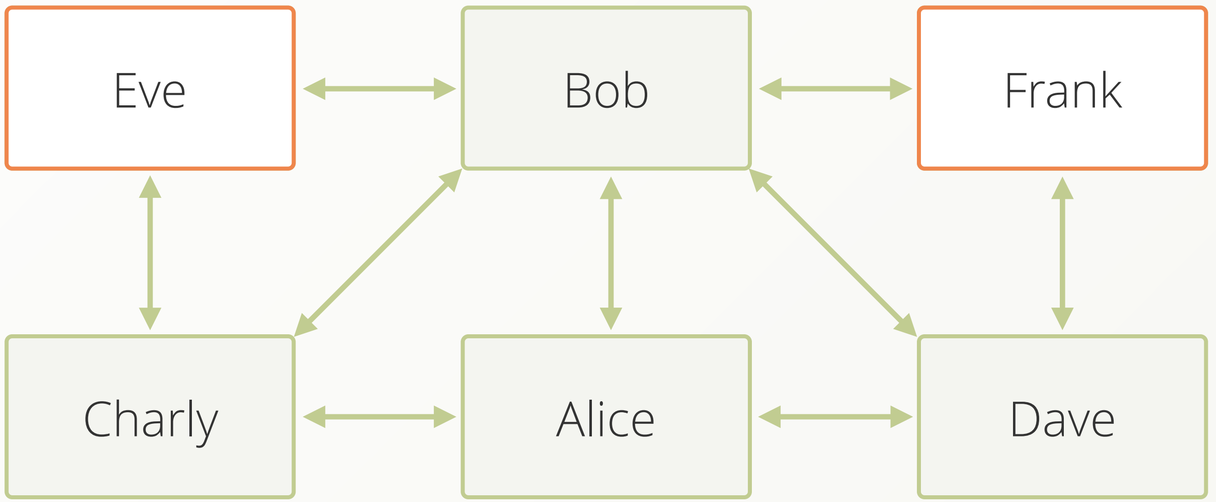
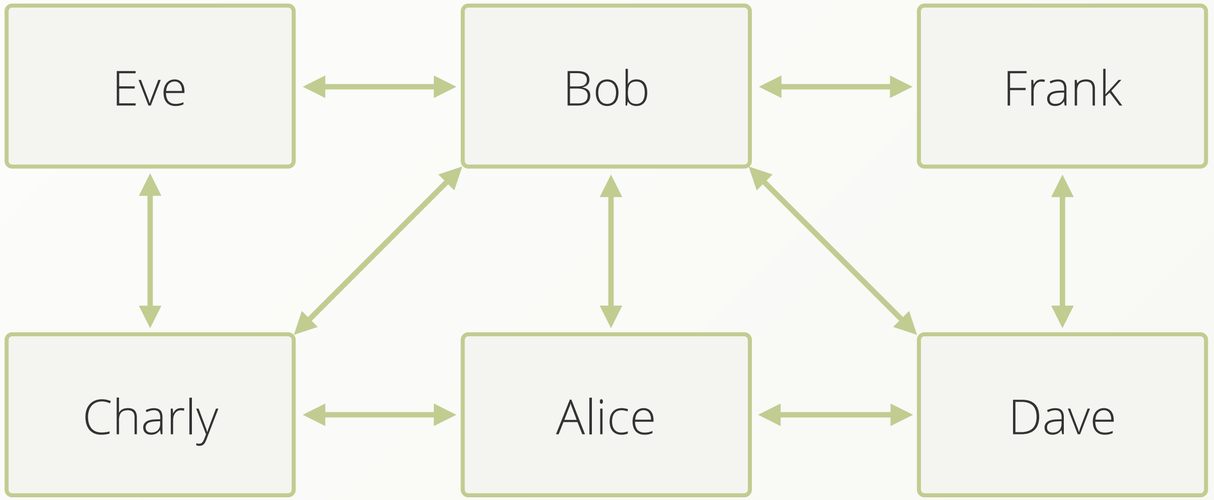


- What is the linking path between Alice and Eve



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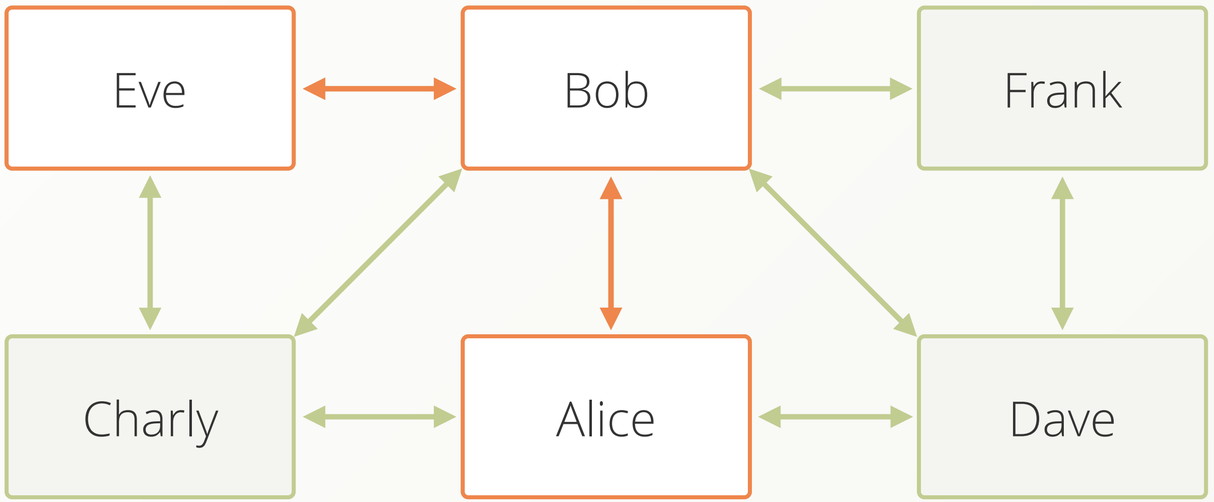
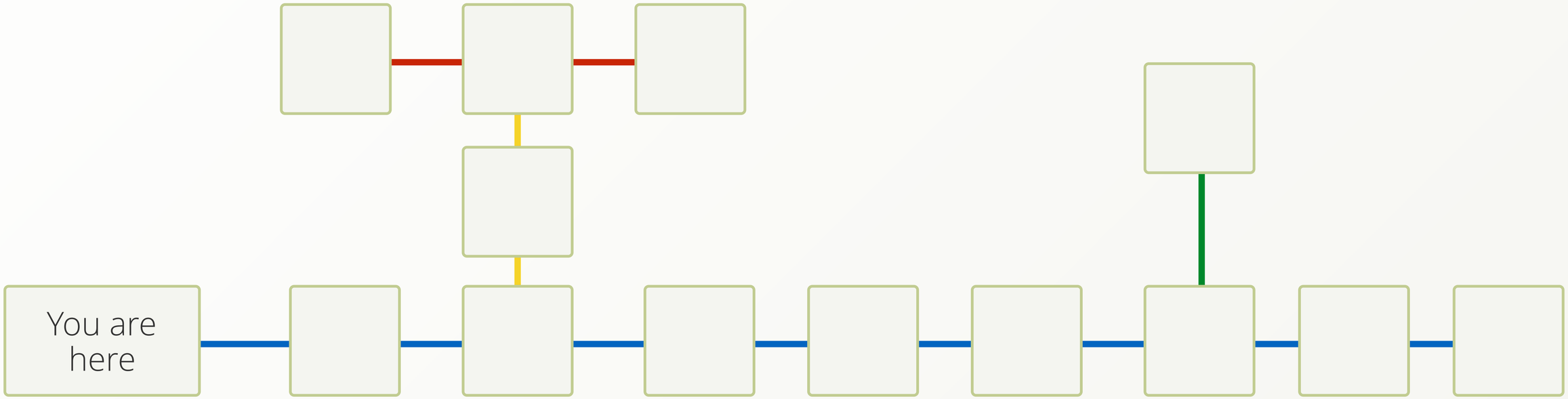


