Eywa

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BLADE RUNNER
2049
Ryan Gosling / K
Replicant
Ana de Armas / Joi
AI
A movie about Fog Computing

Fog Computing Sci-Fi

Blade Runner 2049's **Joi** lives in the Fog

Smart Home Hologram

Joi lives on a **console** in K's home rather than the cloud. She can control all actuators in the house.

Emanator

Joi can reside on the **portable emanator** and move around with K. A Fog Computing device?

K's Spinner Car

Joi is connected to the car. When the spinner goes down, she loses the ability to project herself.

The **Internet** of **Things**

Cloud

Dynamic provisioning of scalable resources e.g. analytics on a **huge volume** of historical data.

Fog Computing

An emerging technology that bridges the gap, deployed **close to the source**.

Things

Connected sensors and actuators producing **streams of time-series data.**

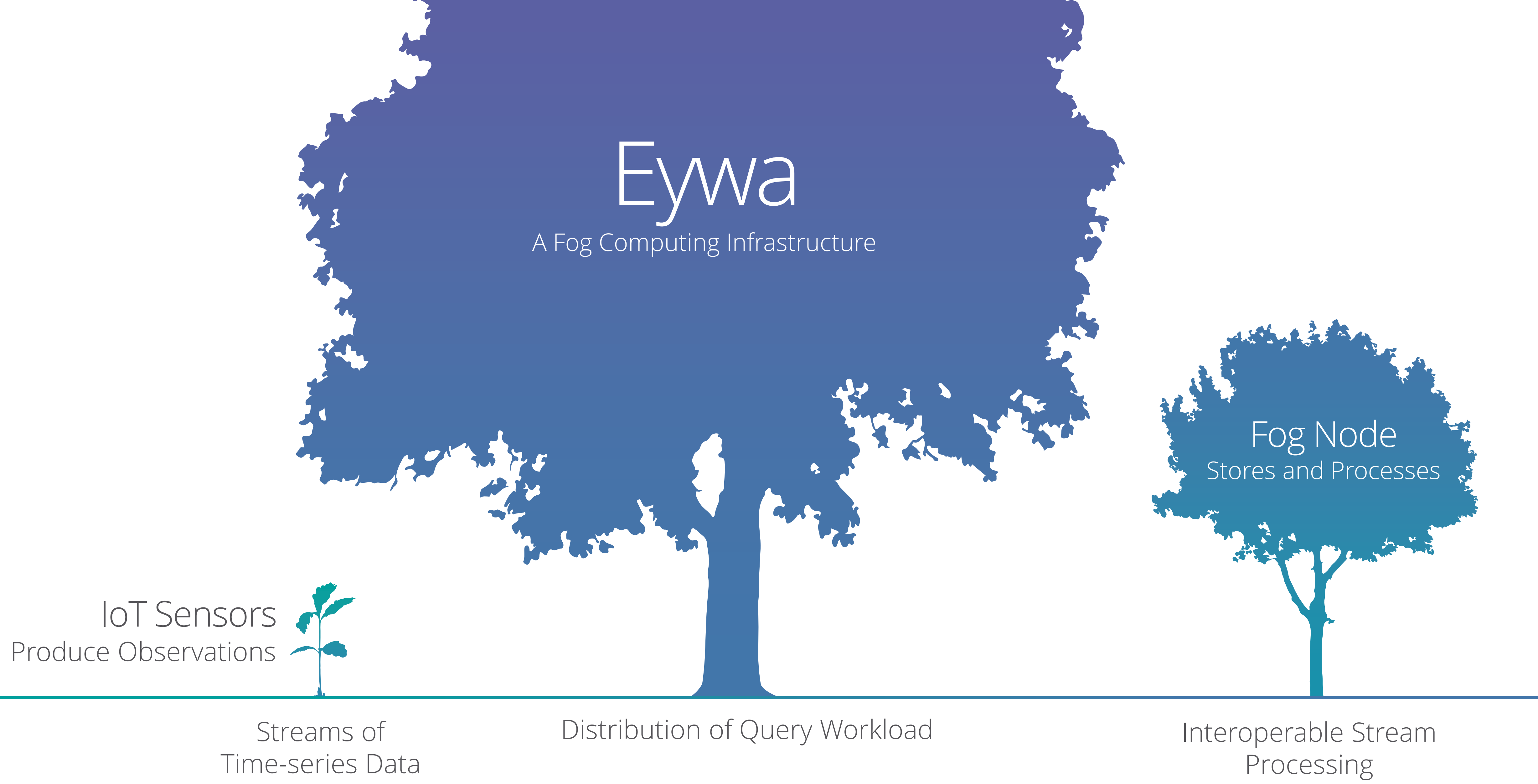
Challenges for **Fog Computing**

01 Interoperability
Heterogeneity of device, platform and data

02 Stream Processing
Performant and scalable processing of multiple streams in real-time

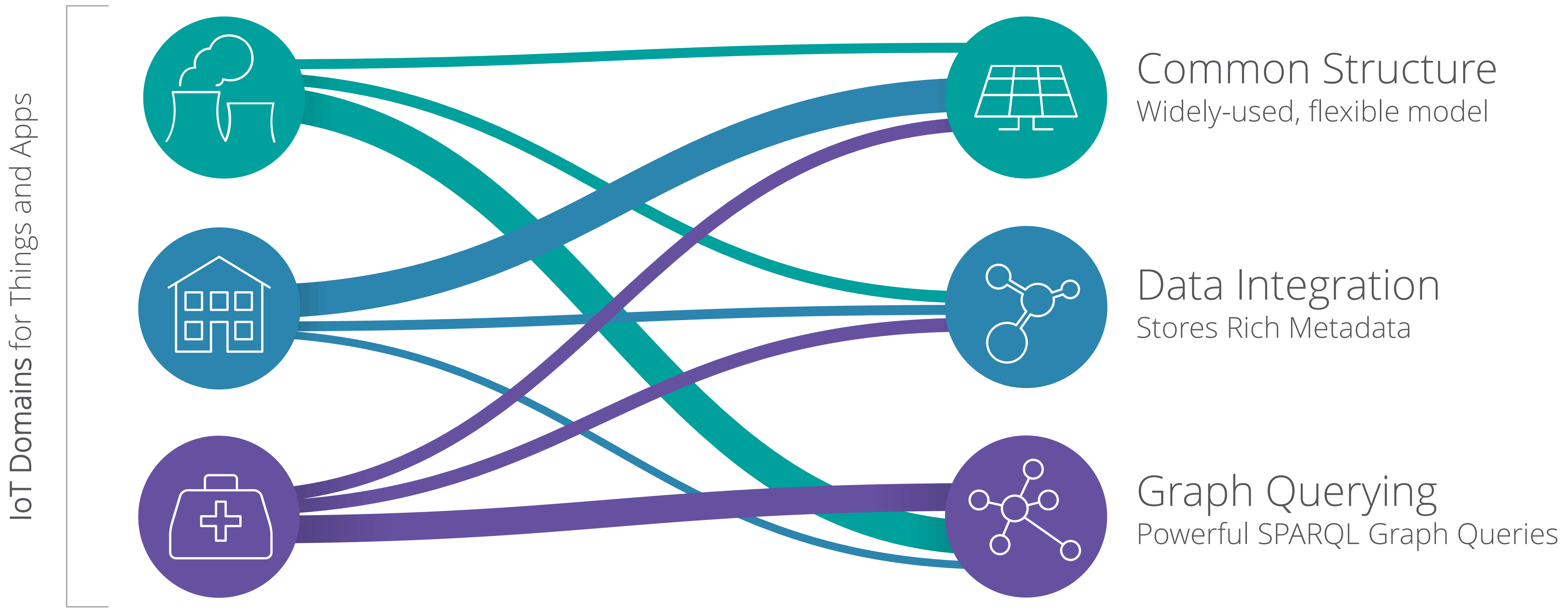
03 Distribution
Provisioning of resources and distribution of work load


Eywa is like a huge biological internet; the trees are fog computing nodes that store and process information and sensors are connected flora and fauna
Avatar
By James Cameron


Eywa
A Fog Computing Infrastructure
Fog Node
Stores and Processes
IoT Sensors
Produce Observations
Streams of
Time-series Data
Distribution of Query Workload
Interoperable Stream
Processing

