DEBS Grand Challenge: RDF Stream Processing with CQELS Framework for Real-time Analysis

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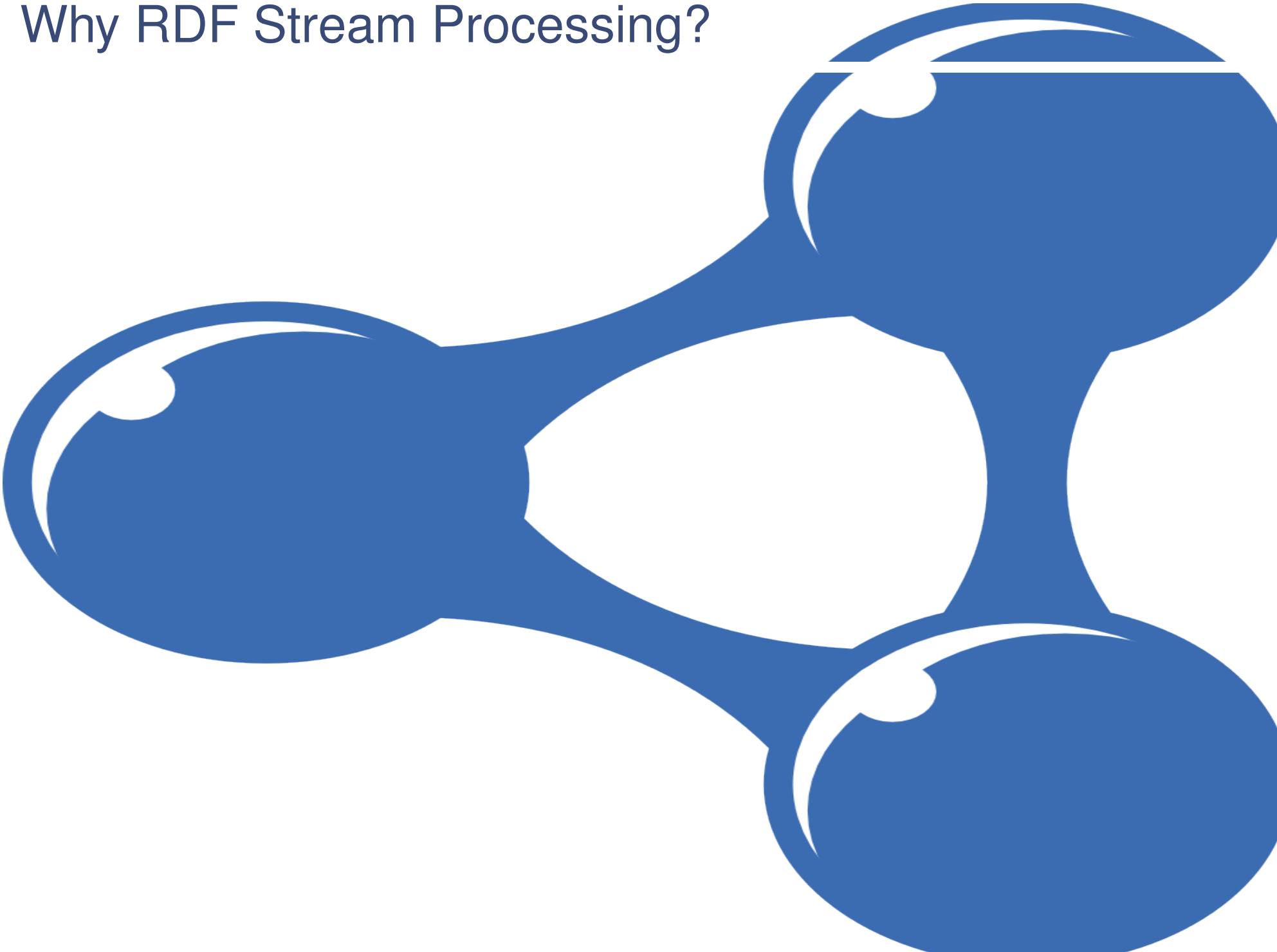
FÜR !NFORMATIK
Faculty of Informatics

Technische Universität Berlin

Why RDF Stream Processing?



