WEB STREAM PROCESSING

WITH RSP4J AND ONTOPSTREAM

TheWebConf 2022, Online, hosted by Lyon, France - 26-4-2022

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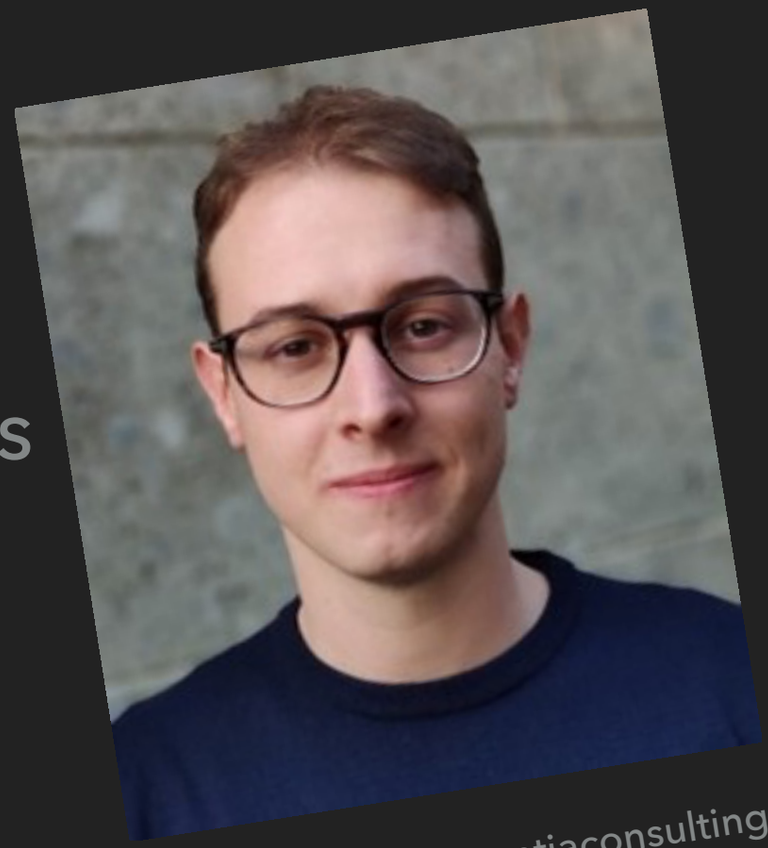

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PRELIMINARY SETUP

- During this introduction, you can get ready for the hands-on sessions:
  - Install docker and docker-compose:
    - docker: https://docs.docker.com/engine/install/
    - docker-compose: https://docs.docker.com/compose/install/
  - Clone our repository: https://github.com/pbonte/WSP-TheWebConf2022Tutorial
    - e.g., `git clone https://github.com/pbonte/WSP-TheWebConf2022Tutorial.git`
    - Also downloading the zip is ok

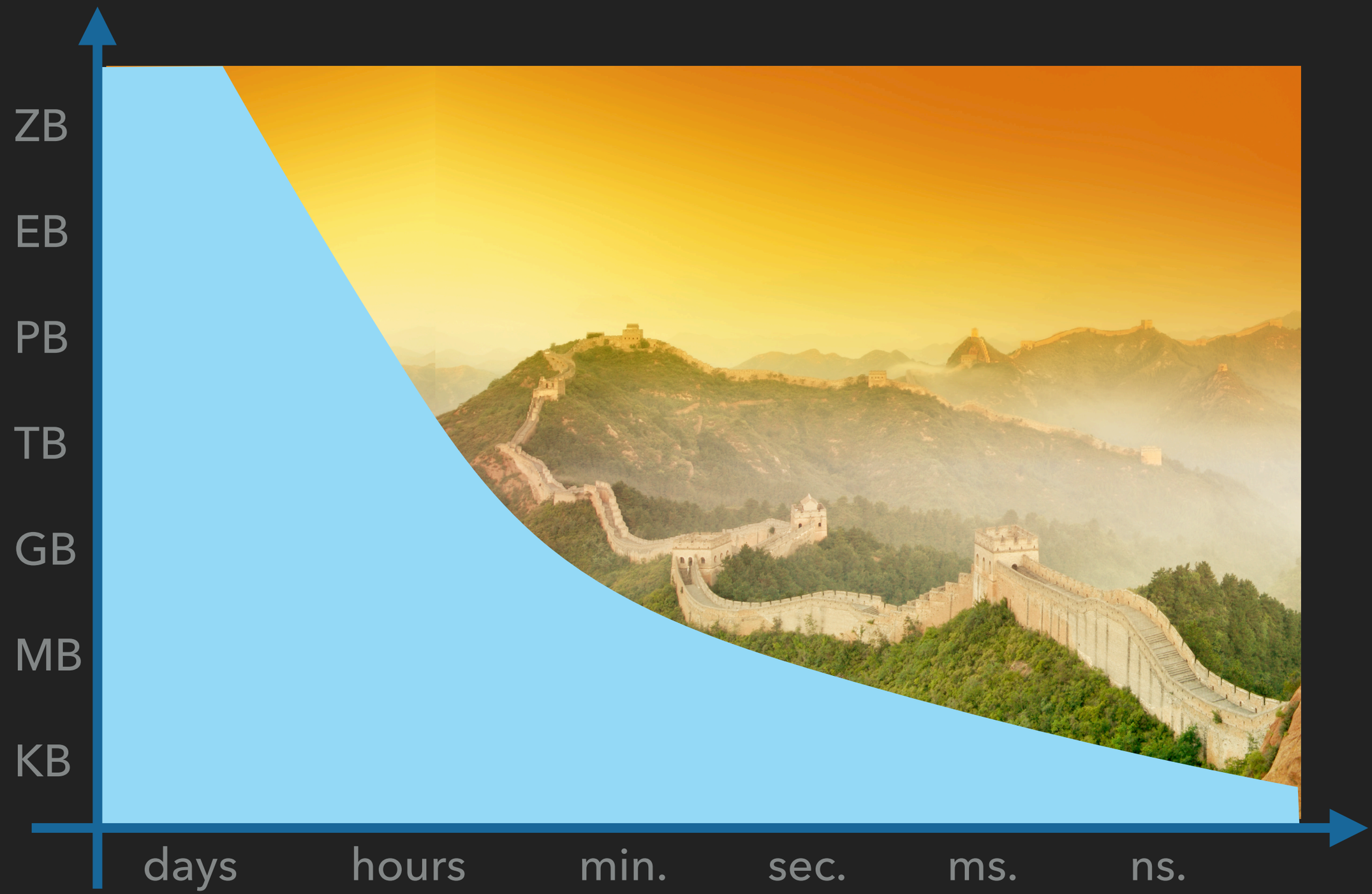
BIG DATA TECHS CAN TAME VOLUME

- Hadoop, MapReduce, HIVE
- “schema on read” methodology
- spark (x100 faster)
- “data lake” concept