Semantic Interoperability in Eywa

Using a Common **RDF Graph Model**

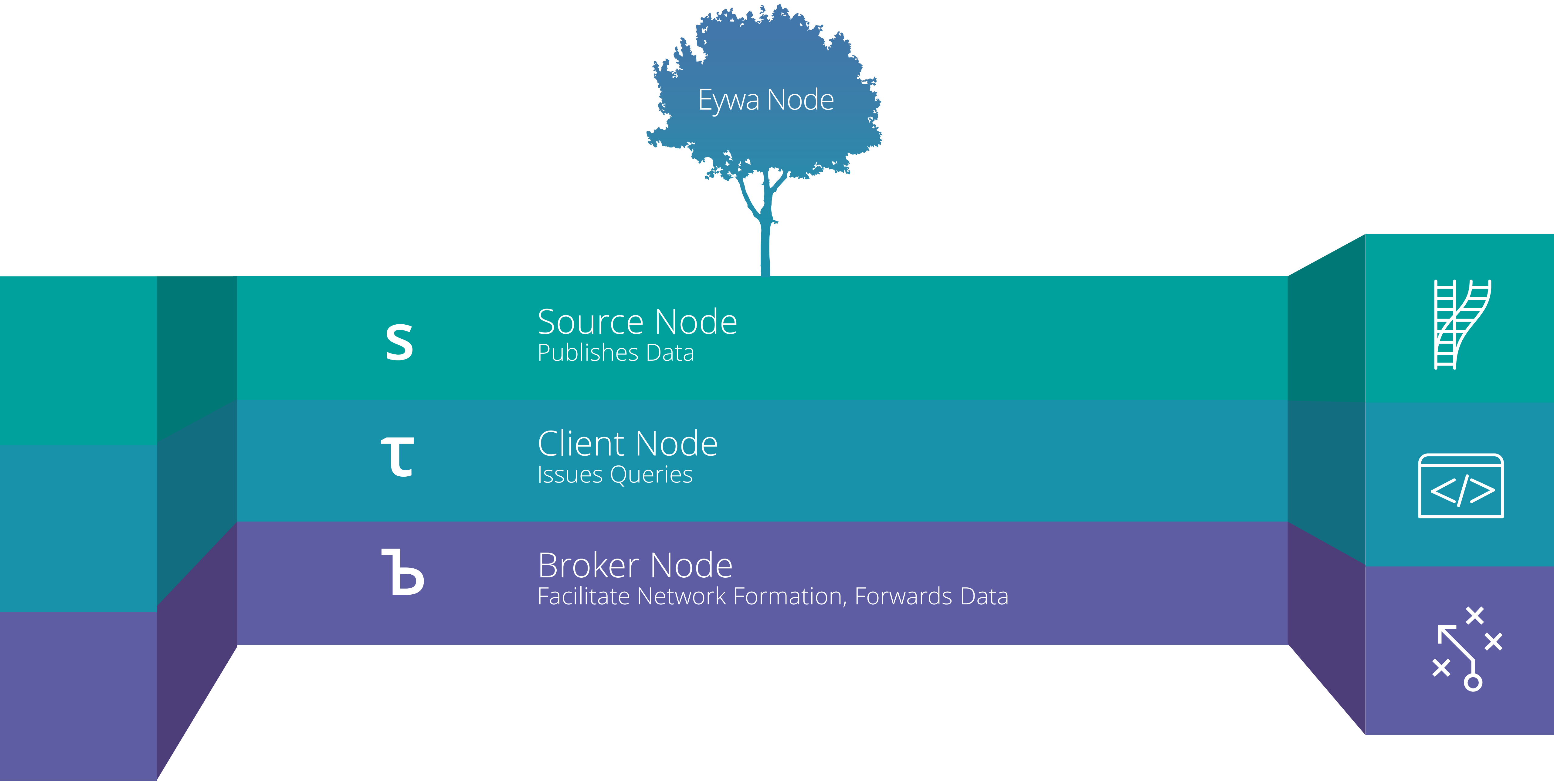


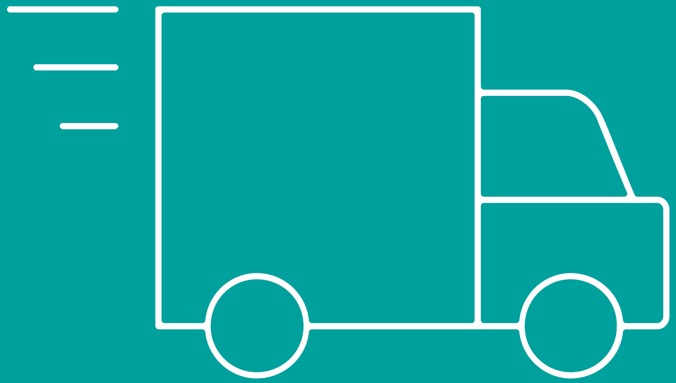
Siow, E., Tiropanis, T., Hall, W. (2016). **Interoperable and Efficient: Linked Data for the Internet of Things.** The 3rd International Conference on Internet Science.

Deliver
Inverse-publish-subscribe

Distribute
Workload Distribution by Projection Pushdown

Process
Stream Processing by Query Translation


Eywa Node
s
Source Node
Publishes Data
τ
Client Node
Issues Queries
ъ
Broker Node
Facilitate Network Formation, Forwards Data
</>



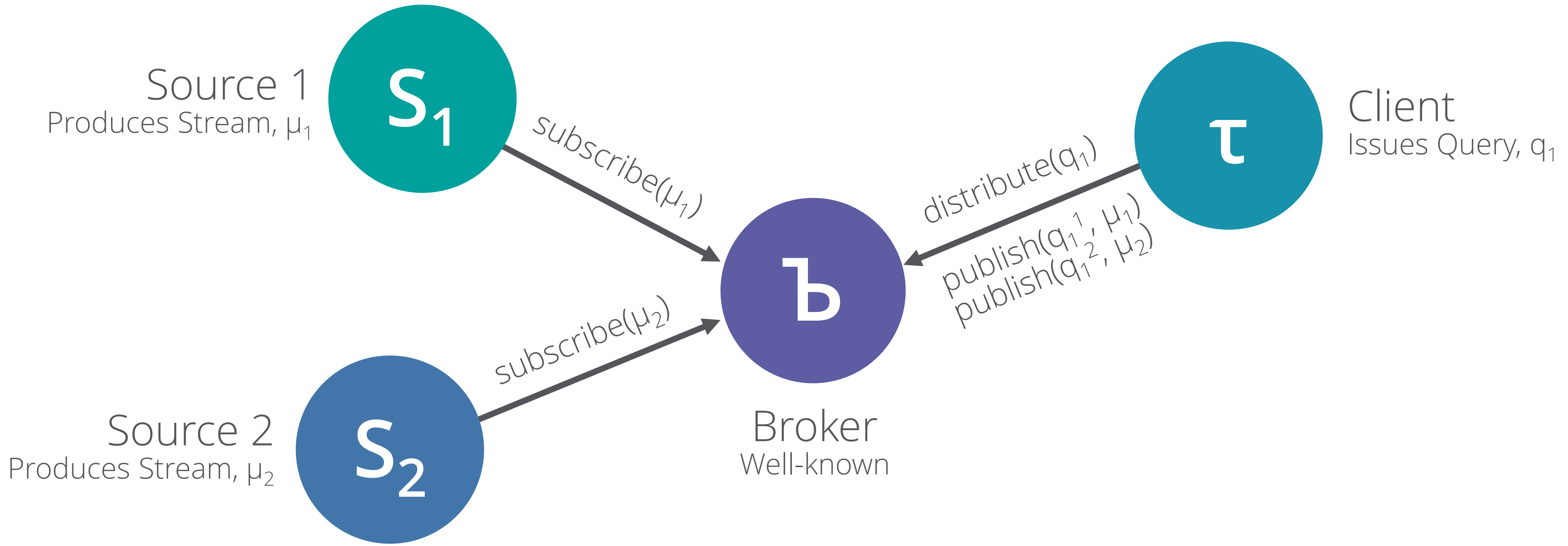
Deliver Queries

Inverse-Publish-Subscribe

A novel system for **best-effort, co-operative query delivery** in fog computing ***control-plane***

