CC5212-1

Procesamiento Masivo de Datos

Otoño 2021

Lecture 6

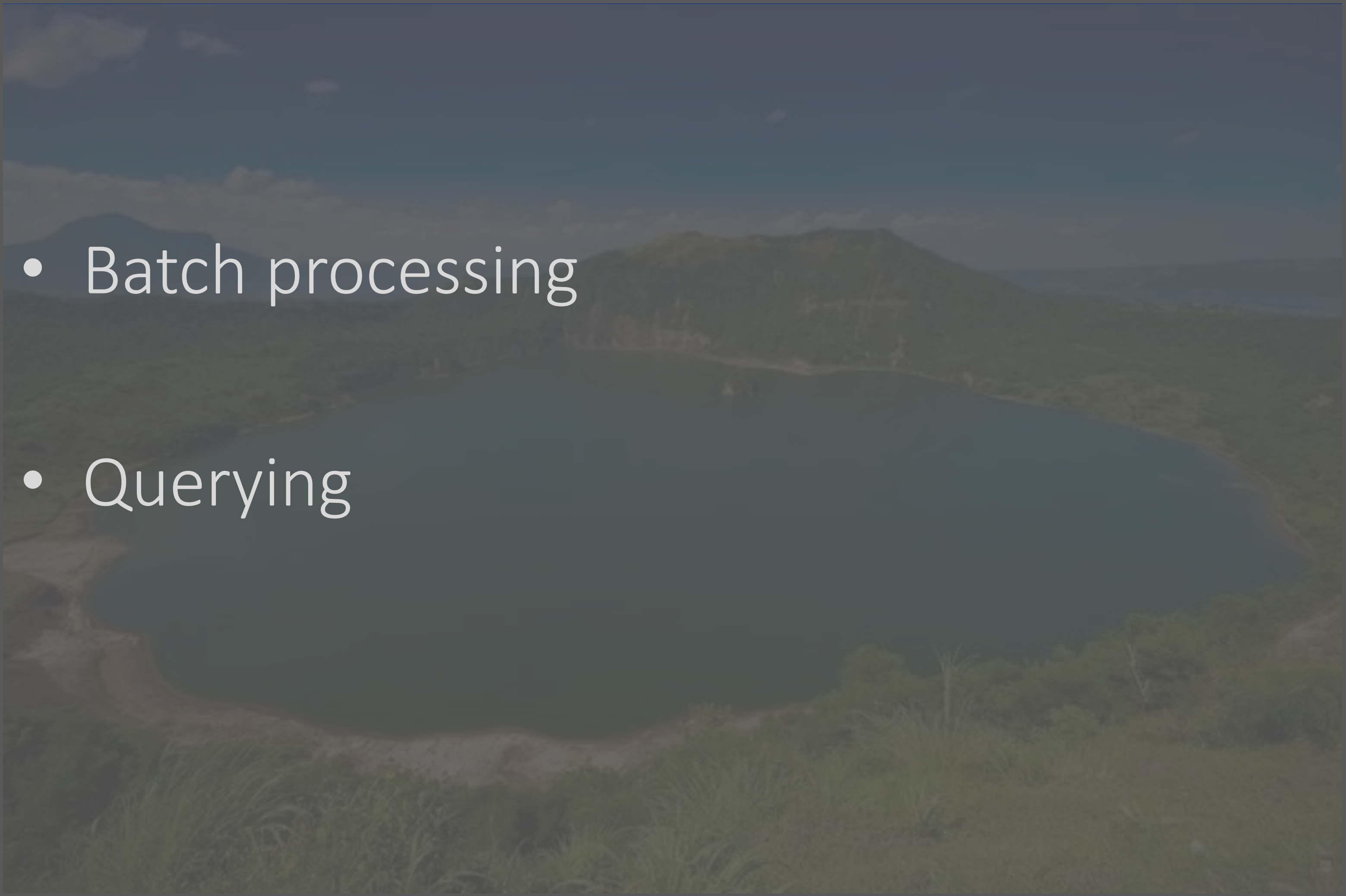
Streaming: Kafka

Aidan Hogan

aidhog@gmail.com

Files

Files

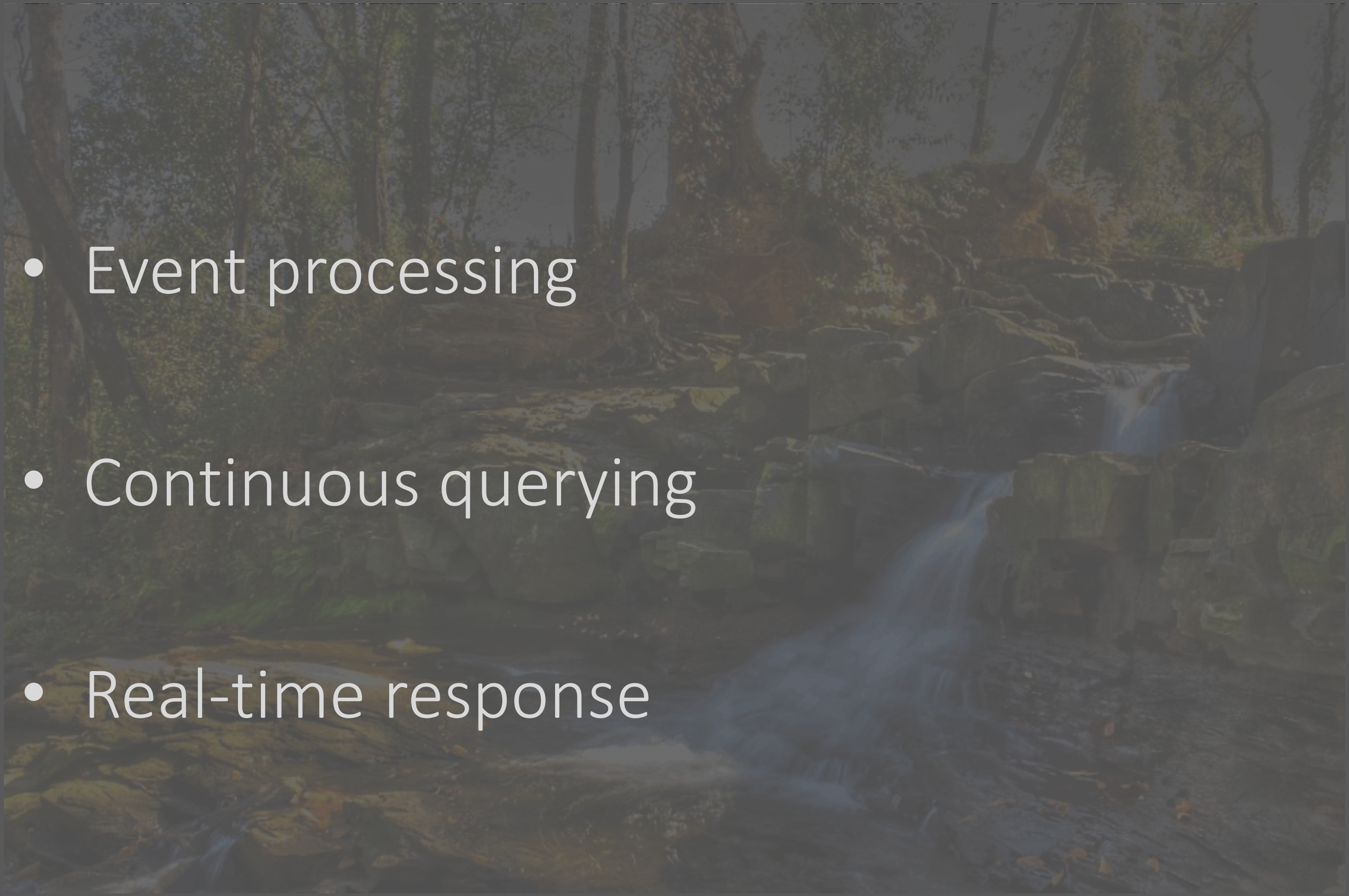


- Batch processing

- Querying

Streams

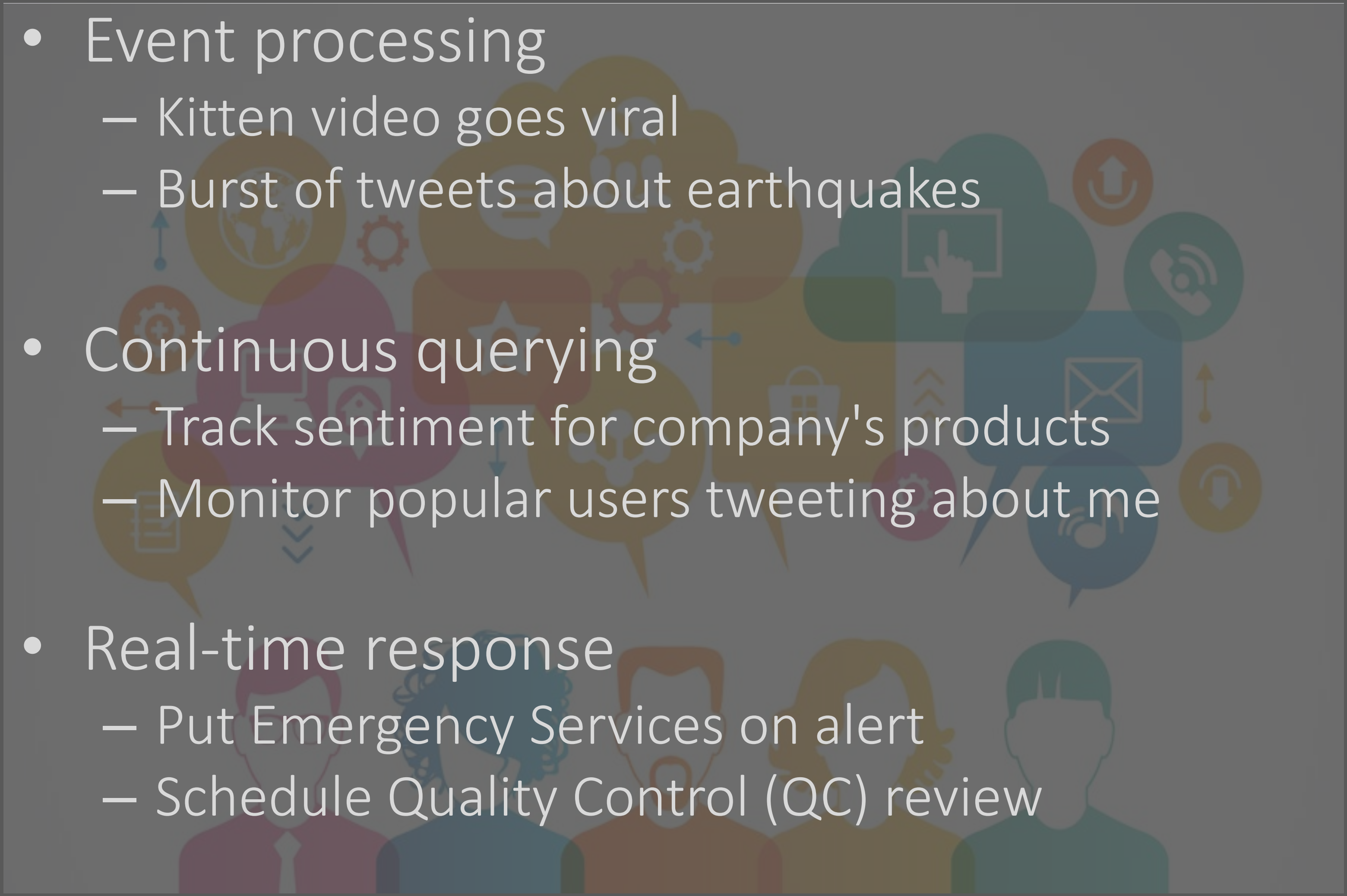
Streams



- Event processing
- Continuous querying
- Real-time response

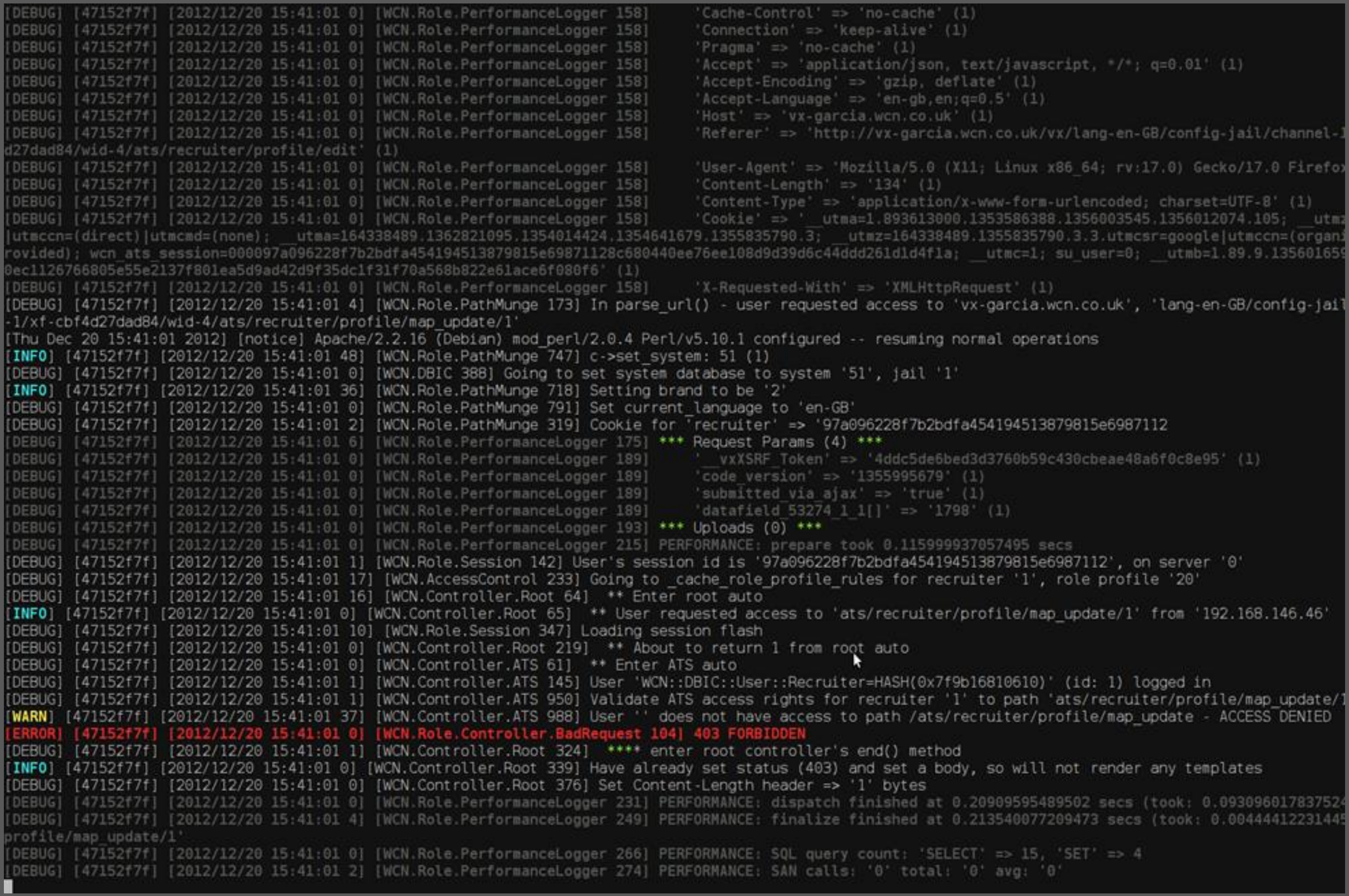
Applications: Social Media Analytics

Applications: Social Media Analytics



- Event processing
  - Kitten video goes viral
  - Burst of tweets about earthquakes
- Continuous querying
  - Track sentiment for company's products
  - Monitor popular users tweeting about me
- Real-time response
  - Put Emergency Services on alert
  - Schedule Quality Control (QC) review

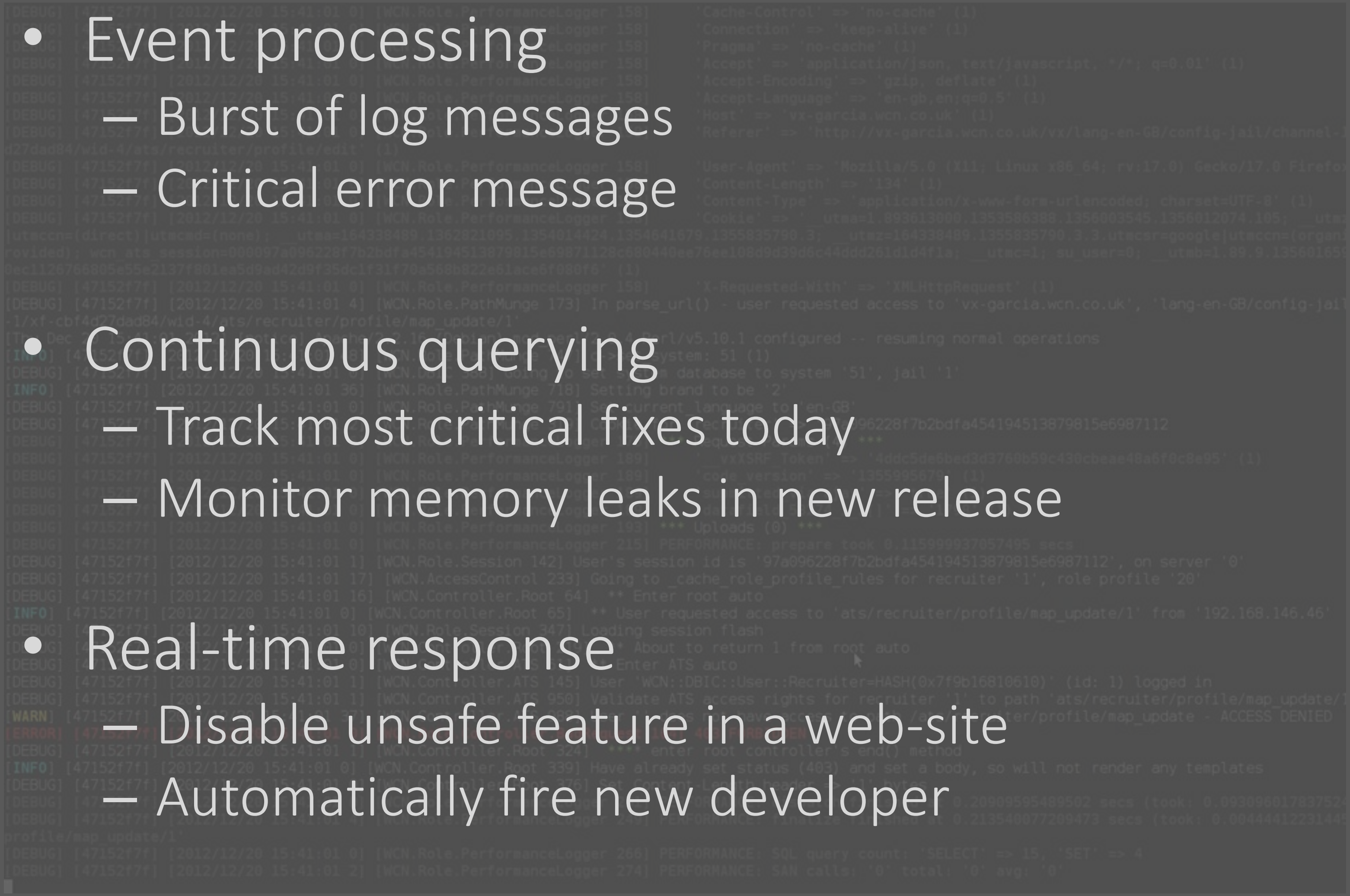
Applications: Log Monitoring



```
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Cache-Control' => 'no-cache' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Connection' => 'keep-alive' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Pragma' => 'no-cache' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Accept' => 'application/json, text/javascript, */*; q=0.01' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Accept-Encoding' => 'gzip, deflate' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Accept-Language' => 'en-gb,en;q=0.5' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Host' => 'vx-garcia.wcn.co.uk' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Referer' => 'http://vx-garcia.wcn.co.uk/vx/lang-en-GB/config-jail/channel-1
d27dad84/wid-4/ats/recruiter/profile/edit' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'User-Agent' => 'Mozilla/5.0 (X11; Linux x86_64; rv:17.0) Gecko/17.0 Firefox
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Content-Length' => '134' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Content-Type' => 'application/x-www-form-urlencoded; charset=UTF-8' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Cookie' => '__utma=1.893613000.1353586388.1356003545.1356012074.105; __utmz
|utmccn=(direct)|utmcmd=(none); __utma=164338489.1362821095.1354014424.1354641679.1355835790.3; __utmz=164338489.1355835790.3.3.utmcsr=google|utmccn=(organi
rovided); wcn_ats_session=000097a096228f7b2bdfa454194513879815e69871128c680440ee76ee108d9d39d6c44ddd261d1d4f1a; __utmc=1; su_user=0; __utmb=1.89.9.135601659
0ec1126766805e55e2137f801ea5d9ad42d9f35dc1f31f70a568b822e61ace6f080f6' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'X-Requested-With' => 'XMLHttpRequest' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 4] [WCN.Role.PathMunge 173] In parse_url() - user requested access to 'vx-garcia.wcn.co.uk', 'lang-en-GB/config-jail
-1/xf-cbf4d27dad84/wid-4/ats/recruiter/profile/map_update/1'
[Thu Dec 20 15:41:01 2012] [notice] Apache/2.2.16 (Debian) mod_perl/2.0.4 Perl/v5.10.1 configured -- resuming normal operations
[INFO] [47152f7f] [2012/12/20 15:41:01 48] [WCN.Role.PathMunge 747] c->set_system: 51 (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.DBIC 388] Going to set system database to system '51', jail '1'
[INFO] [47152f7f] [2012/12/20 15:41:01 36] [WCN.Role.PathMunge 718] Setting brand to be '2'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PathMunge 791] Set current_language to 'en-GB'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 2] [WCN.Role.PathMunge 319] Cookie for 'recruiter' => '97a096228f7b2bdfa454194513879815e6987112
[DEBUG] [47152f7f] [2012/12/20 15:41:01 6] [WCN.Role.PerformanceLogger 175] *** Request Params (4) ***
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     '__vxXSRF_Token' => '4ddc5de6bed3d3760b59c430cbeae48a6f0c8e95' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     'code_version' => '1355995679' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     'submitted_via_ajax' => 'true' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     'datafield_53274_1_1[]' => '1798' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 193] *** Uploads (0) ***
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 215] PERFORMANCE: prepare took 0.115999937057495 secs
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Role.Session 142] User's session id is '97a096228f7b2bdfa454194513879815e6987112', on server '0'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 17] [WCN.AccessControl 233] Going to _cache_role_profile_rules for recruiter '1', role profile '20'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 16] [WCN.Controller.Root 64]  ** Enter root auto
[INFO] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 65]  ** User requested access to 'ats/recruiter/profile/map_update/1' from '192.168.146.46'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 10] [WCN.Role.Session 347] Loading session flash
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 219]  ** About to return 1 from root auto
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.ATS 61]  ** Enter ATS auto
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.ATS 145] User 'WCN::DBIC::User::Recruiter=HASH(0x7f9b16810610)' (id: 1) logged in
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.ATS 950] Validate ATS access rights for recruiter '1' to path 'ats/recruiter/profile/map_update/1
[WARN] [47152f7f] [2012/12/20 15:41:01 37] [WCN.Controller.ATS 988] User '' does not have access to path /ats/recruiter/profile/map_update - ACCESS DENIED
[ERROR] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.Controller.BadRequest 104] 403 FORBIDDEN
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.Root 324]  **** enter root controller's end() method
[INFO] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 339] Have already set status (403) and set a body, so will not render any templates
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 376] Set Content-Length header => '1' bytes
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 231] PERFORMANCE: dispatch finished at 0.20909595489502 secs (took: 0.0930960178375245
[DEBUG] [47152f7f] [2012/12/20 15:41:01 4] [WCN.Role.PerformanceLogger 249] PERFORMANCE: finalize finished at 0.213540077209473 secs (took: 0.00444412231445
profile/map_update/1'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 266] PERFORMANCE: SQL query count: 'SELECT' => 15, 'SET' => 4
[DEBUG] [47152f7f] [2012/12/20 15:41:01 2] [WCN.Role.PerformanceLogger 274] PERFORMANCE: SAN calls: '0' total: '0' avg: '0'
```

Applications: Log Monitoring

- Event processing
  - Burst of log messages
  - Critical error message
- Continuous querying
  - Track most critical fixes today
  - Monitor memory leaks in new release
- Real-time response
  - Disable unsafe feature in a web-site
  - Automatically fire new developer



```
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Cache-Control' => 'no-cache' (1)
[DEBUG] [illegible]Logger 158]     'Connection' => 'keep-alive' (1)
[DEBUG] [illegible]Logger 158]     'Pragma' => 'no-cache' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.Perfor[illegible]Logger 158]     'Accept' => 'application/json, text/javascript, */*; q=0.01' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Accept-Encoding' => 'gzip, deflate' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Accept-Language' => 'en-gb,en;q=0.5' (1)
[DEBUG] [47[illegible]     'Host' => 'vx-garcia.wcn.co.uk' (1)
[DEBUG] [47152f7f[illegible]     'Referer' => 'http://vx-garcia.wcn.co.uk/vx/lang-en-GB/config-jail/channel-1
d27dad84/wid-4/ats/recruiter/profile/edit' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'User-Agent' => 'Mozilla/5.0 (X11; Linux x86_64; rv:17.0) Gecko/17.0 Firefox
[DEBUG] [47152f7[illegible]     'Content-Length' => '134' (1)
[DEBUG] [47152f7[illegible]     'Content-Type' => 'application/x-www-form-urlencoded; charset=UTF-8' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'Cookie' => '__utma=1.893613000.1353586388.1356003545.1356012074.105; __utmz
|utmccn=(direct)|utmcmd=(none); __utma=164338489.1362821095.1354014424.1354641679.1355835790.3; __utmz=164338489.1355835790.3.3.utmcsr=google|utmccn=(organi
rovided); wcn_ats_session=000097a096228f7b2bdfa454194513879815e69871128c680440ee76ee108d9d39d6c44ddd261d1d4f1a; __utmc=1; su_user=0; __utmb=1.89.9.13560165
0ec1126766805e55e2137f801ea5d9ad42d9f35dc1f31f70a568b822e61ace6f080f6' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 158]     'X-Requested-With' => 'XMLHttpRequest' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 4] [WCN.Role.PathMunge 173] In parse_url() - user requested access to 'vx-garcia.wcn.co.uk', 'lang-en-GB/config-jail
-1/xf-cbf4d27dad84/wid-4/ats/recruiter/profile/map_update/1'
[Thu Dec 2[illegible]Perl/v5.10.1 configured -- resuming normal operations
[INFO] [4[illegible]system: 51 (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.D[illegible] database to system '51', jail '1'
[INFO] [47152f7f] [2012/12/20 15:41:01 36] [WCN.Role.PathMunge 718] Setting brand to be '2'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PathMunge 79] Set current language to 'en-GB'
[DEBUG] [47152f7f[illegible]96228f7b2bdfa454194513879815e6987112
[DEBUG] [illegible] ***
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     'vxXSRF_Token' => '4ddc5de6bed3d3760b59c430cbeae48a6f0c8e95' (1)
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 189]     'code_version' => '1355995679' (1)
[DEBUG] [illegible]
[DEBUG] [illegible]
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 193] *** Uploads (0) ***
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 215] PERFORMANCE: prepare took 0.115999937057495 secs
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Role.Session 142] User's session id is '97a096228f7b2bdfa454194513879815e6987112', on server '0'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 17] [WCN.AccessControl 233] Going to _cache_role_profile_rules for recruiter '1', role profile '20'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 16] [WCN.Controller.Root 64]  ** Enter root auto
[INFO] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 65]  ** User requested access to 'ats/recruiter/profile/map_update/1' from '192.168.146.46'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 10] [WCN.Role.Session 347] Loading session flash
[DEBUG] [illegible] About to return 1 from root auto
[DEBUG] [illegible] Enter ATS auto
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.ATS 145] User 'WCN::DBIC::User::Recruiter=HASH(0x7f9b16810610)' (id: 1) logged in
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.ATS 950] Validate ATS access rights for recruiter '1' to path 'ats/recruiter/profile/map_update/1
[WARN] [47152f7f] [illegible]ter/profile/map_update - ACCESS DENIED
[ERROR] [illegible]
[DEBUG] [47152f7f] [2012/12/20 15:41:01 1] [WCN.Controller.Root 324] **** enter root controller's end() method
[INFO] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Controller.Root 339] Have already set status (403) and set a body, so will not render any templates
[DEBUG] [47152f7f] [illegible] 376] Set Content-Length header to '11' bytes
[DEBUG] [illegible] 0.20909595489502 secs (took: 0.0930960178375
[DEBUG] [47152f7f] [illegible]Logger 249] PERFORMANCE: finalize finished at 0.213540077209473 secs (took: 0.00444412231445
profile/map_update/1'
[DEBUG] [47152f7f] [2012/12/20 15:41:01 0] [WCN.Role.PerformanceLogger 266] PERFORMANCE: SQL query count: 'SELECT' => 15, 'SET' => 4
[DEBUG] [47152f7f] [2012/12/20 15:41:01 2] [WCN.Role.PerformanceLogger 274] PERFORMANCE: SAN calls: '0' total: '0' avg: '0'
```