- Which Trainstations can I reach if I am allowed to drive a distance of at most 6 stations on my ticket



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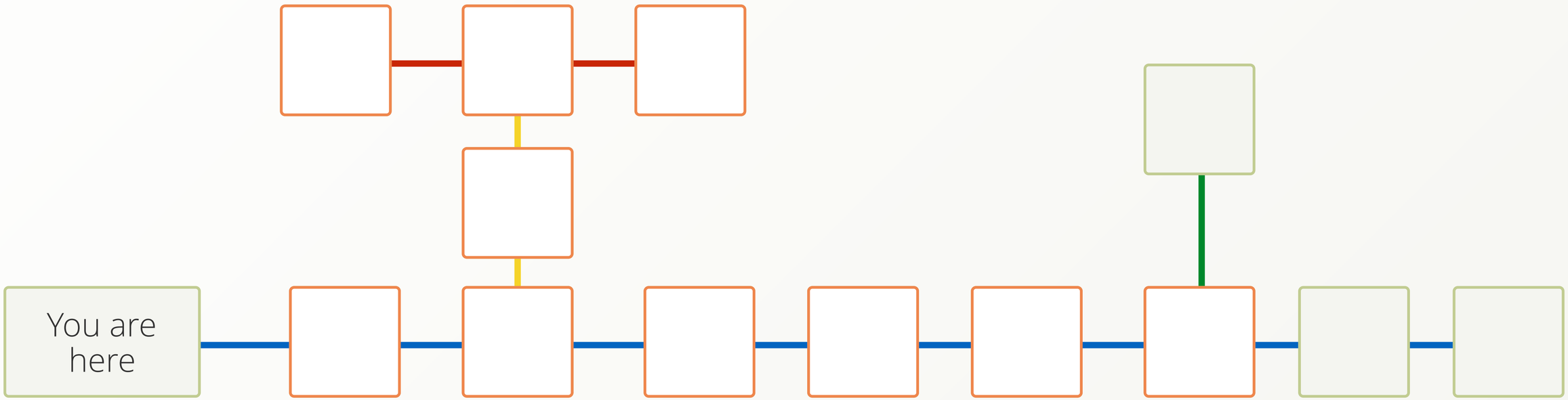

- Give me all users that share two hobbies with Alice

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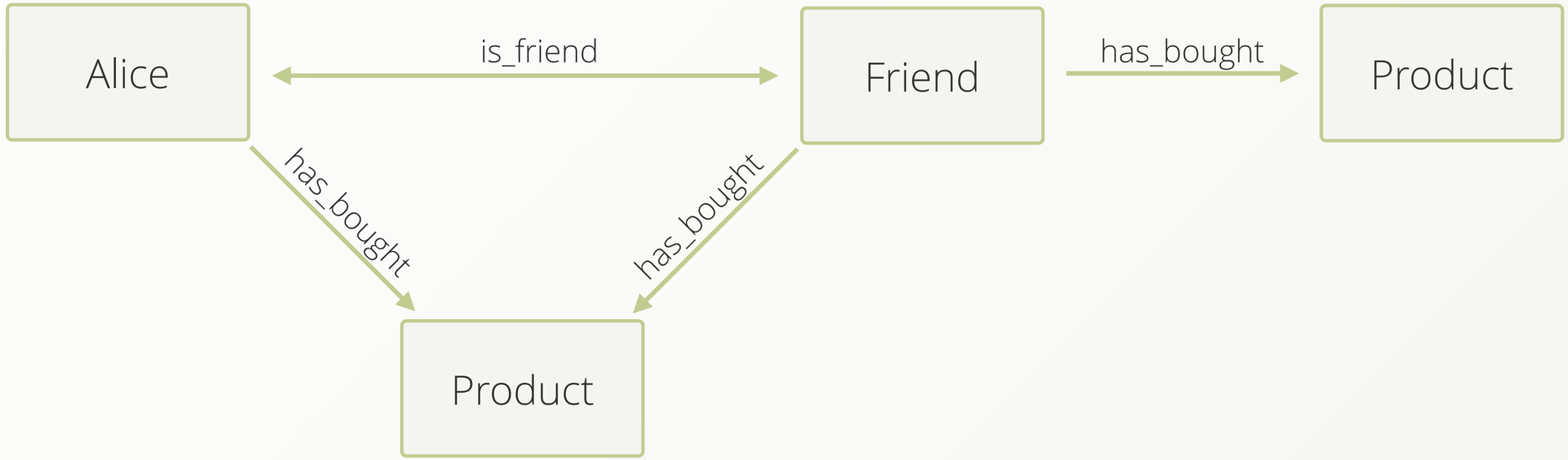
- Give me all products that at least one of my friends has bought together with the products I already own, ordered by how many friends have bought it and the products rating, but only 20 of them.



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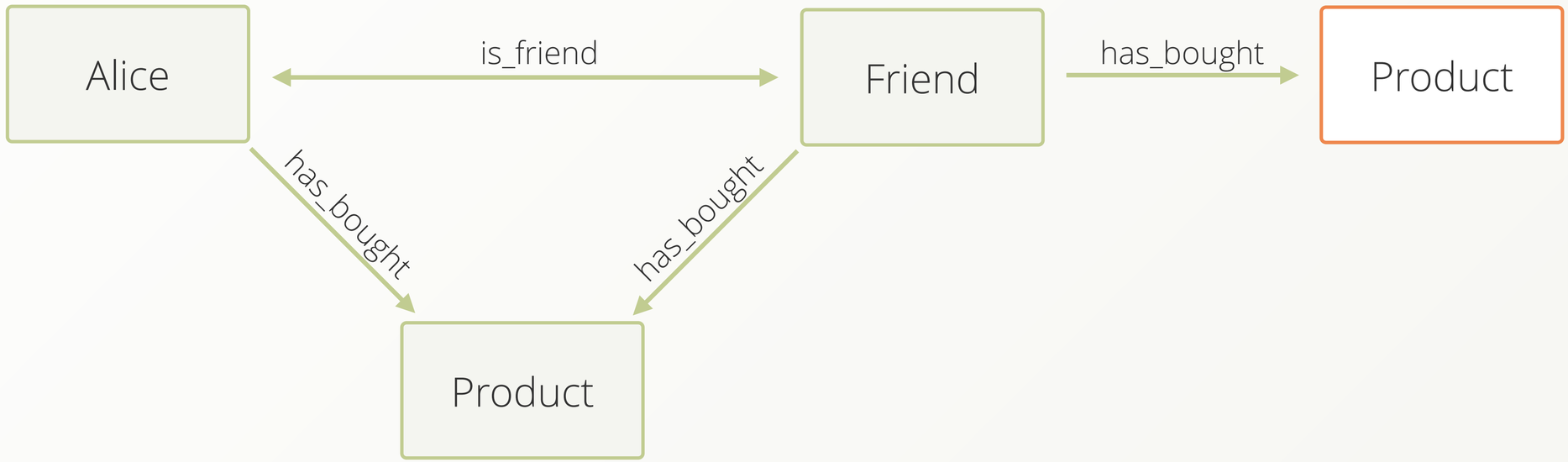

- Give me all users which have an age attribute between 21 and 35.