BIG DATA TECHS CAN TAME VELOCITY

- Storm
- Kafka
- Spark Streaming
- Flink
- paradigmatic change
  - from persistent data and transient queries
  - **to persistent queries and transient data**

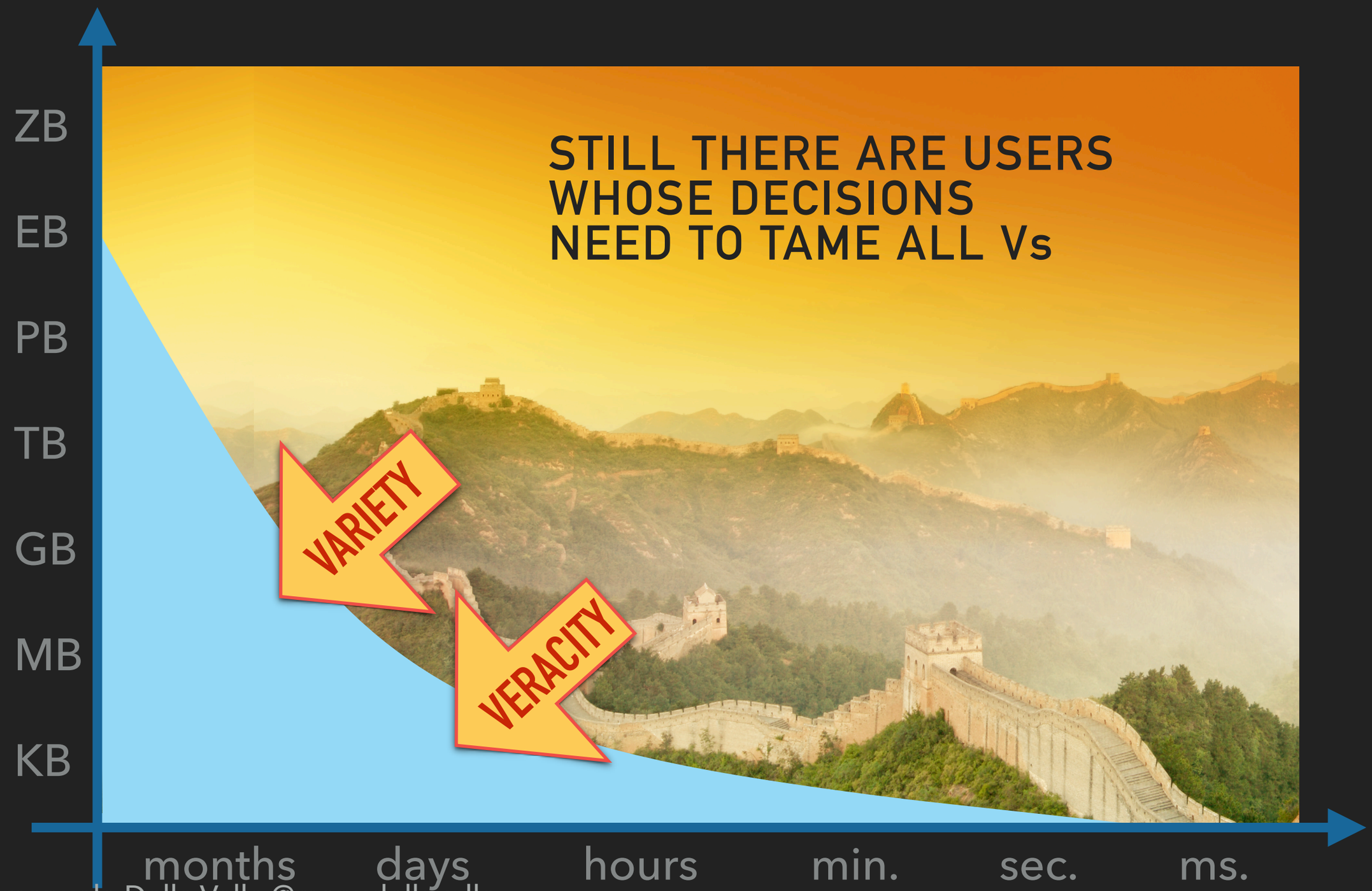
BIG DATA TECHS CANNOT TAME VOLUME AND VELOCITY SIMULTANEOUSLY



BIG DATA TECHS CAN TAME VARIETY USING SEMANTIC WEB TECHNOLOGIES

- RDF data model
- SPARQL query language
- OWL ontological language
- R2RML mapping language
- Ontology Based Data Access methodology

VARIETY & VERACITY MAKES PROBLEMS HARDER



WEB STREAM PROCESSING FOR SMART CITIES

- Can you **suggest where to spend my next hours** given my interests, the presence of people and what their doing?
- **100,000s people** leaving **10,000s digital footprint per second** via Call Data Records, Bluetooth, WiFi, Social Media, …

REQUIREMENT ANALYSIS

A system able to answer those queries must be able to

- handle **massive** datasets
- process **data streams** on the fly
- cope with **heterogeneous** datasets
- cope with **incomplete** data
- cope with **noisy** data
- provide **reactive answers**
- support **fine-grained information access**
- integrate **complex** domain **models**