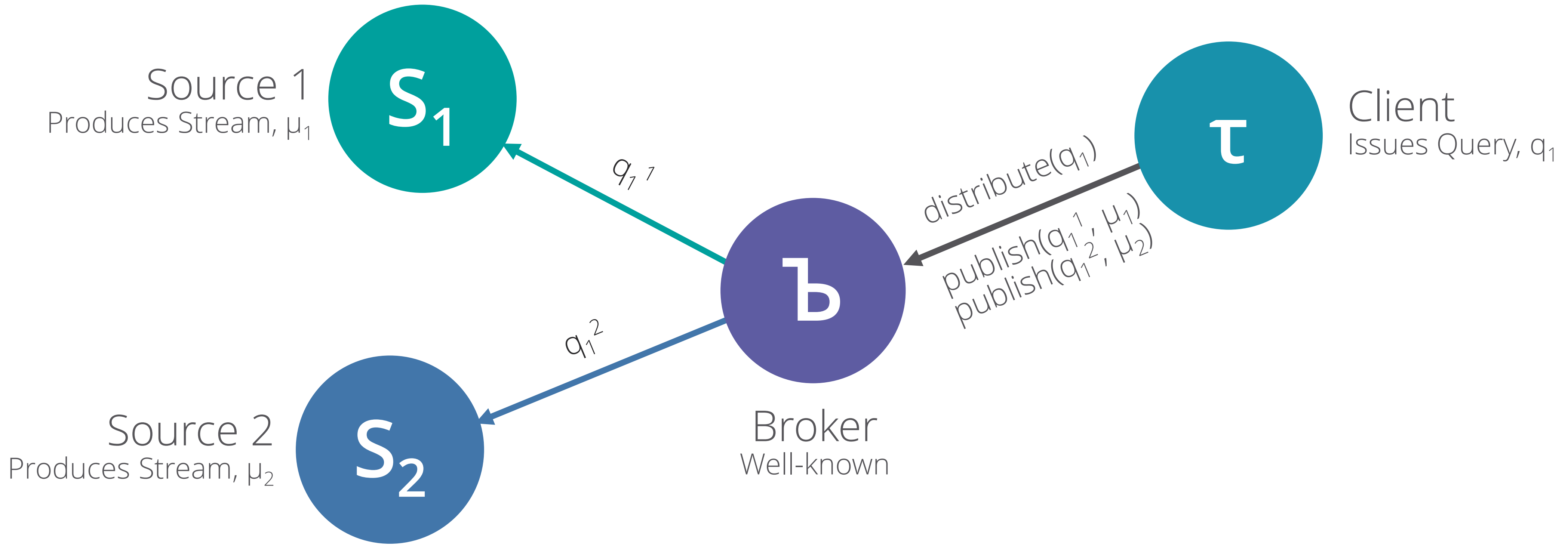
Deliver Queries

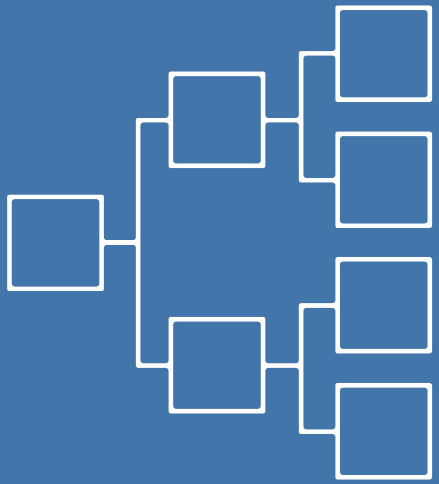
Inverse Publish-Subscribe (1)



Deliver Queries

Inverse Publish-Subscribe (2)





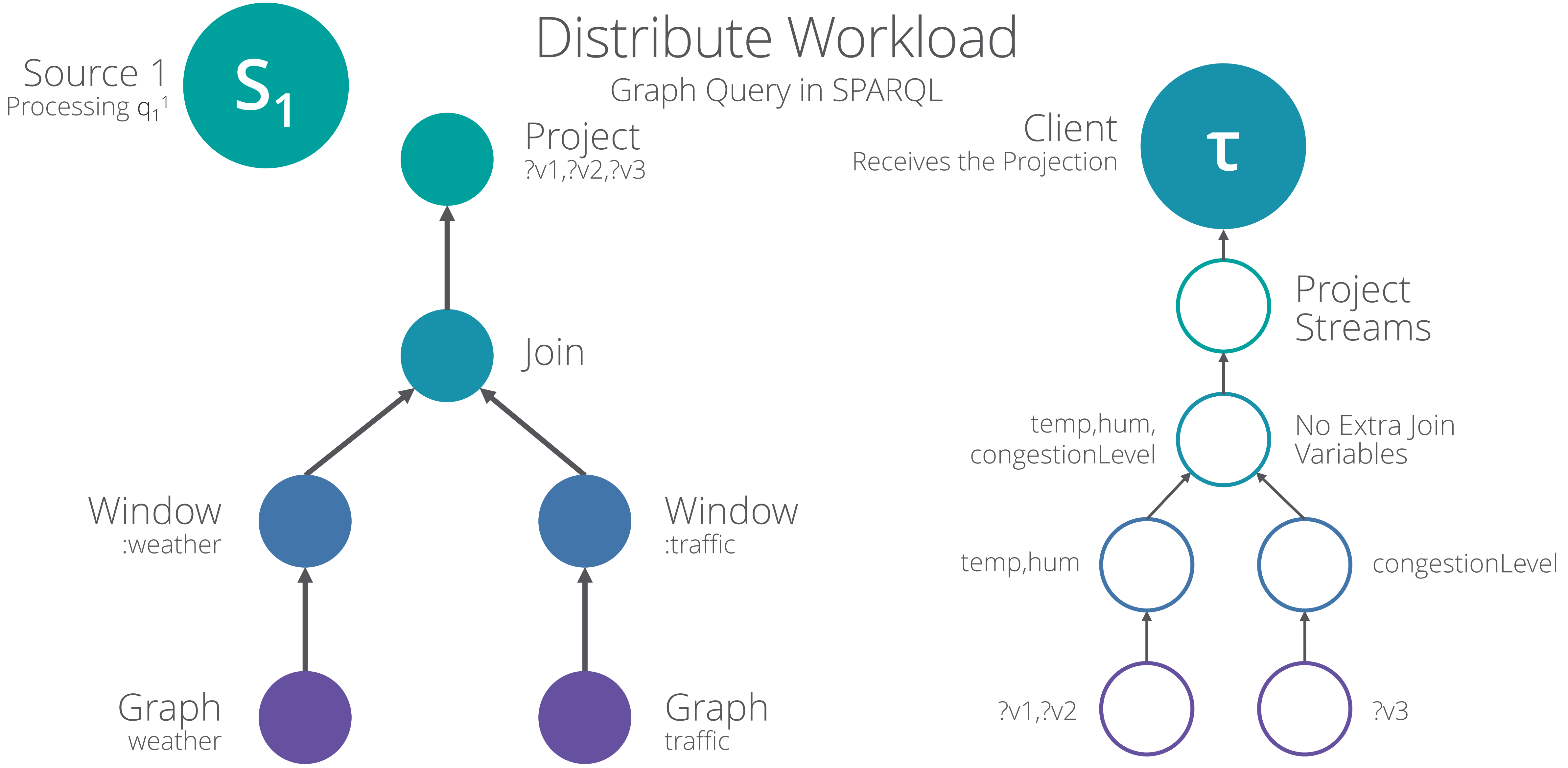
Distribute Workload

Projection Pushdown

Efficient streaming of only **projected data** in the fog computing ***data-plane***