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- Give me the age distribution of all users

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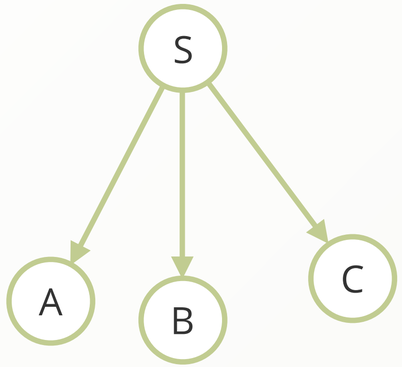
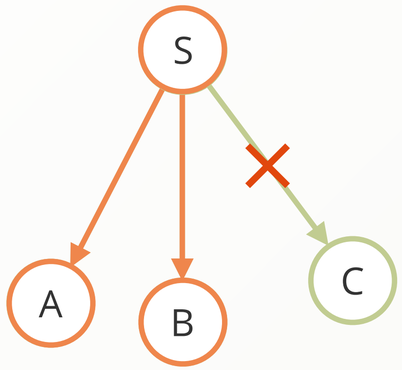
- Give me the age distribution of all users
- Group all users by their name

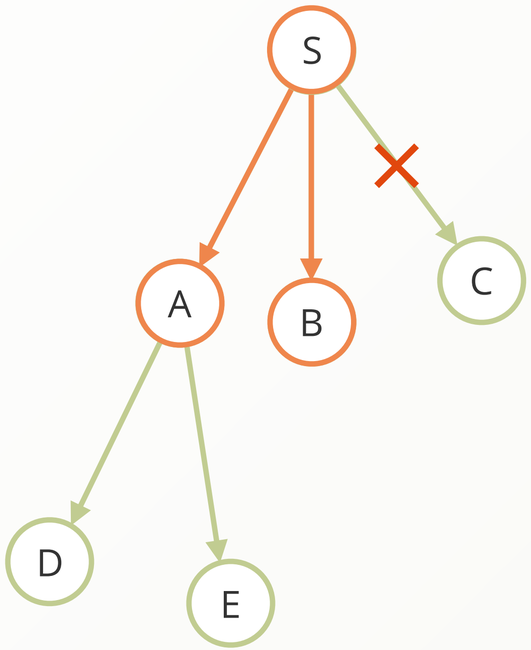
- We first pick a start vertex (S)



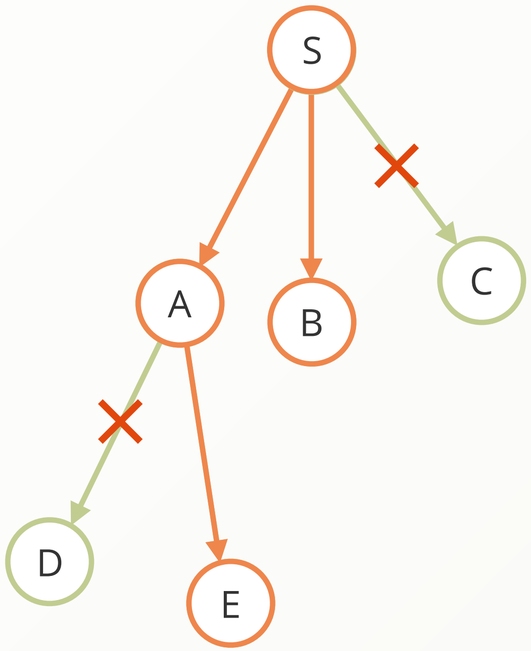
- We first pick a start vertex (S)
- We collect all edges on S



- We first pick a start vertex (S)
- We collect all edges on S
- We apply filters on edges



- We first pick a start vertex (S)
- We collect all edges on S
- We apply filters on edges
- We iterate down one of the new vertices (A)



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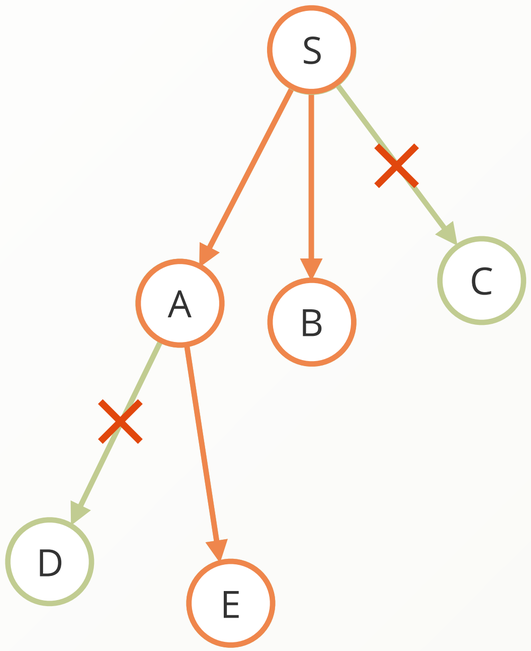

- We first pick a start vertex (S)
- We collect all edges on S
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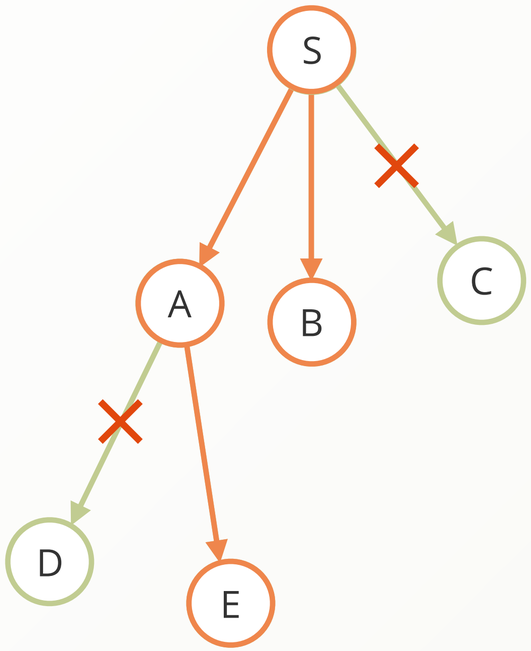
- We iterate down one of the new vertices (A)
- We apply filters on edges
- The next vertex (E) is in desired depth. Return the path S -> A -> E



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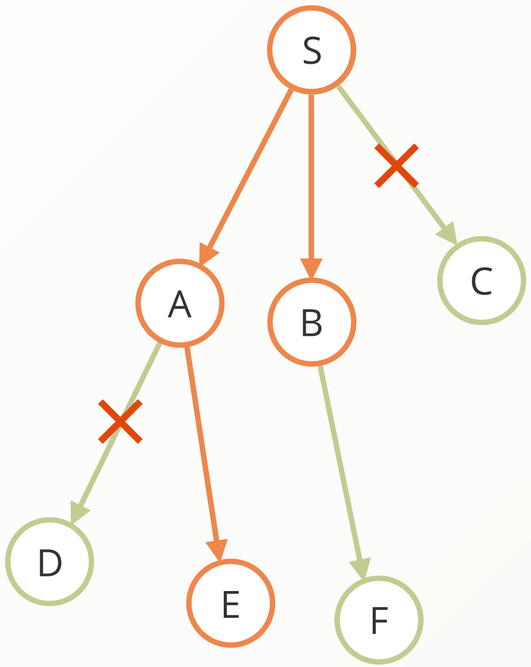
- Go back to the next unfinished vertex (B)