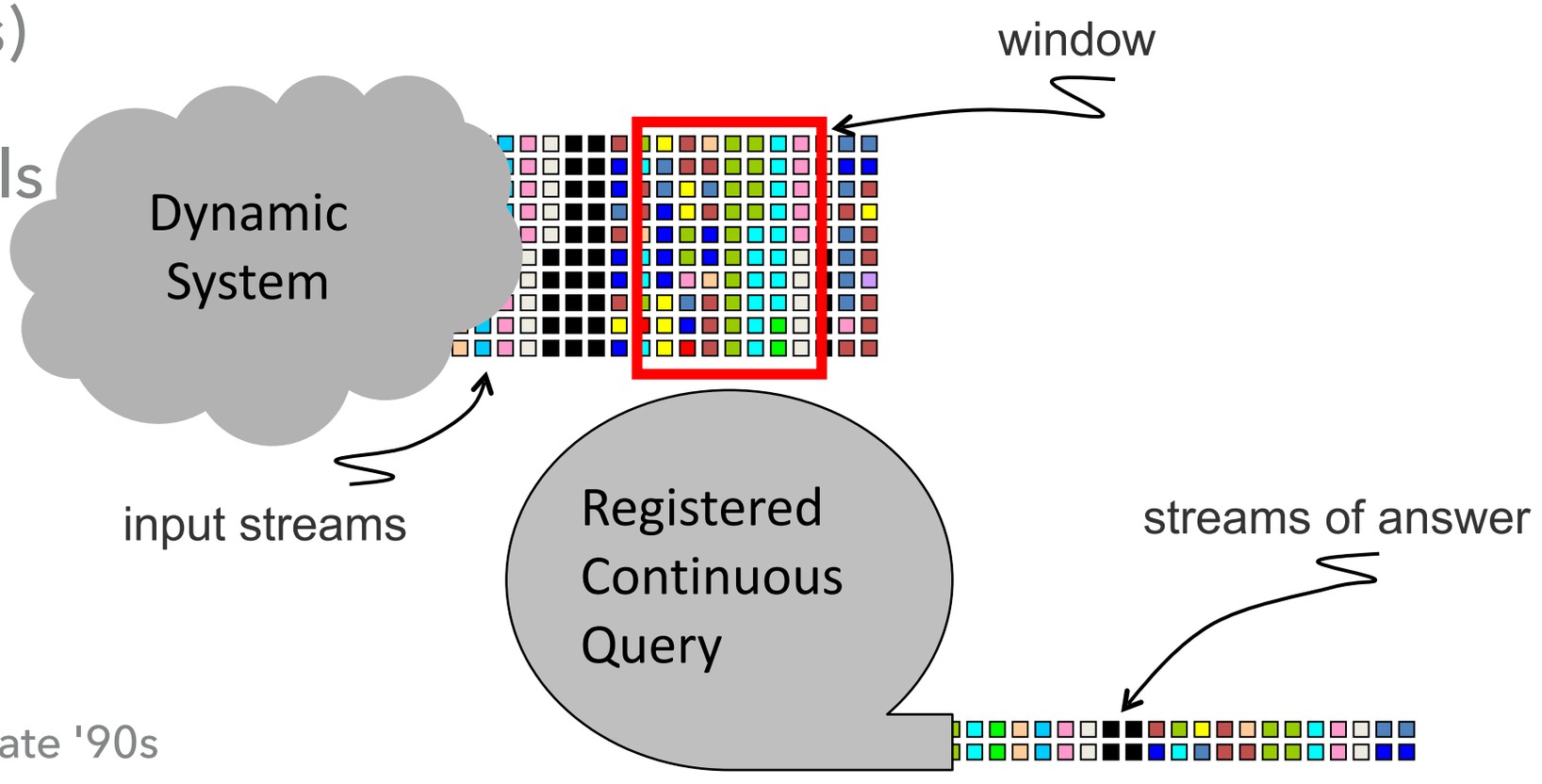
Volume	Velocity	Variety	Veracity
x			
	x		
		x	
		x	x
			x
		x	
		x	x
		x	

DATA STREAMS

- Data Streams are usually **unbounded**
- **No assumption** can be made **on** data arrival **order**
- Data items in streams often represent **observations not facts**
- Size and time constraints make it **difficult to store** and process data stream elements **after their arrival**
- **One-time processing** is the typical mechanism used to deal with streams

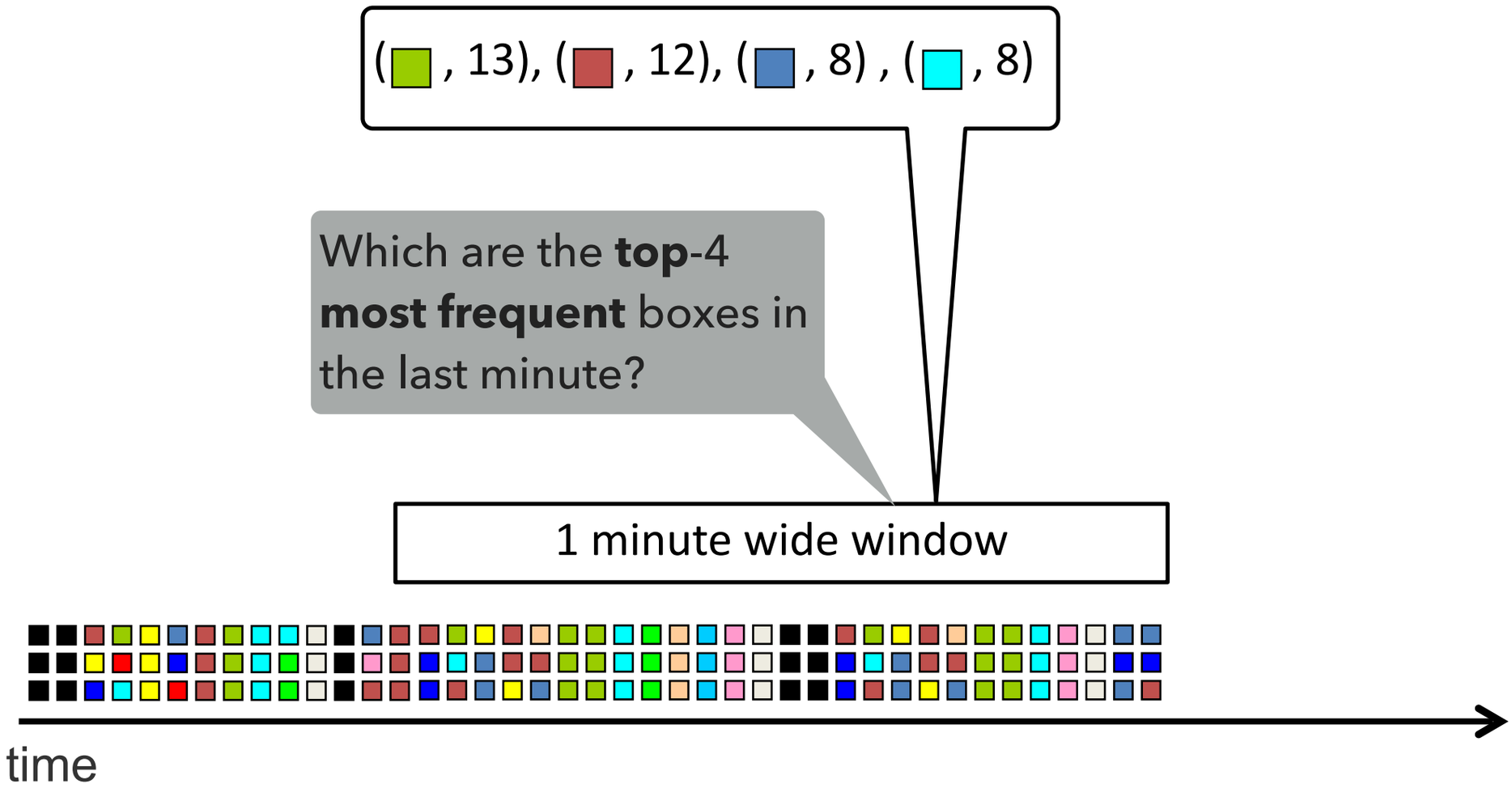
THE PARADIGMATIC CHANGE* OF STREAM PROCESSING