Interoperability

Interoperability

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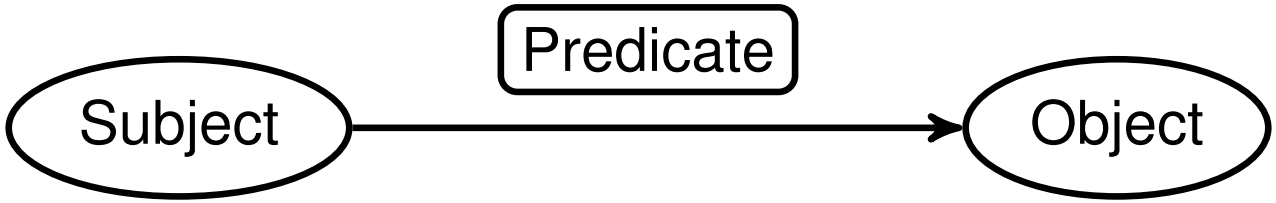
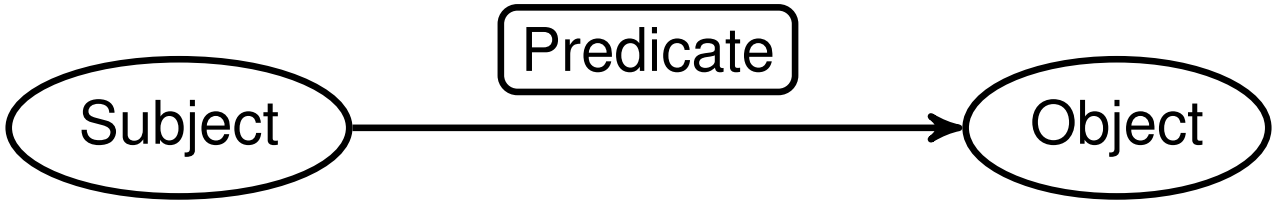
Interoperability

RDF

RDF

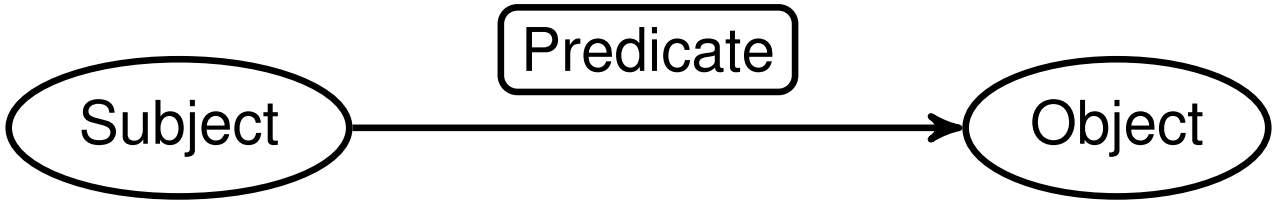


RDF




```
07290D3599E7A0D62097A346EFCC1FB5,
2013-01-01 00:00:00,2013-01-01 00:02:00,
-73.956528,40.716976,-73.962440,40.715008, 3.50,0.00
```

RDF




```
07290D3599E7A0D62097A346EFCC1FB5,
2013-01-01 00:00:00,2013-01-01 00:02:00,
-73.956528,40.716976,-73.962440,40.715008, 3.50,0.00
```

$$
\left\{
\begin{array}{l}
:trip_1\ :taxi\ \texttt{"07290D3599E7A0D62097A346EFCC1FB5"}. \\
:trip_1\ :pickup\_datetime\ \texttt{"2013-01-01 00:00:00"}. \\
:trip_1\ :dropoff\_datetime\ \texttt{"2013-01-01 00:02:00"}. \\
:trip_1\ :pickLon\ -73.956528. \\
:trip_1\ :pickLat\ 40.716976. \\
:trip_1\ :dropLon\ -73.962440. \\
:trip_1\ :dropLat\ 40.715008. \\
:trip_1\ :fare\ 3.5. \\
:trip_1\ :tip\ 0.0.
\end{array}
\right\}
$$

SPARQL

```
SELECT


FROM
WHERE
```

SPARQL

```
SELECT


FROM <http://example/taxi.rdf>
WHERE
```

SPARQL

```
SELECT


FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}
```

SPARQL

```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)

FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}
```

SPARQL

```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)

FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}

HAVING  (?pE>0 && ?pE<301 && ?pS>0 && ?pS<301 &&
         ?dE>0 && ?dE<301 && ?dS>0 && ?dS<301)
```

SPARQL

```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)
       (COUNT(?trip) AS ?freq)
FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}
GROUP BY ?pE ?pS ?dE ?dS
HAVING  (?pE>0 && ?pE<301 && ?pS>0 && ?pS<301 &&
         ?dE>0 && ?dE<301 && ?dS>0 && ?dS<301)
```

SPARQL

```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)
       (COUNT(?trip) AS ?freq)
FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}
GROUP BY ?pE ?pS ?dE ?dS
HAVING  (?pE>0 && ?pE<301 && ?pS>0 && ?pS<301 &&
         ?dE>0 && ?dE<301 && ?dS>0 && ?dS<301)
ORDER BY ?freq
LIMIT 10
```