Distribute Workload

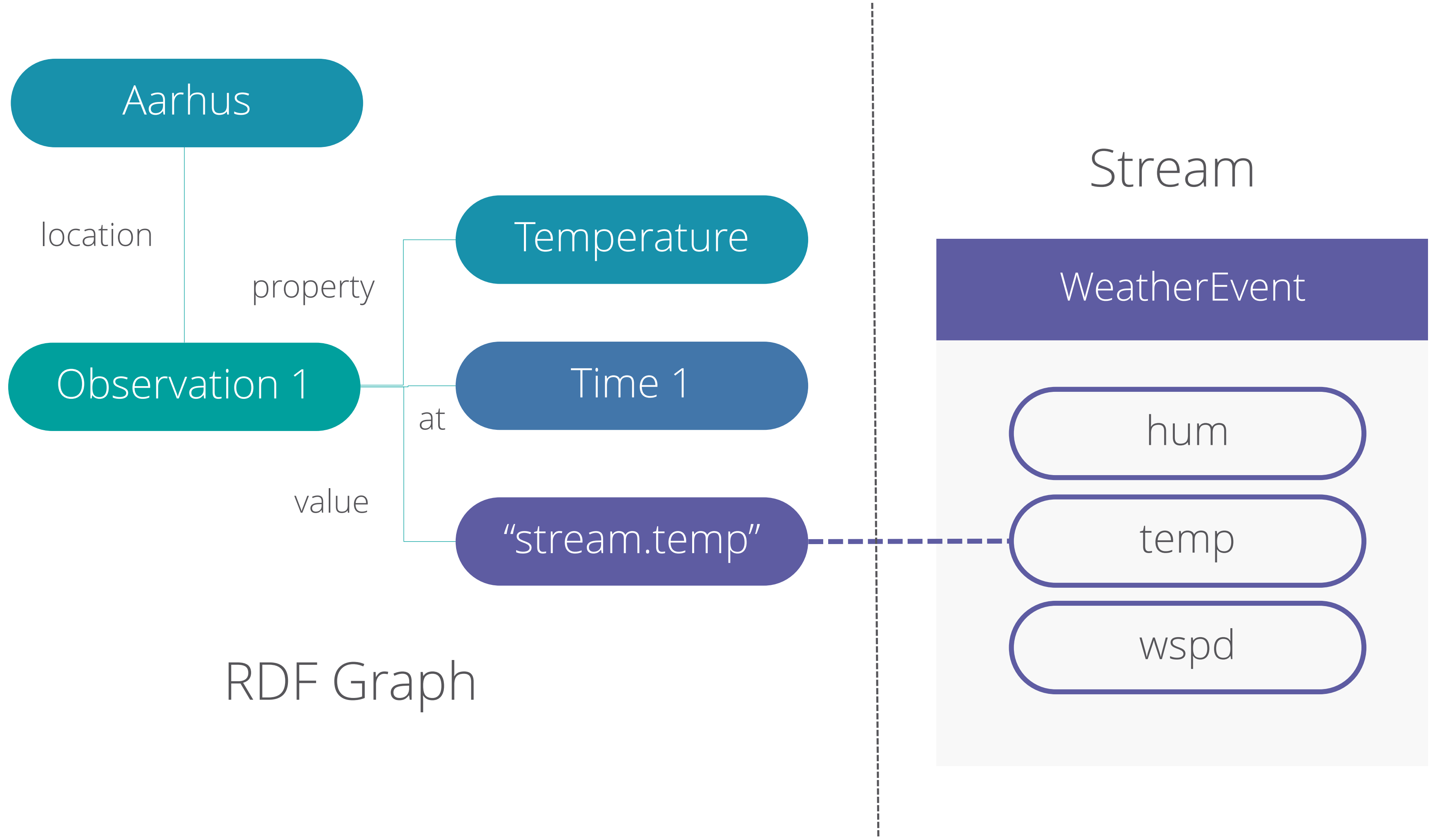
Graph Query in SPARQL



From CityBench (Smart City Streams) Query 2. Finding the traffic congestion level and weather conditions of my planned journey.

Distribute Workload

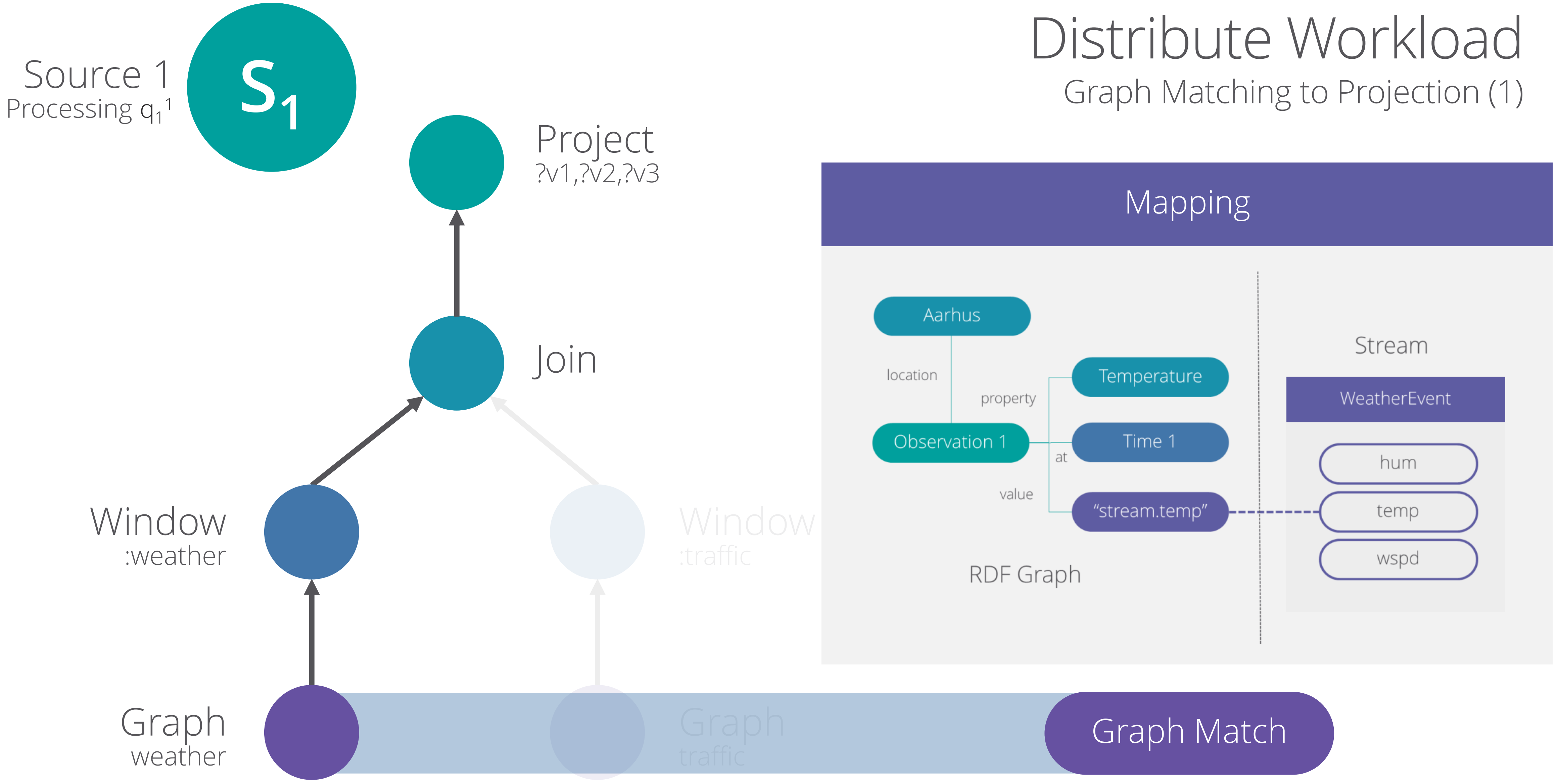
Efficient Mappings for RDF Stream Processing



Siow, E., Tiropanis, T. and Hall, W. (2016) SPARQL-to-SQL on internet of things databases and streams. ISWC2016: The 15th International Semantic Web Conference