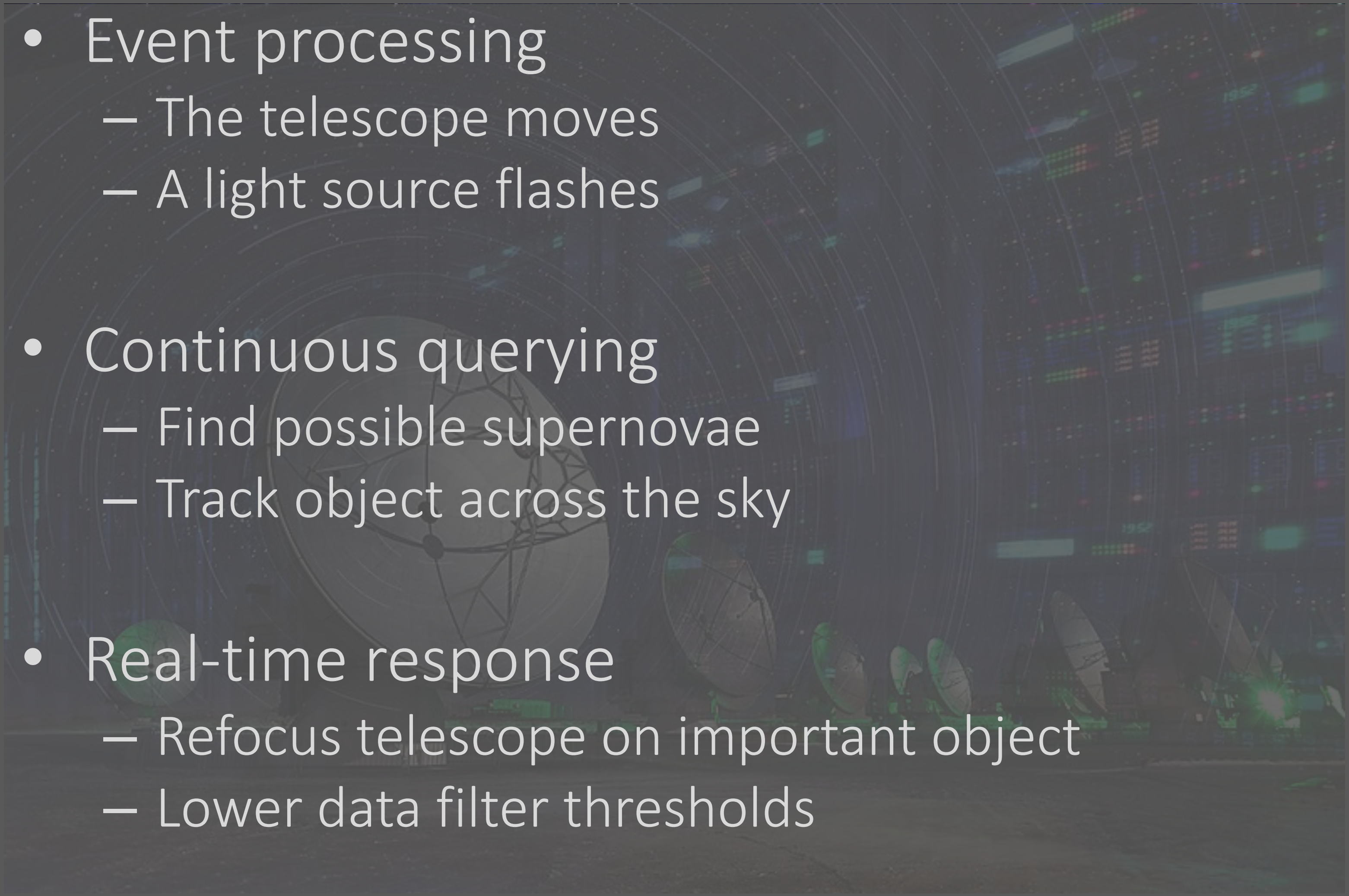
Applications: Finance

Applications: Finance

- Event processing
  - Company goes public
  - Stock drops sharply
- Continuous querying
  - Track stocks with gains of 10% in a day
  - Create alerts for major buy/sell transactions
- Real-time response
  - BUY BUY BUY
  - SELL SELL SELL

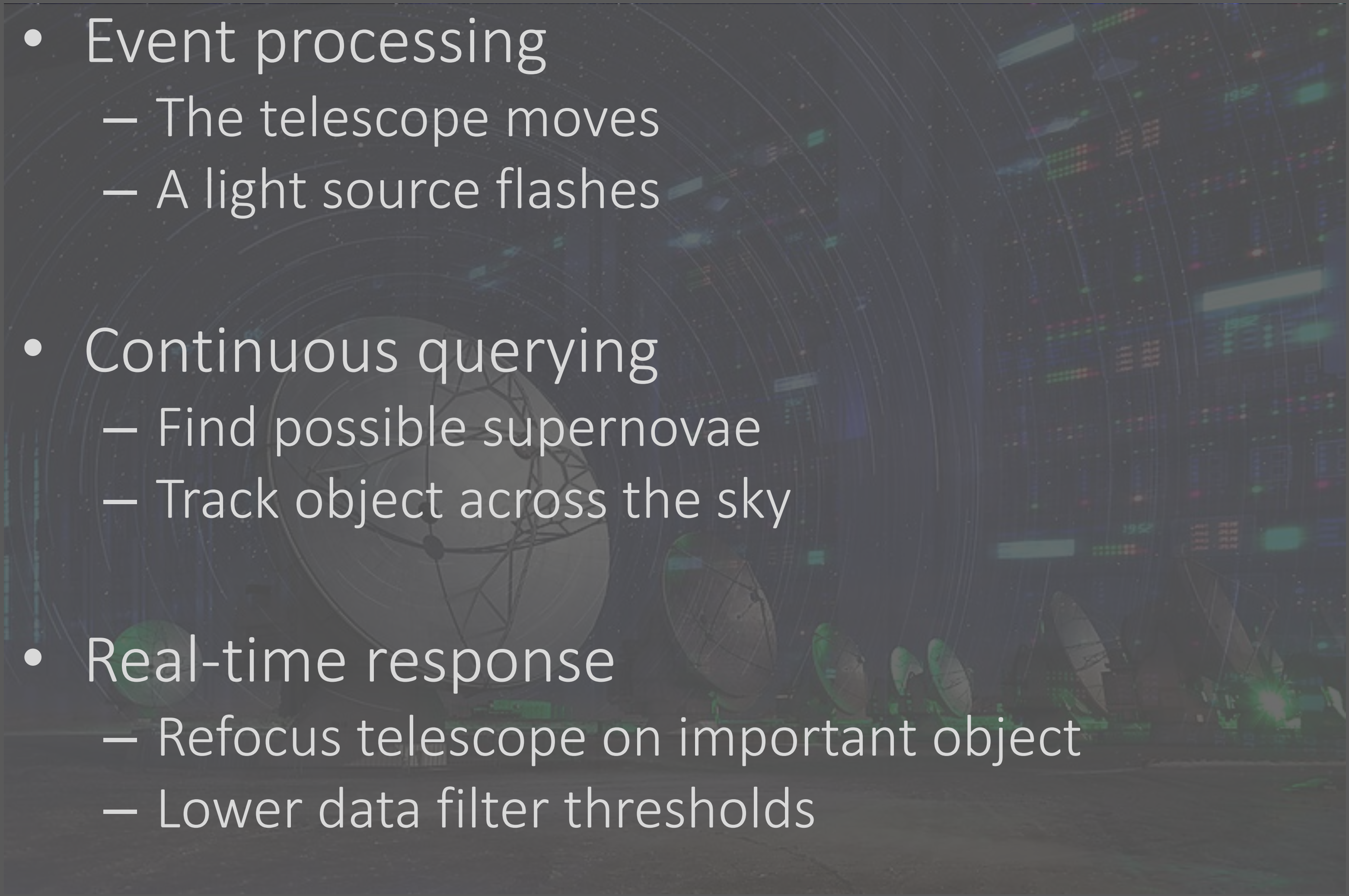
Applications: Astronomy

Applications: Astronomy



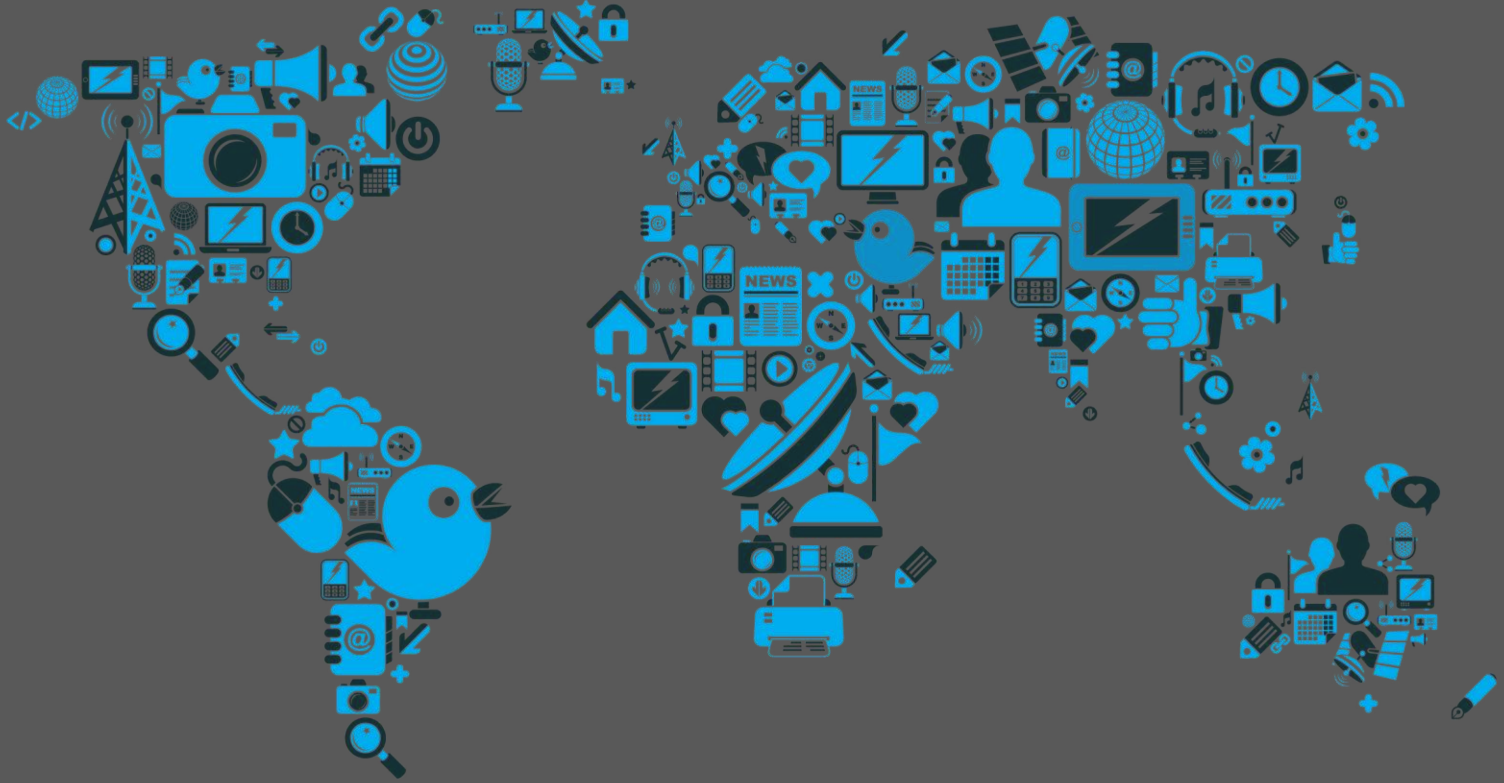
- Event processing
  - The telescope moves
  - A light source flashes
- Continuous querying
  - Find possible supernovae
  - Track object across the sky
- Real-time response
  - Refocus telescope on important object
  - Lower data filter thresholds

Applications: Astronomy

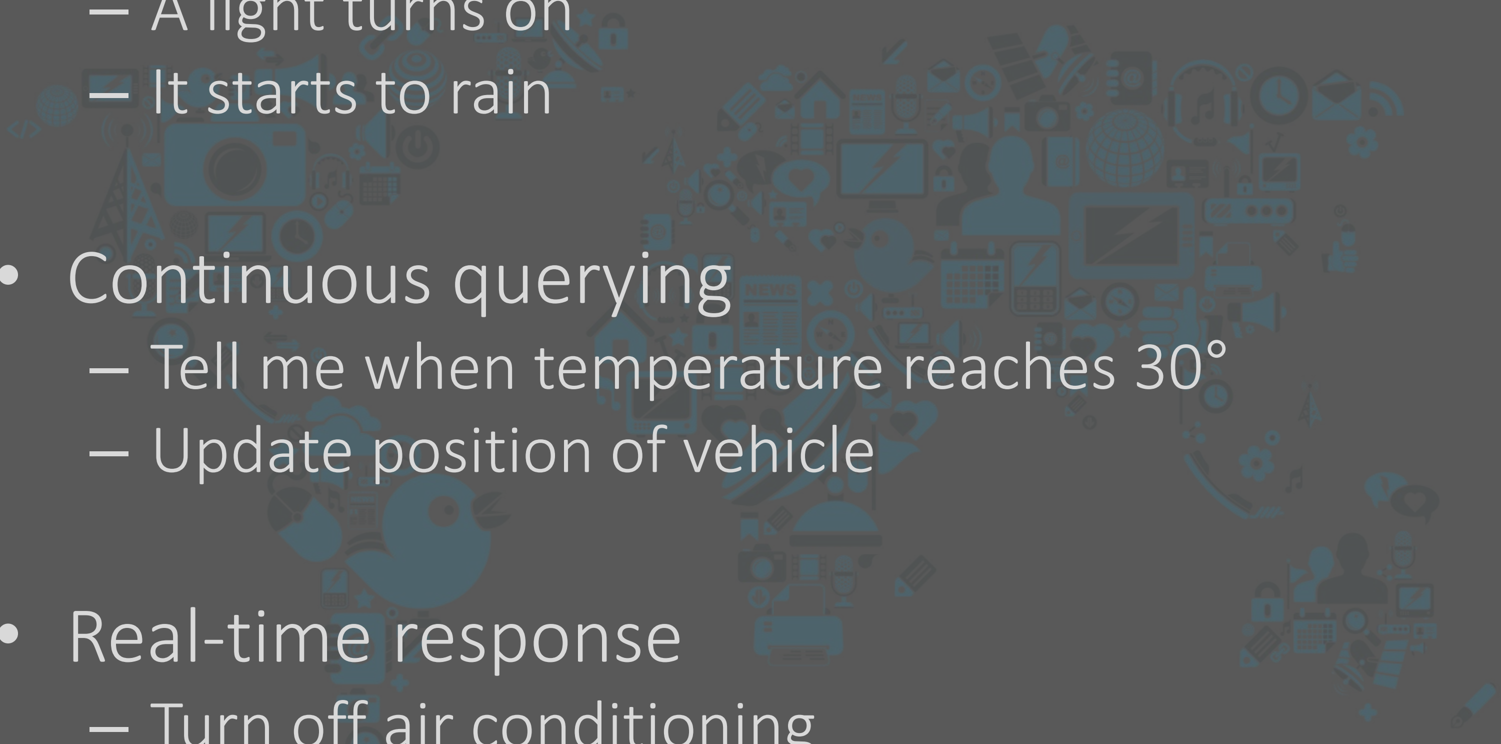


- Event processing
  - The telescope moves
  - A light source flashes
- Continuous querying
  - Find possible supernovae
  - Track object across the sky
- Real-time response
  - Refocus telescope on important object
  - Lower data filter thresholds

Streams: Internet of Things



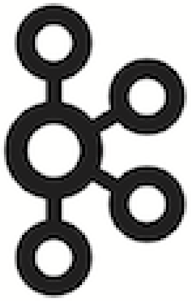
Streams: Internet of Things



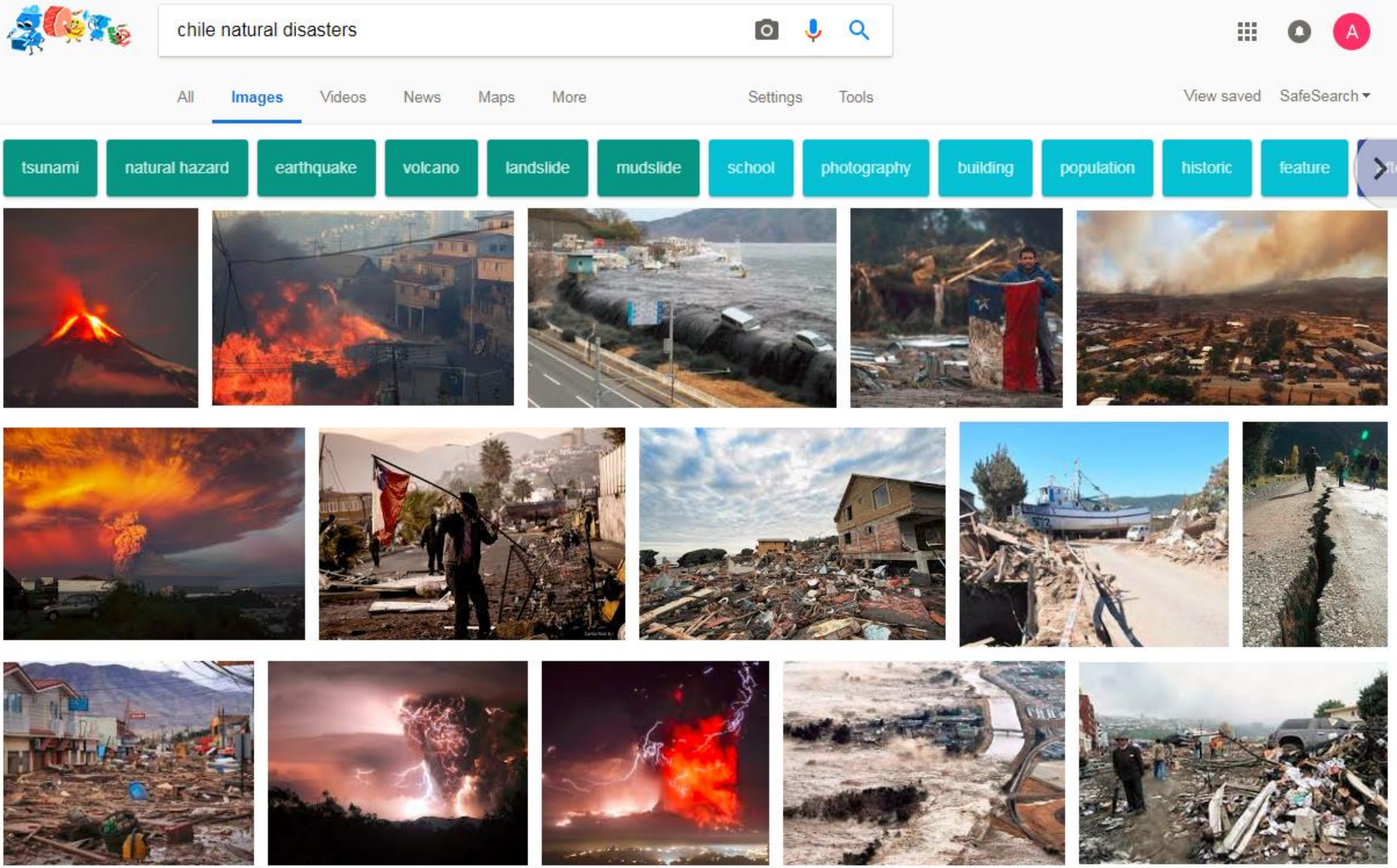
- Event processing
  - A light turns on
  - It starts to rain
- Continuous querying
  - Tell me when temperature reaches 30°
  - Update position of vehicle
- Real-time response
  - Turn off air conditioning
  - Take another route