SPARQL

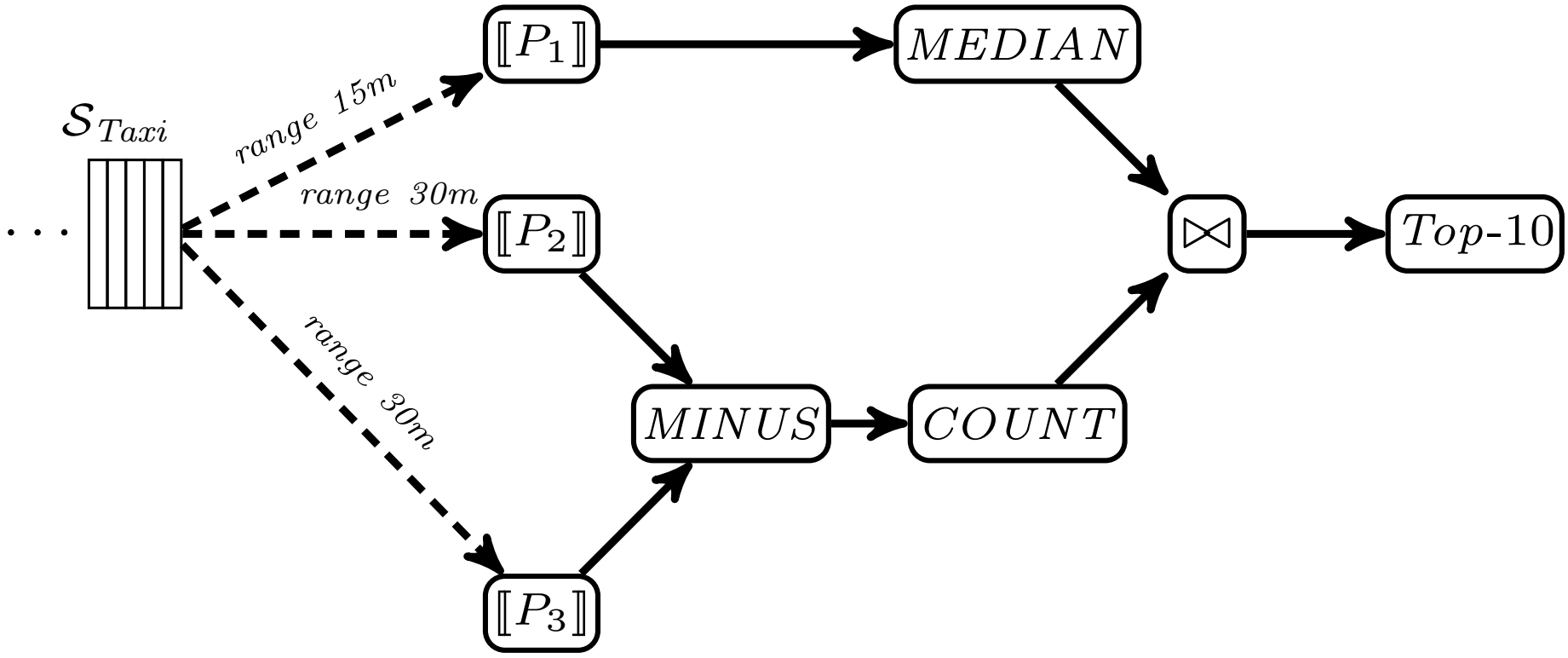
```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)
       (COUNT(?trip) AS ?freq)
FROM <http://example/taxi.rdf>
WHERE {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
}
GROUP BY ?pE ?pS ?dE ?dS
HAVING  (?pE>0 && ?pE<301 && ?pS>0 && ?pS<301 &&
         ?dE>0 && ?dE<301 && ?dS>0 && ?dS<301)
ORDER BY ?freq
LIMIT 10
```

$\{\{\texttt{?pE} \mapsto 127, \texttt{?pS} \mapsto 213, \texttt{?dE} \mapsto 127, \texttt{?dS} \mapsto 212, \texttt{?freq} \mapsto 1\}\}$.

RSP Queries in CQELS

```
SELECT (ROUND((41.474937-?pLat)/0.005986)     AS ?pE)
       (ROUND((74.913585+?pLon)/0.004491556) AS ?pS)
       (ROUND((41.474937-?dLat)/0.005986)     AS ?dE)
       (ROUND((74.913585+?dLon)/0.004491556) AS ?dS)
       (COUNT(?trip) AS ?freq)
WHERE {
  STREAM <Taxi> [RANGE 30 minutes] {
    ?trip :pickLon ?pLon.  ?trip :pickLat ?pLat.
    ?trip :dropLon ?dLon.  ?trip :dropLat ?dLat.
  }
}
GROUP BY ?pE ?pS ?dE ?dS
HAVING  (?pE>0 && ?pE<301 && ?pS>0 && ?pS<301 &&
         ?dE>0 && ?dE<301 && ?dS>0 && ?dS<301)
ORDER BY ?freq
LIMIT 10
```