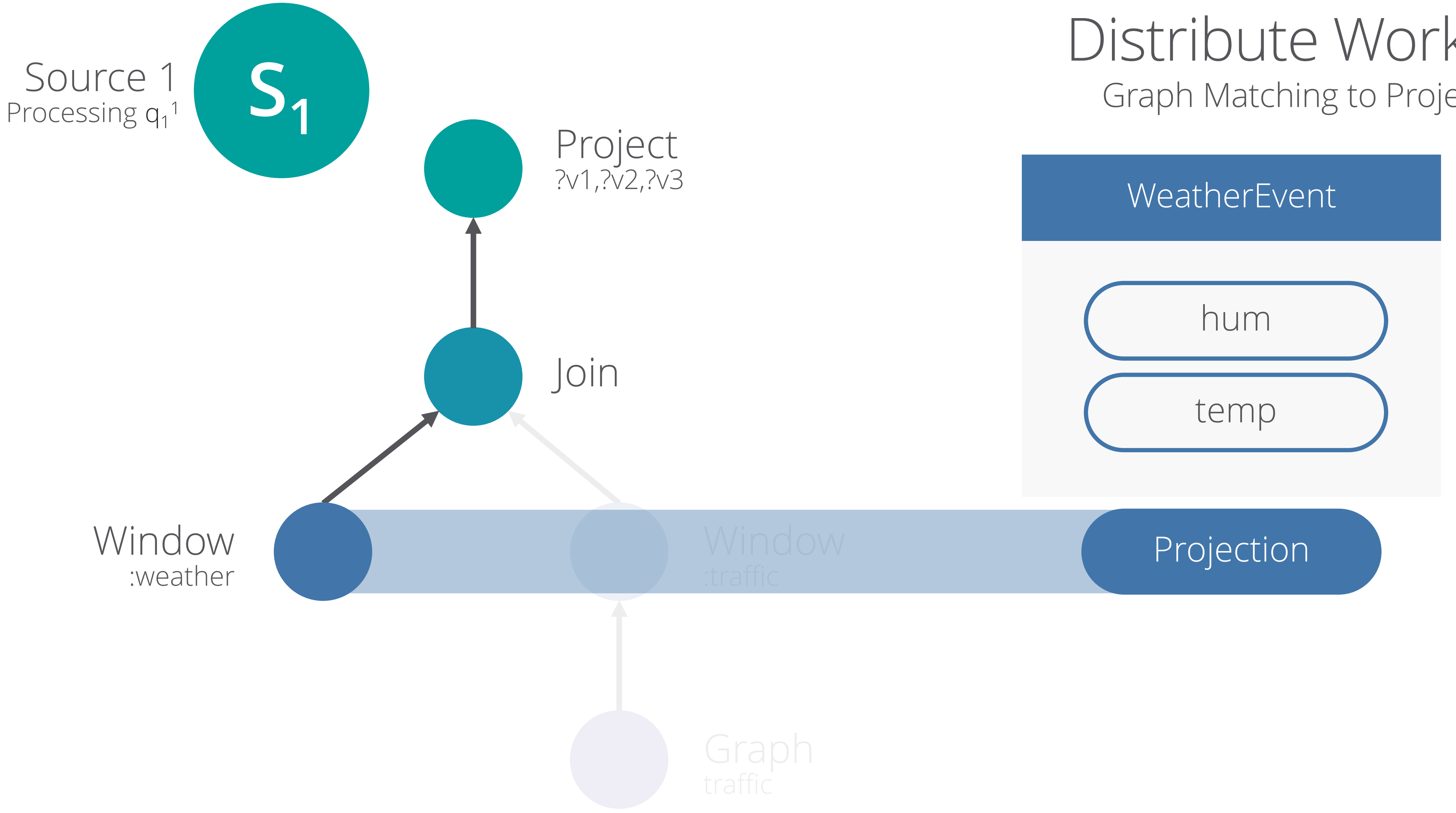
Distribute Workload

Graph Matching to Projection (1)



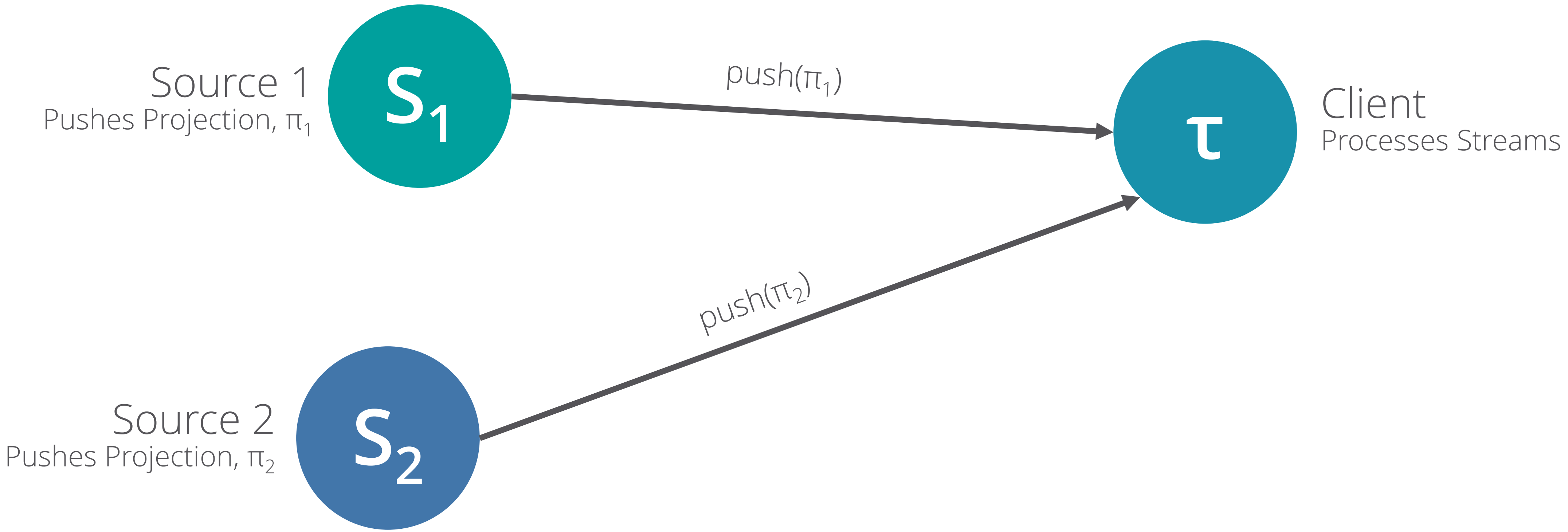
Distribute Workload

Graph Matching to Projection (2)