Distributed Streaming Platform

Available Frameworks

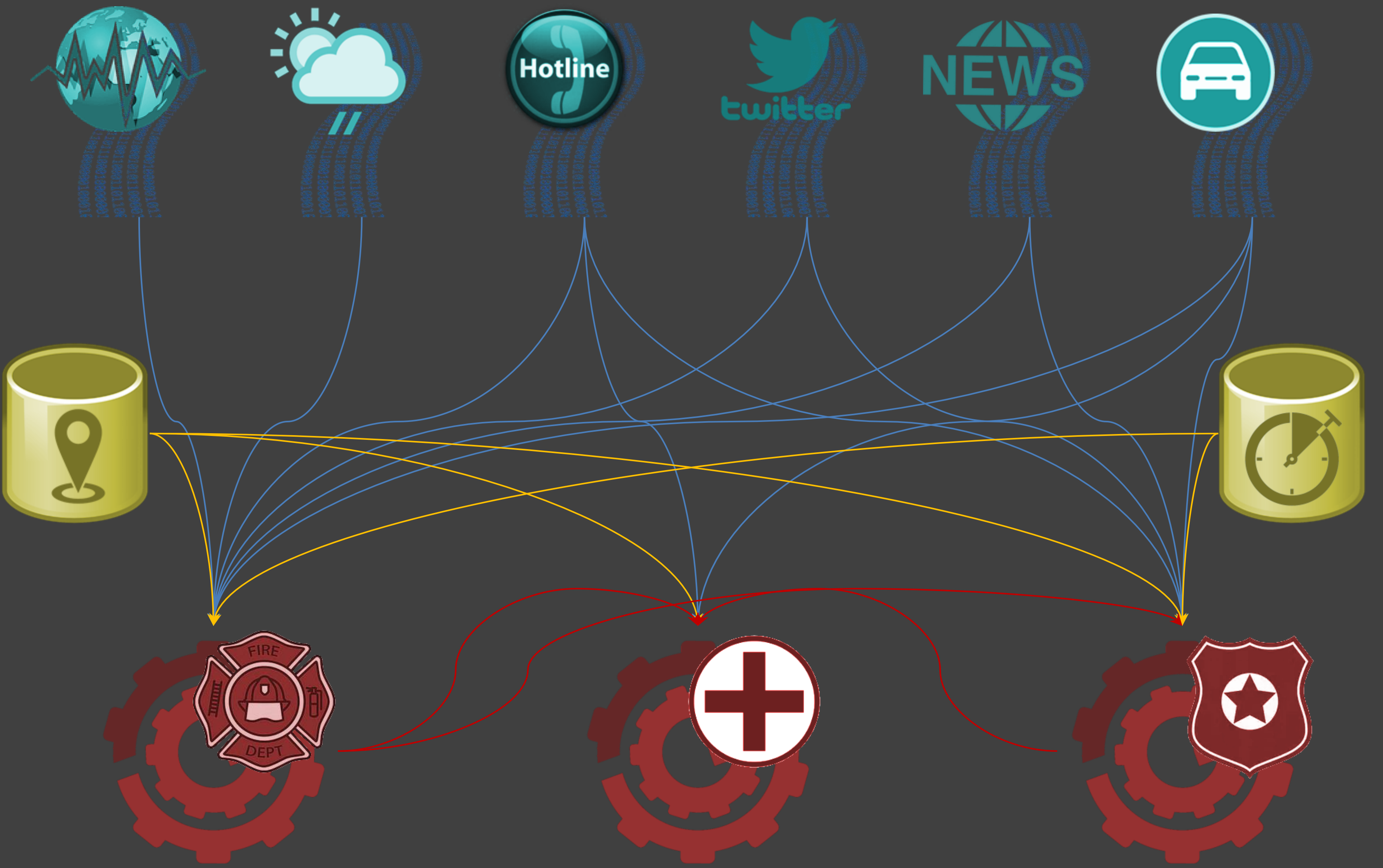


Application: Emergency Response

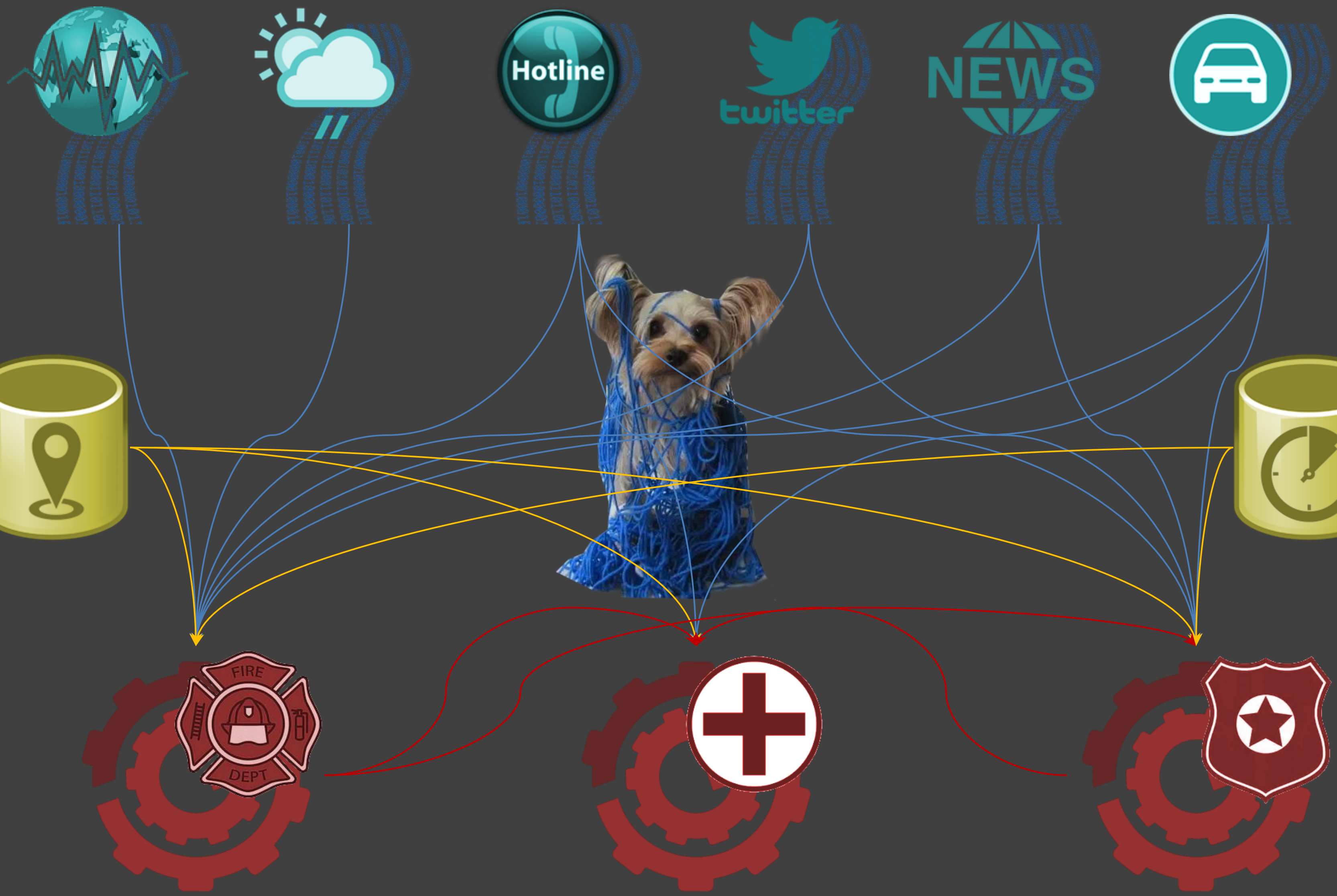


chile natural disasters

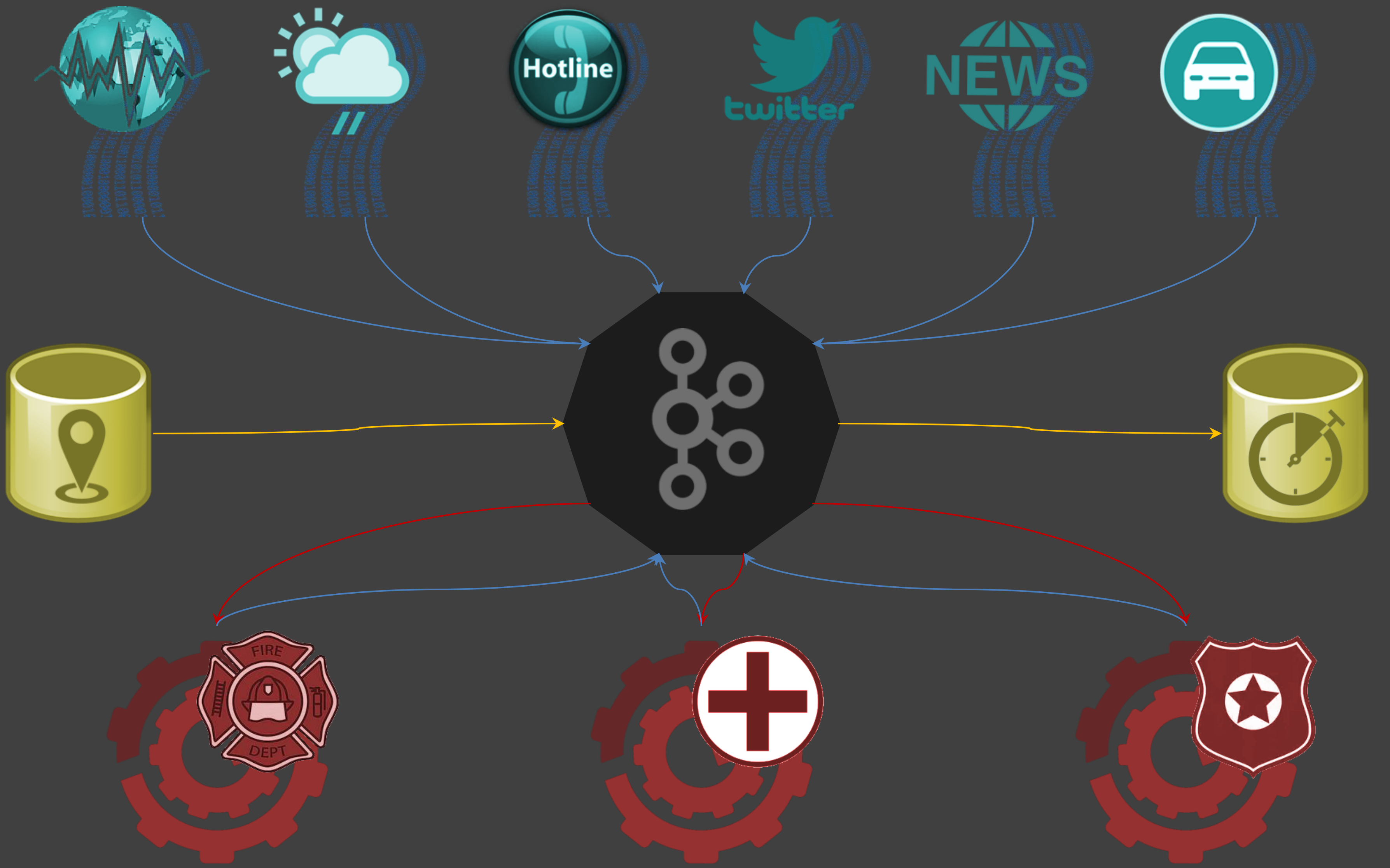
Real-Time Emergency Response



Real-Time Emergency Response

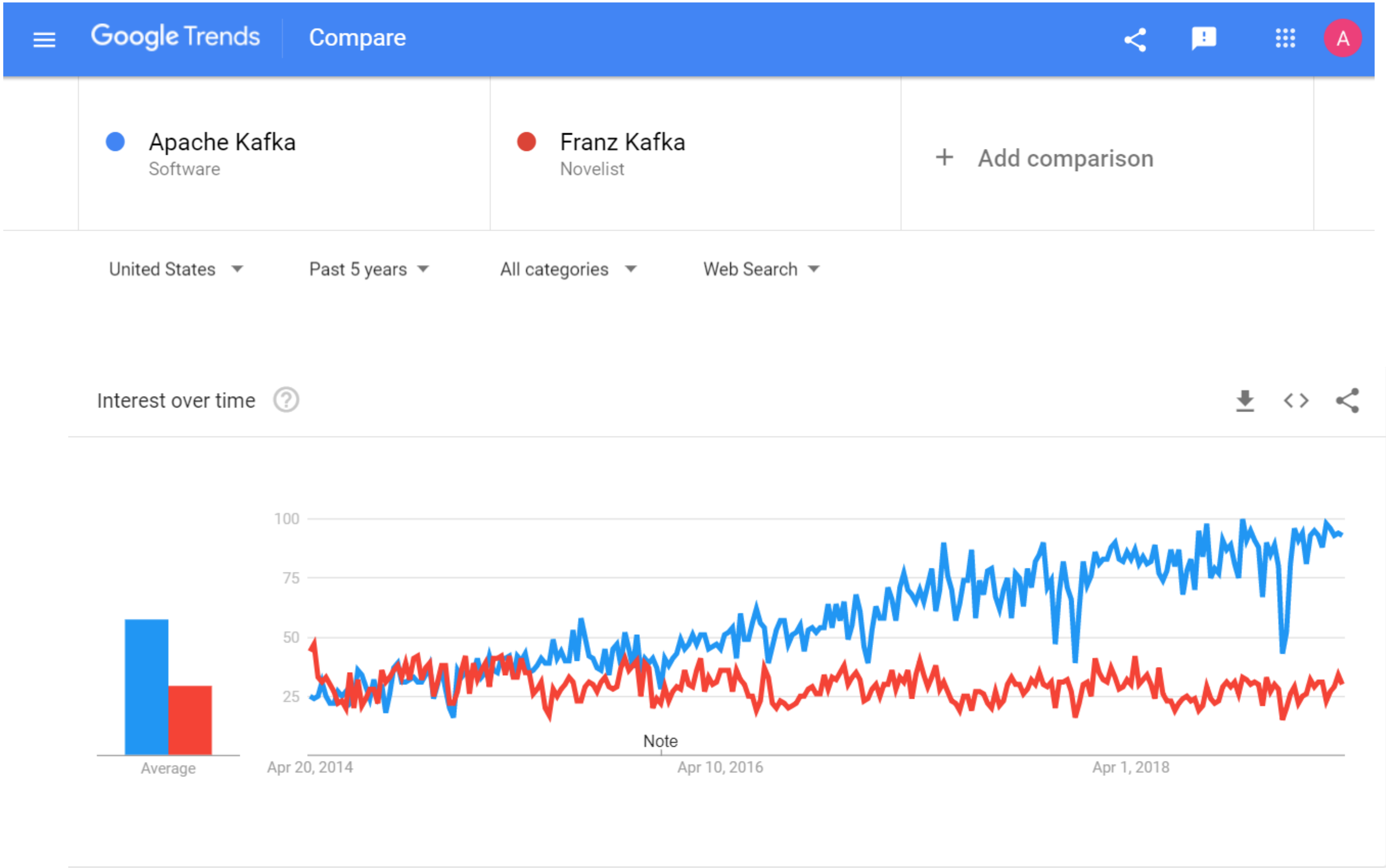


Real-Time Emergency Response



Apache Kafka

Apache Kafka vs. Franz Kafka



Google Trends Compare

● Apache Kafka
Software

● Franz Kafka
Novelist

+ Add comparison

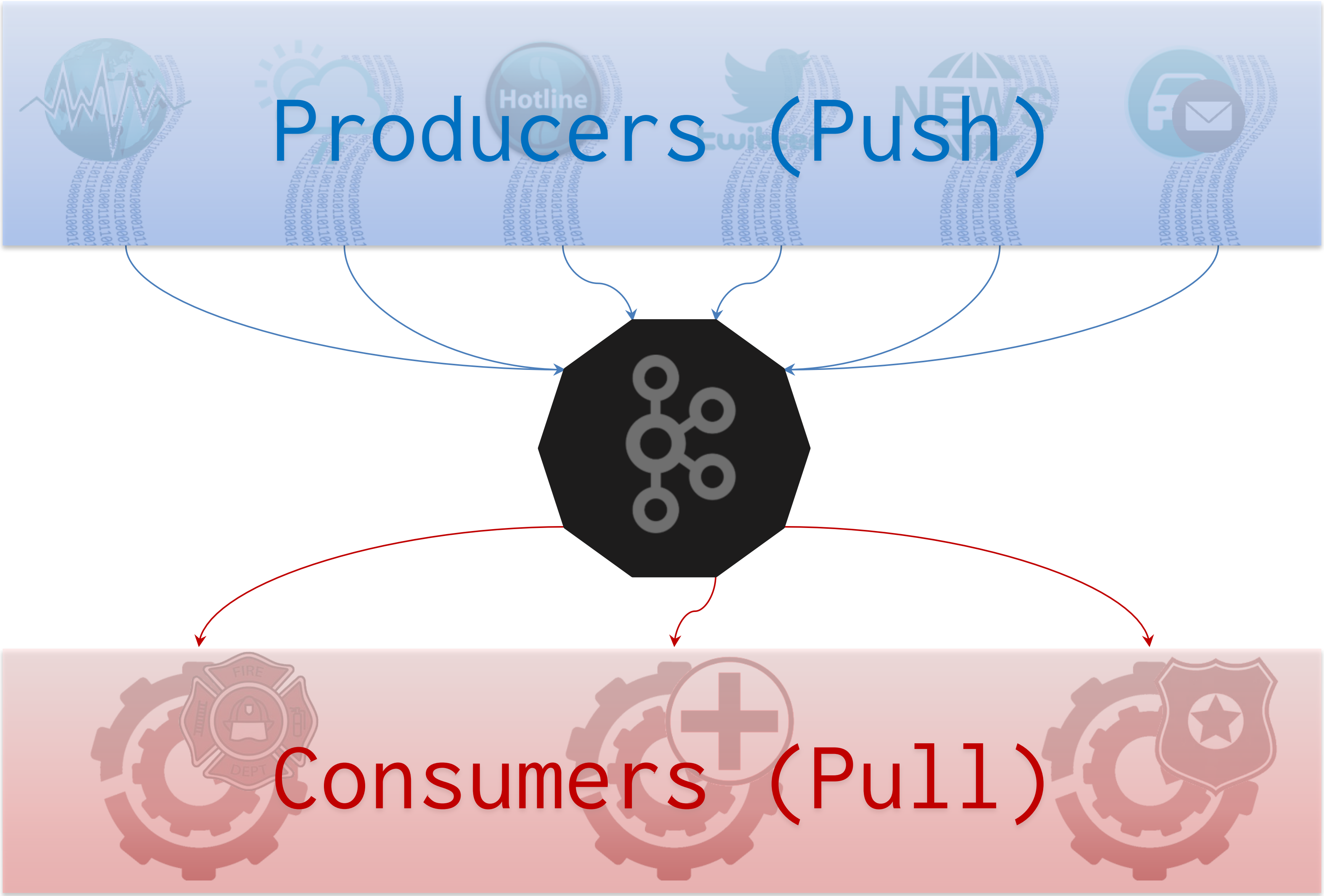
United States ▾ Past 5 years ▾ All categories ▾ Web Search ▾

Interest over time

Apache Kafka

- Open Source
- Scala / Java
- Originated in LinkedIn

Kafka Overview

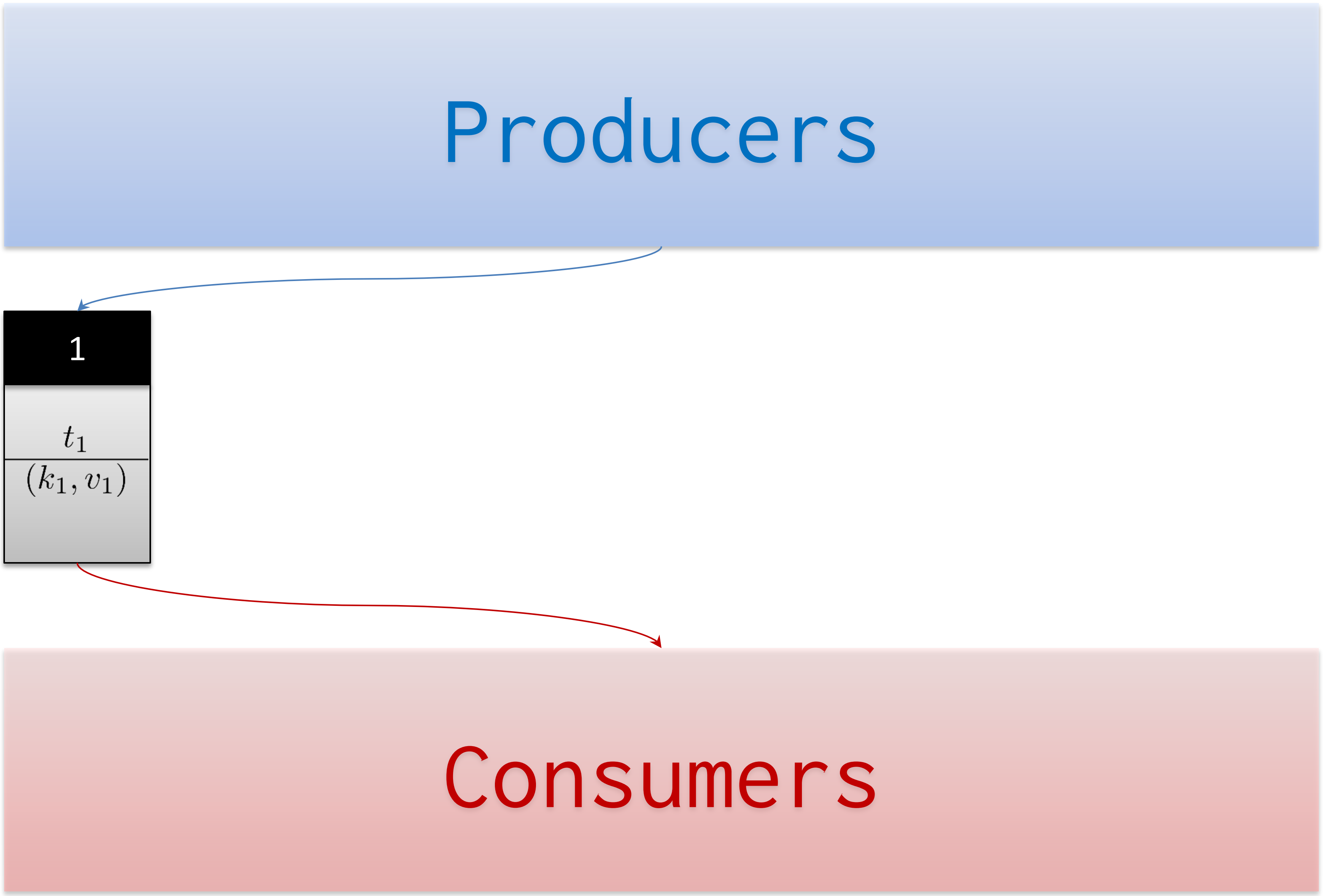


Producers (Push)

Consumers (Pull)

Kafka: Data Model

Kafka Record



Producers

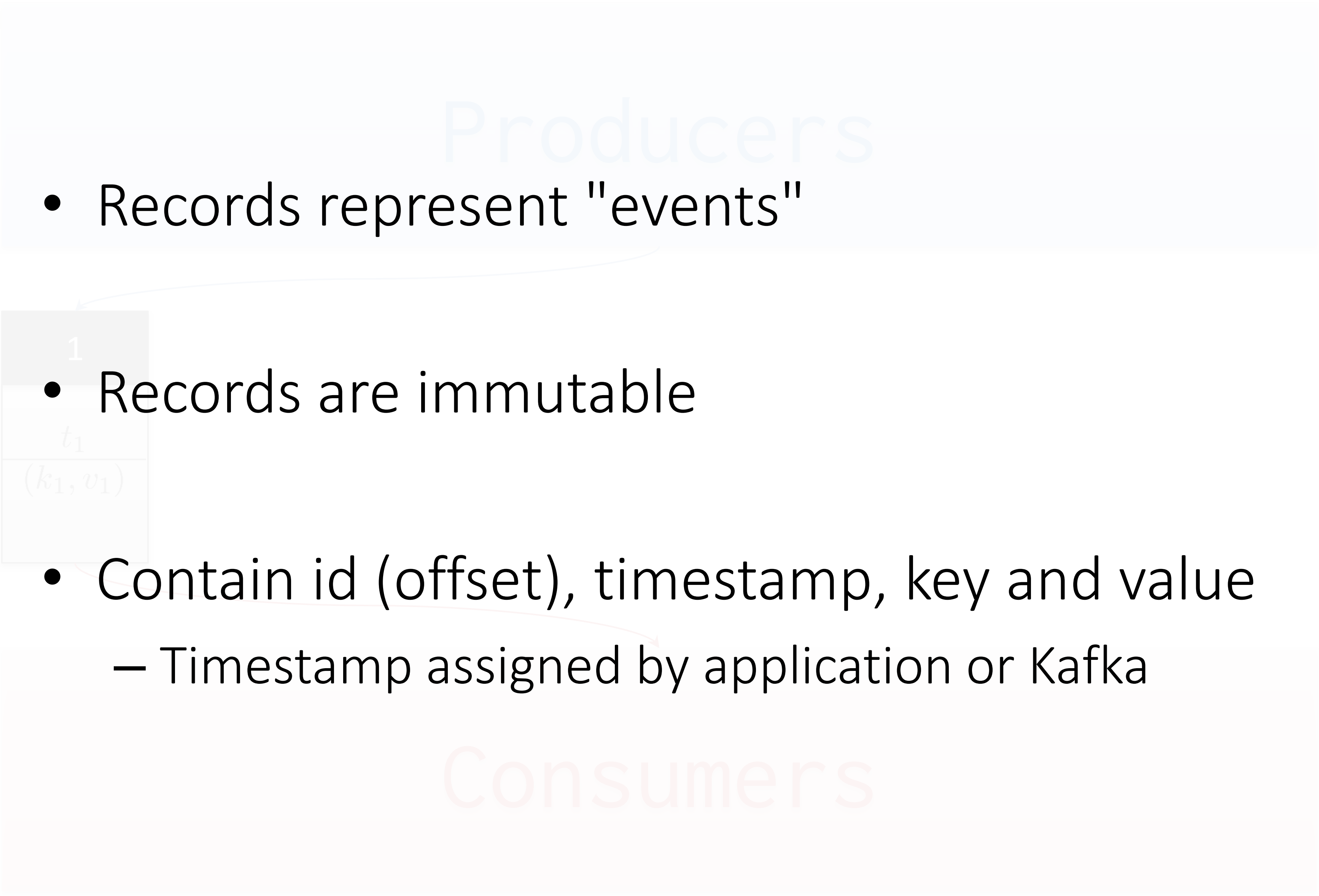
1

t_1

(k_1, v_1)

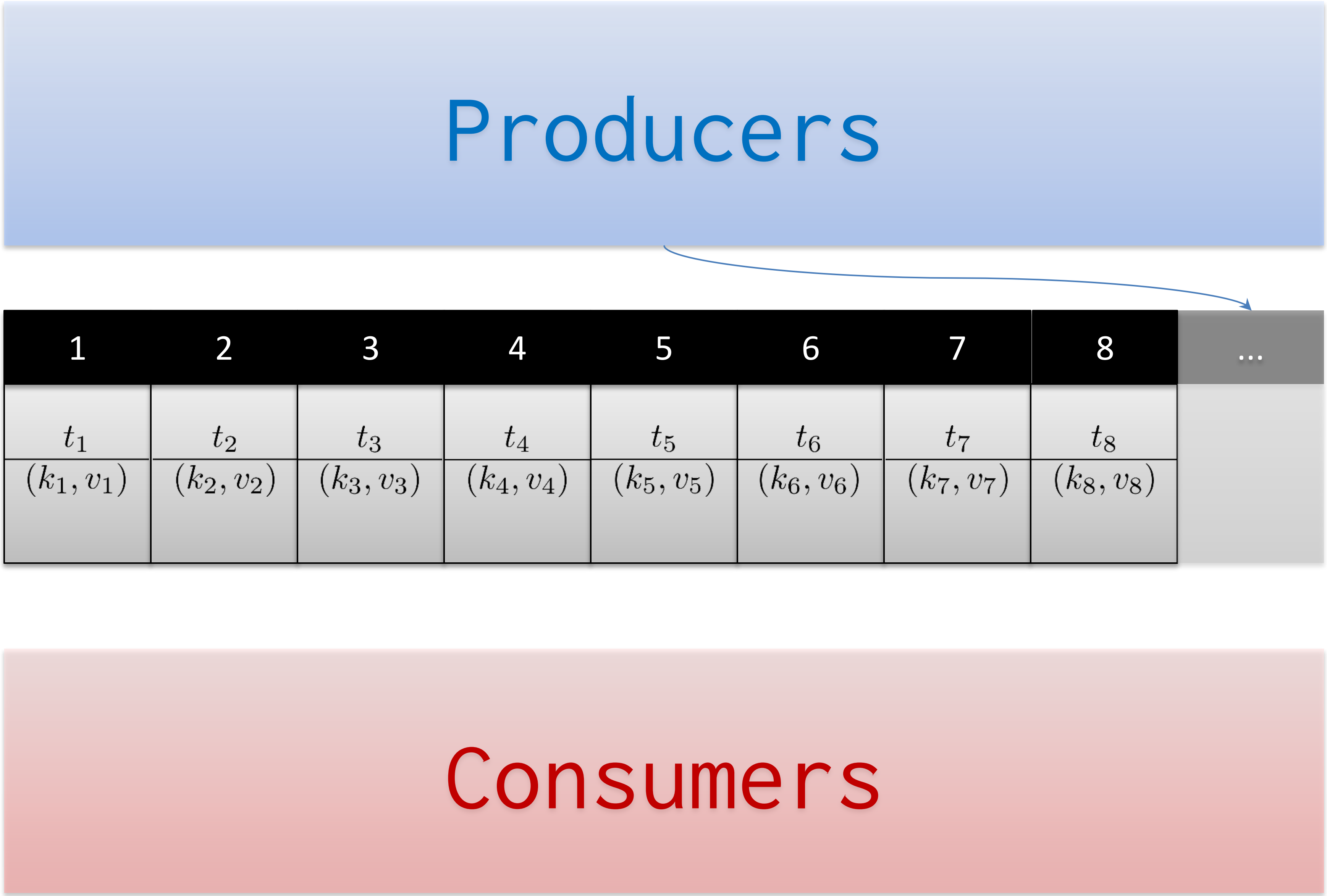
Consumers

Kafka Record



- Records represent "events"
- Records are immutable
- Contain id (offset), timestamp, key and value
  - Timestamp assigned by application or Kafka