Query Plan of Q_2



CQELS Solutions for the Grand Challenge

CQELS Solutions for the Grand Challenge

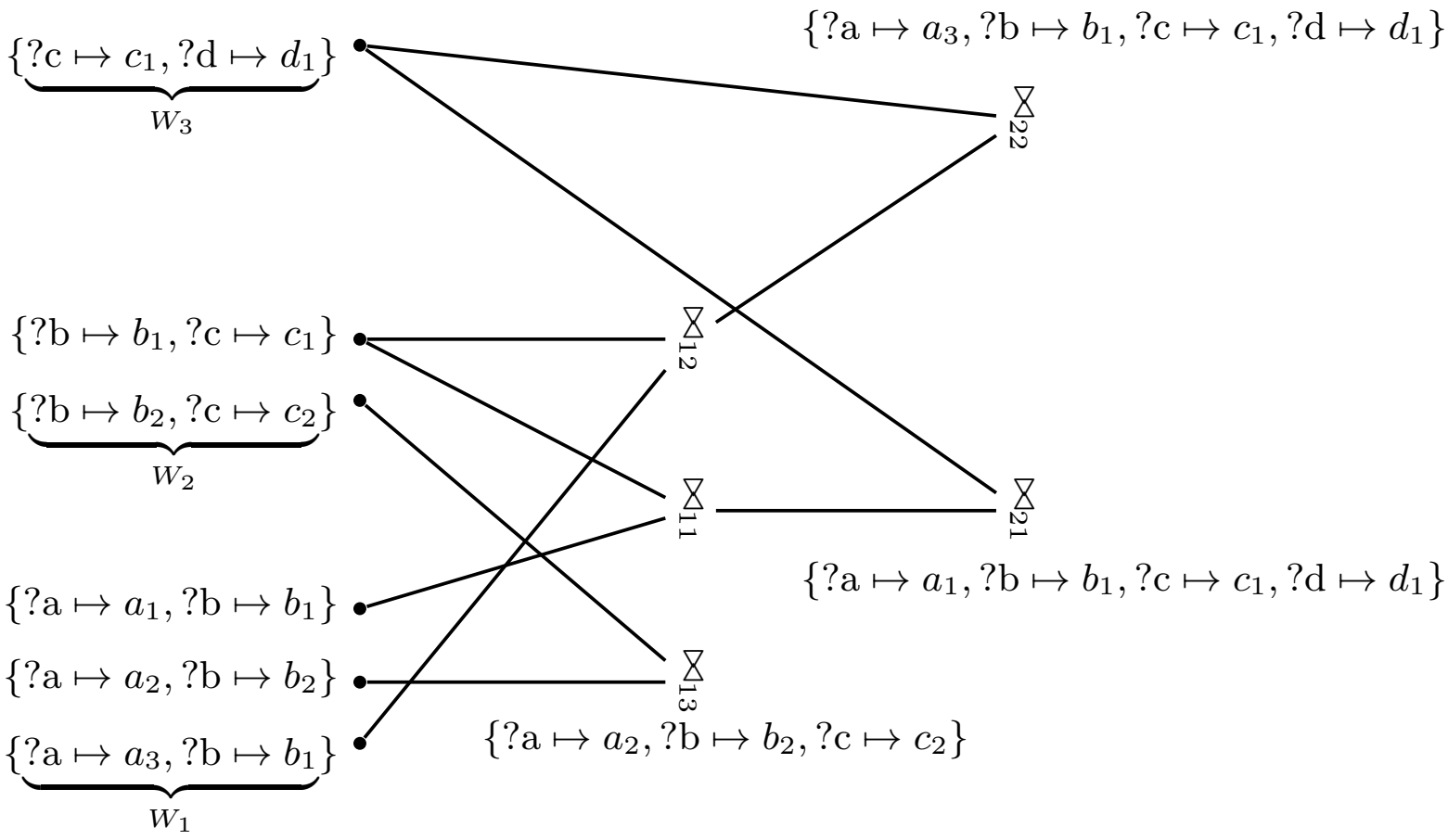
High Performance Data Structures

CQELS Solutions for the Grand Challenge

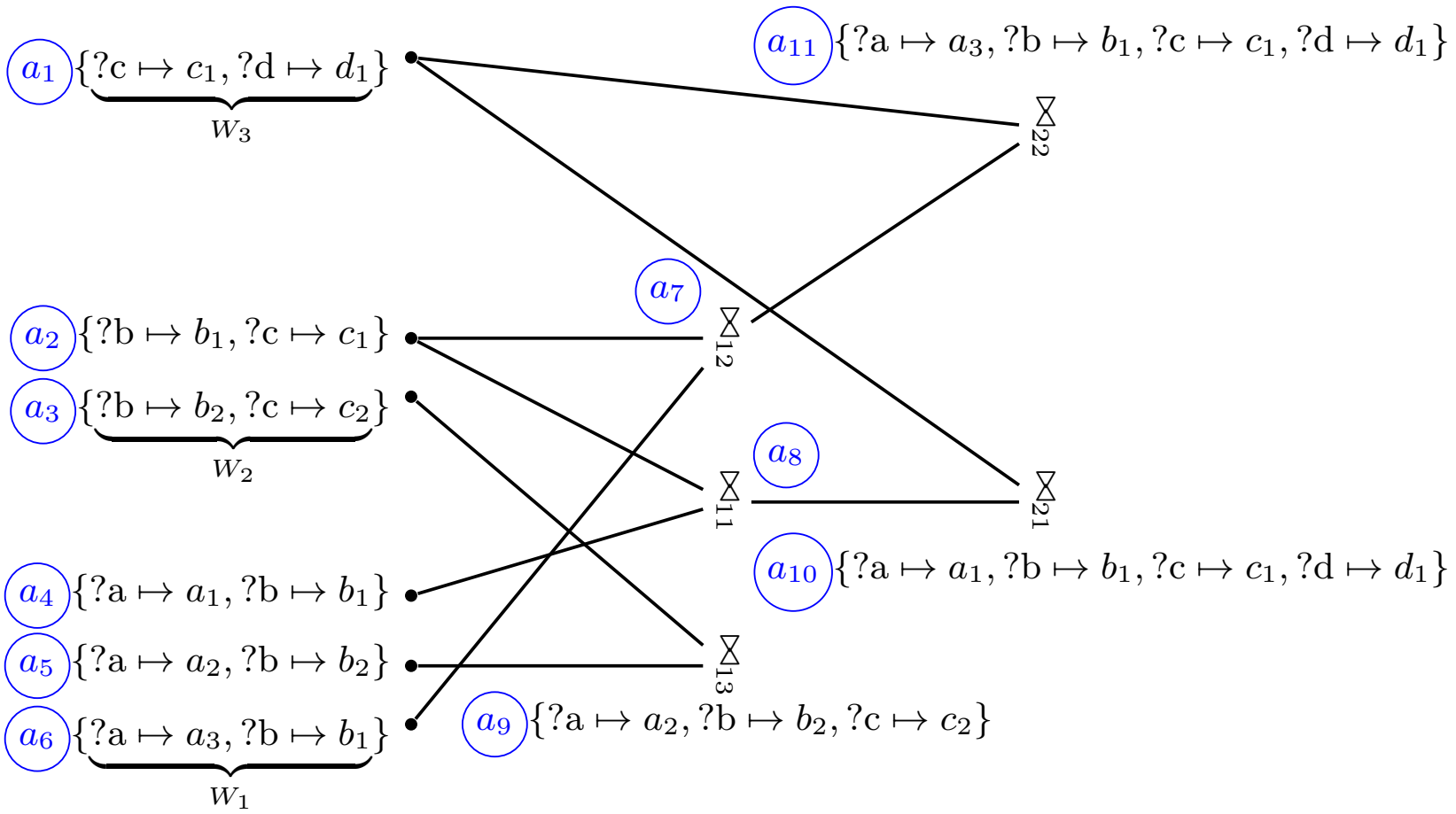
High Performance Data Structures

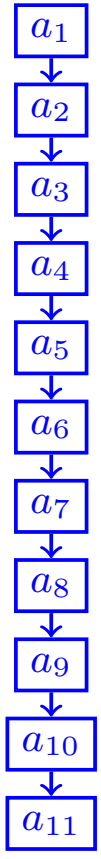
Incremental Algorithms

Tree-based Data Structures