- From **persistent data** and **transient queries** (one time semantics)
- To **transient data** and **persistent queries** (continuous semantics)
- Two competing models
  - DSMS
  - CEP



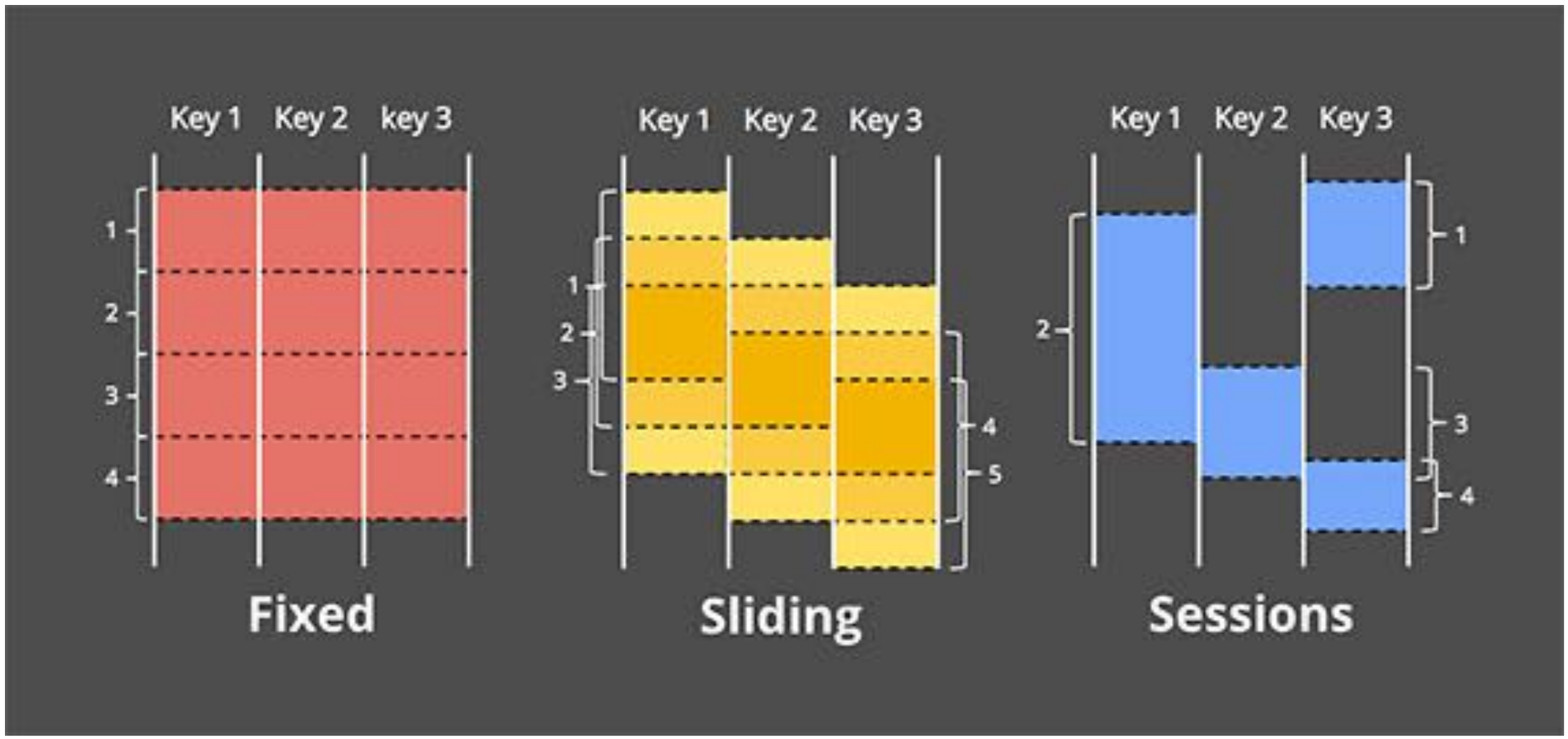
*first arose in DB community in the late '90s