Kafka Ledger



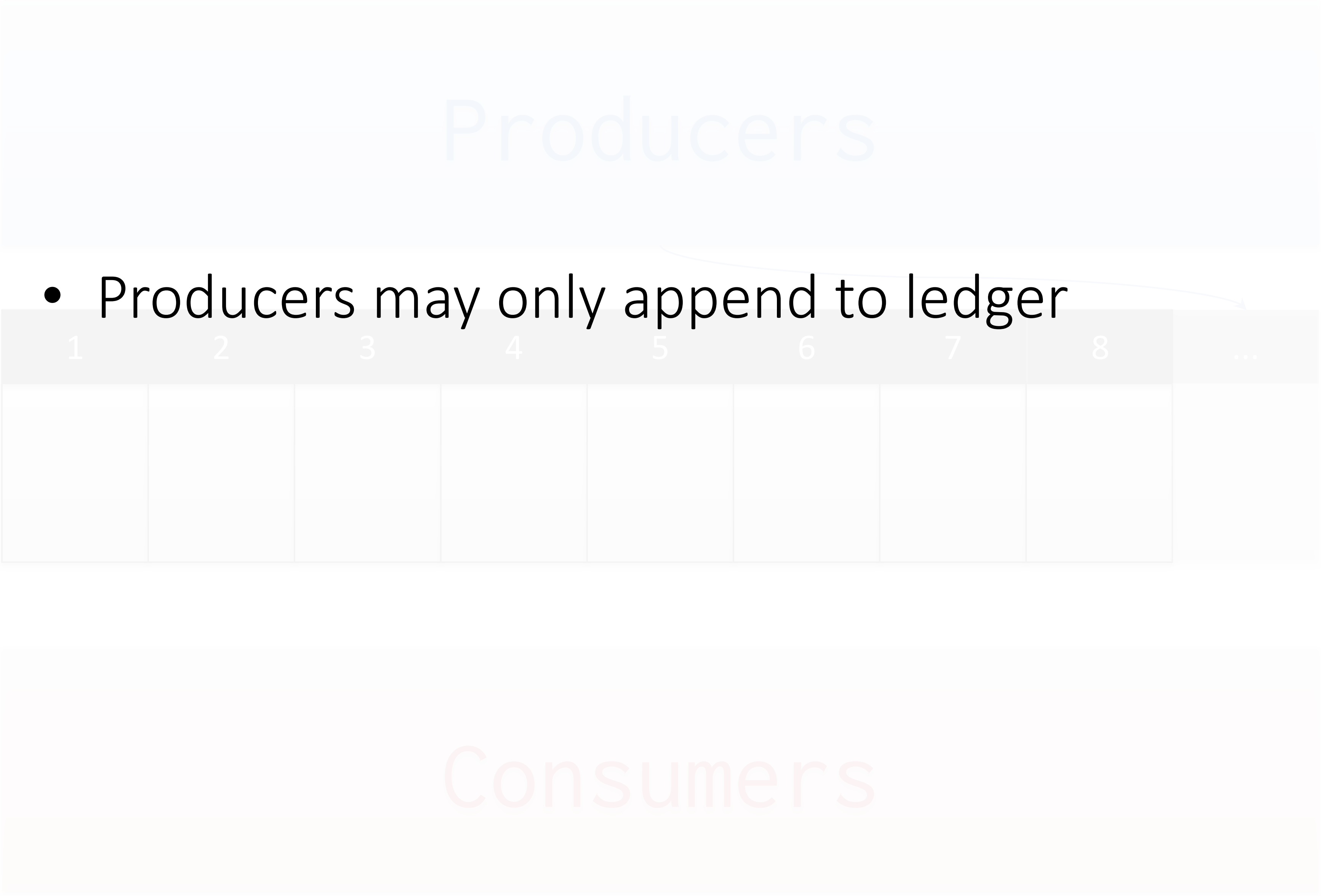
Producers

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

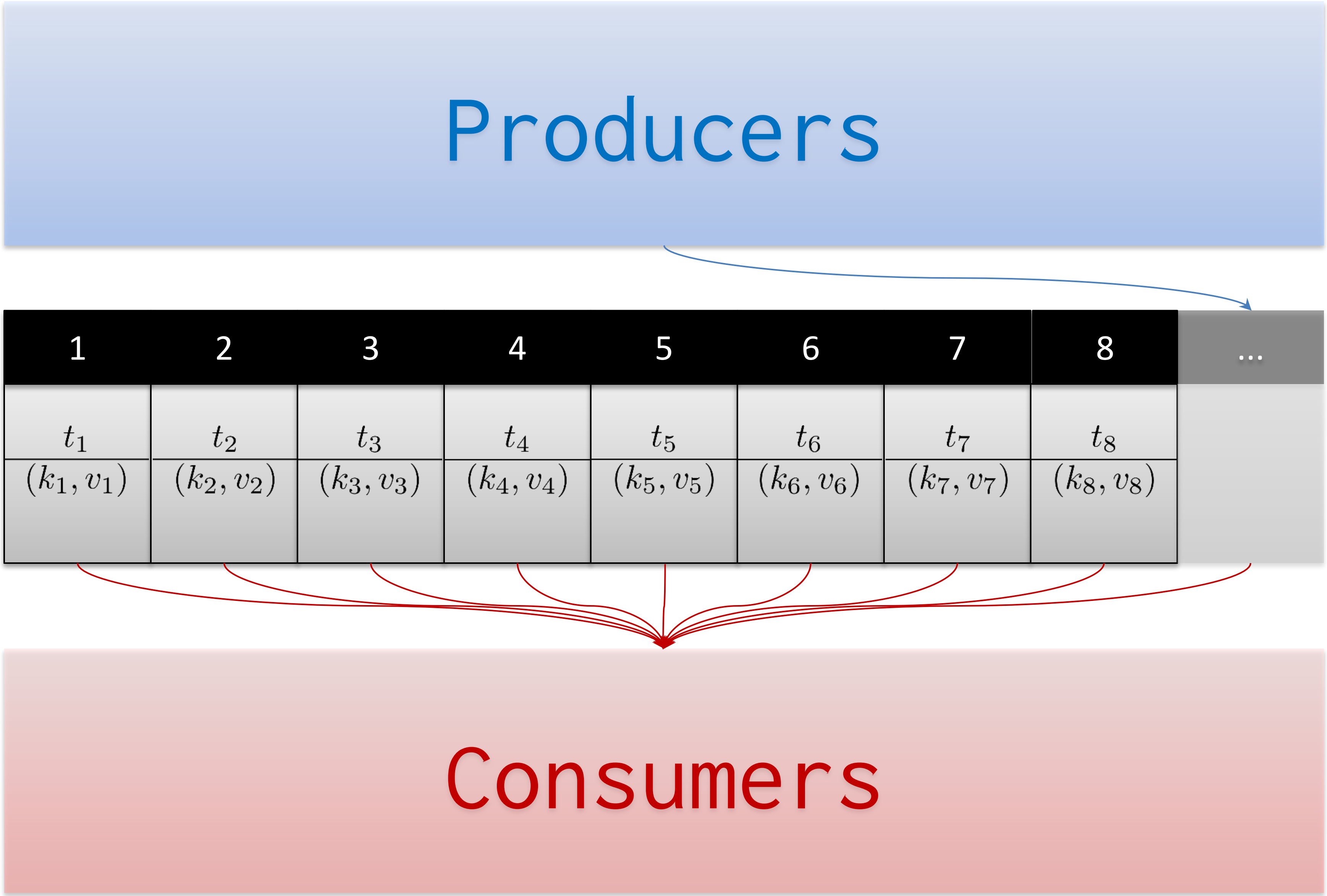
Consumers

Kafka Ledger

- Producers may only append to ledger



Kafka Log



Producers

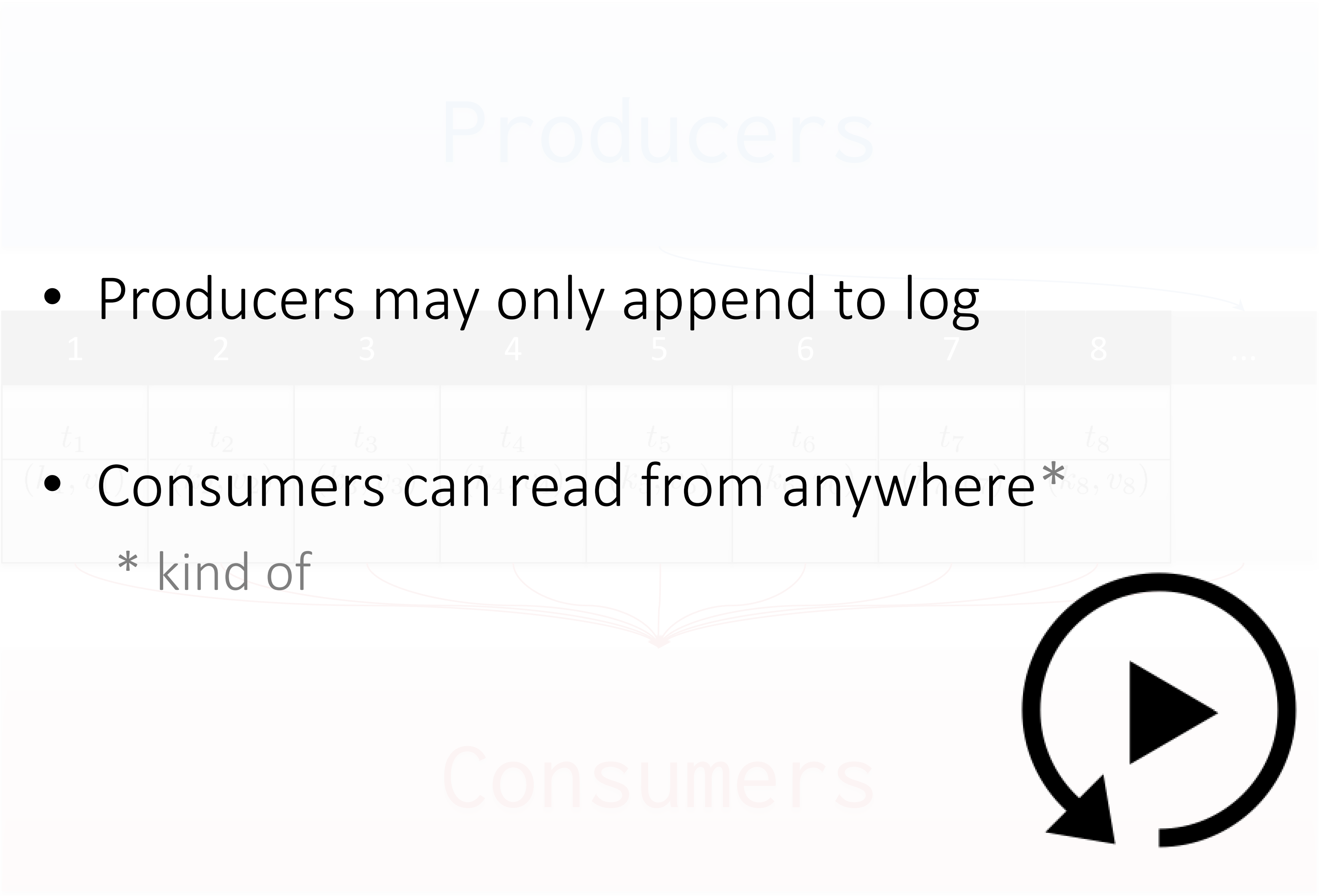
1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Consumers

Kafka Log

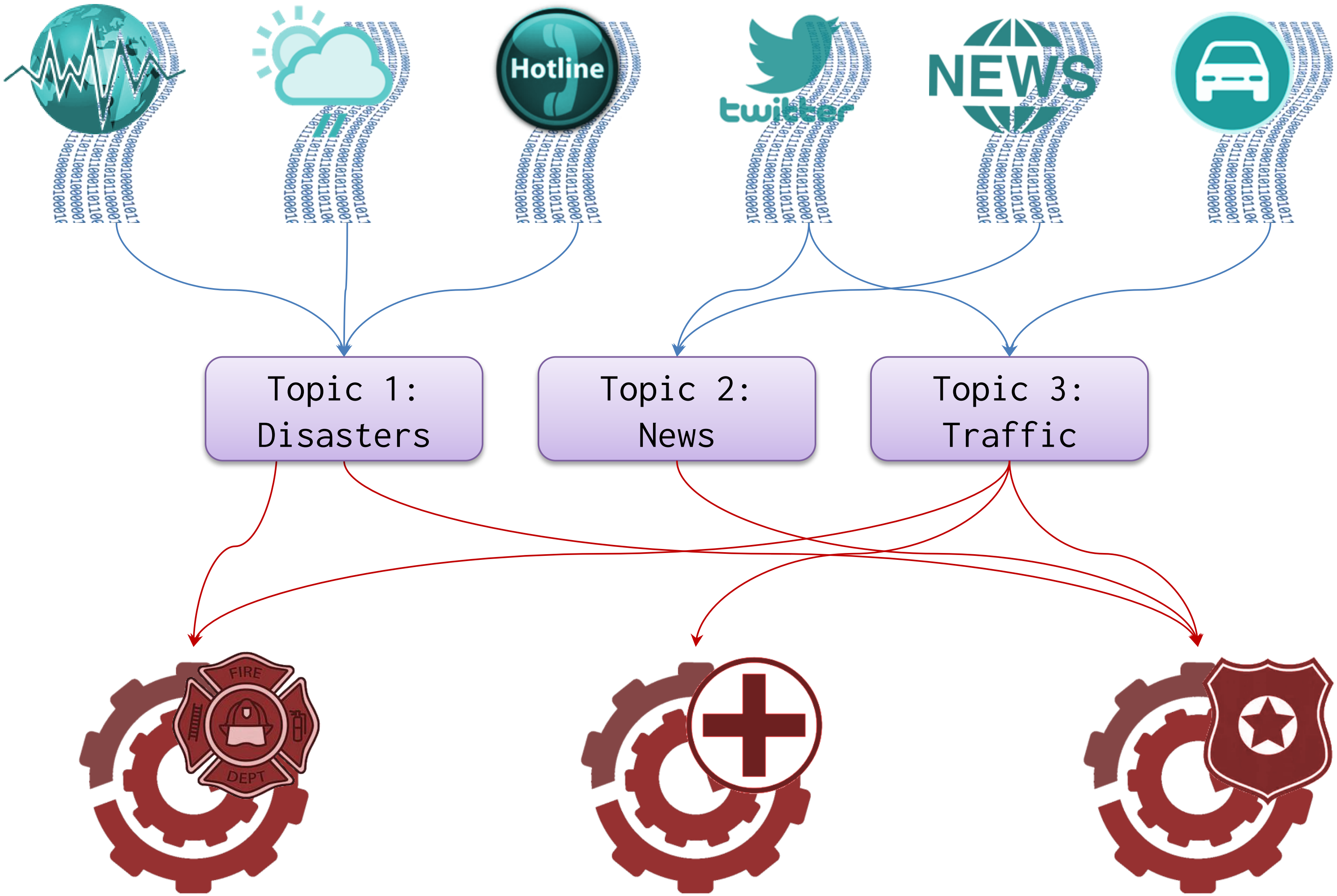
- Producers may only append to log
- Consumers can read from anywhere*

  * kind of



Kafka: Topics

Kafka Topics

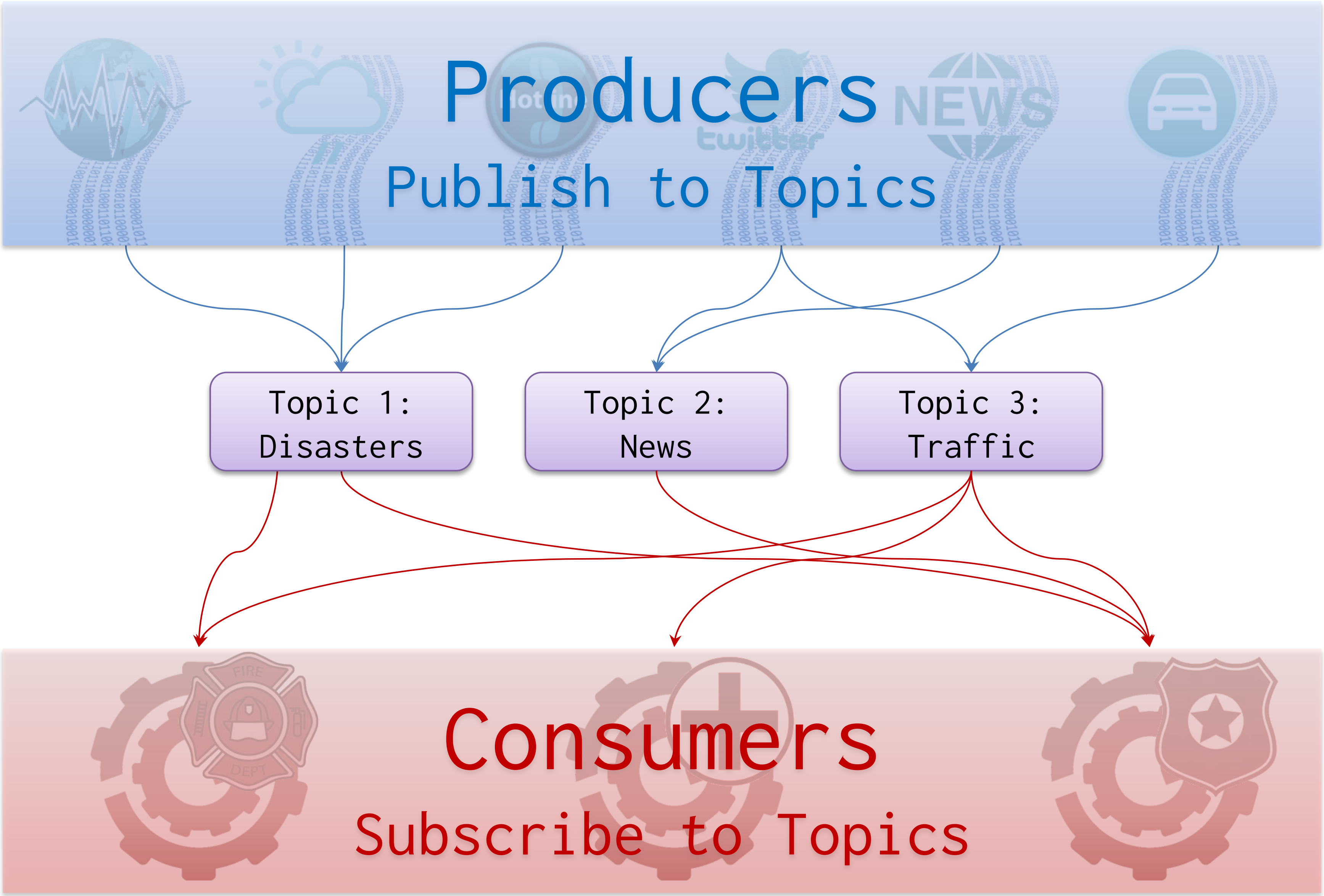


Topic 1: Disasters

Topic 2: News

Topic 3: Traffic

Kafka Topics



Producers

Publish to Topics

Topic 1: Disasters

Topic 2: News

Topic 3: Traffic

Consumers

Subscribe to Topics

Topic

- Topics are persistent (on disk)
  - Configurable retention policy
    - Keep everything
    - Delete once consumed
    - Keep for a period of time
    - Use fixed amount of space

Partition 1

1	2	3	4	5	6	...
t_1^1	t_2^1	t_3^1	t_4^1	t_5^1	t_6^1	
(k_1^1, v_1^1)	(k_2^1, v_2^1)	(k_3^1, v_3^1)	(k_4^1, v_4^1)	(k_5^1, v_5^1)	(k_6^1, v_6^1)	

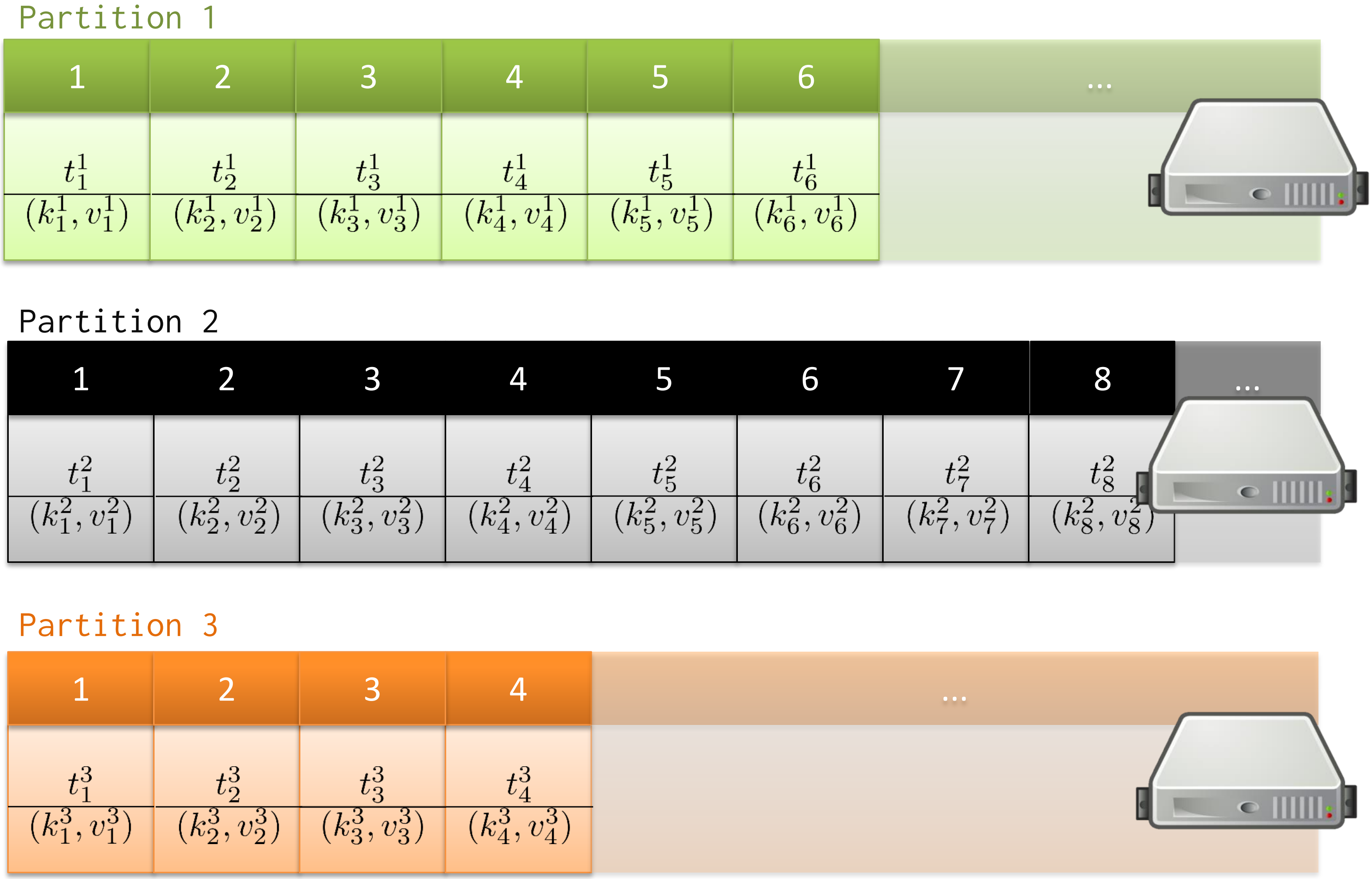
Partition 2

1	2	3	4	5	6
t_1^2	t_2^2	t_3^2	t_4^2	t_5^2	t_6^2
(k_1^2, v_1^2)	(k_2^2, v_2^2)	(k_3^2, v_3^2)	(k_4^2, v_4^2)	(k_5^2, v_5^2)	(k_6^2, v_6^2)

Partition 3

1	2	3	4
t_1^3	t_2^3	t_3^3	t_4^3
(k_1^3, v_1^3)	(k_2^3, v_2^3)	(k_3^3, v_3^3)	(k_4^3, v_4^3)

Topic: Default Partitioning by Key



Partition 1

1	2	3	4	5	6	...
t_1^1	t_2^1	t_3^1	t_4^1	t_5^1	t_6^1	
(k_1^1, v_1^1)	(k_2^1, v_2^1)	(k_3^1, v_3^1)	(k_4^1, v_4^1)	(k_5^1, v_5^1)	(k_6^1, v_6^1)	

Partition 2

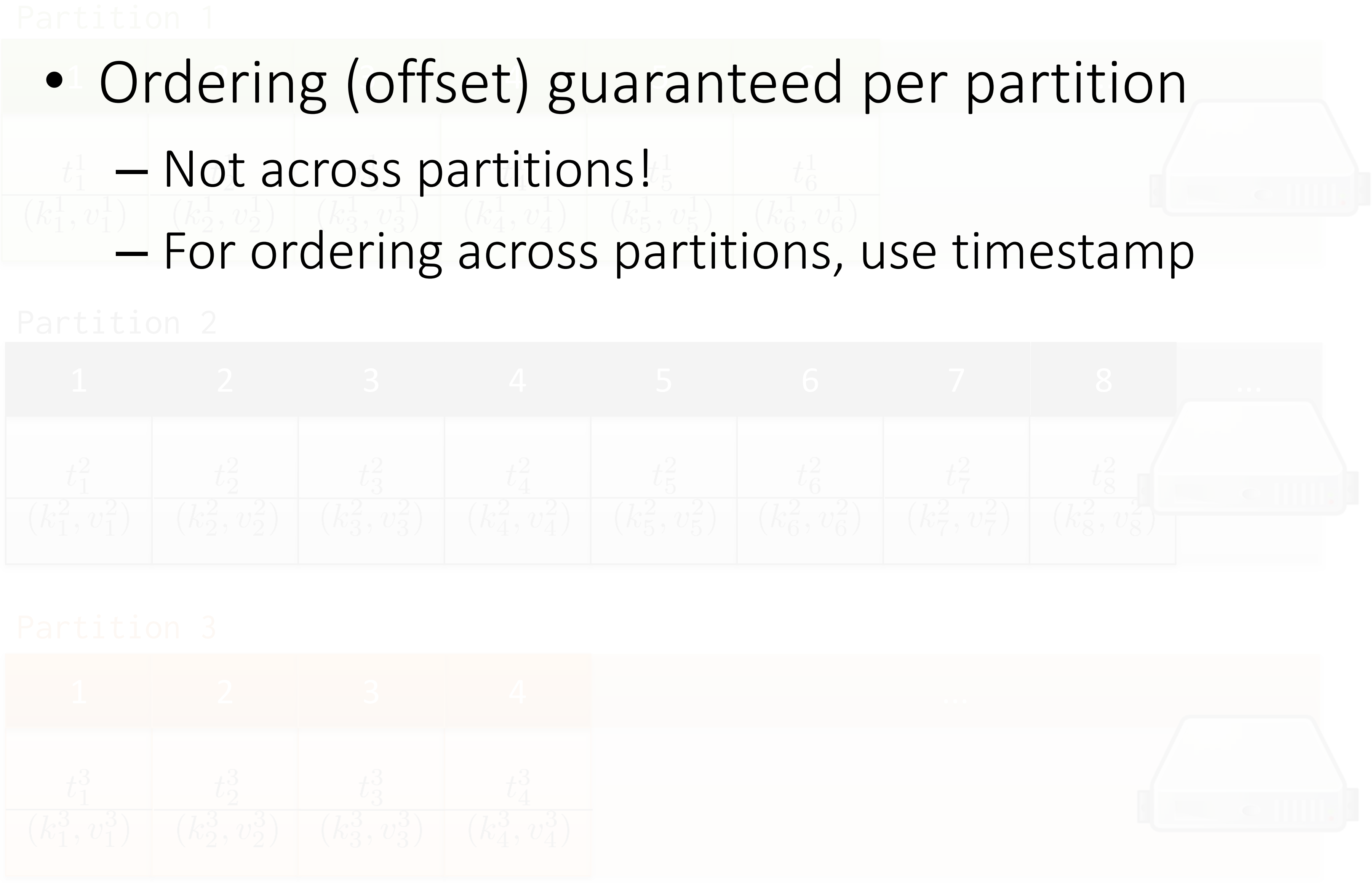
1	2	3	4	5	6	7	8	...
t_1^2	t_2^2	t_3^2	t_4^2	t_5^2	t_6^2	t_7^2	t_8^2	
(k_1^2, v_1^2)	(k_2^2, v_2^2)	(k_3^2, v_3^2)	(k_4^2, v_4^2)	(k_5^2, v_5^2)	(k_6^2, v_6^2)	(k_7^2, v_7^2)	(k_8^2, v_8^2)	

Partition 3

1	2	3	4	...
t_1^3	t_2^3	t_3^3	t_4^3	
(k_1^3, v_1^3)	(k_2^3, v_2^3)	(k_3^3, v_3^3)	(k_4^3, v_4^3)	

Topic: Default Partitioning by Key

- Ordering (offset) guaranteed per partition
  - Not across partitions!
  - For ordering across partitions, use timestamp

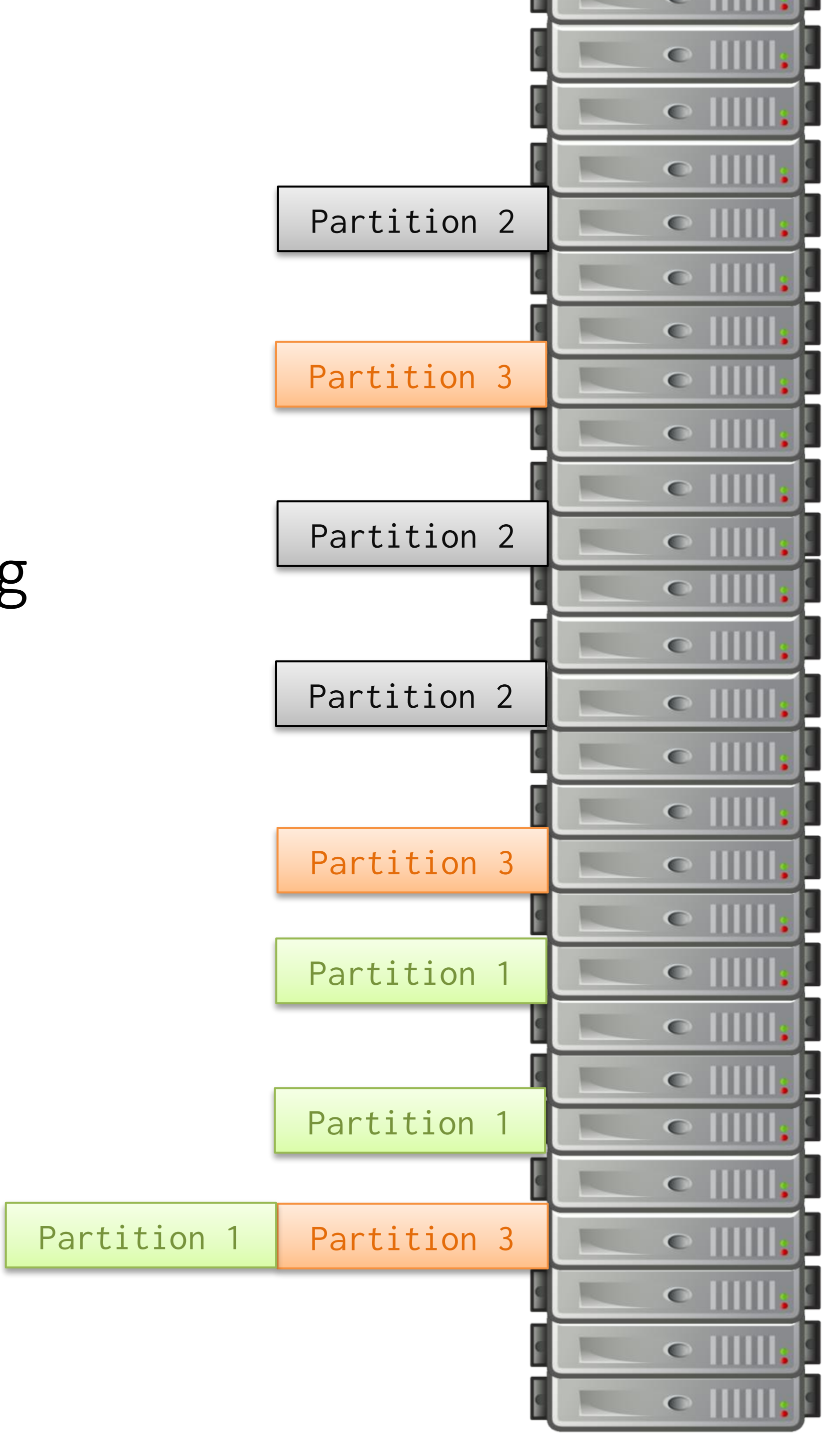

Partition 1
t_1^1 t_2^1 t_3^1 t_4^1 t_5^1 t_6^1
(k_1^1, v_1^1) (k_2^1, v_2^1) (k_3^1, v_3^1) (k_4^1, v_4^1) (k_5^1, v_5^1) (k_6^1, v_6^1)
Partition 2
1 2 3 4 5 6 7 8 ...
t_1^2 t_2^2 t_3^2 t_4^2 t_5^2 t_6^2 t_7^2 t_8^2
(k_1^2, v_1^2) (k_2^2, v_2^2) (k_3^2, v_3^2) (k_4^2, v_4^2) (k_5^2, v_5^2) (k_6^2, v_6^2) (k_7^2, v_7^2) (k_8^2, v_8^2)
Partition 3
1 2 3 4 ...
t_1^3 t_2^3 t_3^3 t_4^3
(k_1^3, v_1^3) (k_2^3, v_2^3) (k_3^3, v_3^3) (k_4^3, v_4^3)

Replication

- Topics can be replicated
  - Choose factor per topic
  - Automatic load balancing

Problem? ?