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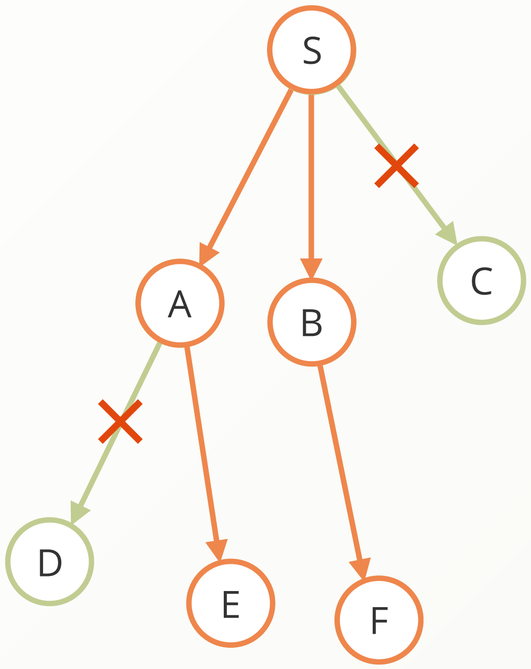
- We iterate down on (B)



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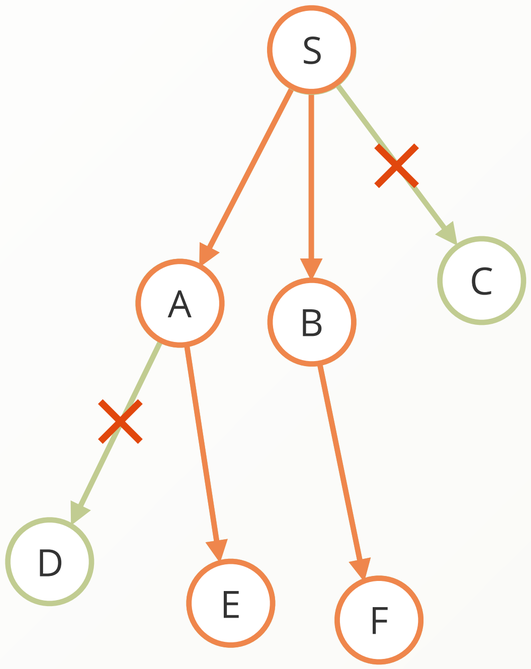

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- Go back to the next unfinished vertex (B)
- We iterate down on (B)
- We apply filters on edges
- The next vertex (F) is in desired depth. Return the path S -> B -> F

- Once:
  - Find the start vertex

	O
Depends on indexes: Hash:	1

- For every depth:
  - Find all connected edges
  - Filter non-matching edges
  - Find connected vertices
  - Filter non-matching vertices

Edge-Index or Index-Free:	1
Linear in edges:	n
Depends on indexes: Hash:	n * 1
Linear in vertices:	n
Only one pass:	3n

- Linear sounds evil?
  - NOT linear in All Edges O(E)
  - Only Linear in relevant Edges n < E
- Traversals solely scale with their result size
- They are not effected at all by total amount of data
- BUT: Every depth increases the exponent: $O((3n)^d)$
- "7 degrees of separation": $(3n)^6 < E < (3n)^7$

ArangoDB

- MULTI-MODEL database
  - Stores Key Value, Documents, and Graphs
  - All in one core
- Query language AQL
  - Document Queries
  - Graph Queries
  - Joins
  - All can be combined in the same statement
- ACID support including Multi Collection Transactions

```
FOR user IN users
  RETURN user
```

```
FOR user IN users
  FILTER user.name == "alice"
  RETURN user
```