STREAM PROCESSING A USER PERSPECTIVE



WINDOWS

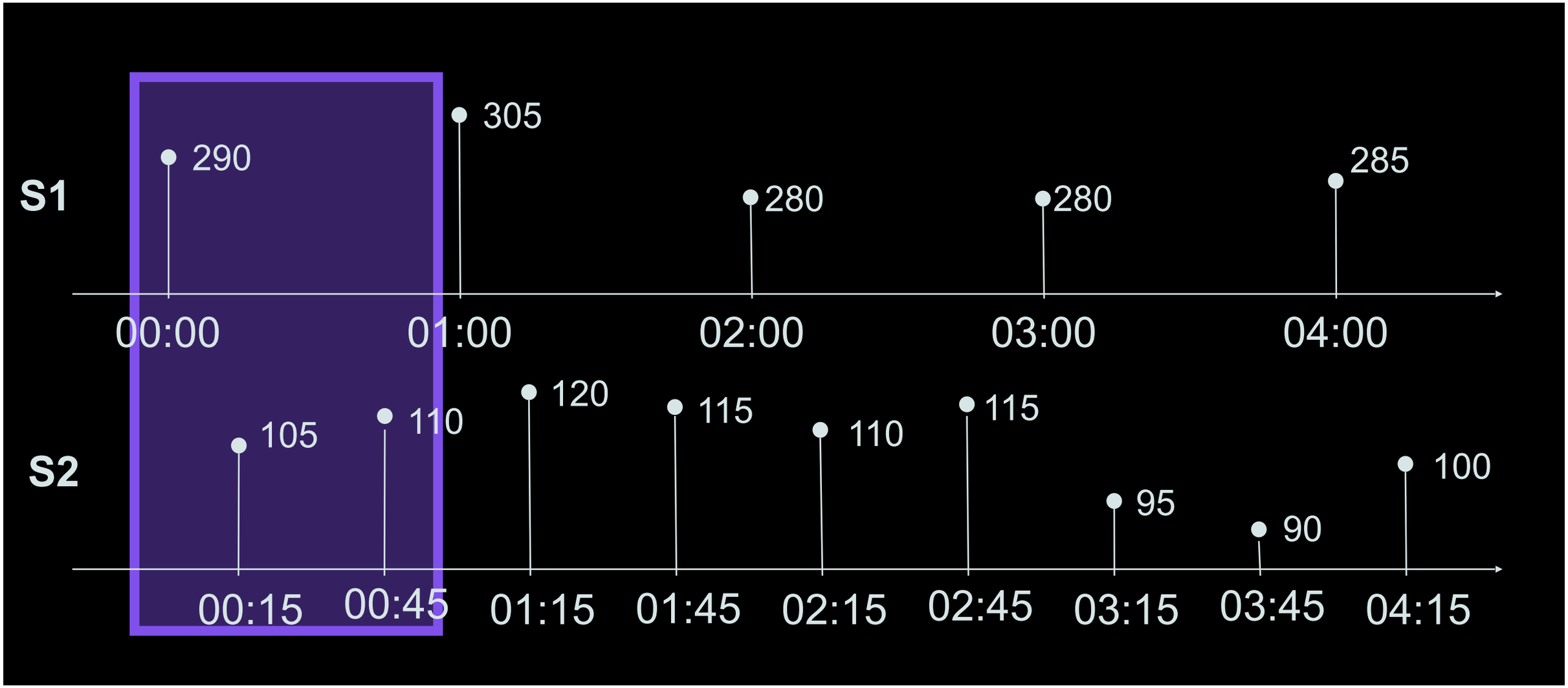
- Windows define a finite sub-streams of an unbounded stream



- They can be interpreted as locally closed worlds

JOINING STREAMS IT'S OF SYNCRONIZATION

TUMBLING WINDOWS CAN SYNCHRONIZE STREAMS!



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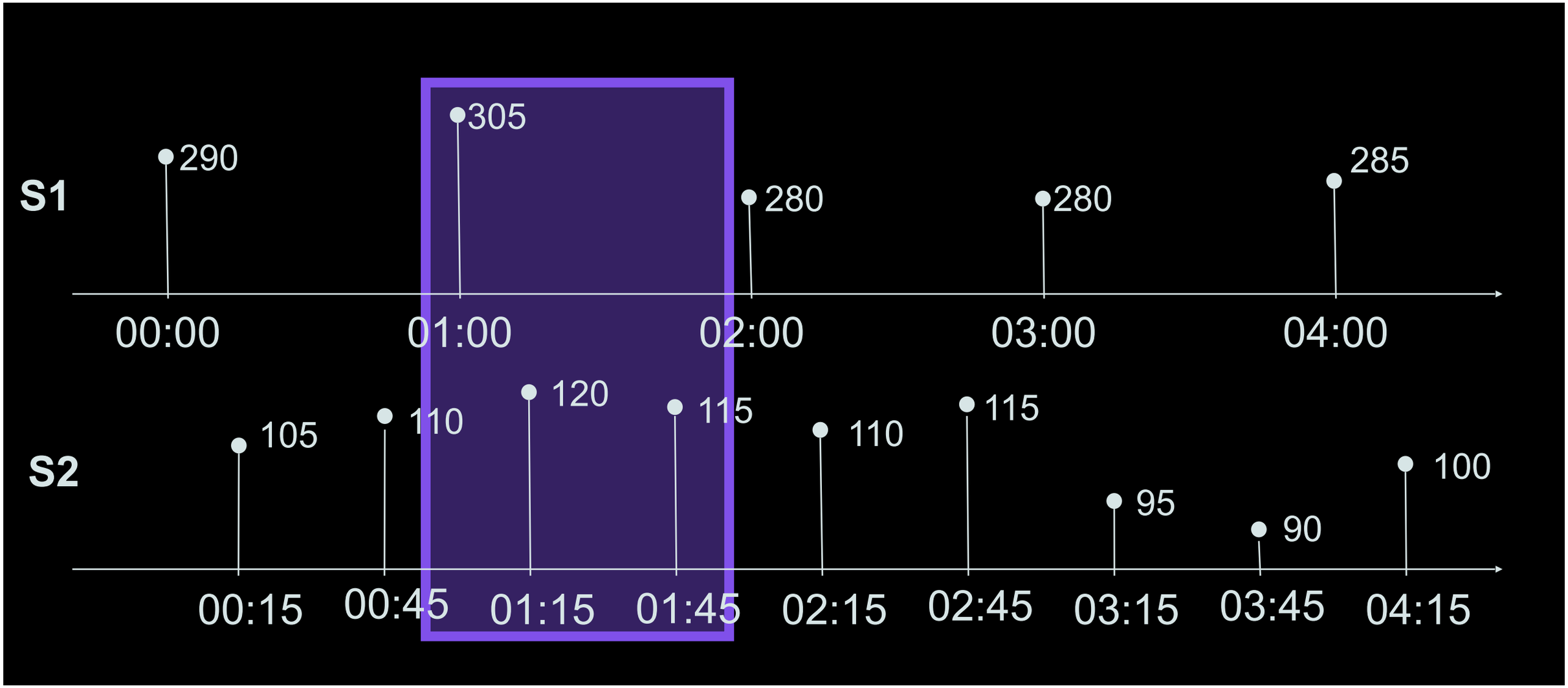
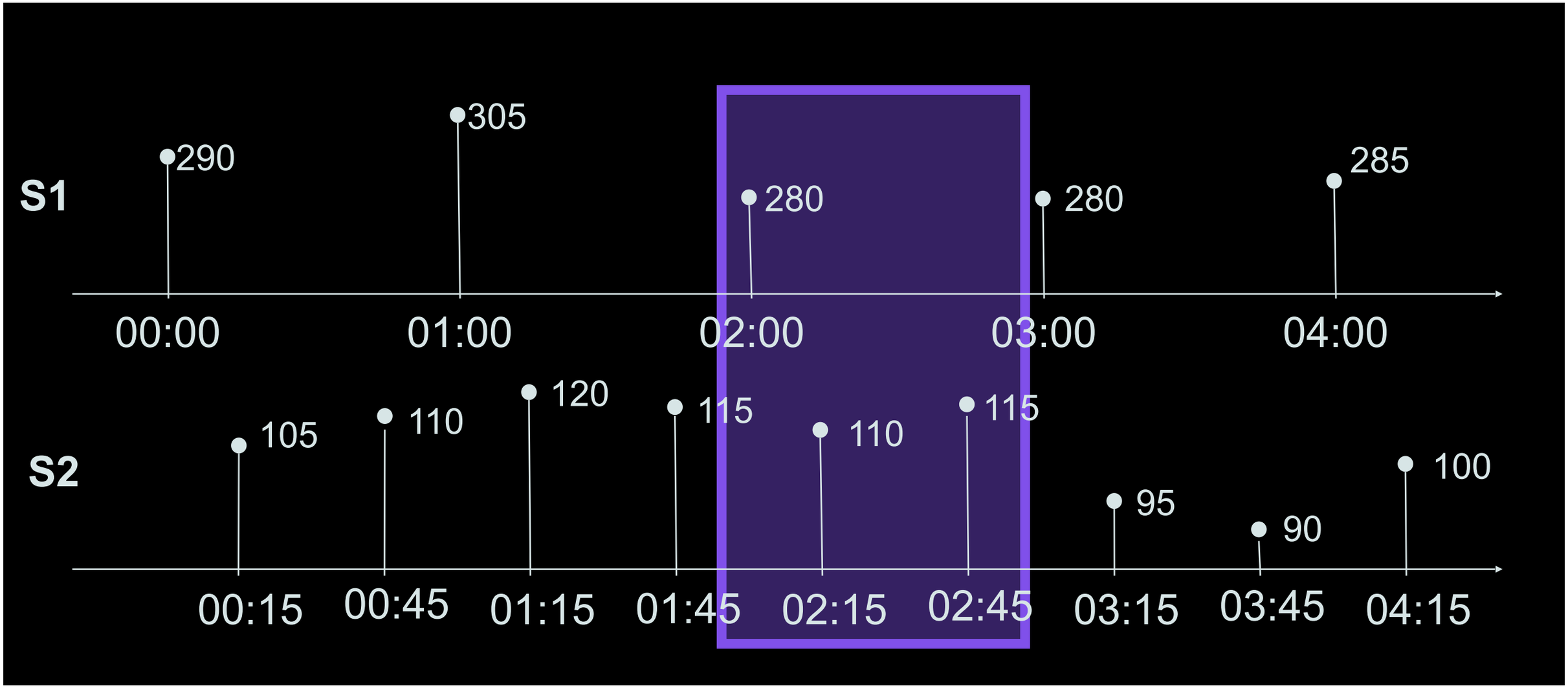