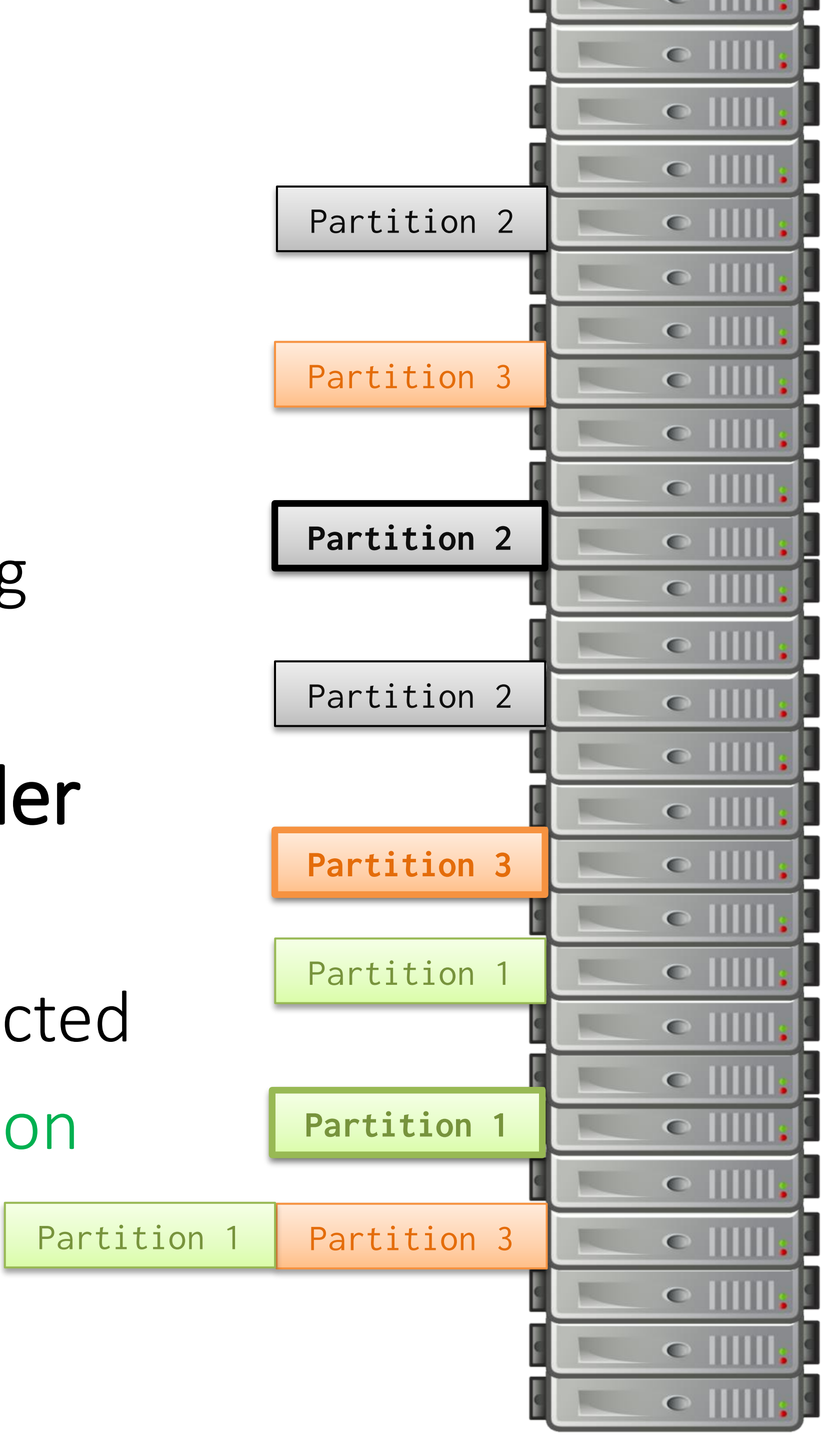
Order? ?



Leader

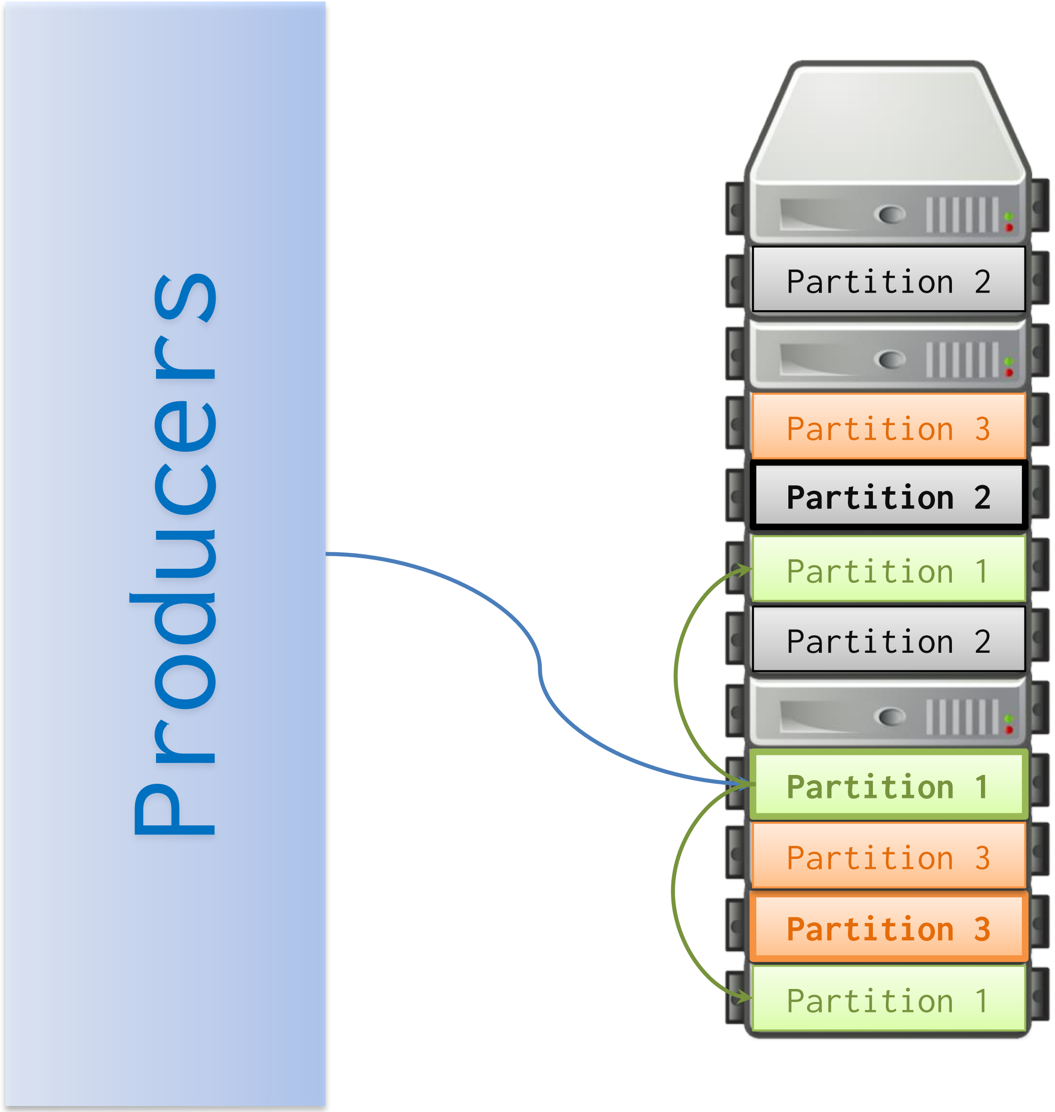
- Topics can be replicated
  - Choose factor per topic
  - Automatic load balancing

- One machine is the **leader**
  - The others are followers
  - Leader automatically elected
  - Ensures order per partition
  - Reads/writes to leader

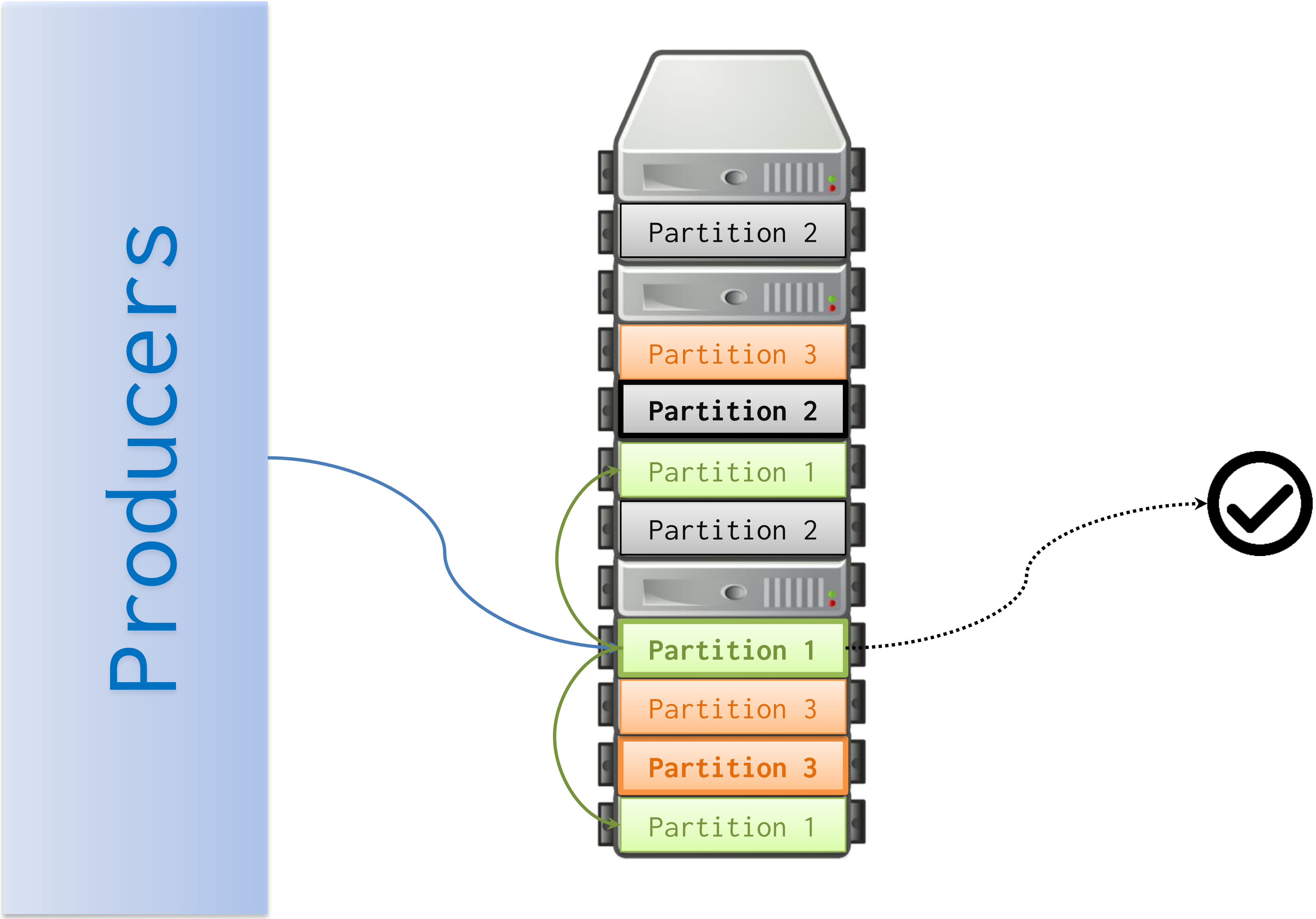


Kafka: Write Guarantees

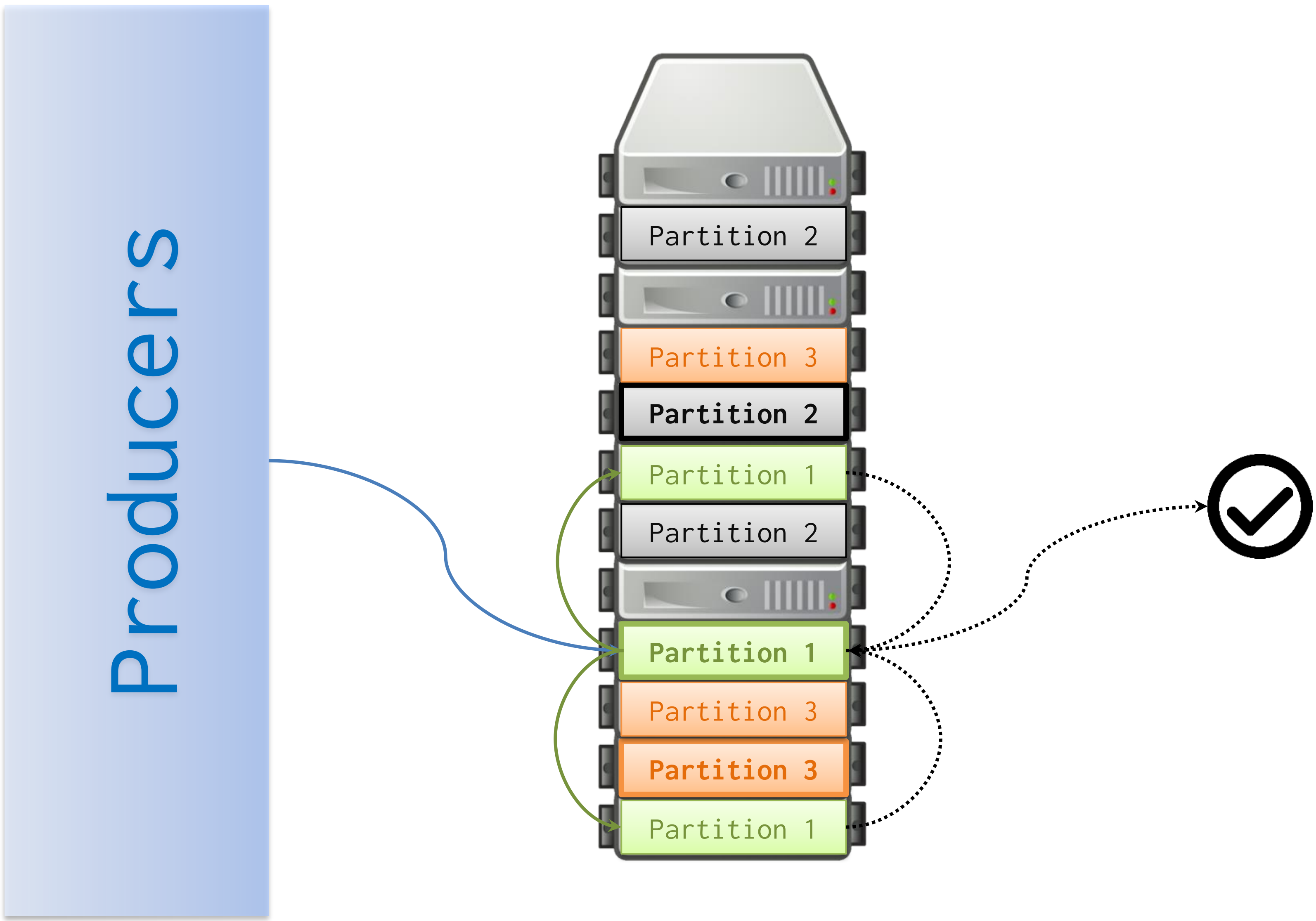
Writes: Asynchronous (No Guarantee)



Writes: Leader Commit



Writes: Leader Commit + Quorum (2)

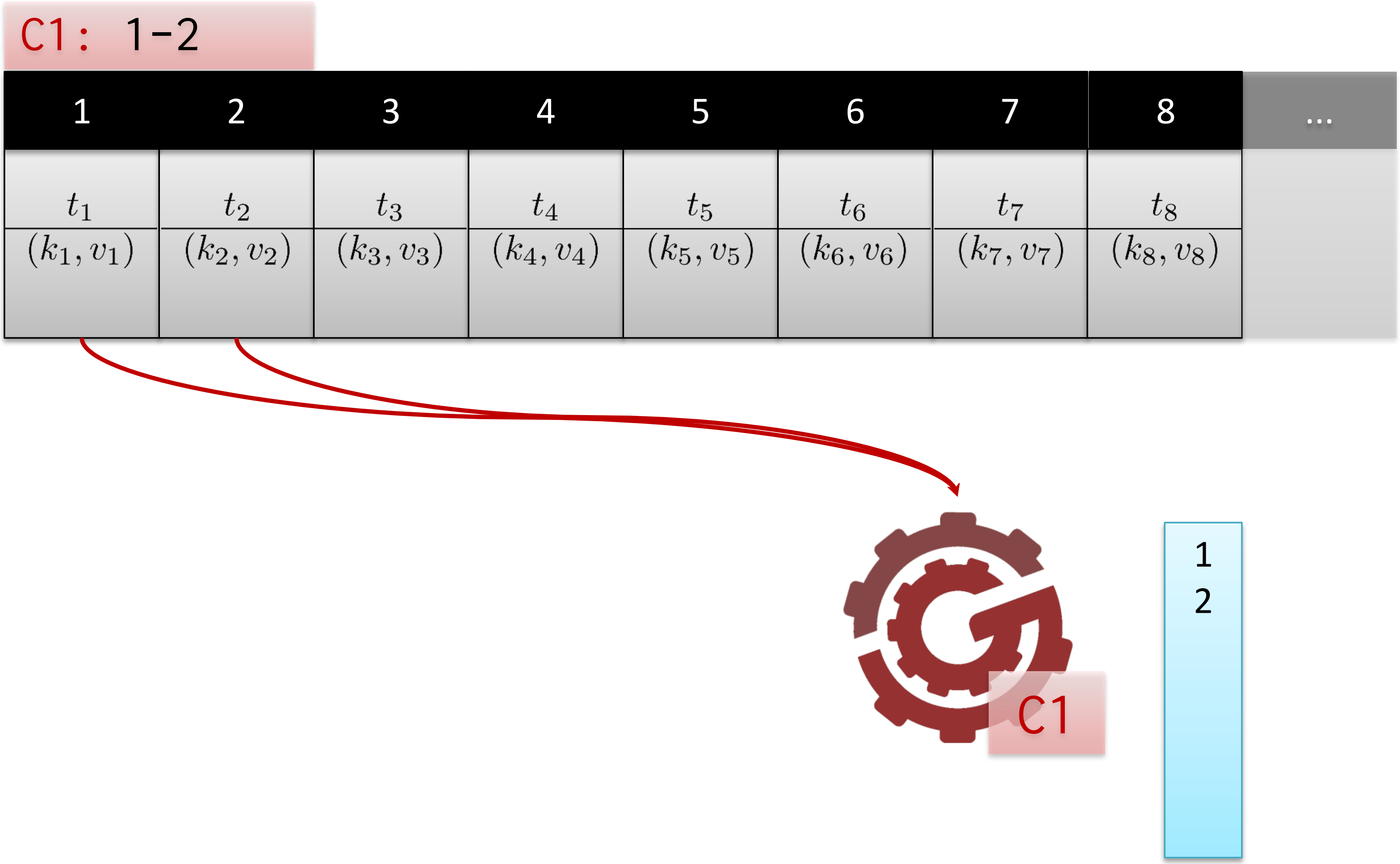


Write Guarantees

- Asynchronous
  - No guarantee
  - Very low latency
- Leader Commit
  - Persistent on leader
  - Medium latency (disk write + network ack)
- Leader Commit + Quorum *n*
  - Persistent on leader + *n* machines
  - High latency (disk writes + network acks)

Kafka: Reads

Kafka tracks consumer offset



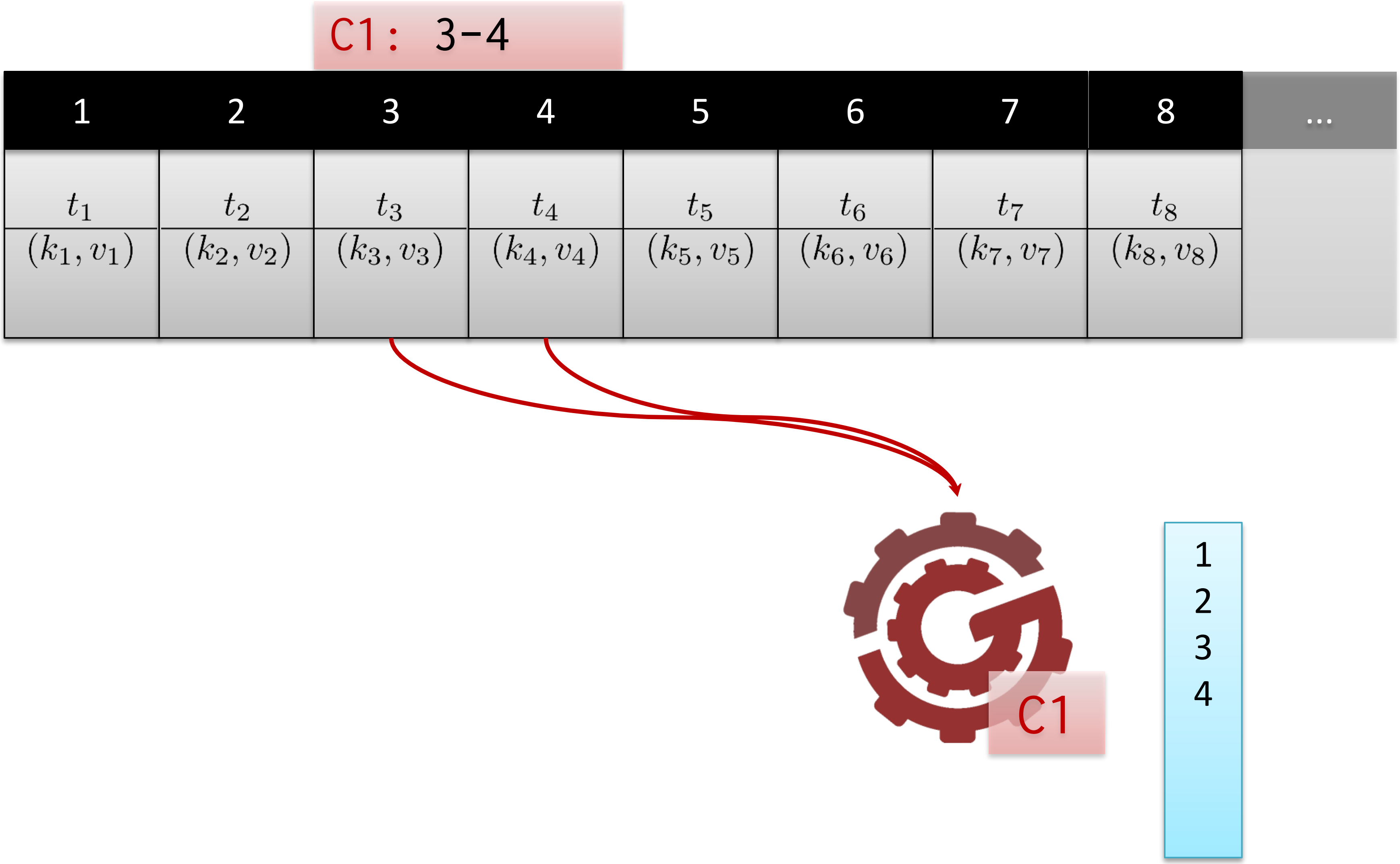
C1: 1–2

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

C1

1
2

Kafka tracks consumer offset



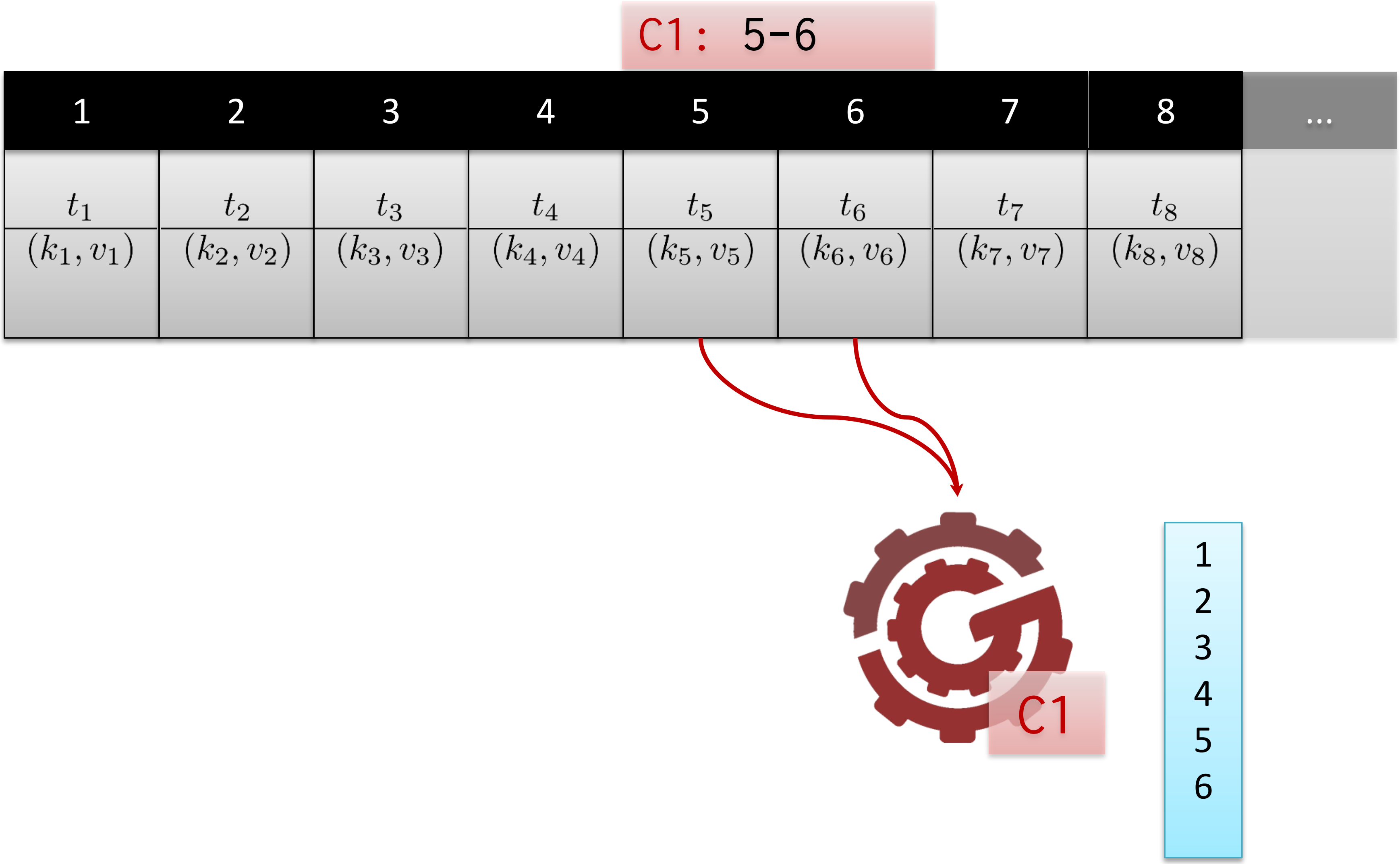
C1: 3-4

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

C1

1
2
3
4

Kafka tracks consumer offset

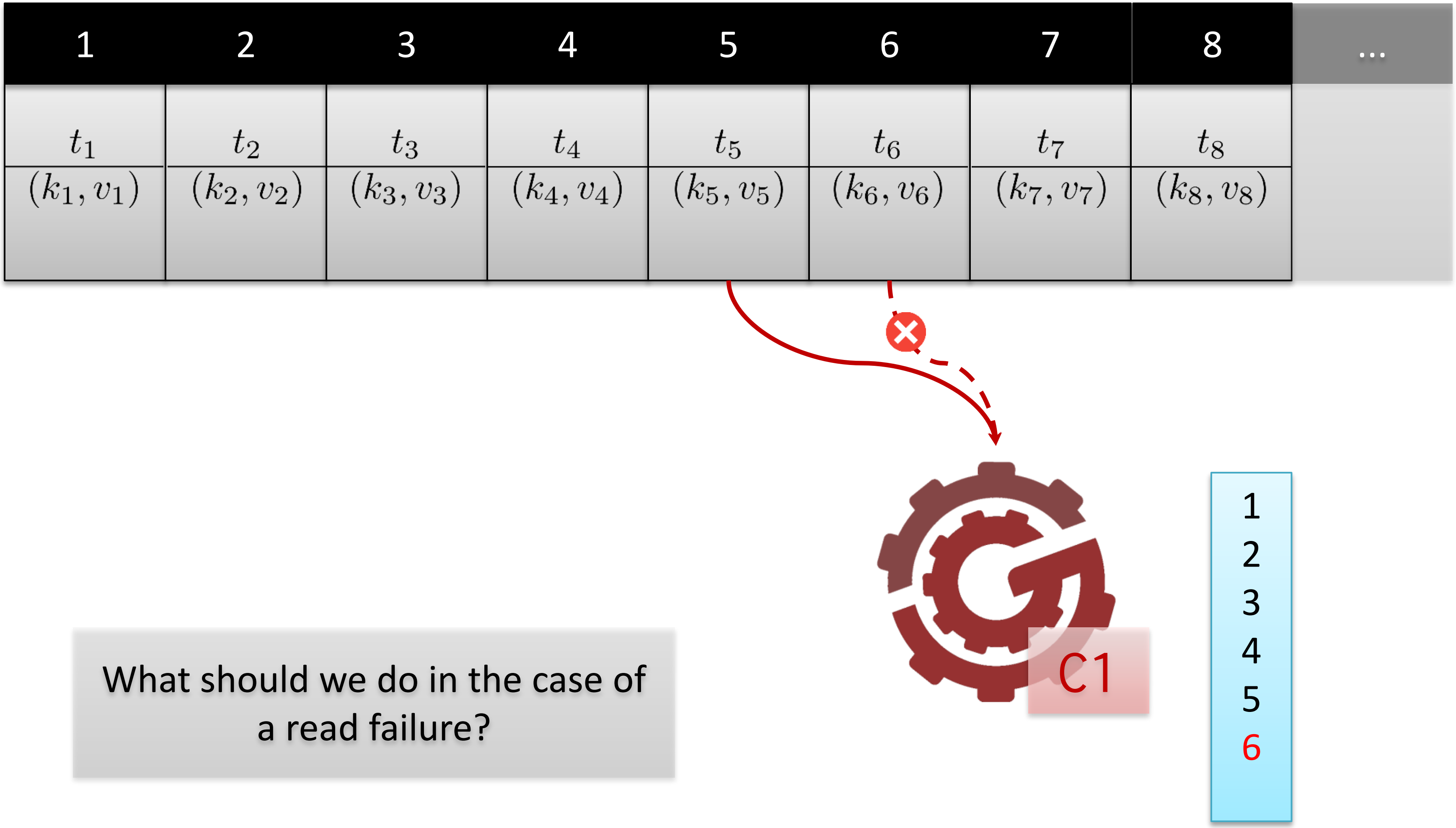


C1: 5-6

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

1
2
3
4
5
6

Failures?