Alice

```
FOR user IN users
  FILTER user.name == "alice"
  FOR product IN OUTBOUND user has_bought
  RETURN product
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FOR user IN users
  FILTER user.name == "alice"
  FOR recommendation, action, path IN 3 ANY user has_bought
    FILTER path.vertices[2].age <= user.age + 5
    AND path.vertices[2].age >= user.age - 5
    FILTER recommendation.price < 25
    LIMIT 10
    RETURN recommendation
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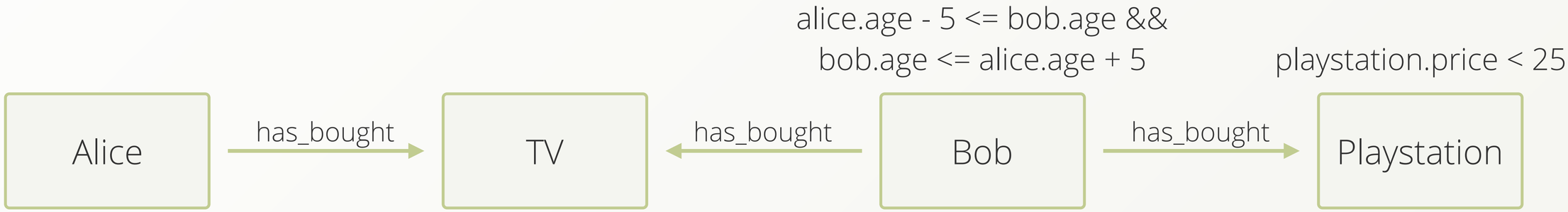
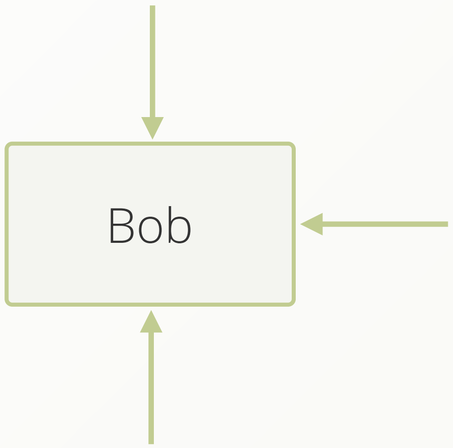
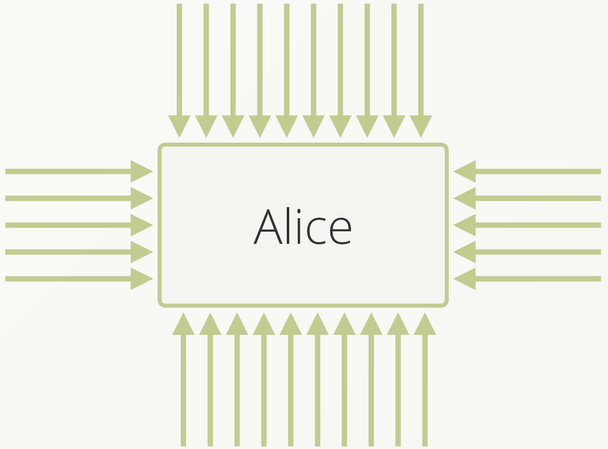


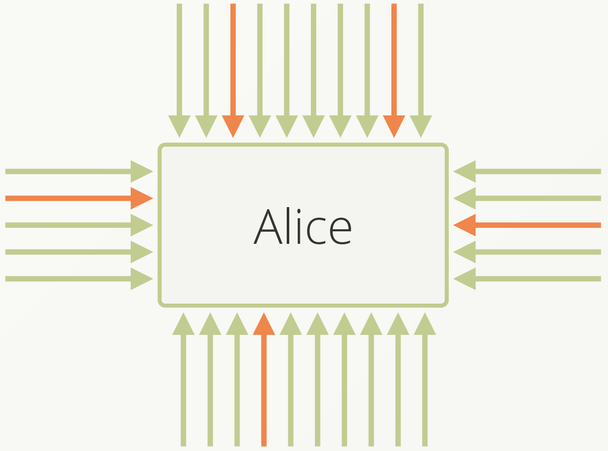
- Many graphs have "Supernodes"
  - Vertices with many inbound and/or outbound edges
- Traversing over them is expensive
- Often you only need a subset of edges





- Remember Complexity? $O((3n)^d)$
- Filtering of non-matching edges is linear for every depth

- Index all edges based on their vertices and arbitrary other attributes
  - Find initial set of edges in identical time
  - Less / No post-filtering required
  - This decreases the n significantly



- We have the rise of big data
  - Store everything you can
- Dataset easily grows beyond one machine
- This includes graph data!