Distribute Workload

Projection Pushdown, Push Projection

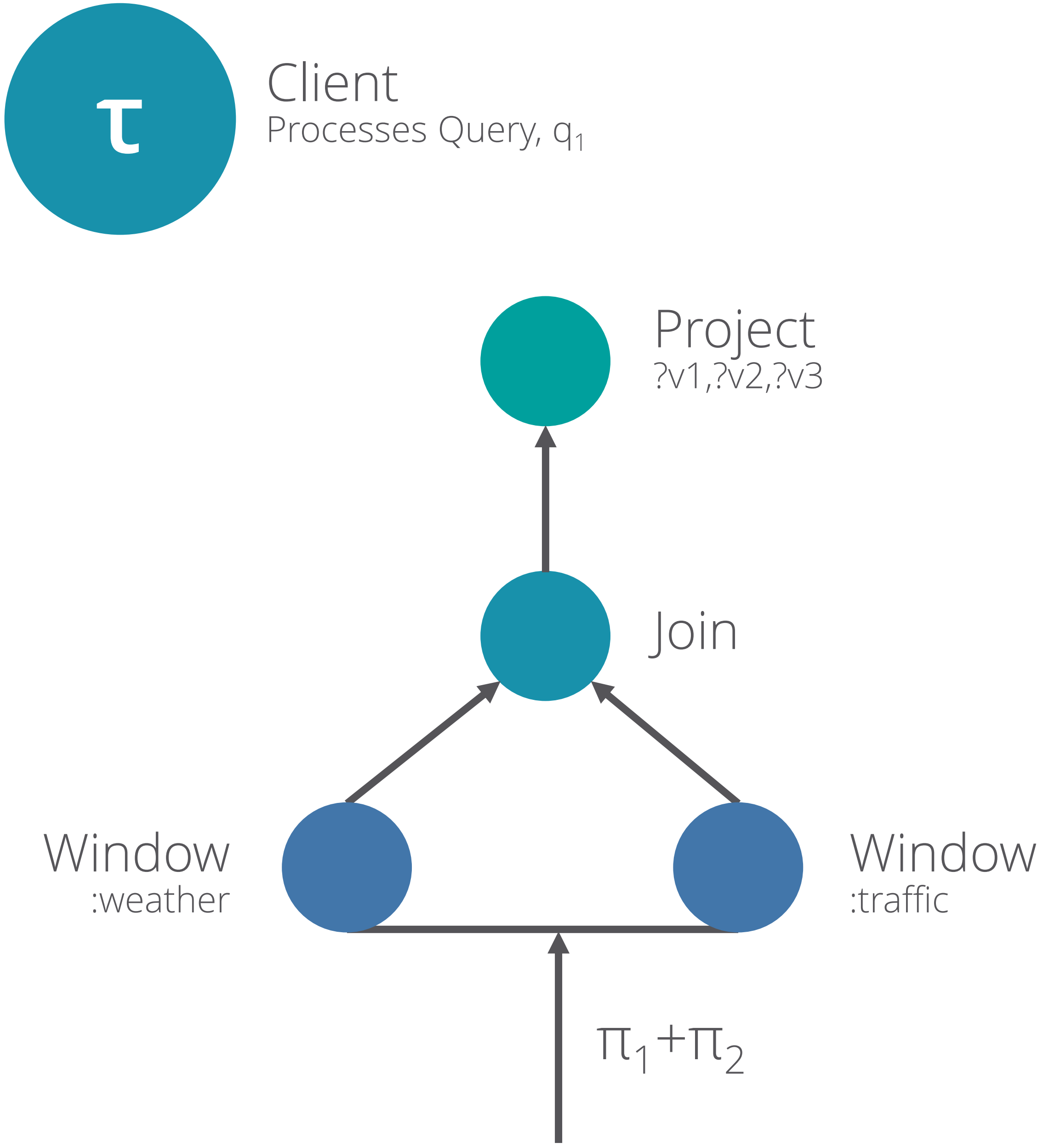


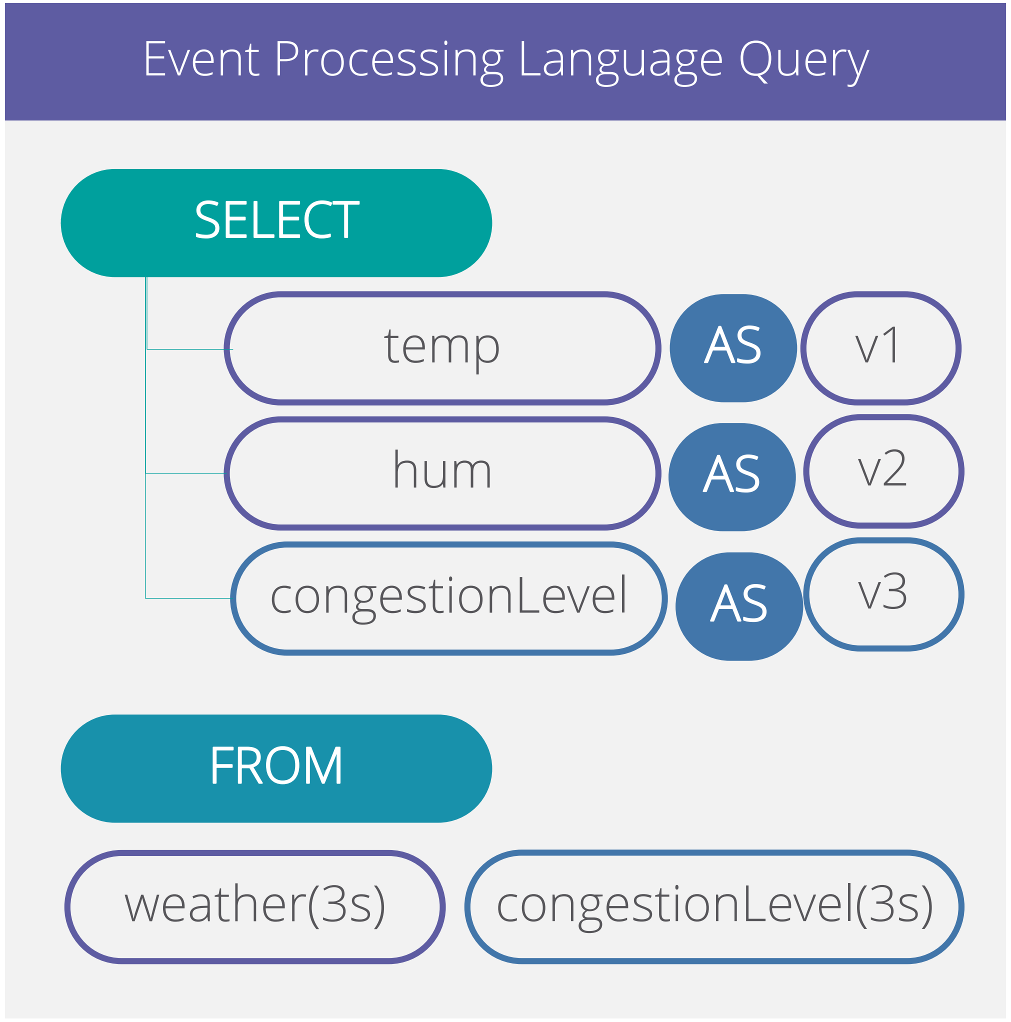
Process

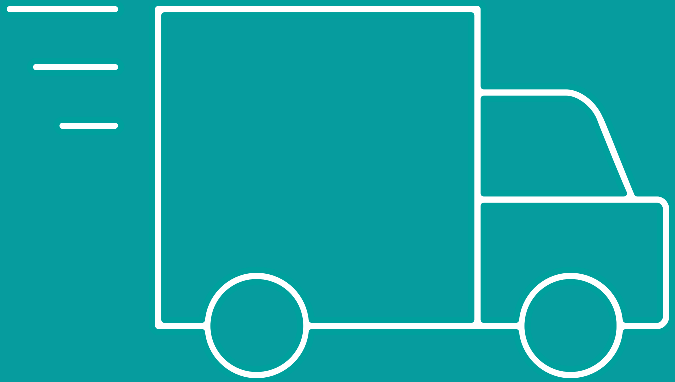
Query Translation

Processing Streams

Query Translation for Stream Processing







Evaluation

CityBench Smart City Benchmark

Latency and Scalability

Evaluation on 3 Stream Processing Engines

Smart City RDF Streams

CITYBENCH

- Real-time streams (e.g. vehicle traffic, parking, weather, pollution)
- Based on smart city applications (e.g. parking space finder, admin console)
- Run on resource-constrained Raspberry Pis as Fog Nodes (~500mhz CPU, 512mb ram, SD CARD)

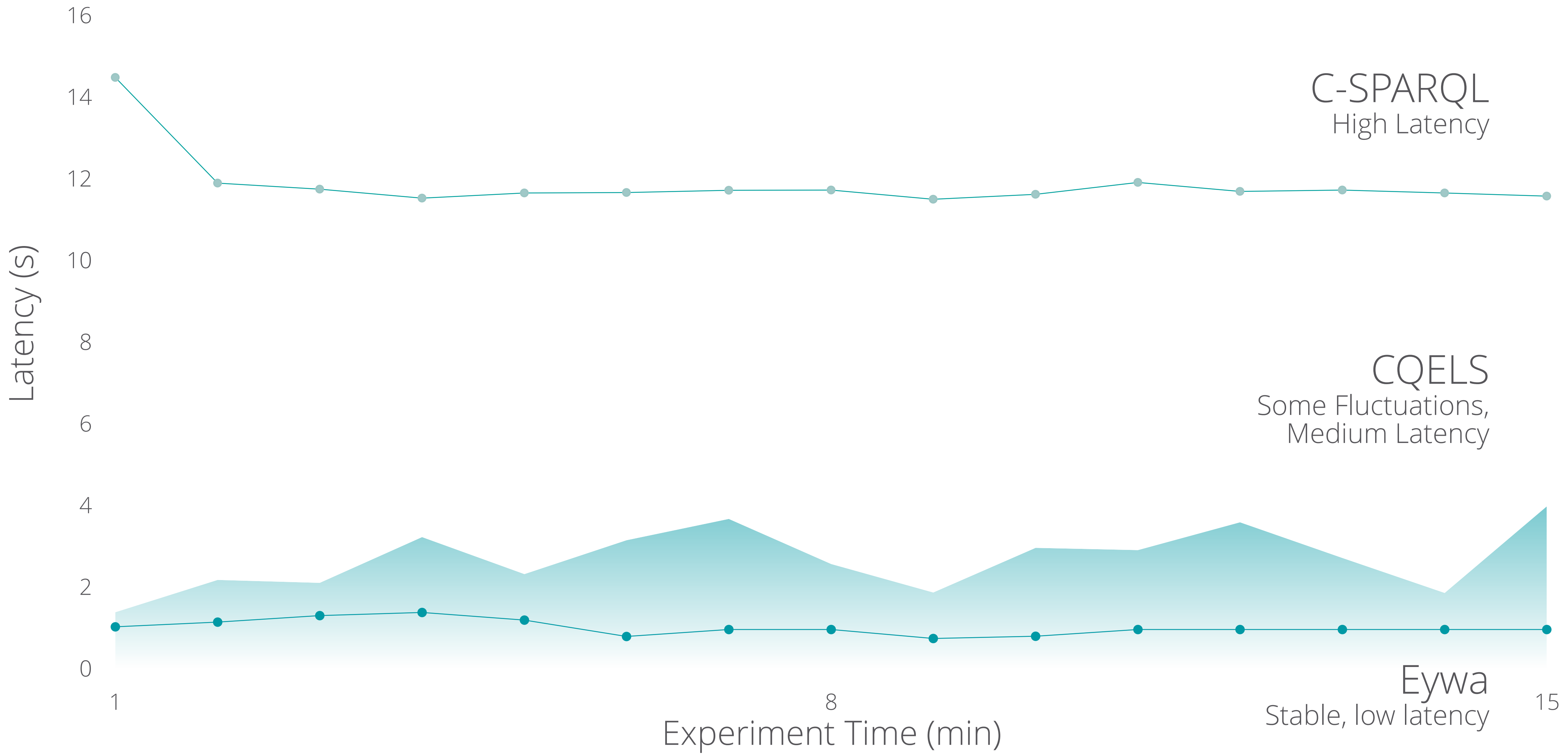
01 **C-SPARQL**
Barbieri et al. "C-SPARQL: SPARQL for continuous querying." WWW2009.