1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

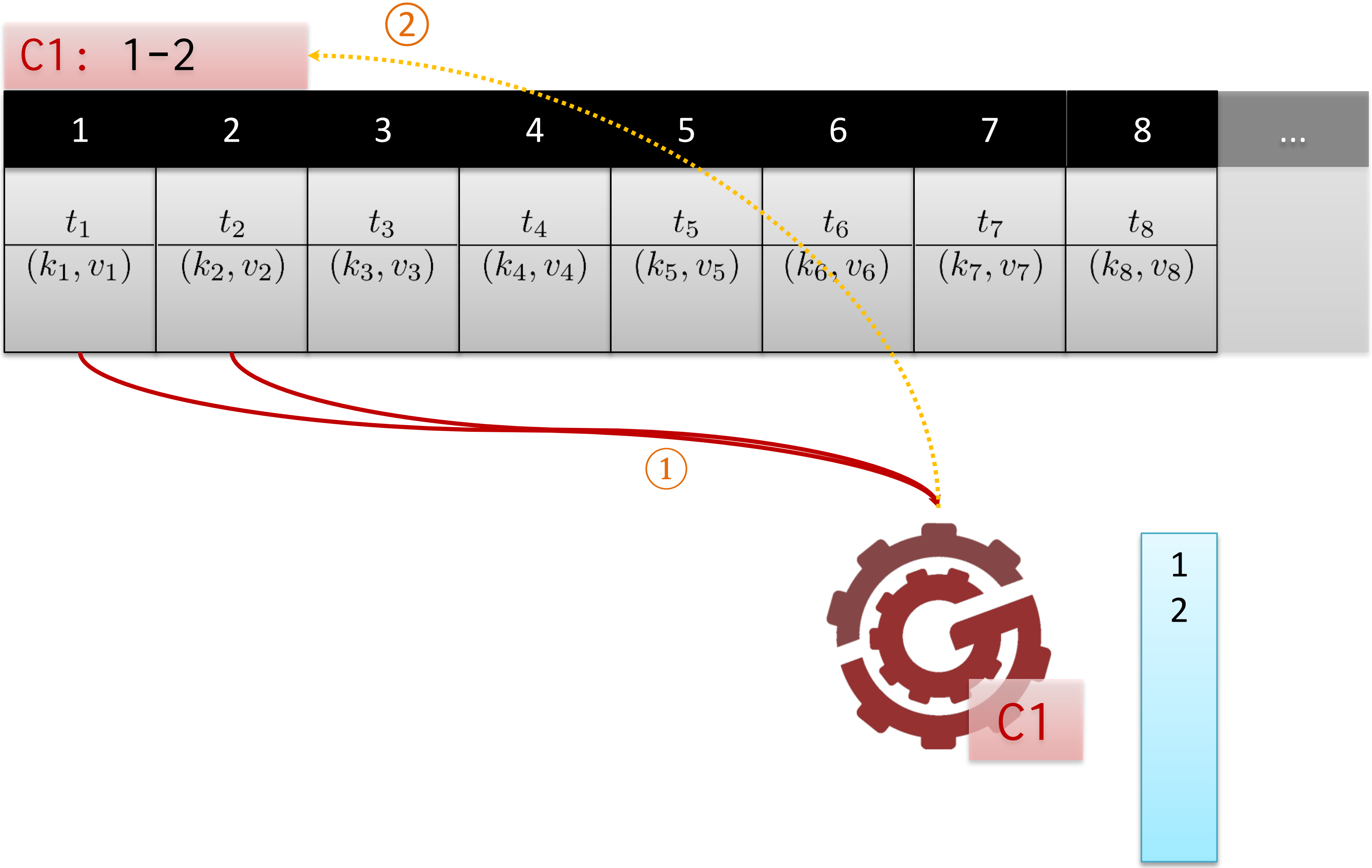
What should we do in the case of a read failure?

Kafka: Read Guarantees

Read Guarantees

- At least once
  - Each value processed at least once
  - Consumer offset updated on consumer ACK
- At most once
- Effectively once
- Exactly once

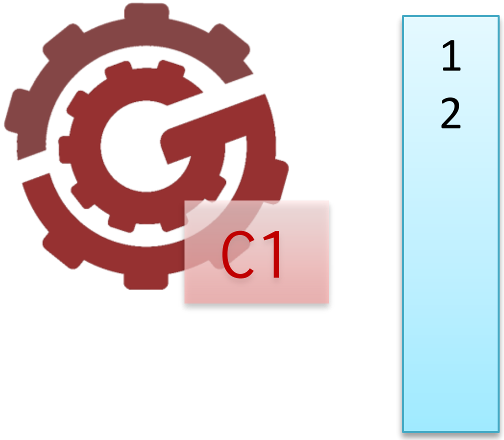
Read: At Least Once (Default)



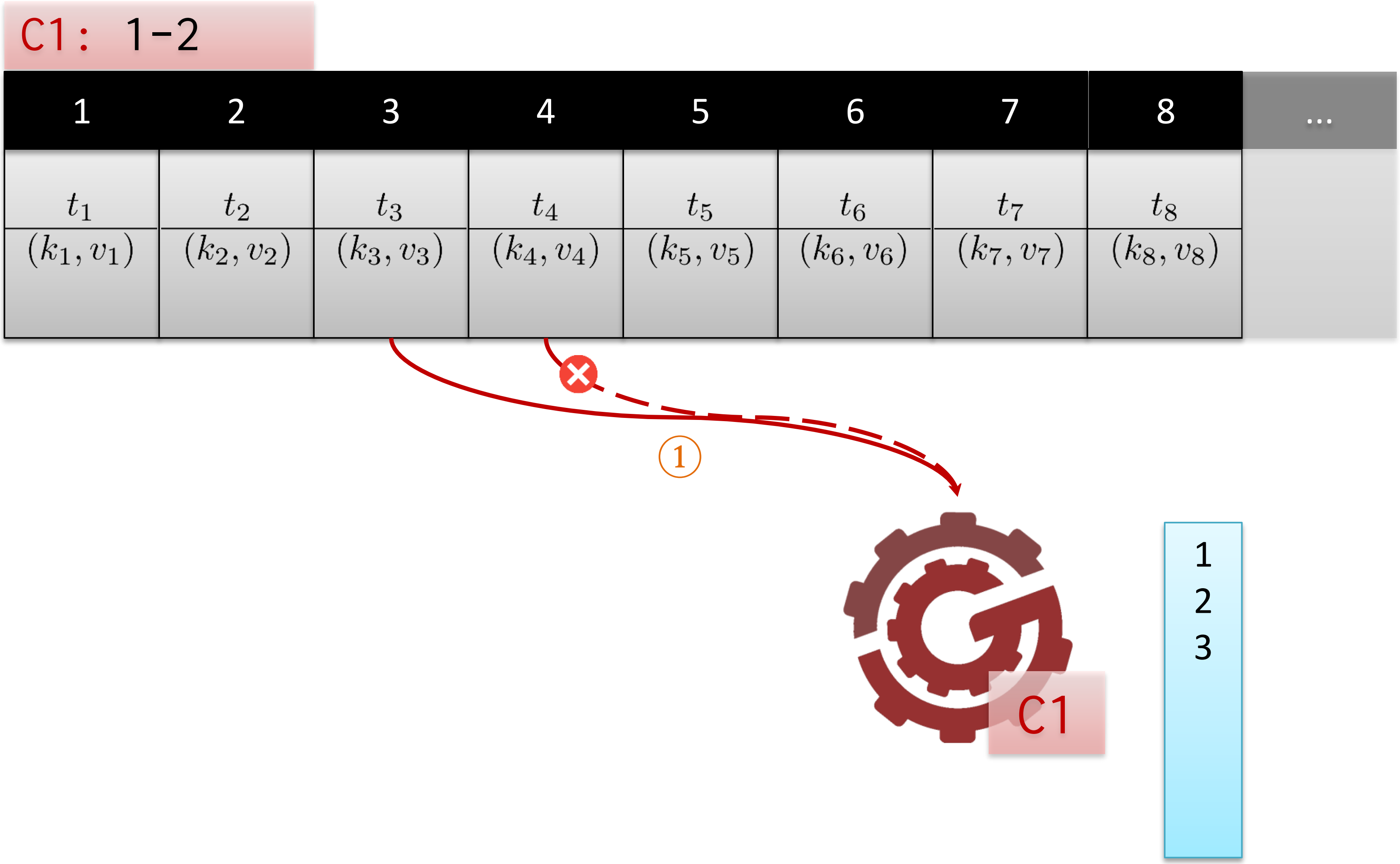
Read: At Least Once (Default)

C1 : 1–2

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	



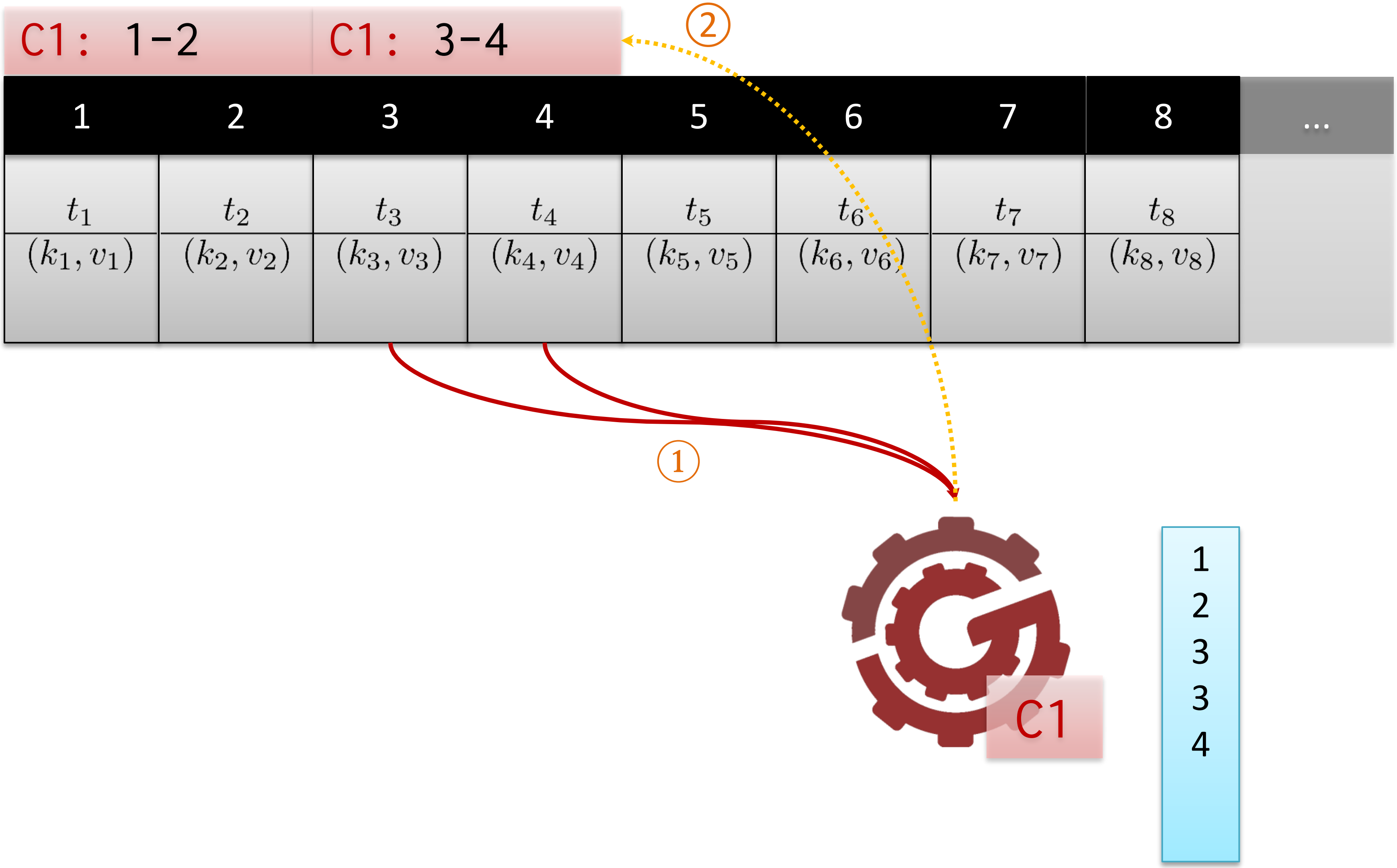
Read: At Least Once (Default)



C1 : 1–2

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read: At Least Once (Default)



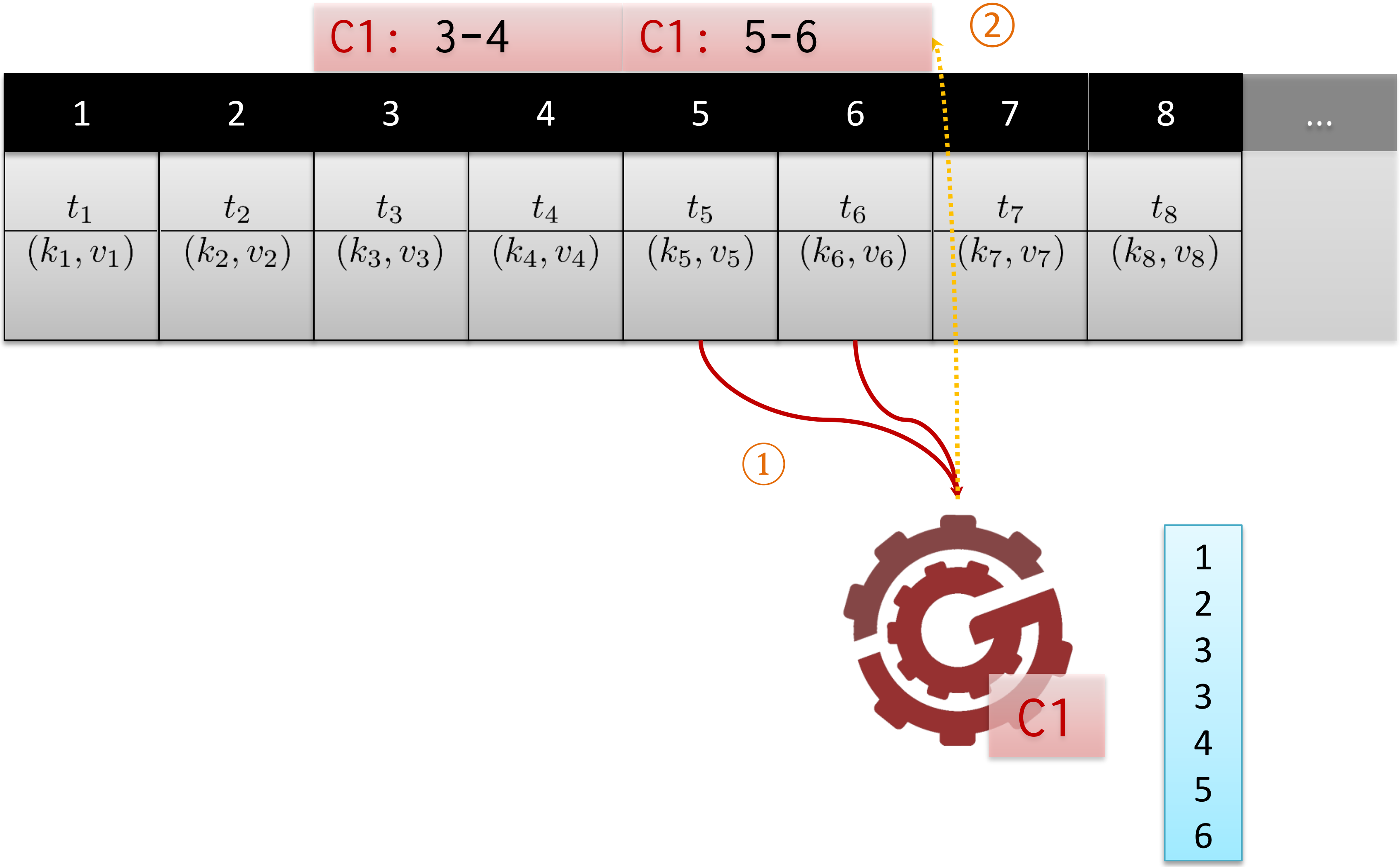
C1: 1-2

C1: 3-4

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

1
2
3
3
4

Read: At Least Once (Default)

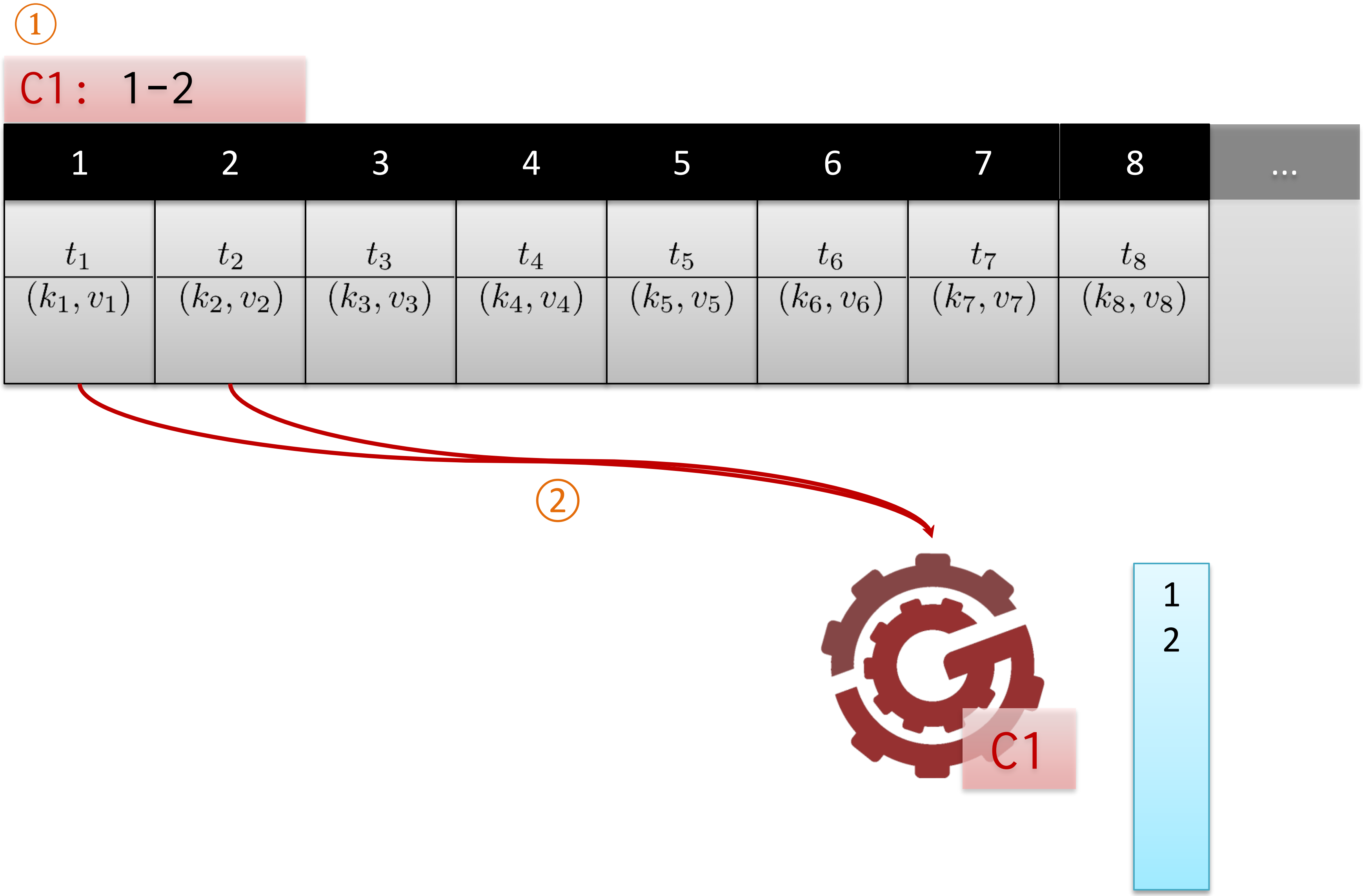


1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read Guarantees

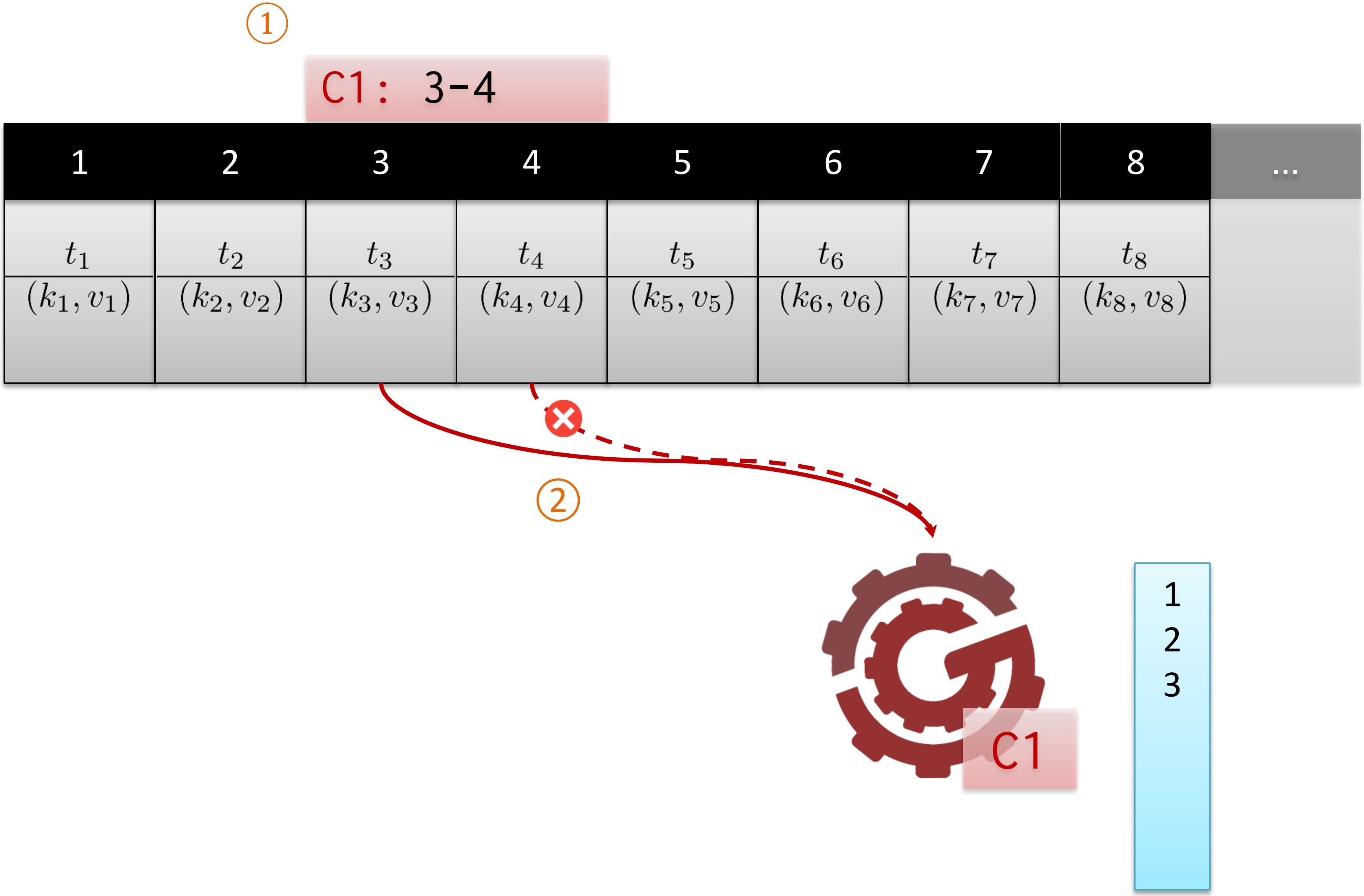
- At least once
- At most once
  - Each value processed at most once
  - Consumer offset updated immediately
- Effectively once
- Exactly once

Read: At Most Once



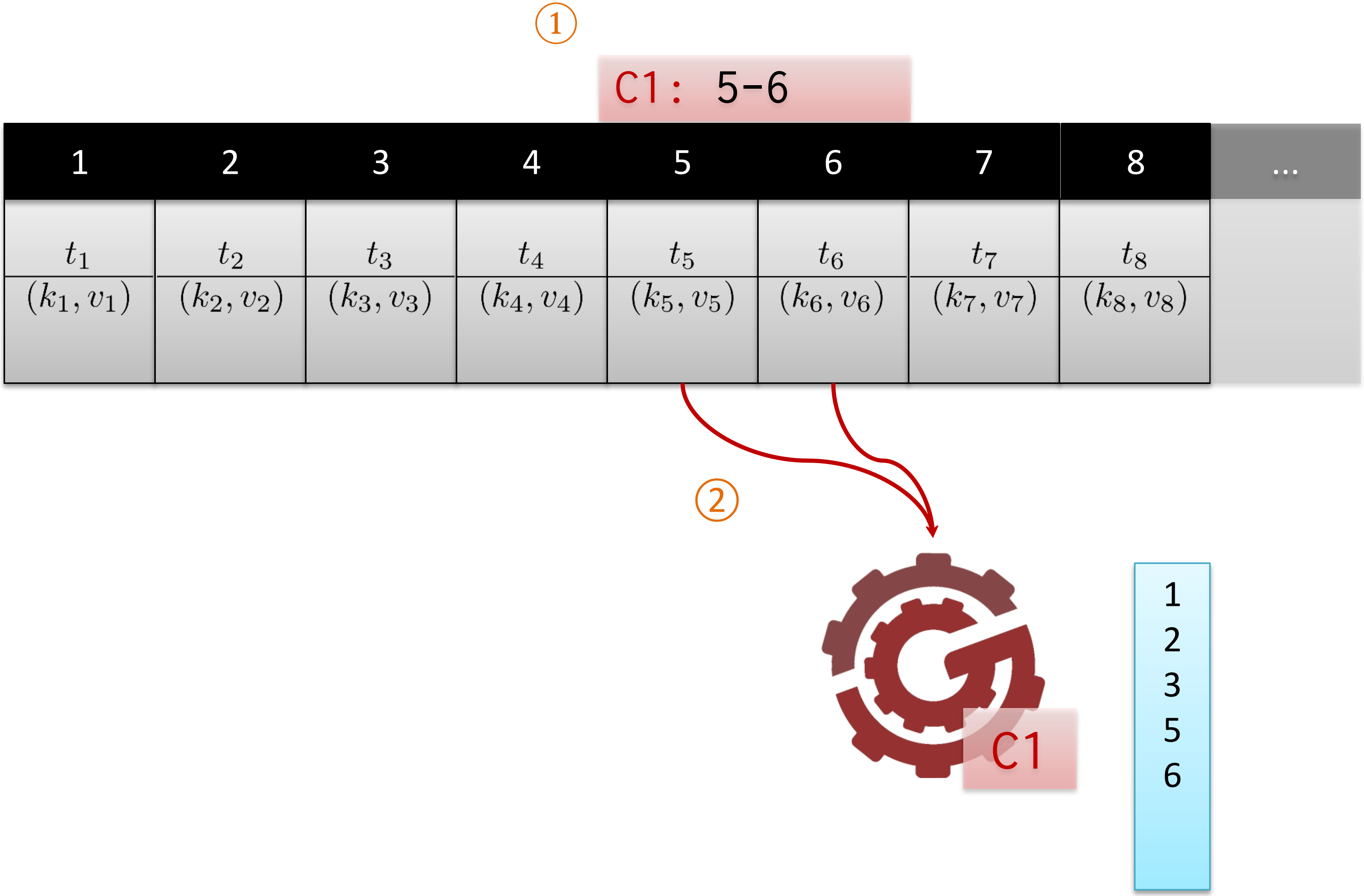
1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read: At Most Once