- Distribute graph on several machines (sharding)
- How to query it now?
  - No global view of the graph possible any more
  - What about edges between servers?
- In a shared environment network most of the time is the bottleneck
  - Reduce network hops
- Vertex-Centric Indexes again help with super-nodes
  - But: Only on a local machine

First let's do
the cluster thingy

- ArangoDB is the first fully certified database including the persistence primitives for DC/OS
- ArangoDB's cluster resource management is based on Apache Mesos
- Later this year we will also support Kubernetes

DC/OS

- ArangoDB can run clusters without it
  - Setup Requires manual effort (can be scripted)
- This works:
  - Automatic Failover (Follower takes over if leader dies)
  - Rebalancing of shards
  - Everything inside of ArangoDB
- This is based on Mesos:
  - Complete self healing
  - Automatic restart of ArangoDBs (on new machines)

➡ We suggest you have someone on call

Demo Time
DC/OS

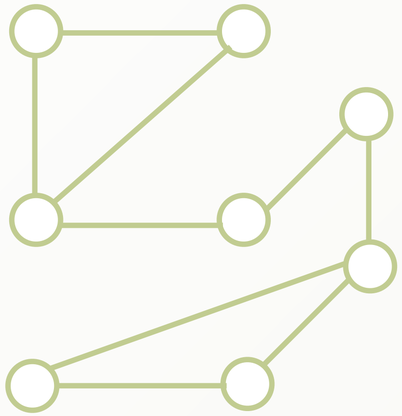
Now distribute the graph

- Only parts of the graph on every machine
- Neighboring vertices may be on different machines
- Even edges could be on other machines than their vertices

- Queries need to be executed in a distributed way
- Result needs to be merged locally