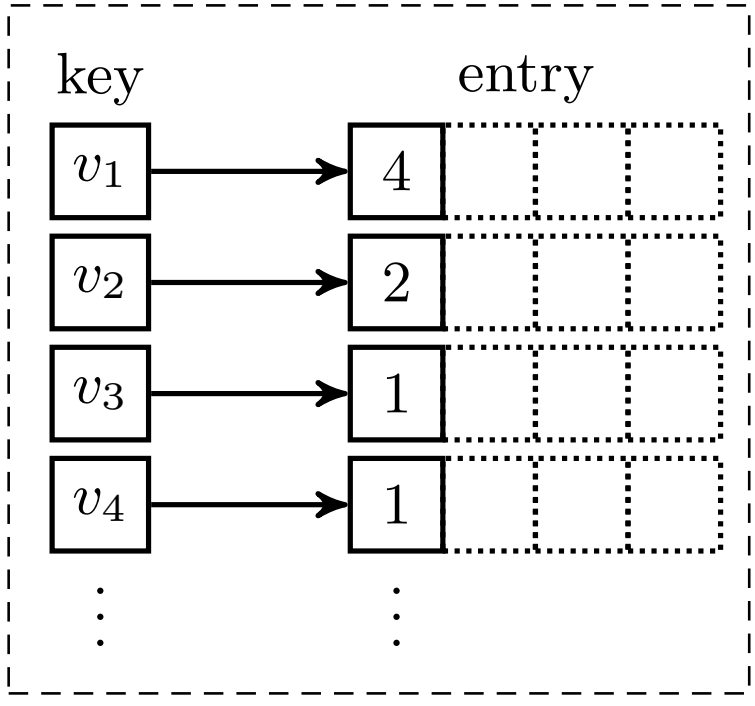


Input Buffers

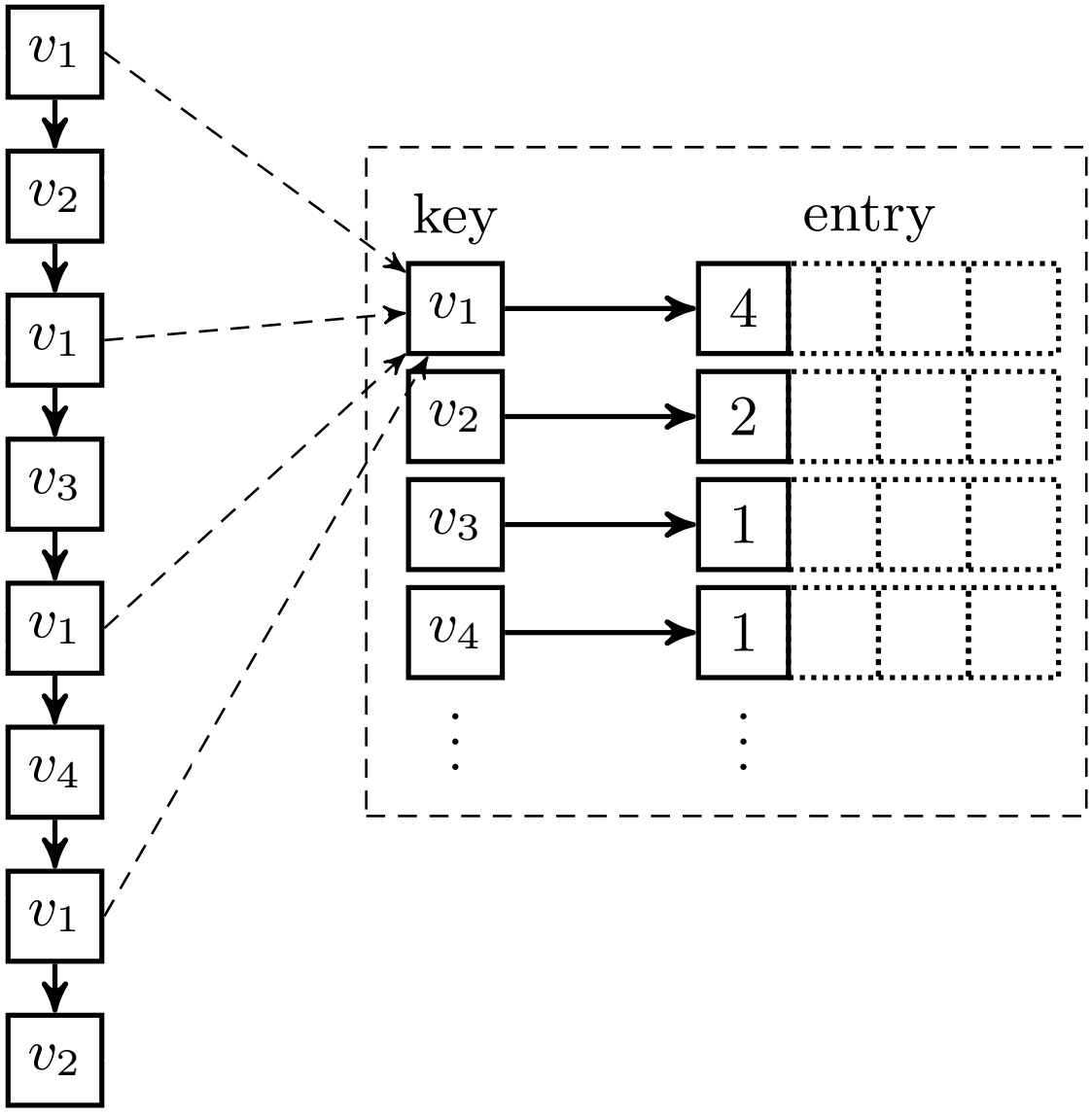




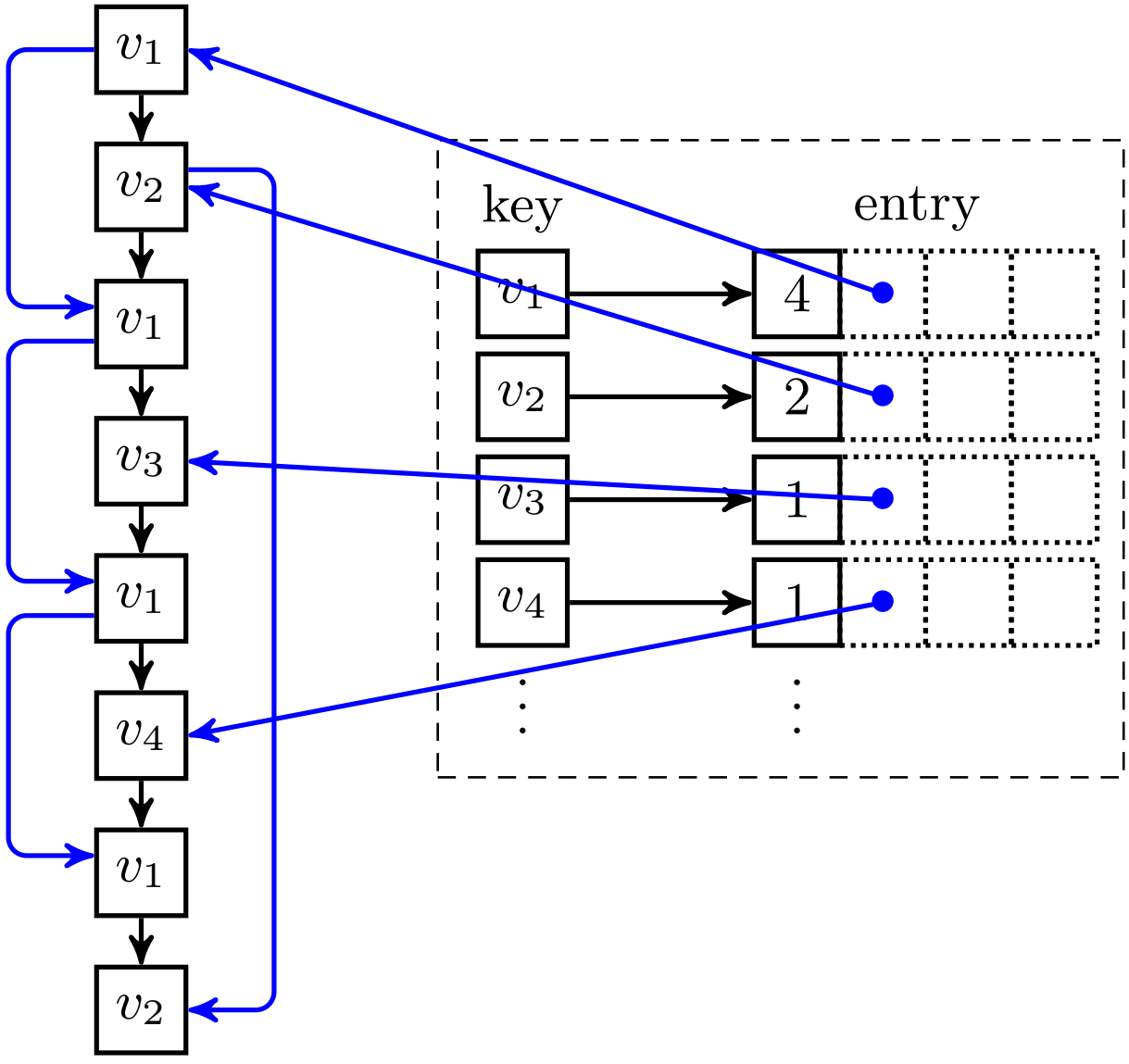
Indexed Buffers



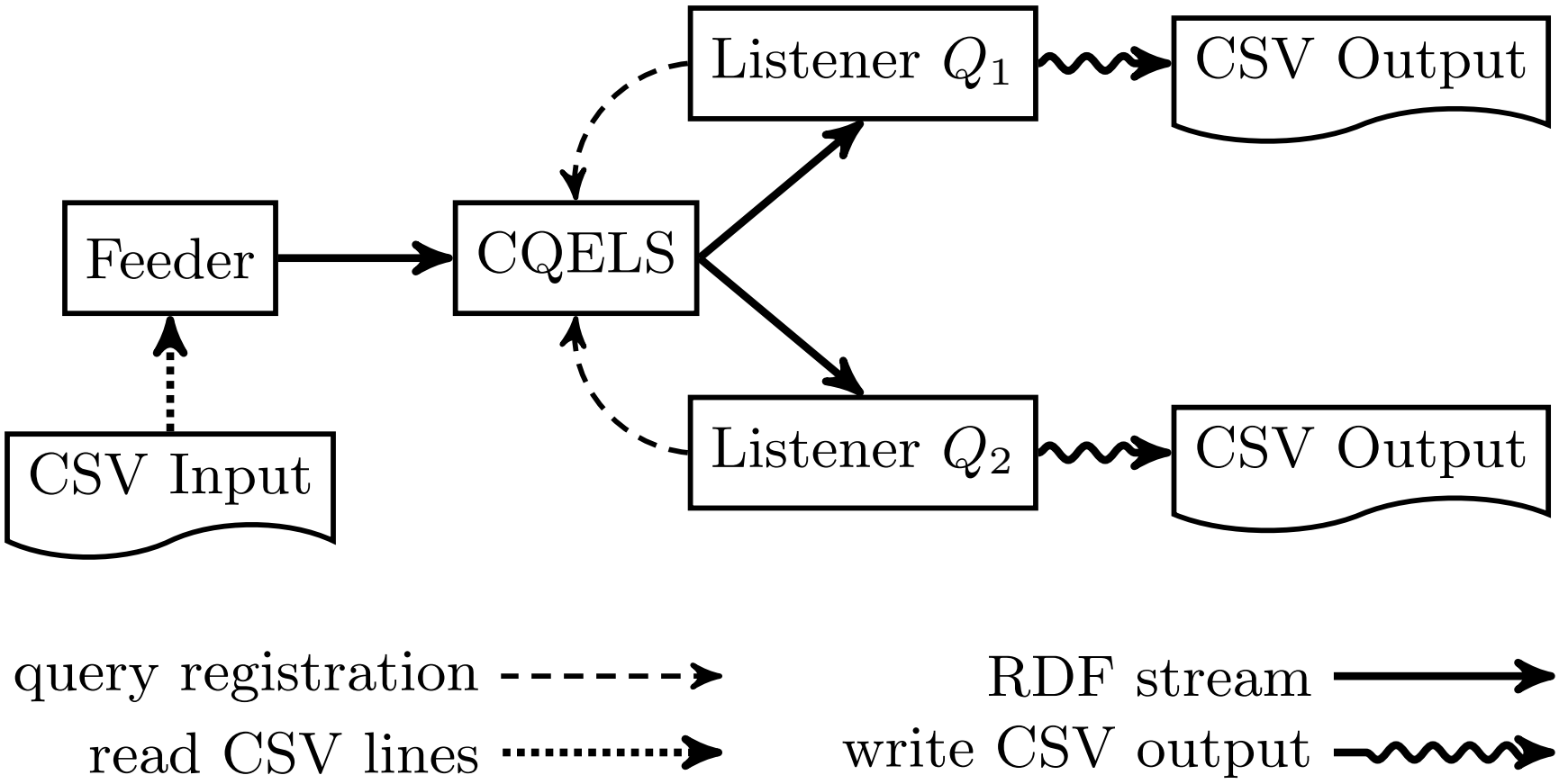
One-way Index



Ring Index



Deployment and Tests



Compare CQELS to a Base-line System

	Avg. delay time (ms)				Exe. time (s)		
	Indv.		Mixed		Indv.		Mixed
	Q_1	Q_2	Q_1	Q_2	Q_1	Q_2	Q_1 & Q_2
C	0.022	0.068	0.023	0.075	65.77	69.02	76.64
B	5	194	174	220	5000	22000	28000

Delay time (per output):
right after reading the input $\rightarrow$ right before writing the output

Execution time:
first input line read $\rightarrow$ final output streamed out

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	Avg. delay time (ms)				Exe. time (s)		
	Indv.		Mixed		Indv.		Mixed
	Q_1	Q_2	Q_1	Q_2	Q_1	Q_2	Q_1 & Q_2
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Exp: vary window sizes

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	Q_1	Q_2	Q_1	Q_2	Q_1	Q_2	Q_1 & Q_2
C	0.022	0.068	0.023	0.075	65.77	69.02	76.64
B	5	194	174	220	5000	22000	28000

Delay time (per output):
right after reading the input $\rightarrow$ right before writing the output

Execution time:
first input line read $\rightarrow$ final output streamed out

Exp: vary window sizes $\rightarrow$ no change in average delay time!

Conclusions

RDF Stream Processing for the DEBS 2015 Grand Challenge

Techniques implemented in CQELS

- High performance data structures
- Incremental algorithms (details in paper)

Experimental results

- Comparison to a base-line system
- Experiment on varying window sizes