02 **CQELS**
Le-Phuoc et al. "A native and adaptive approach for unified processing of linked streams and linked data." ISWC2011

03 **Eywa**

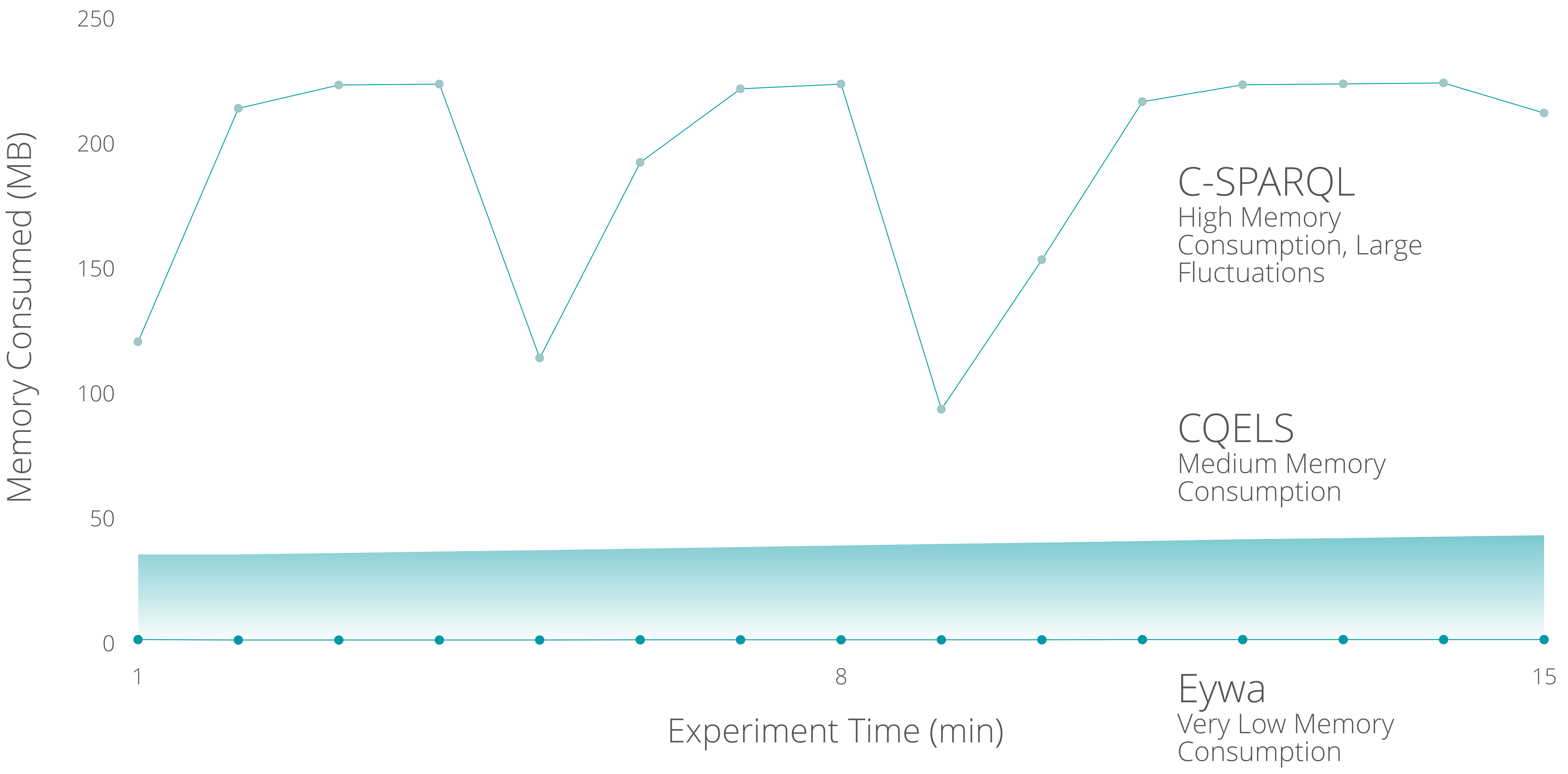
Latency Evaluation

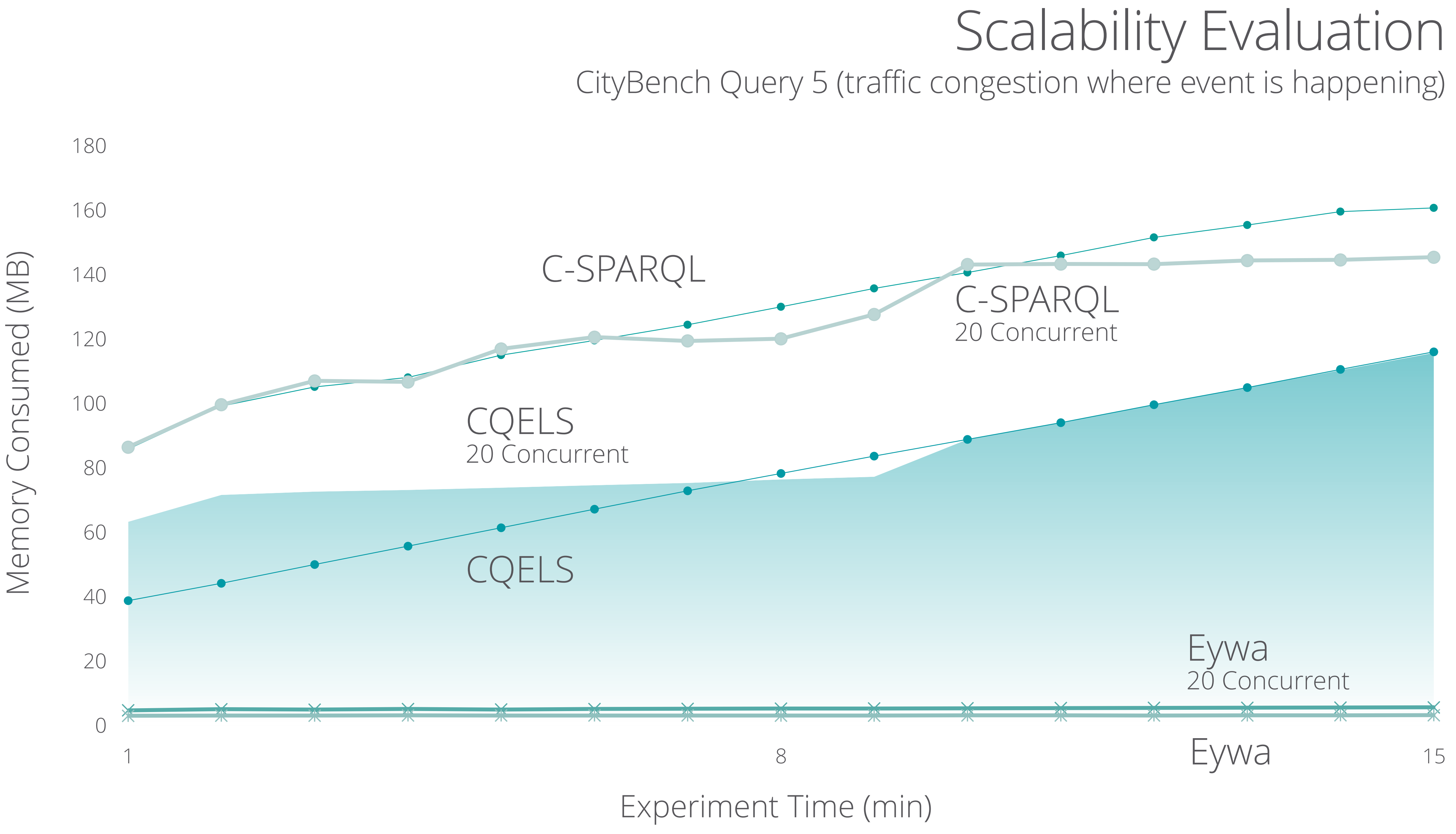
CityBench Query 1 (traffic congestion level on two roads)