Random Distribution

- Advantages:
  - every server takes an equal portion of data
  - easy to realize
  - no knowledge about data required
  - always works
- Disadvantages:
  - Neighbors on different machines
  - Probably edges on other machines than their vertices
  - A lot of network overhead is required for querying



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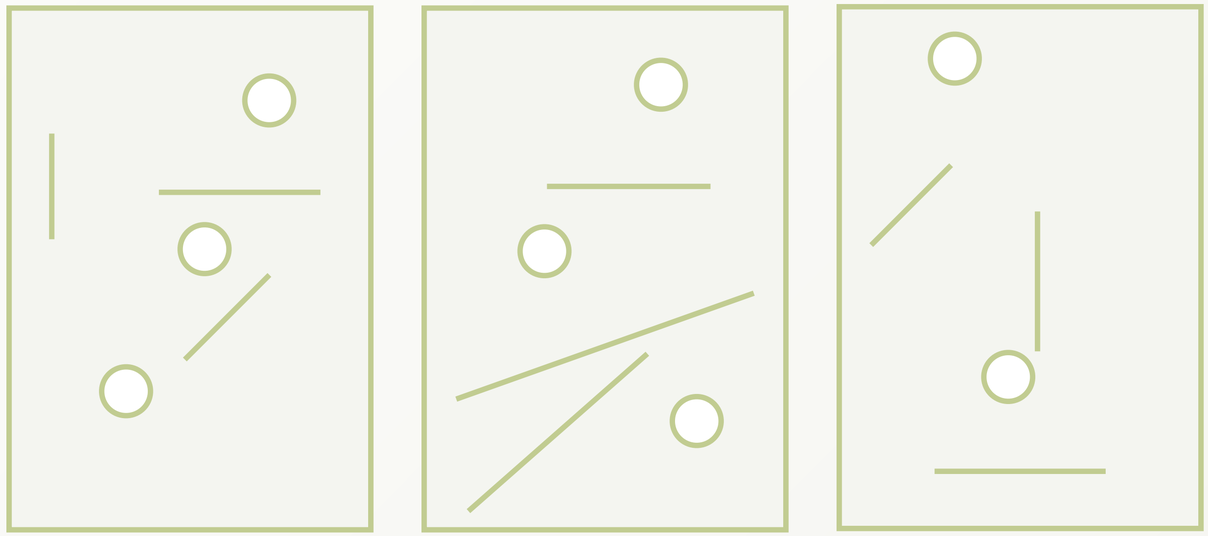
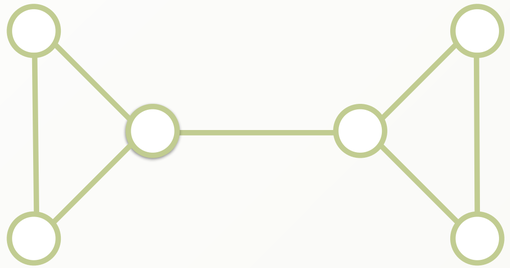


Index-Free Adjacency

- Used by most other graph databases
- Every vertex maintains two lists of it's edges (IN and OUT)
  - Do not use an index to find edges
  - How to shard this?



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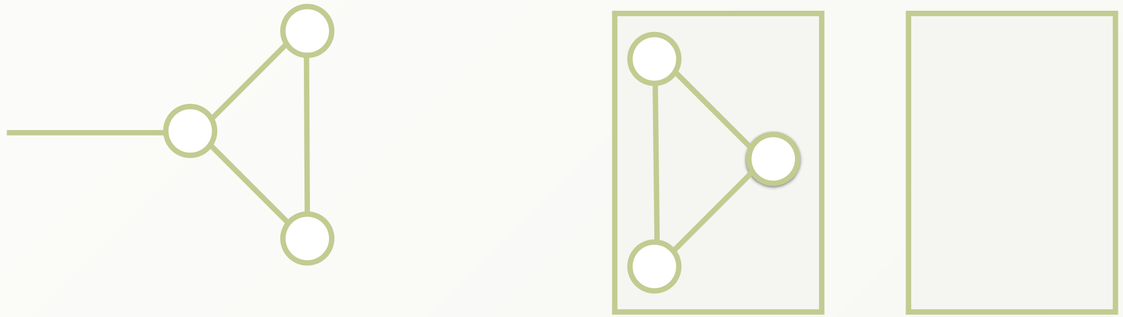

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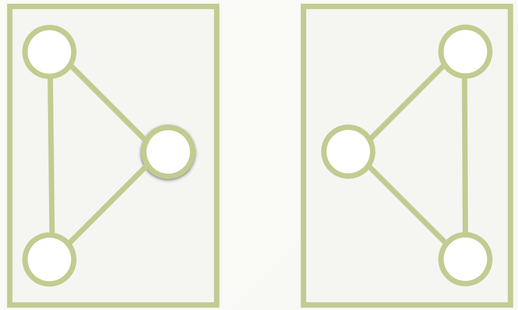

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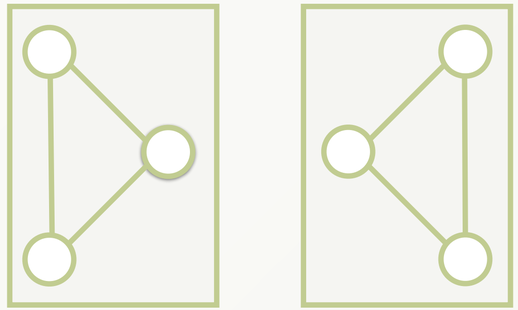

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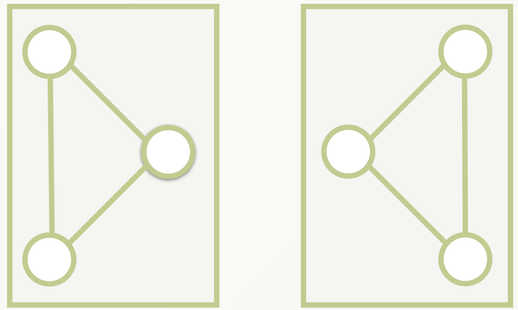
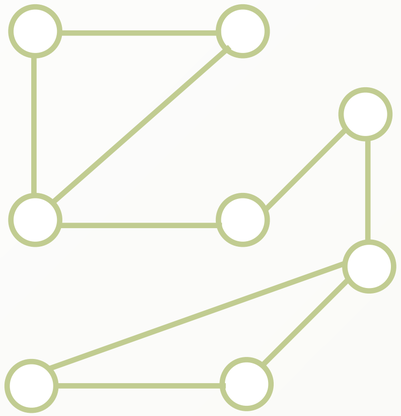


- ArangoDB uses an hash-based EdgeIndex (O(1) - lookup)
  - The vertex is independent of it's edges
  - It can be stored on a different machine

Domain Based Distribution