TUMBLING WINDOWS CAN SYNCHRONIZE STREAMS!



STREAM PROCESSING VS. REQUIREMENTS

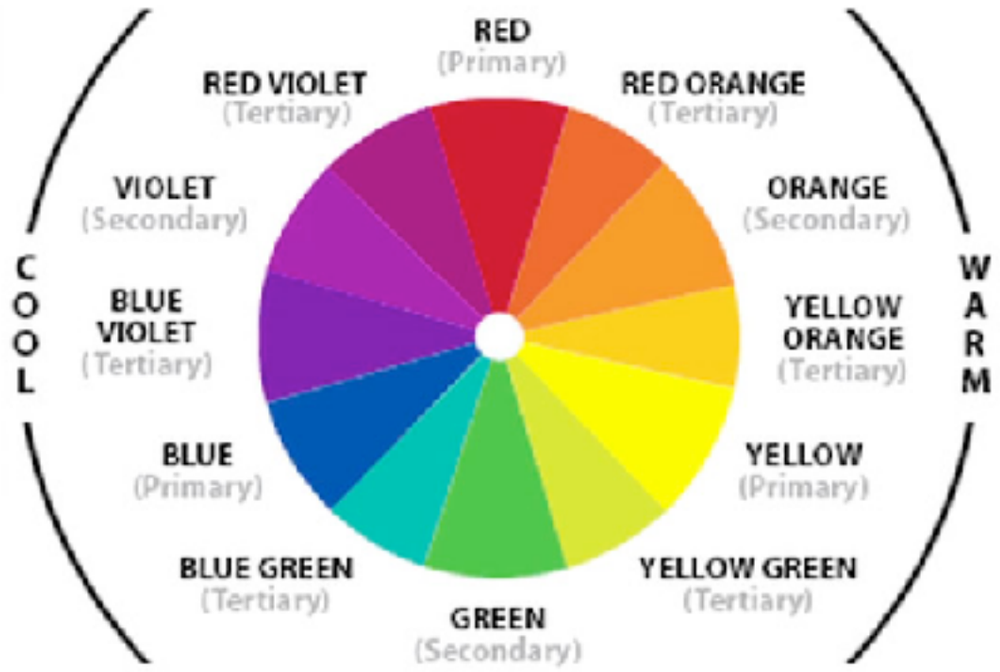
Requirement	SP
massive datasets	✓
data **streams**	✓
heterogeneous dataset	✗
incomplete data	✗
noisy data	✓
reactive answers	✓
fine-grained information **access**	✓
complex domain **models**	✗

SEMANTIC WEB TECHS A USER PERSPECTIVE

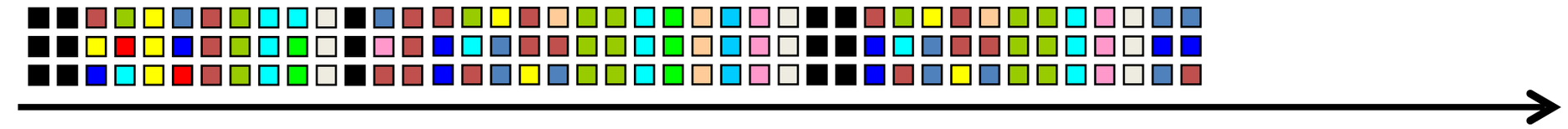
Are there any **cool colored** box?

yes, 7 , 13 , ...