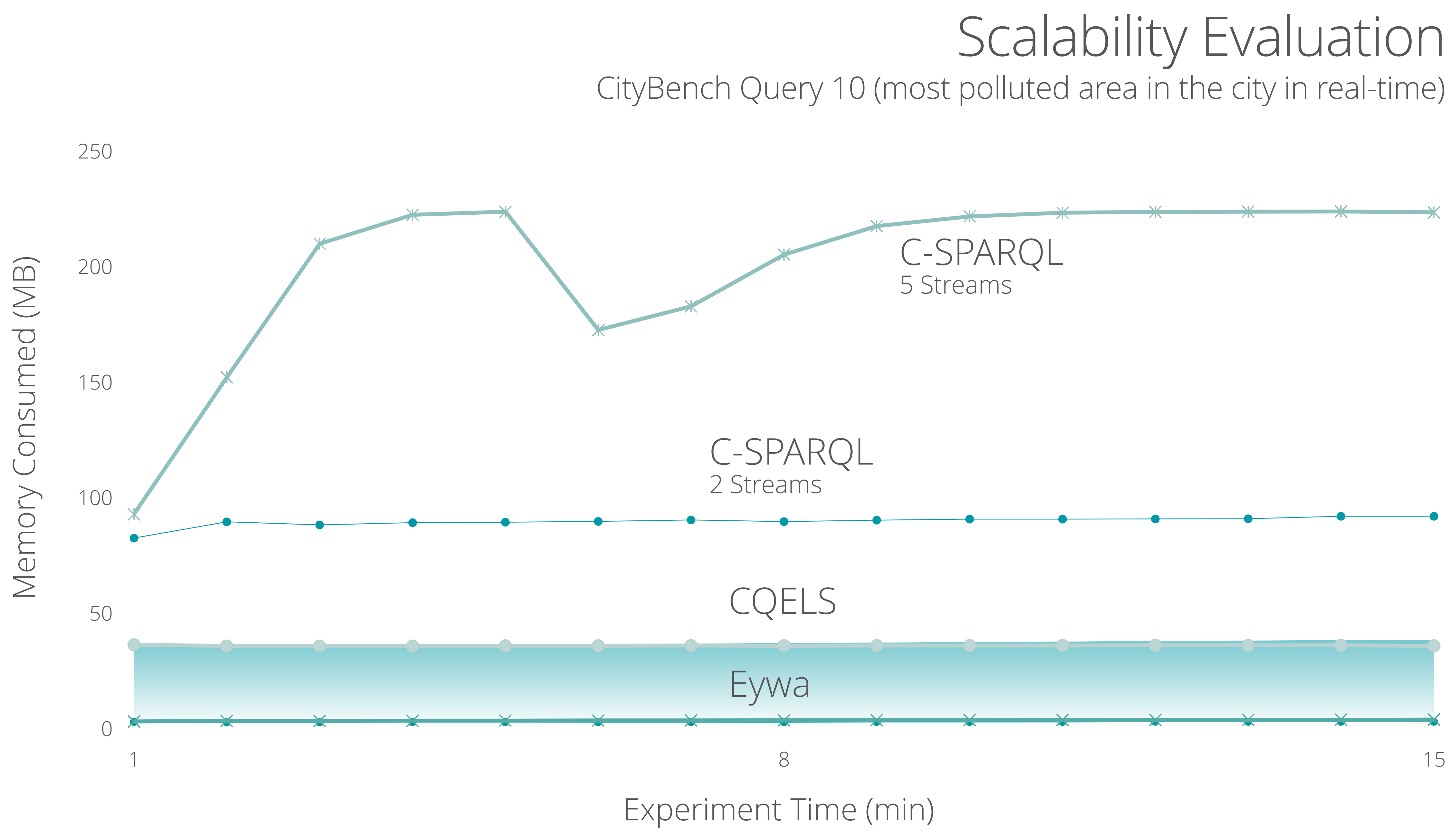
Scalability Evaluation

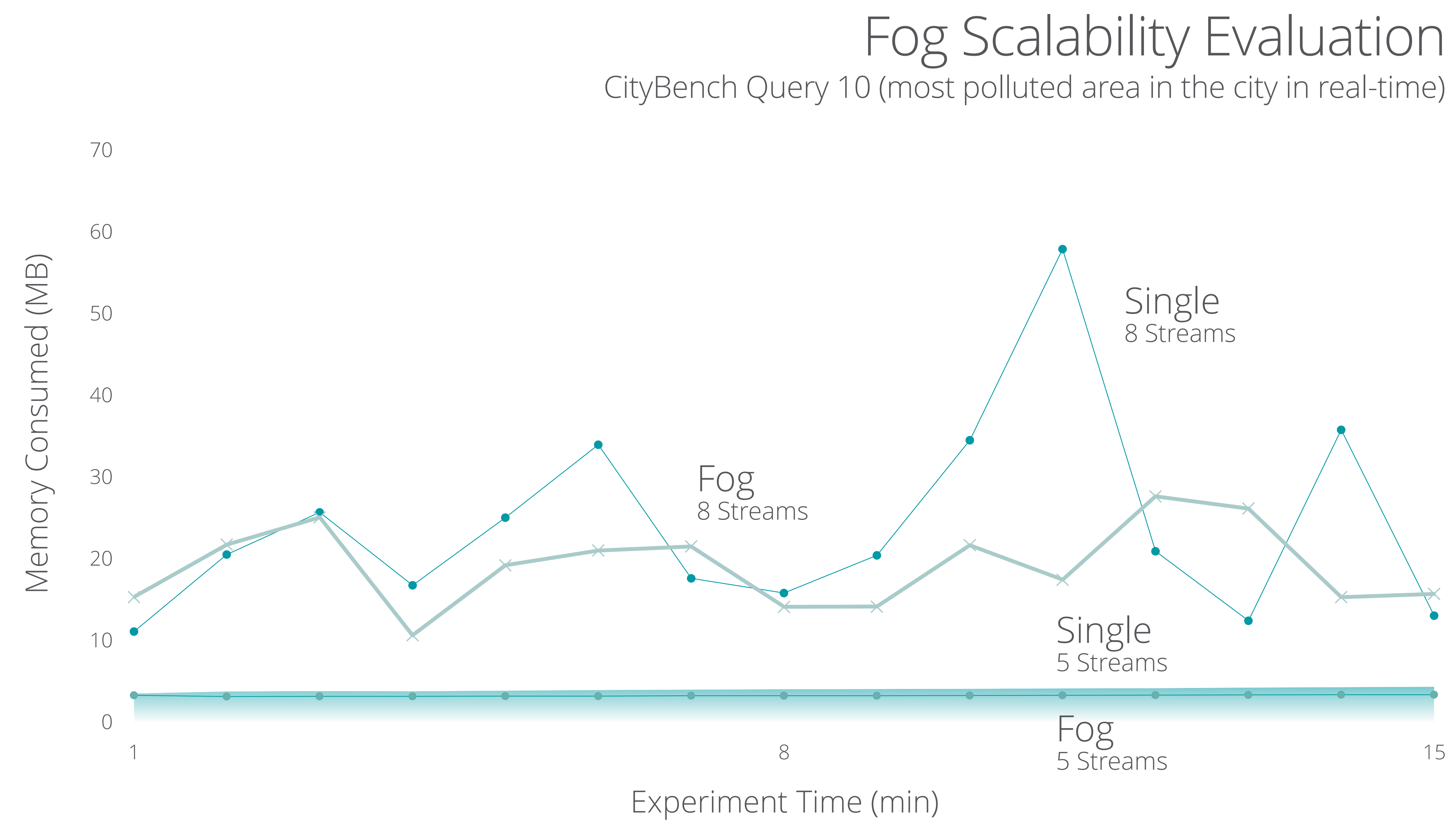
CityBench Query 2 (traffic congestion level and weather)





Scalability Evaluation
CityBench Query 5 (traffic congestion where event is happening)
Memory Consumed (MB)
180
160
140
120
100
80
60
40
20
0
C-SPARQL
C-SPARQL
20 Concurrent
CQELS
20 Concurrent
CQELS
Eywa
20 Concurrent
Eywa
1
8
15
Experiment Time (min)


Scalability Evaluation
CityBench Query 10 (most polluted area in the city in real-time)
Memory Consumed (MB)
250
200
150
100
50
0
C-SPARQL
5 Streams
C-SPARQL
2 Streams
CQELS
Eywa
1
8
15
Experiment Time (min)



Fog Scalability Evaluation
CityBench Query 10 (most polluted area in the city in real-time)
Memory Consumed (MB)
70
60
50
40
30
20
10
0
Single
8 Streams
Fog
8 Streams
Single
5 Streams
Fog
5 Streams
1
8
15
Experiment Time (min)

Conclusions

Latency
01 Eywa is fast and performant at stream processing

Scalability
02 Eywa Fog consumes less memory than other engines

Interoperability
03 From the RDF graph model for metadata and data

Distributed
04 Eywa is a means for distributed Fog Computing

Utility for the IoT
05 Data locality, offline access, data ownership