1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read: At Most Once



①

C1: 5-6

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

②

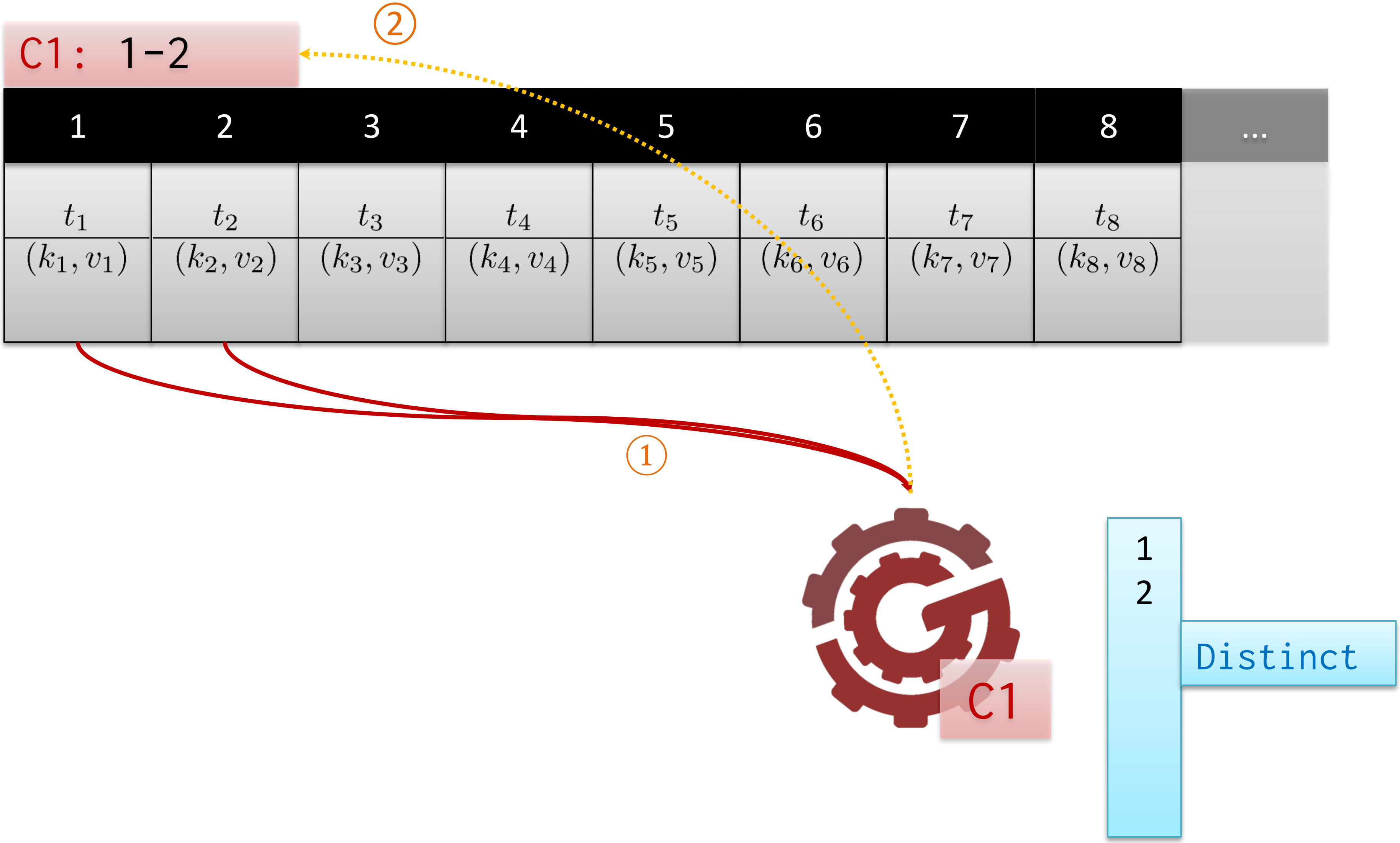
C1

1
2
3
5
6

Read Guarantees

- At least once
- At most once
- Effectively once
  - At least once but ...
  - Consumer takes care of duplicates
- Exactly once

Read: Effectively Once



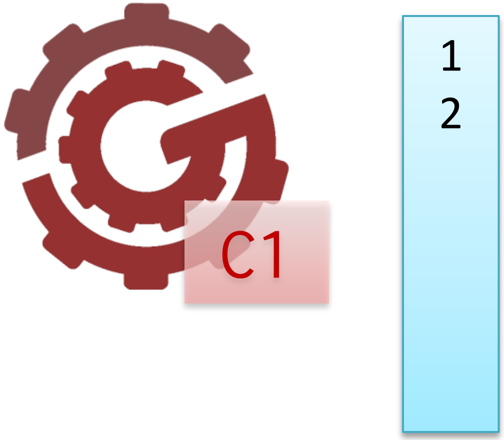
C1: 1-2

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

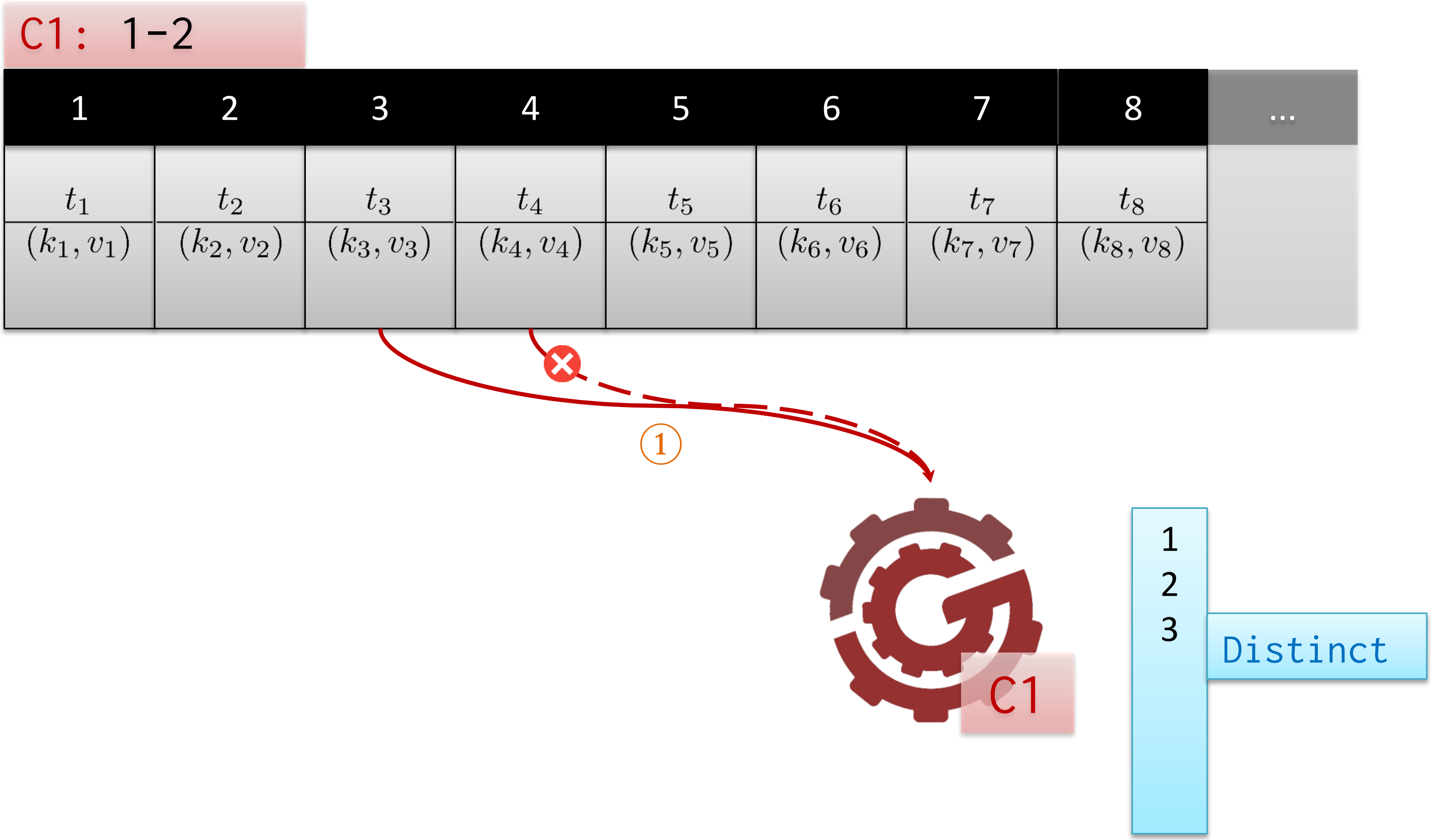
Read: Effectively Once

C1: 1–2

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

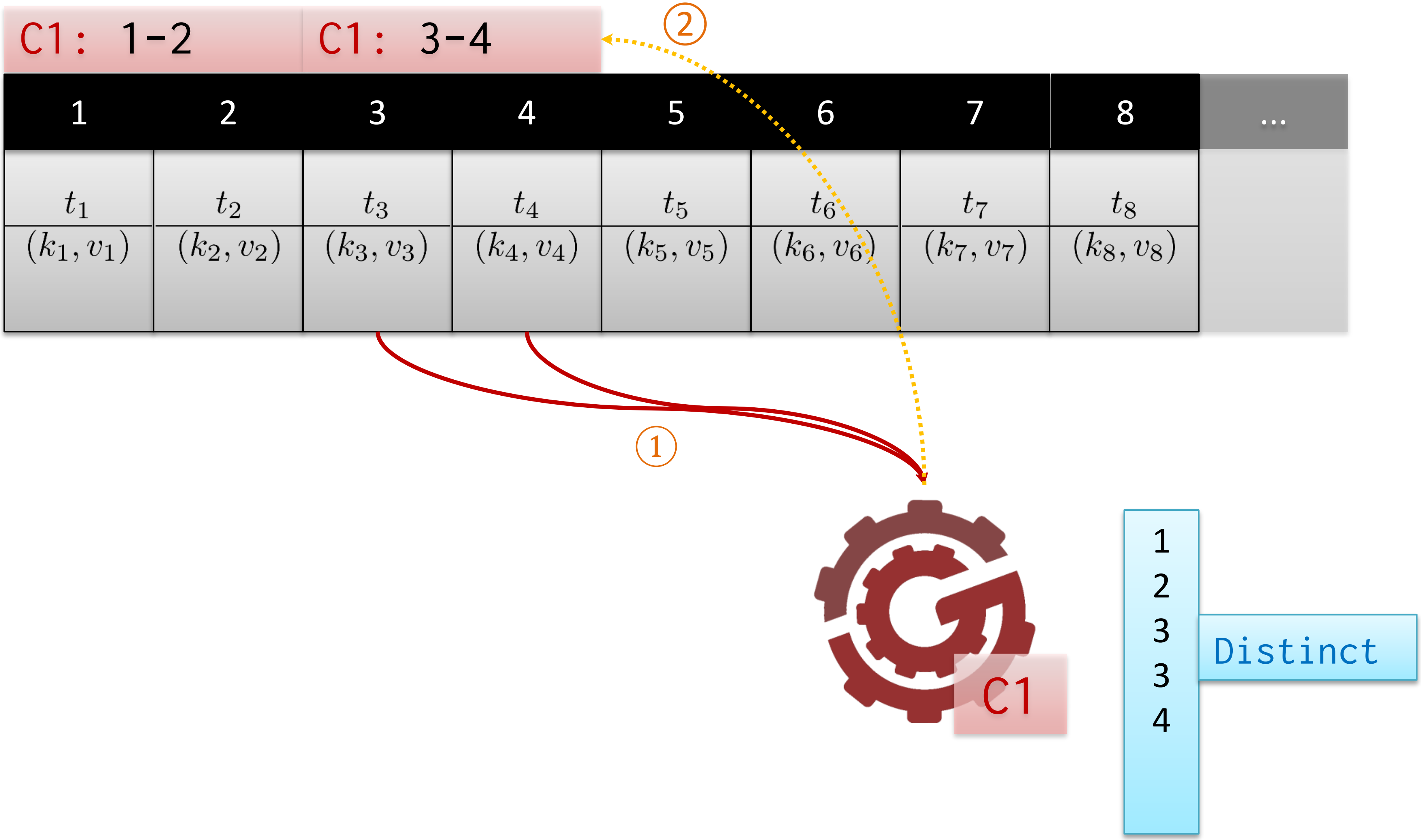


Read: Effectively Once



1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read: Effectively Once



C1: 1-2

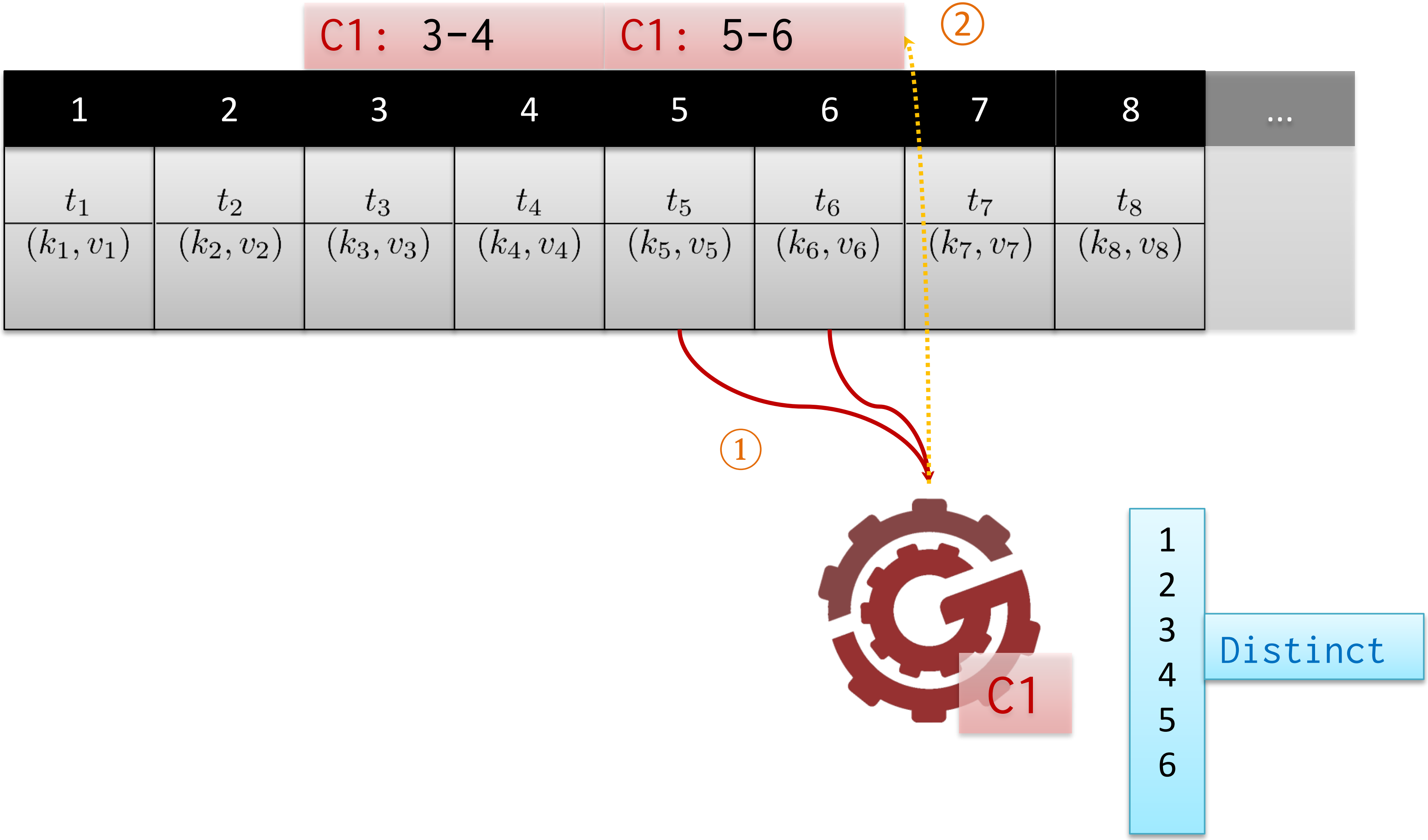
C1: 3-4

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

1
2
3
3
4

Distinct

Read: Effectively Once

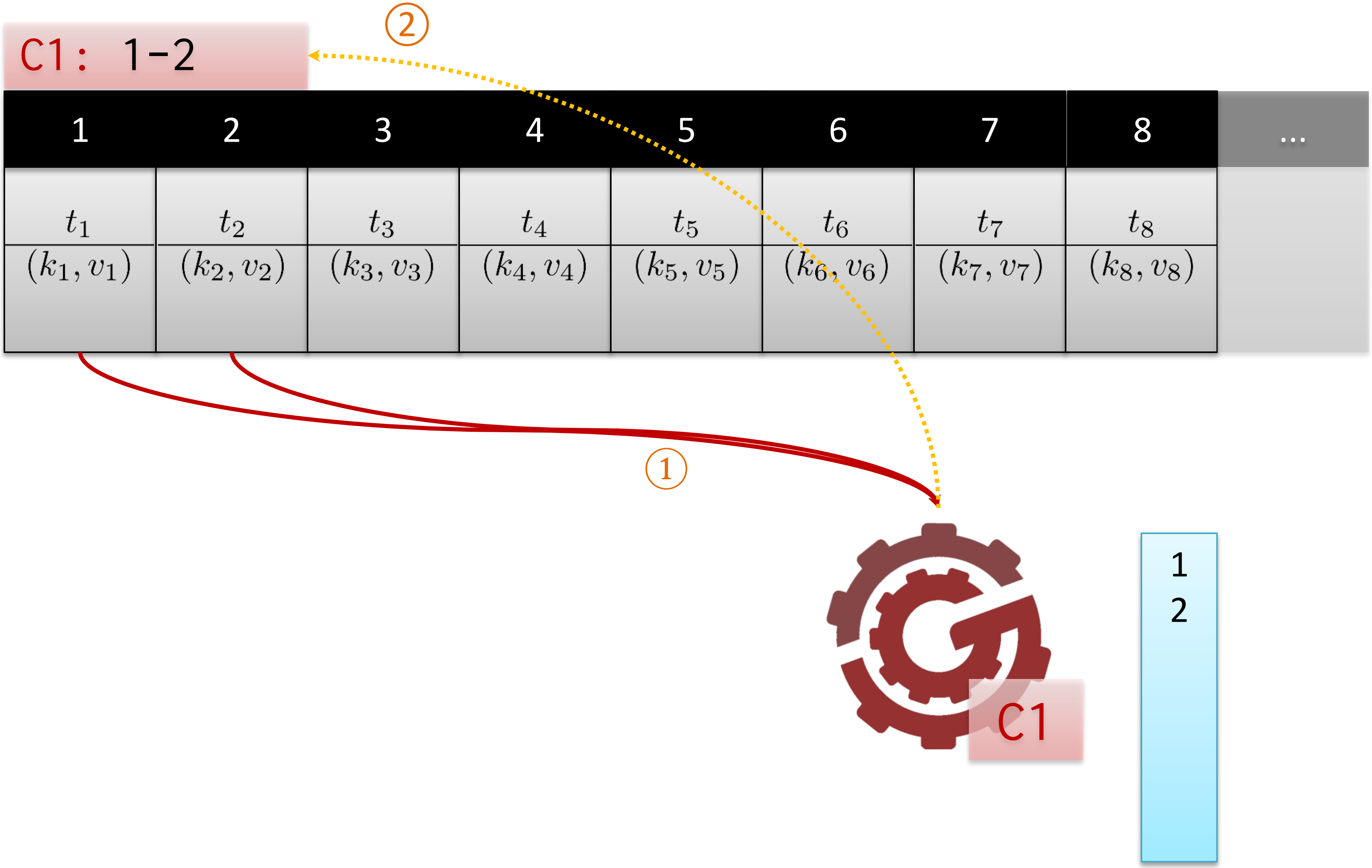


Read Guarantees

- At least once
- At most once
- Effectively once
- Exactly once
  - Data and offset updated as a single transaction