An **ontology** of colors



~~1 minute wide window~~



~~time~~

DATA MODEL

- **RDF**: Resource Description Framework
  - It allows to make **statements about resources** in the form of **subject-predicate-object** expressions
    - In RDF terminology **triples**
    - E.g. `:Alice` (subject) `:posts` (predicate) `"I'm with @Bob"` (object)

- A collection of RDF statements represents a **labelled, directed graph**
  - In RDF terminology a **graph**
  - E.g., the triple above can be connected to millions of others telling information about Rodin and The Thinker

ONTOLOGICAL LANGUAGE

- **OWL**: Web Ontology Language
  - It allows to give **well-defined meaning** to classes, properties, individuals, and data values
    - E.g.
      - `posts` is a property
      - `posts` is a subproperty of `communicates`
      - those who `posts` are `social media users`
      - …
- A collection of classes, properties, individuals, and data values forms a **vocabulary**
- When using **OWL2DL**, **classes and properties** are isolated **in** a **T-box** while **individuals and values** are **in** an **A-box**

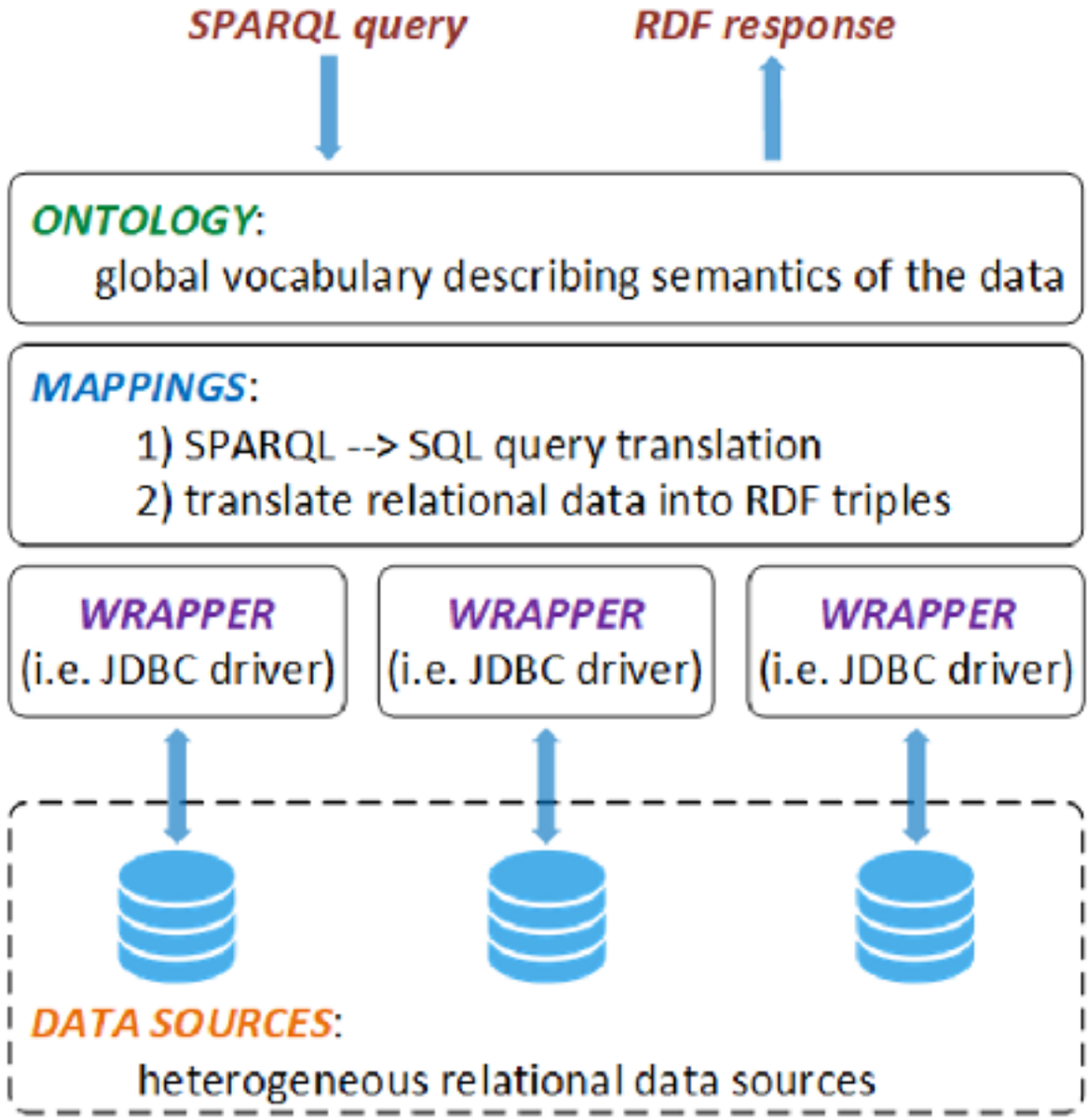
"Now! *That* should clear up a few things around here!"

QUERY LANGUAGE

- **SPARQL**: Querying RDF under OWL entailment regime
  - It allows to make search for **statements about resources**
    - In SPARQL terminology a **triples pattern** is an RDF triple in which users can add variables
      - E.g. 1: what does Alice post? `:Alice :posts ?x`
      - E.g. 2: what does Alice communicate? `:Alice :communicates ?y`
      - E.g. 3: Is there a Social Media User? `?x a :SocialMediaUser?`
  - A collection of triples patterns represents a **graph pattern**
  - Graph patterns can be combined with FILTER, UNION and other clauses to form an expressive query language

ONTOLOGY-BASED DATA ACCESS

- Accessing data in SQL DB via SPARQL + OWL2QL
  - queries expressed using terms whose semantics is specified in an ontology
  - one or more SQL DB appear as a single RDF repository a.k.a. a **Virtual Knowledge Graph**



ONTOLOGY-BASED DATA ACCESS – A SIMPLE EXAMPLE

- Original SPARQL query
  - what does Alice communicate?
  - `:Alice :communicates ?y`
- Knowing that `posts` **is a subproperty of** `communicates` we know
  - `:Alice :posts ?y` implies `:Alice :communicates ?y`
- If triples such as.
  are mapped to the results of

```
:{USER} :posts {TEXT}
SELECT USER, TEXT FROM POSTS
```

- we can *rewrite*
  in SQL as

```
:Alice :posts ?y
SELECT USER,TEXT FROM POSTS
WHERE USER="Alice"
```

- the SQL answers are *certain answers* of the original SPARQL query

SEMANTIC WEB TECHS VS. REQUIREMENTS

Requirement	SP	ST
massive datasets	✓	✓
data **streams**	✓	✗
heterogeneous dataset	✗	✓
incomplete data	✗	✓
noisy data	✓	✗
reactive answers	✓	✗
fine-grained information **access**	✓	✓
complex domain **models**	✗	✓

WEB STREAM PROCESSING RESEARCH QUESTION

Is it possible to **process** in **real time, multiple**, **heterogeneous**, **gigantic** and inevitably **noisy** and **incomplete Web streams** ?