- Many Graphs have a natural distribution
  - By country/region for People
  - By tags for Blogs
  - By category for Products
- Most edges in same group
- Rare edges between groups



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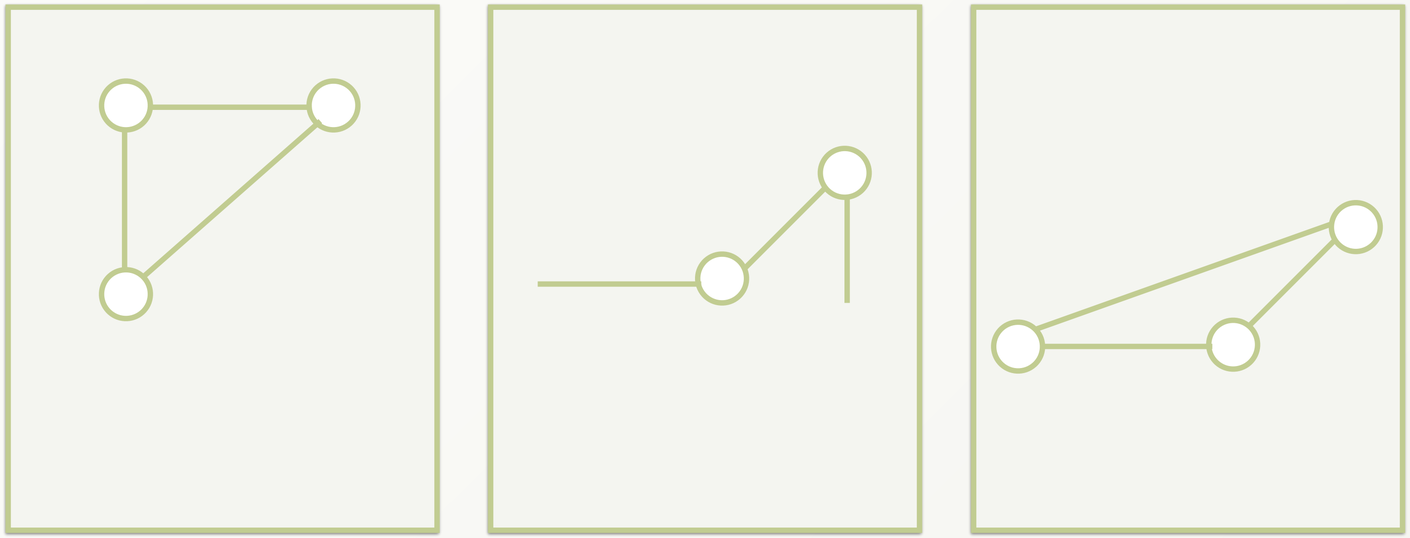
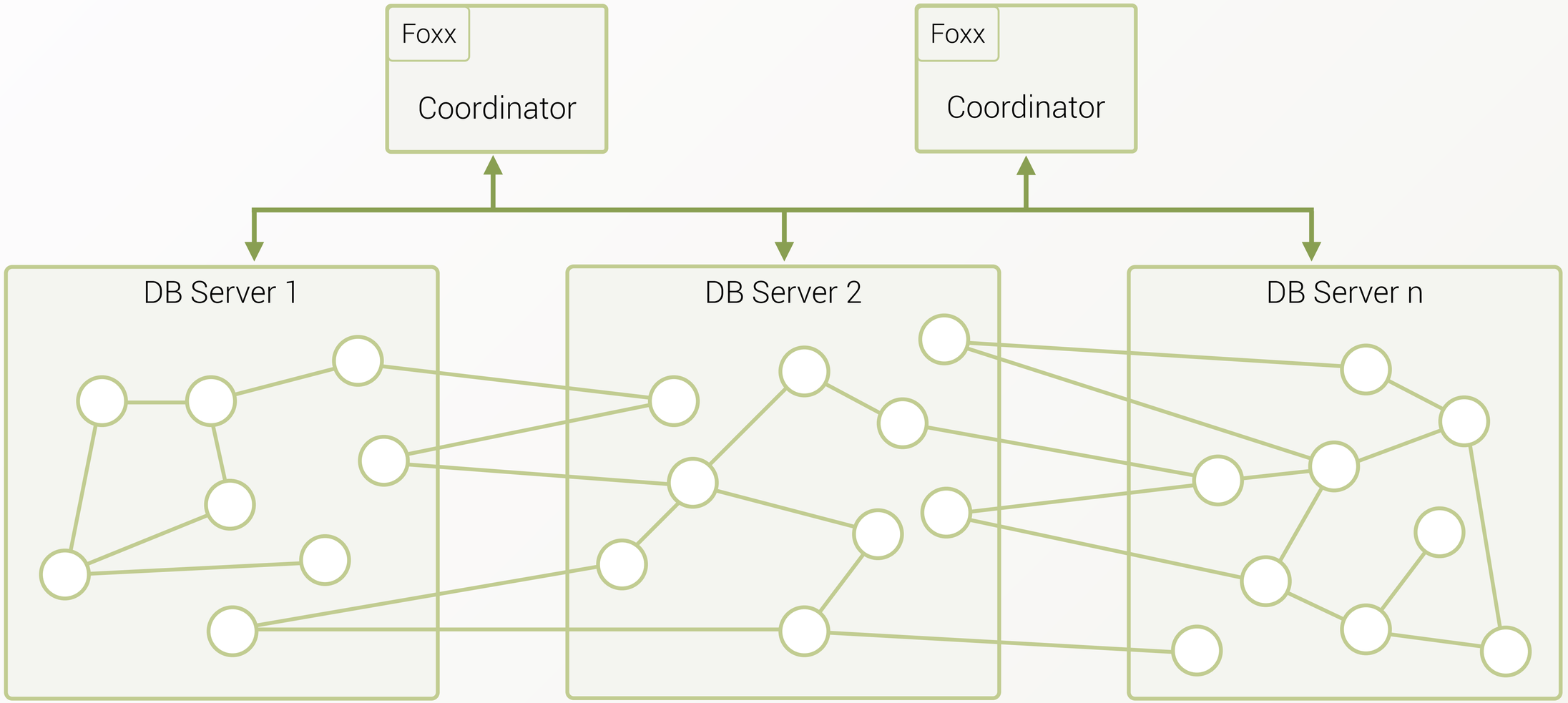


Domain Based Distribution

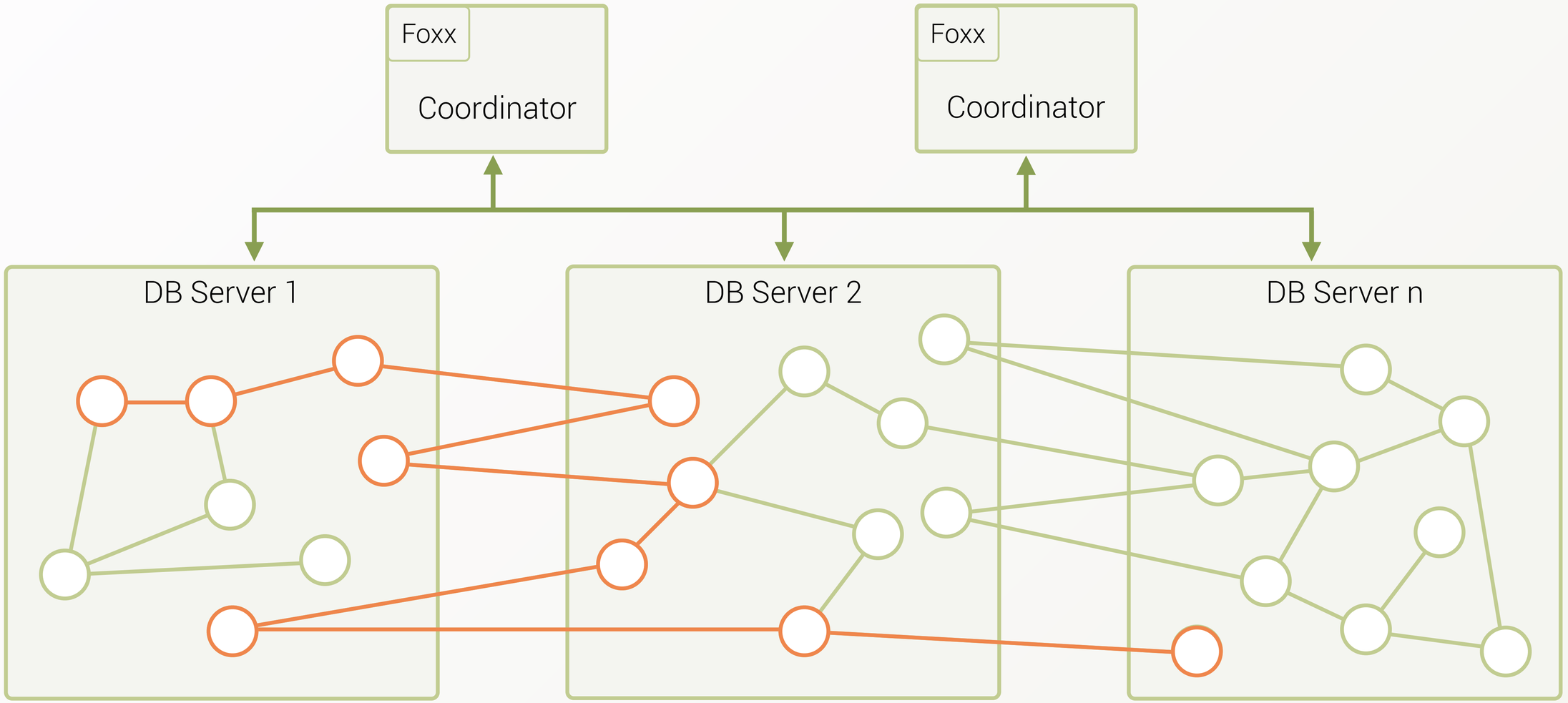
- Many Graphs have a natural distribution
  - By country/region for People
  - By tags for Blogs
  - By category for Products
- Most edges in same group
- Rare edges between groups

ArangoDB Enterprise Edition
uses Domain Knowledge
for short-cuts

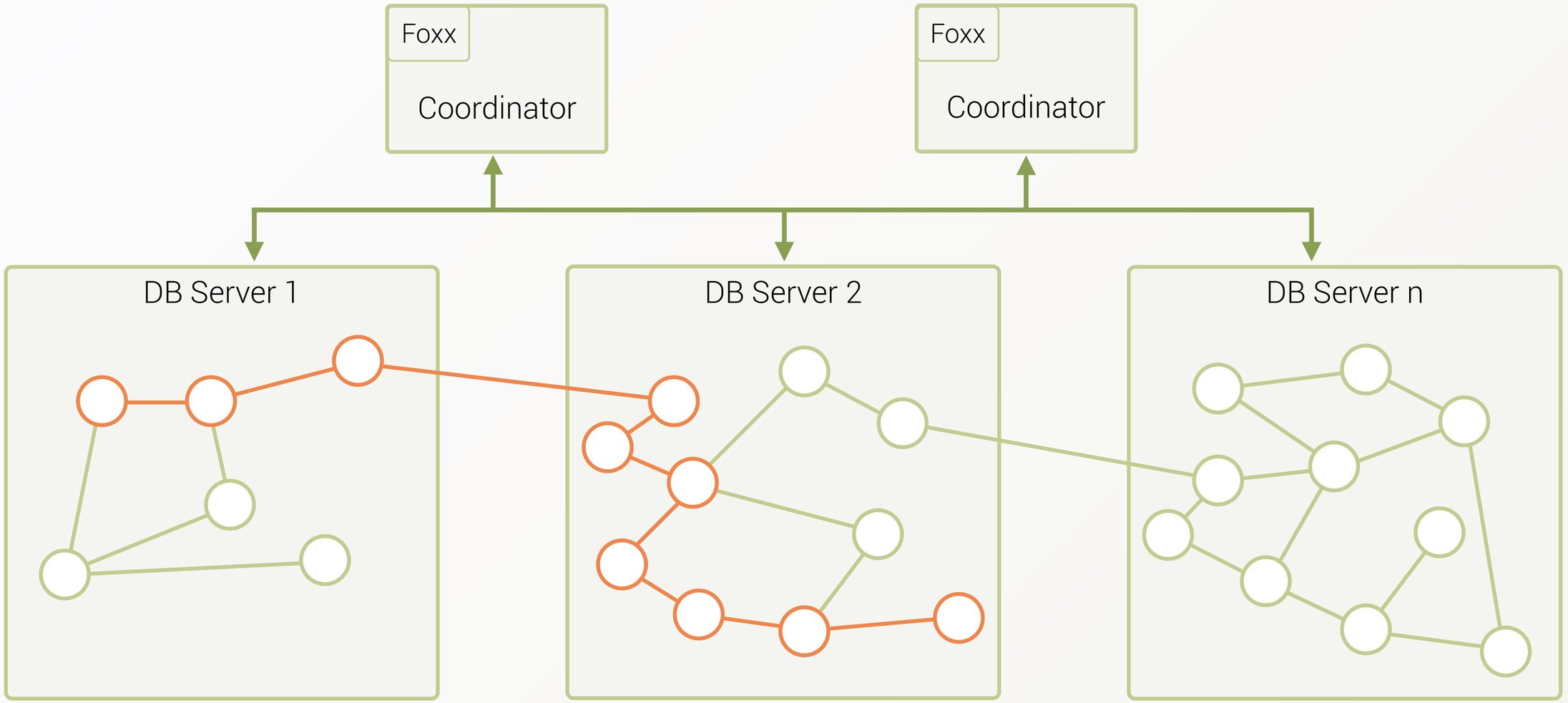
SmartGraphs - How it works



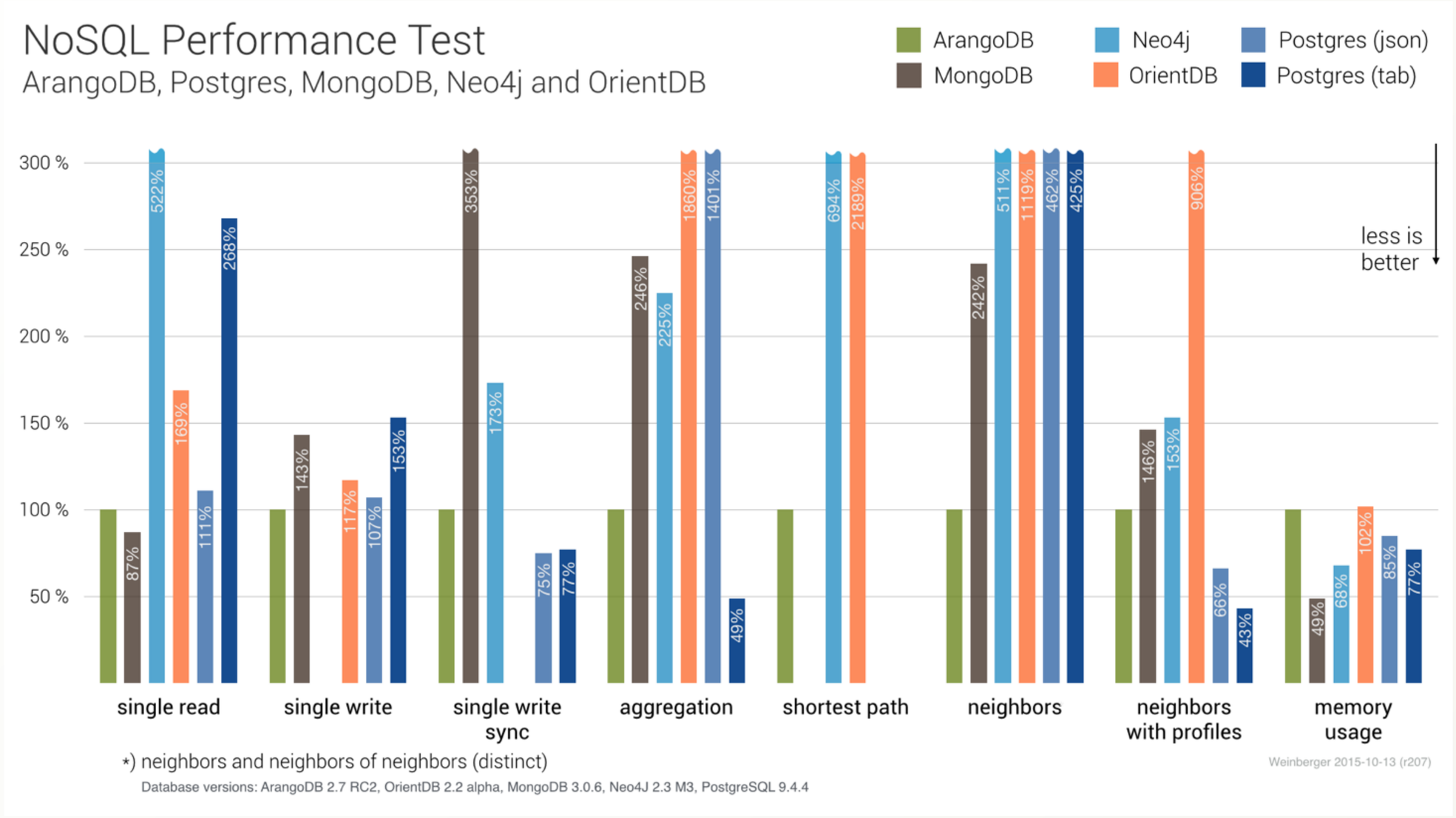
SmartGraphs - How it works



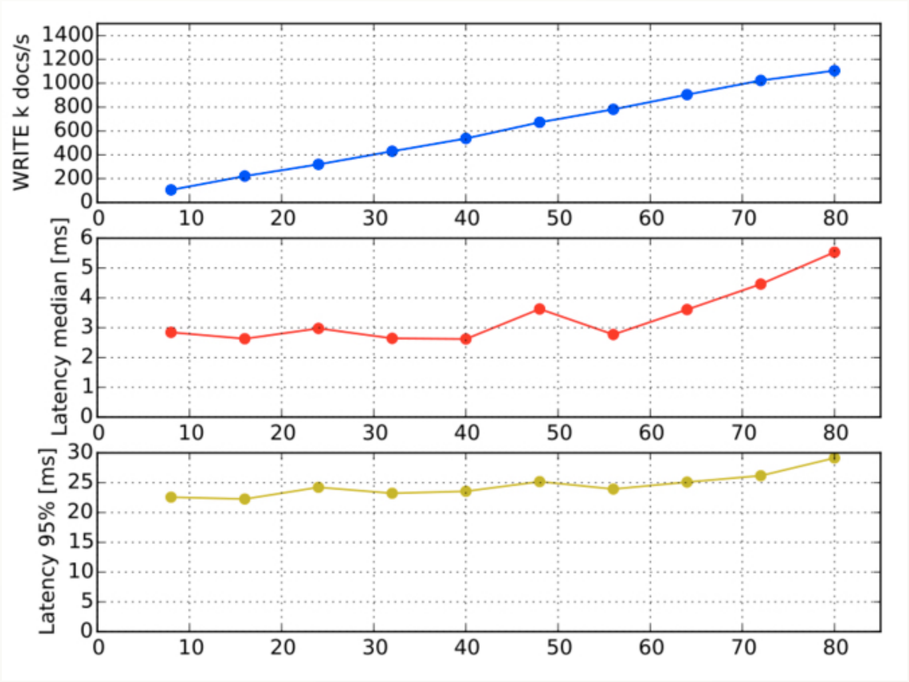
SmartGraphs - How it works



Sneak Preview SmartGraphs



Database	document write transactions per virtual CPU/second
ArangoDB	1,730
Aerospike	2,500
Cassandra	965
Couchbase	1,375
FoundationDB	750



*) Source: https://mesosphere.com/blog/2015/11/30/arangodb-benchmark-dcos/

Thank You

- Further questions?
  - Follow us on twitter: @arangodb
  - Join our slack: slack.arangodb.com

  - Follow me on twitter/github: @mchacki
  - Write me a mail: michael@arangodb.com