Read: Exactly Once

Transaction 1: ①,②



C1: 1-2

②

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

①

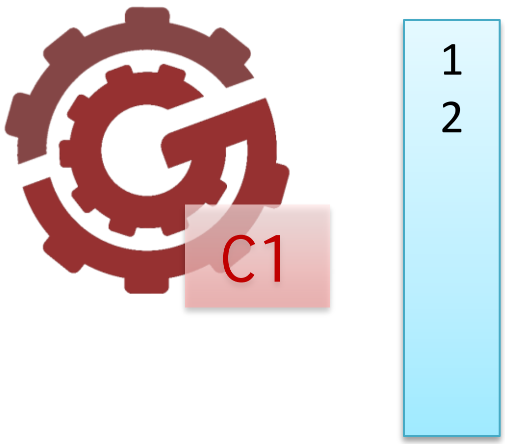
C1

1
2

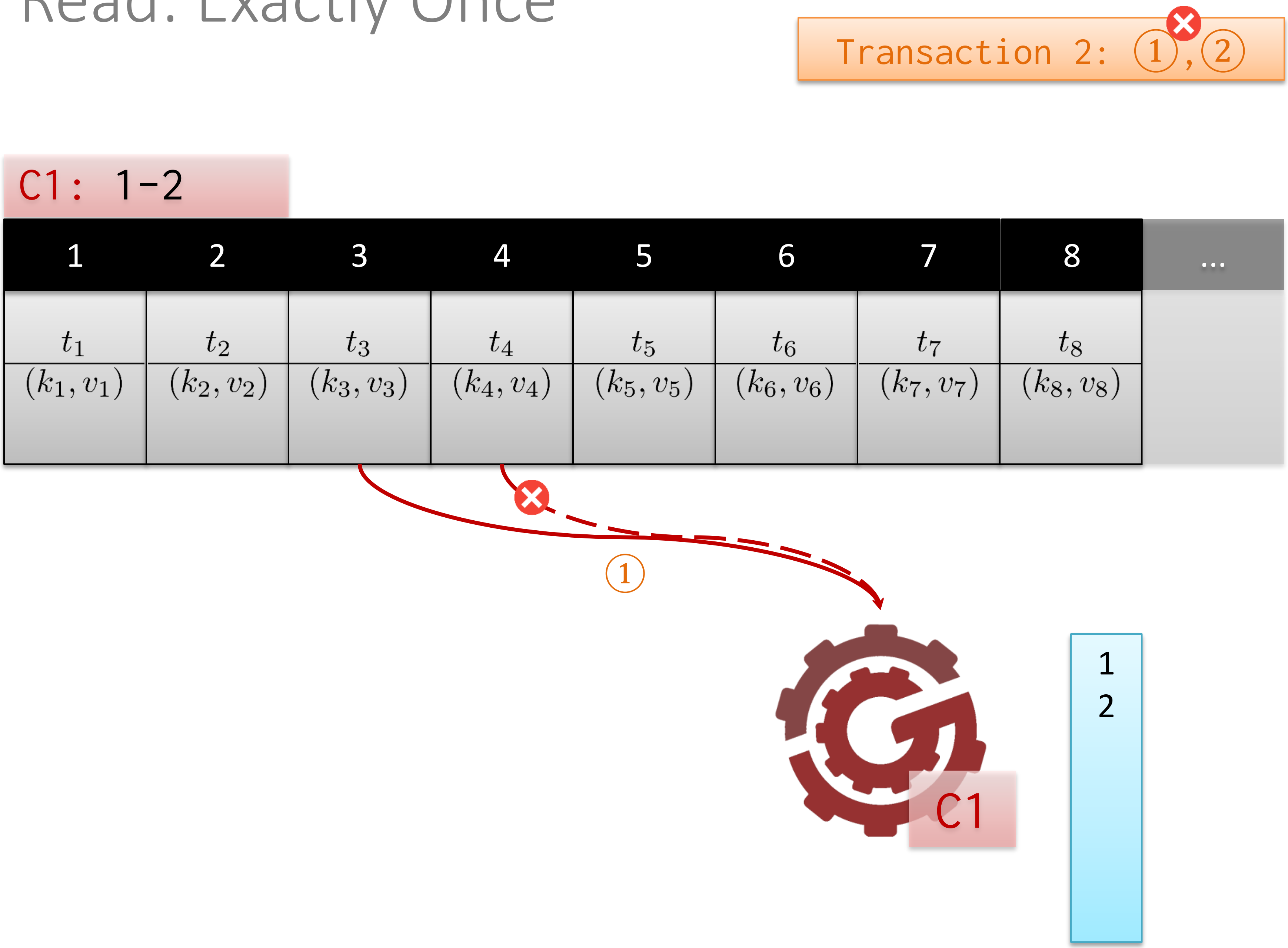
Read: Exactly Once

C1 : 1–2

1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	



Read: Exactly Once



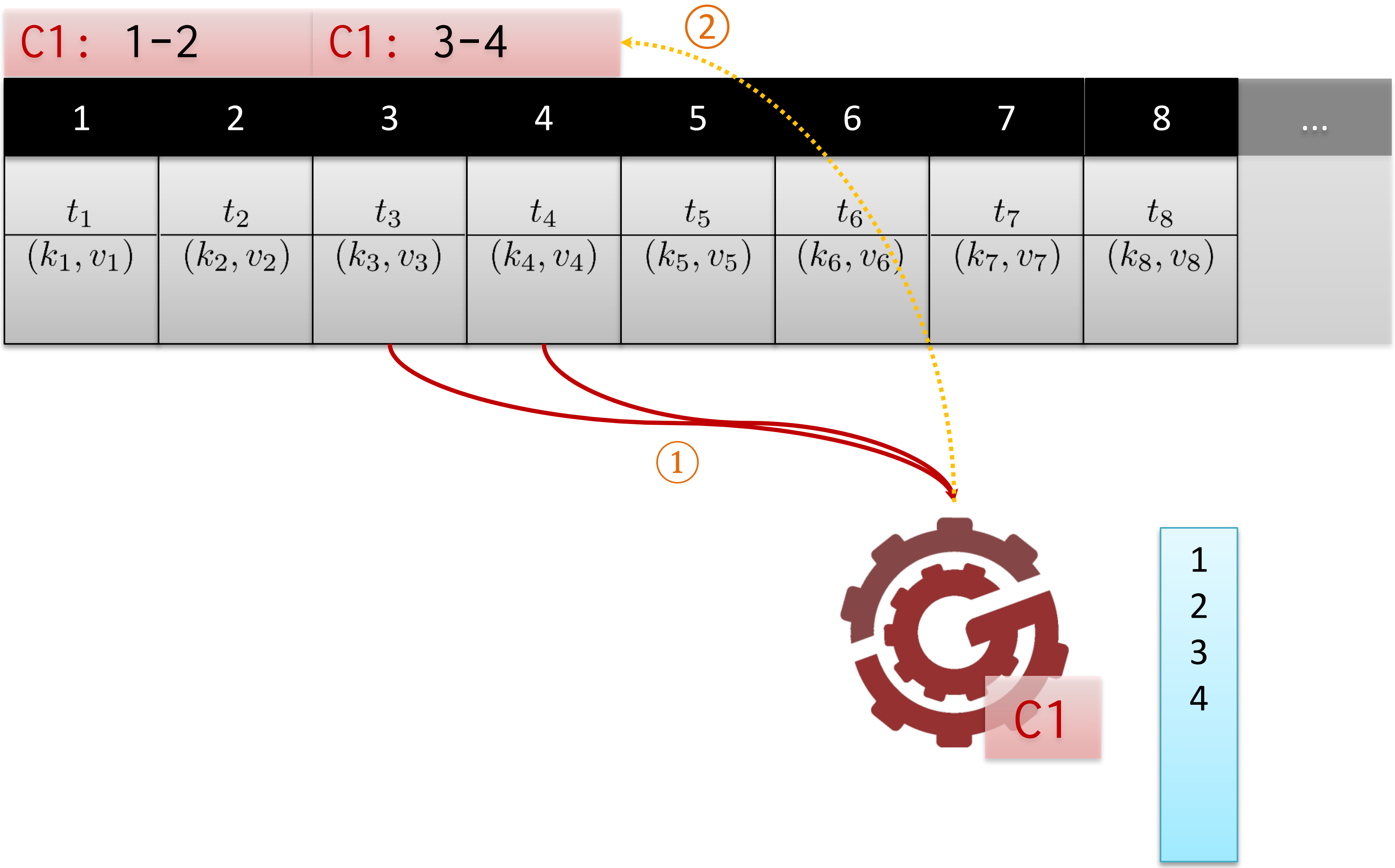
Transaction 2: ①, ②

C1: 1-2

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Read: Exactly Once

Transaction 3: ①,②



C1: 1-2 | C1: 3-4

②

1	2	3	4	5	6	7	8	…
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

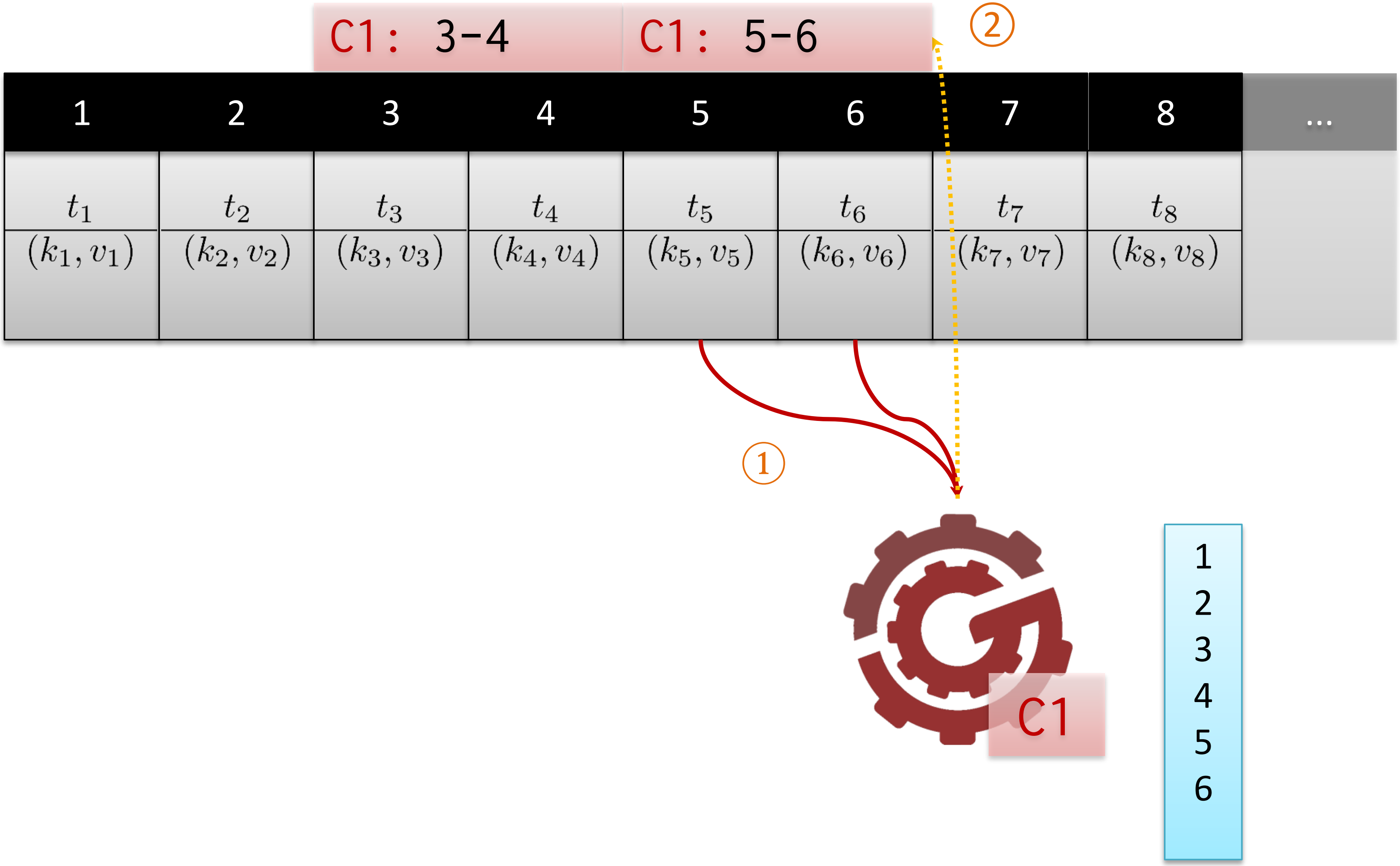
①

C1

1
2
3
4

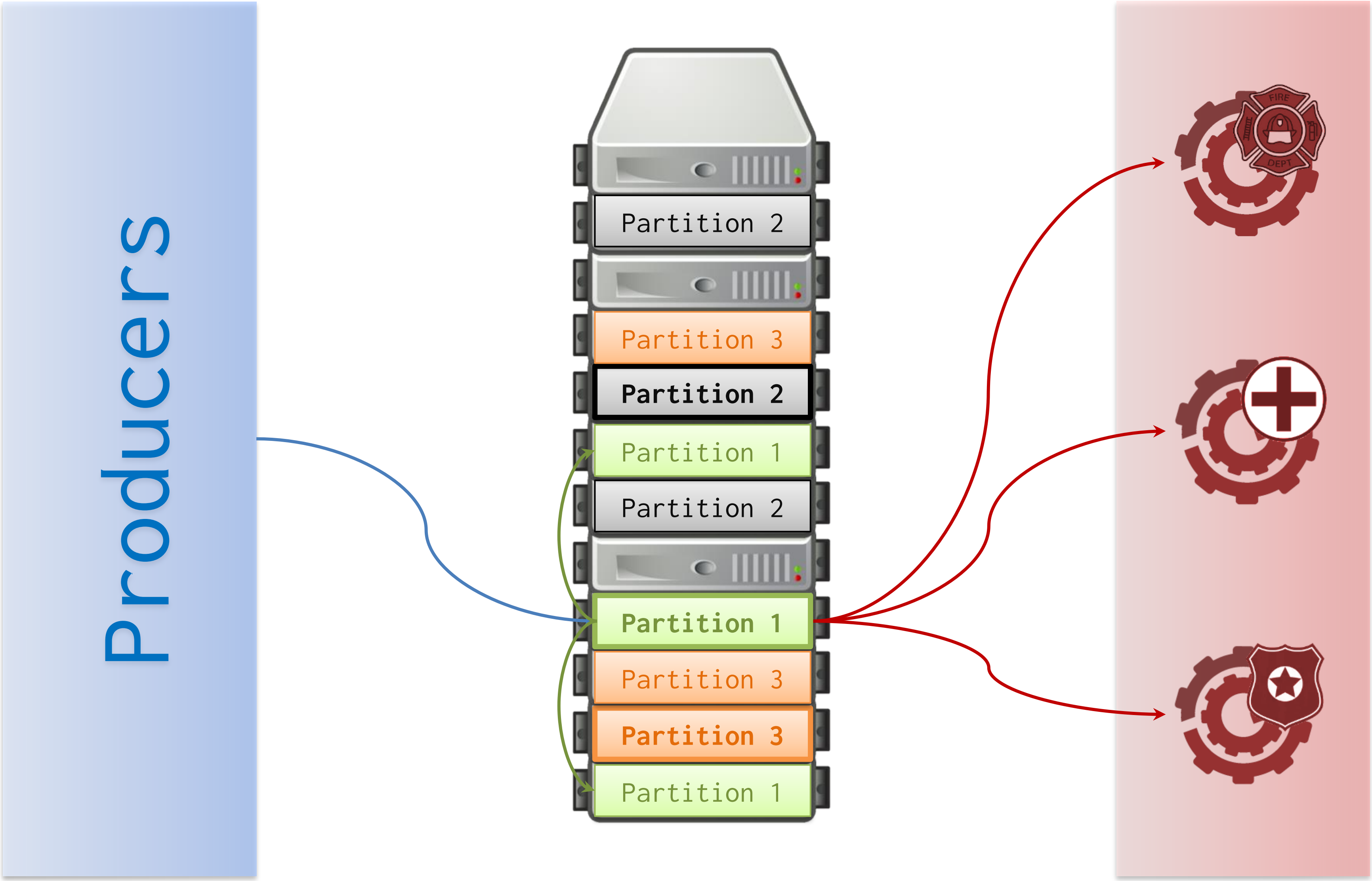
Read: Exactly Once

Transaction 4: ①,②



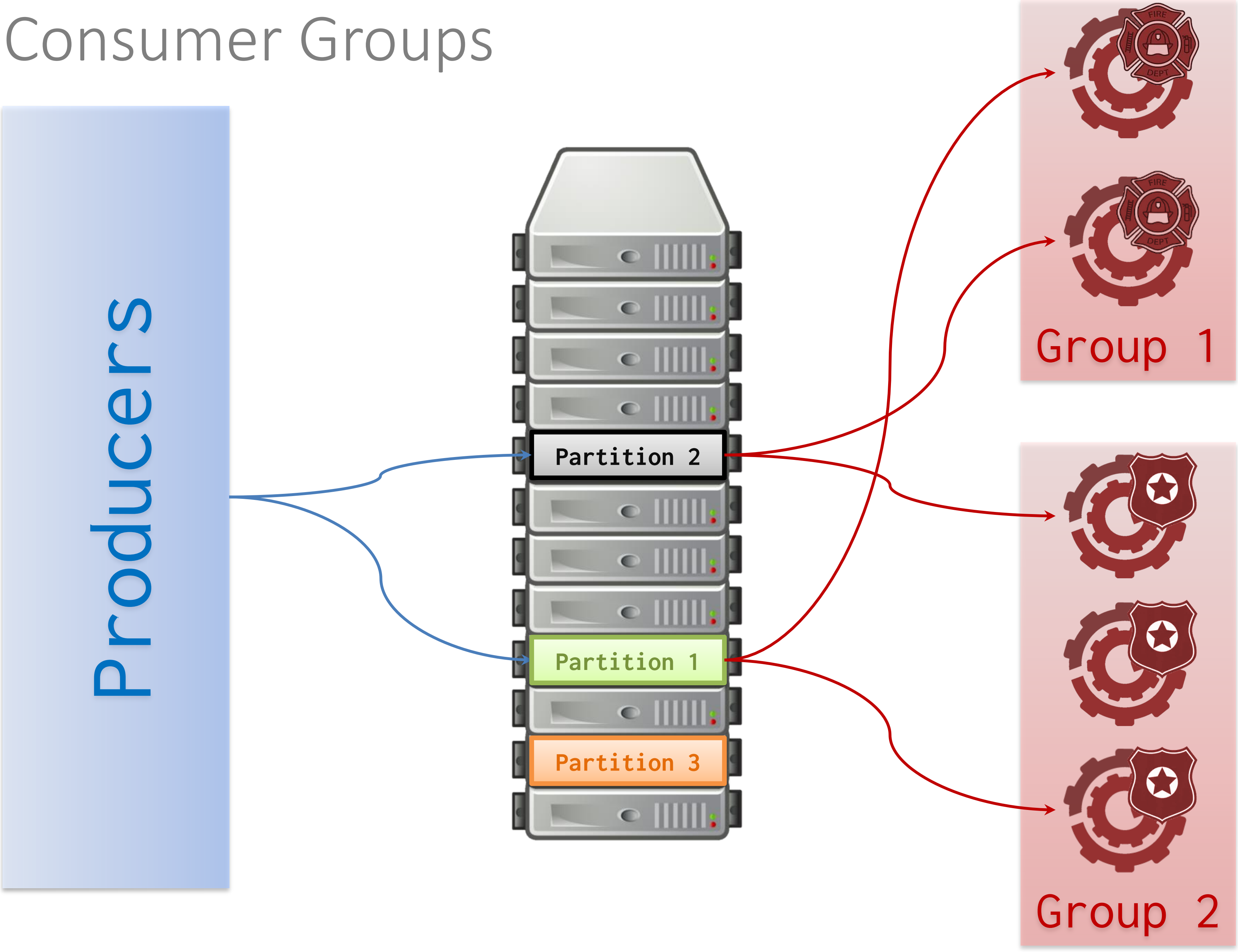
1	2	3	4	5	6	7	8	...
t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	
(k_1, v_1)	(k_2, v_2)	(k_3, v_3)	(k_4, v_4)	(k_5, v_5)	(k_6, v_6)	(k_7, v_7)	(k_8, v_8)	

Leader Replication and Reads



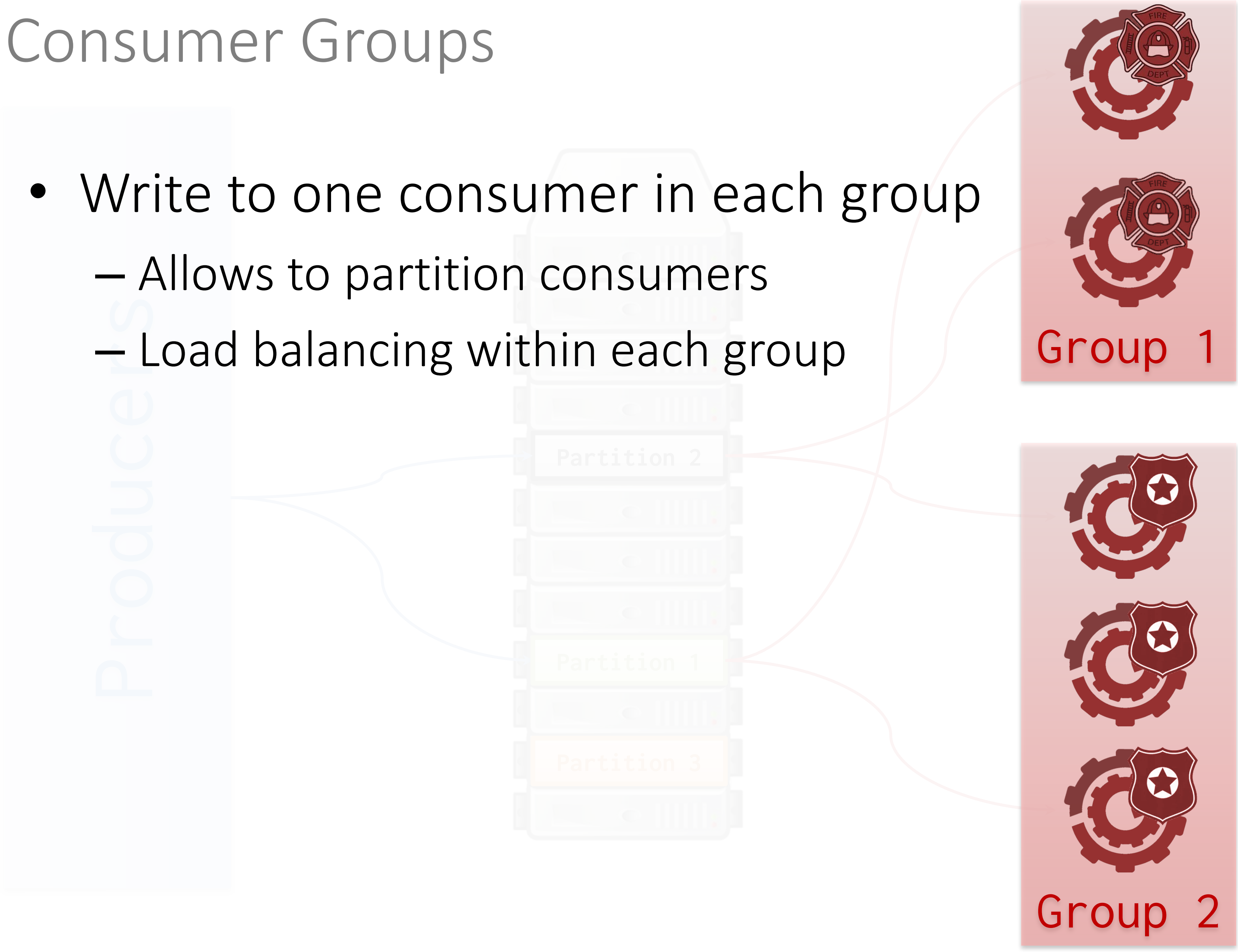
Kafka: Consumer Groups

Consumer Groups



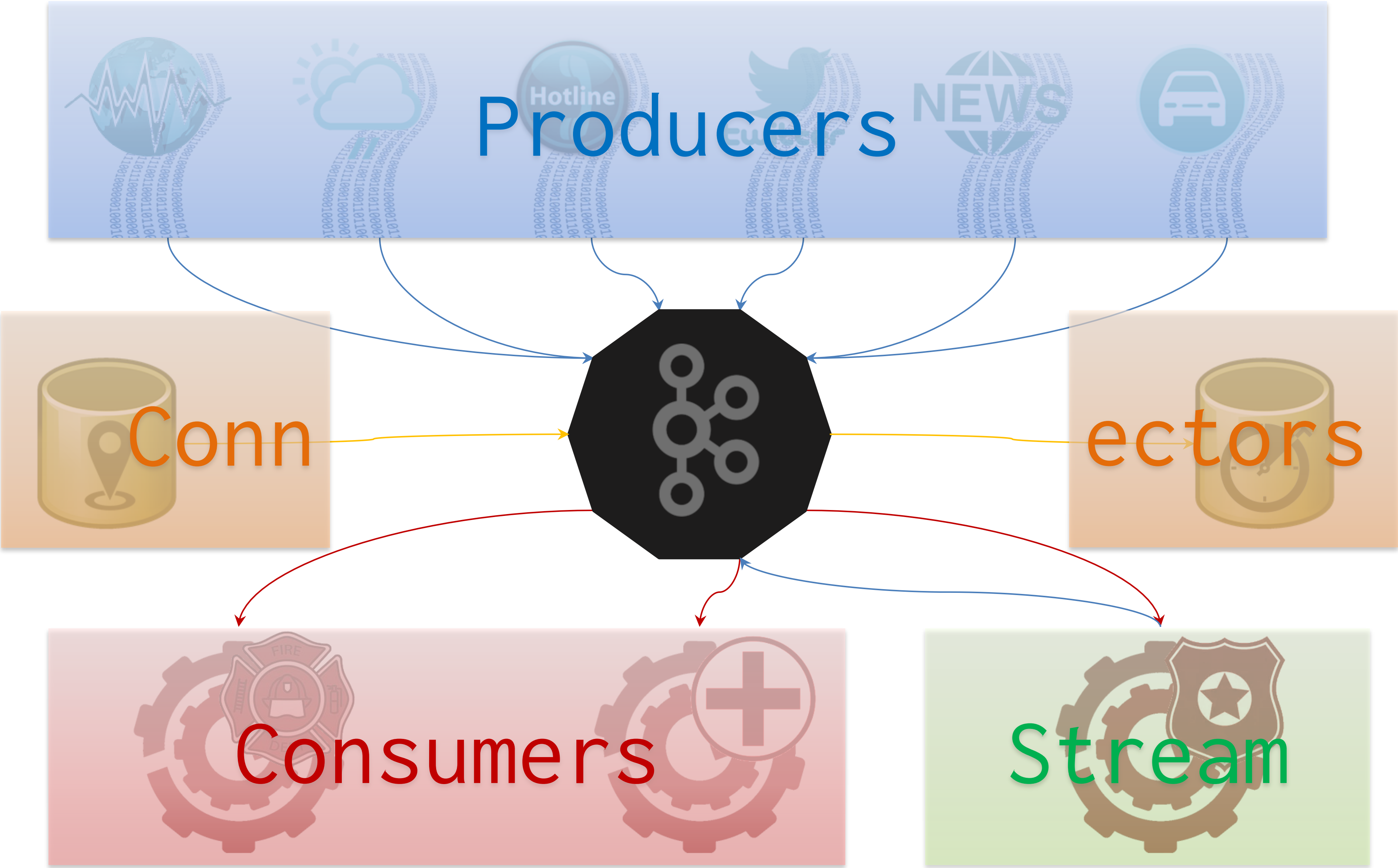
Consumer Groups

- Write to one consumer in each group
  - Allows to partition consumers
  - Load balancing within each group



Kafka: Streams and Connectors

Kafka Overview



Kafka Overview

- Producer API:
  - Append records to topics (push)
- Consumer API:
  - Read records from topics (pull)
- Connector API:
  - Read/write to external components
    - For example, a database or other streaming platforms
- Stream API (Producer + Consumer):
  - Read records from input topics
  - Append records to output topics

Optimisations and Other Features

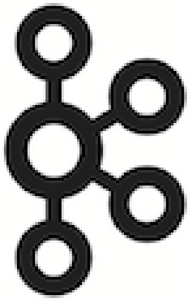
Kafka Optimisations

- Log Compaction
  - Repeated sequential values are suppressed
- Direct Disk-to-Network
  - When data don't need to be loaded into JVM
- Consumer / Producer Quotas
  - Set limits to avoid saturating the system
- ...

Kafka Streams API

- Aggregation (e.g., count messages)
- Joins (e.g., "unify" two streams)
- Windowing (define retention period)
- Continuous Querying (KSQL)

Available Frameworks



Questions?

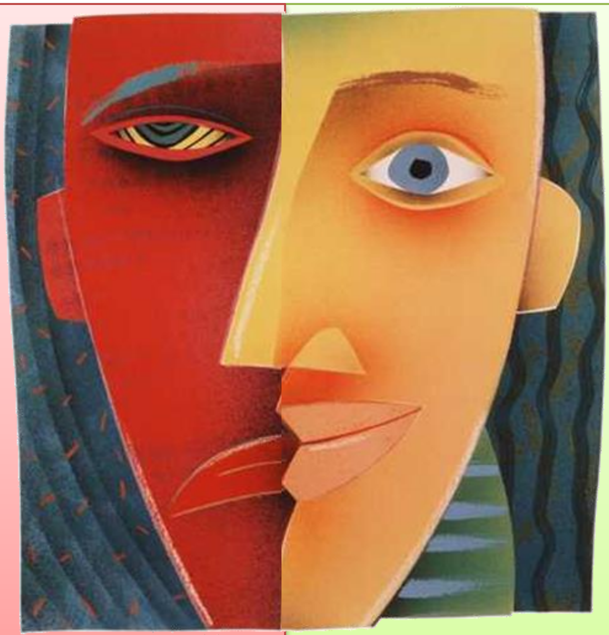
Class Projects

Course Marking

- 80% for Weekly Labs
  - 11 labs total
  - 4 labs will be obligatory
  - 4 best out of the remaining 7 labs will count
- 20% for Class Project

Assignments each week

Working in groups

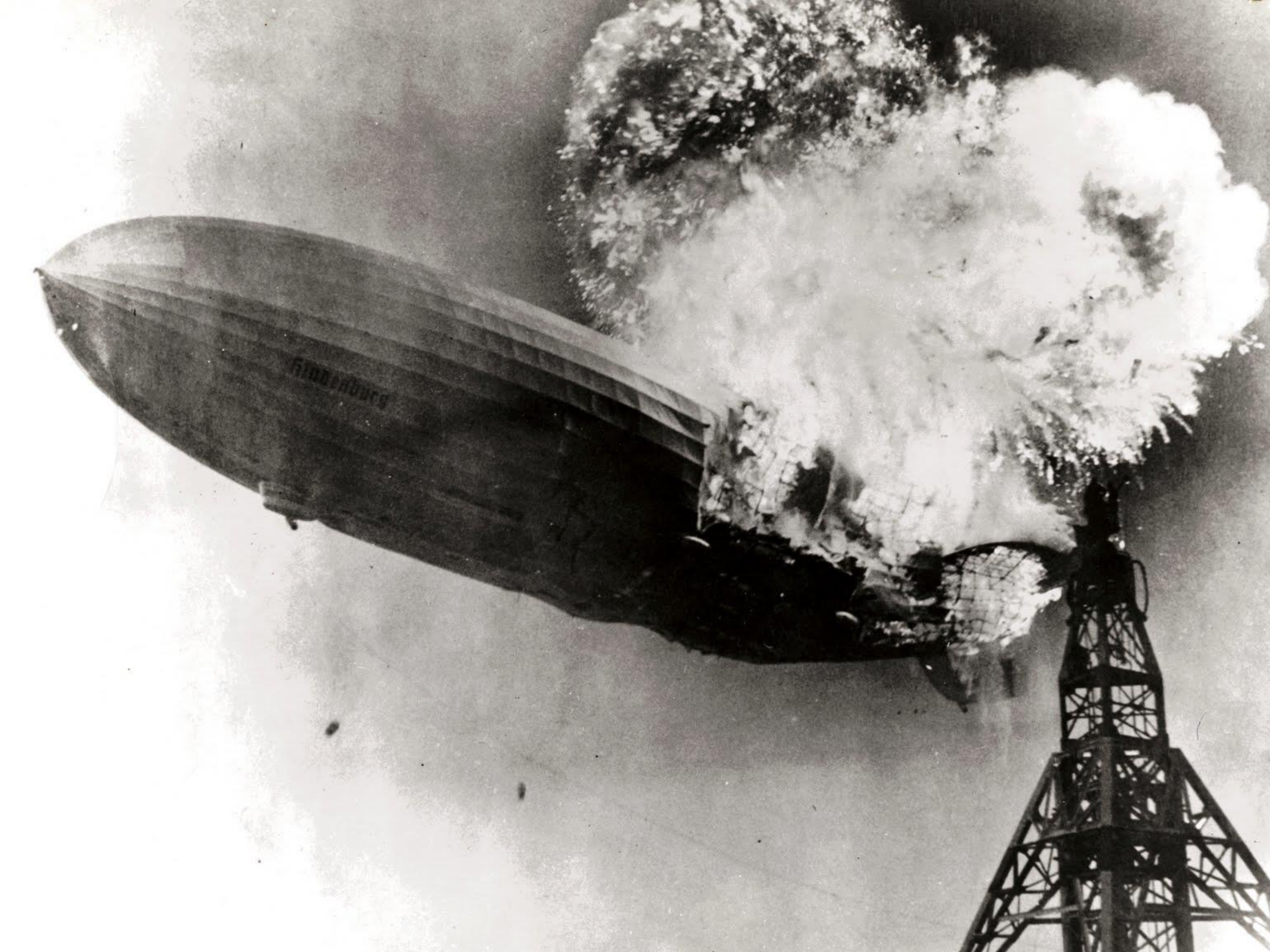


Hands-on each week!

Working in groups!

Class Project

- Done in threes
- Goal: Use what you've learned to do something cool/fun (hopefully)
- Process:
  - Form groups of three or four (in the forum, before April 30th)
  - On April 30th we will assign the rest automatically
  - Start thinking up topics / find interesting datasets!
  - Register topic
  - Work on projects during semester
- Deliverables: 4 minute presentation (video)
- Marked on: Difficulty, appropriateness, scale, good use of techniques, presentation, coolness, creativity, value
  - Ambition is appreciated, even if you don't succeed


Hindenburg

Desiderata for project

- Must focus around some technique from the course!
- Expected difficulty: similar to a lab, but without any instructions
- Data not too small:
  - Should have >250,000 tuples/entries
- Data not too large:
  - Should have <1,000,000,000 tuples/entries
  - If very large, perhaps take a sample?
- In case of COVID-19 data, we can make exceptions

Where to find/explore data?

- Kaggle:
  - https://www.kaggle.com/

- Google Dataset Search:
  - https://datasetsearch.research.google.com/

- Datos Abiertos de Chile:
  - https://datos.gob.cl/
  - https://es.datachile.io/

- …