R. Tommasini, P. Bonte, E. Della Valle, 2022

PRELIMINARY SETUP

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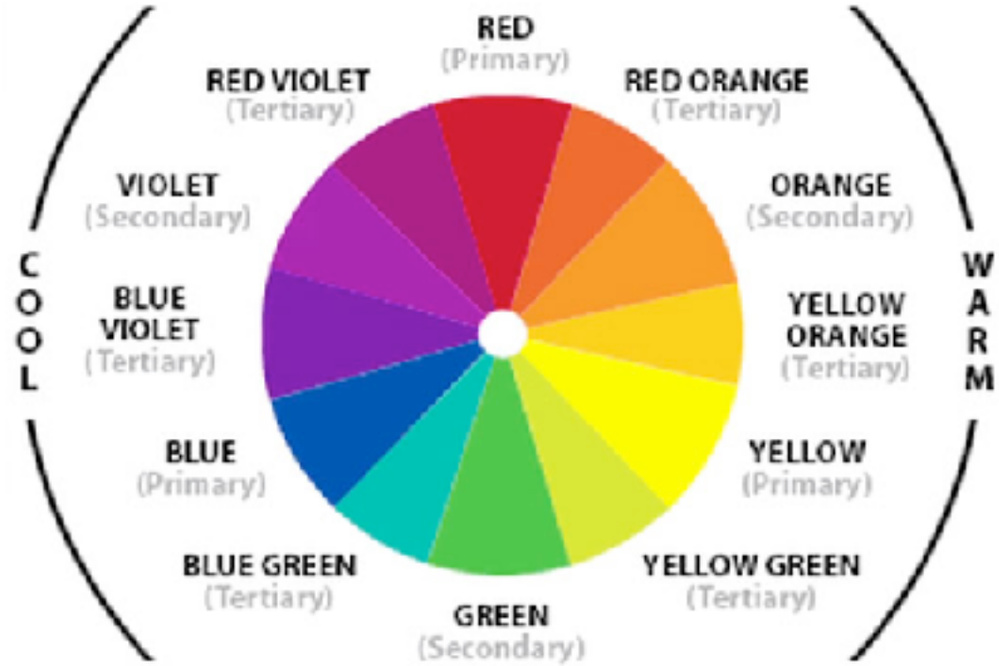
    - Also downloading the zip is ok

GETTING READY FOR THE FIRST HANDS-ON

- Downloading the docker images make take a while …
- You'd better start the platform for the first hands-on:
  - Open a terminal
  - Go the right folder: `cd exercises/part1`
  - Bring up the stack: `docker-compose up`

WEB STREAM PROCESSING A USER PERSPECTIVE

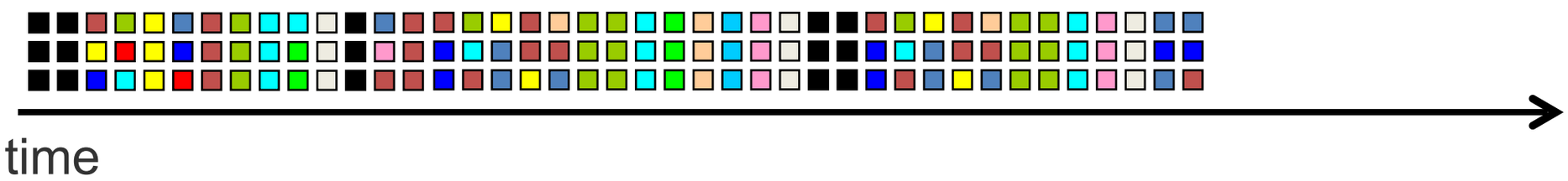
An **ontology** of colors



(■, 13),(■, 8) , (■, 8)

Which are the top-2 most frequent **cool** colors in the last minute?

1 minute wide window



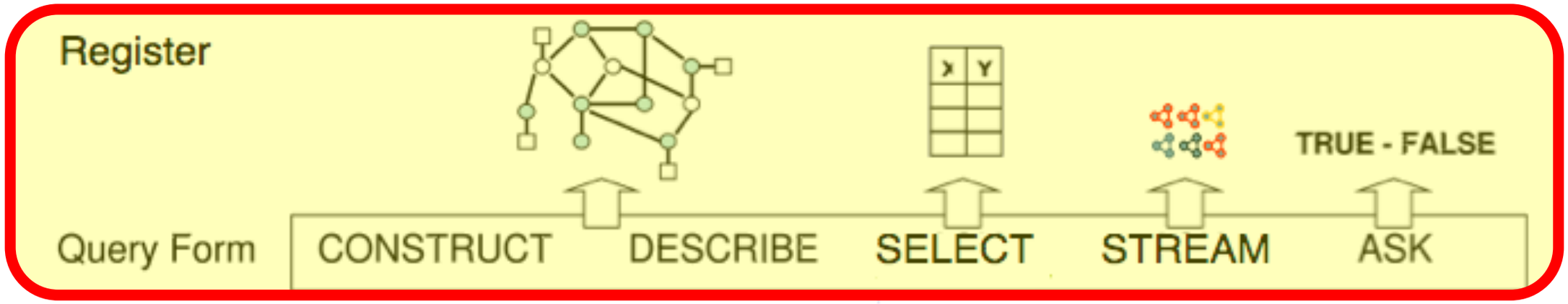
DATA MODEL

- **RDF STREAM**: Stream of Resource Description Framework
  - It allows to make **timestamped statements about resources** in the form of **subject-predicate-object** expressions
    - In RDF terminology **triples**
    - E.g. `:Alice` `:posts` `"I'm with @Bob"` `"2022-4-26"`
      subject, predicate, object, **timestamp**
- An **unbounded sequence of timestamped RDF statements** represents an **RDF stream**

CONTINUOUS QUERY LANGUAGE

- **RSP-QL**: RDF stream processing query language
  - It allows to register contrinous queries that process RDF streams
  - E.g. who have been the most active users in the last minute?
  -
```
REGISTER RSTREAM <MostActiveUsers> AS
SELECT ?user COUNT(?x)
FROM NAMED WINDOW <w1>
     ON <SocialMediaStream> [RANGE PT1M STEP PT1M]
WHERE { WINDOW <w1> { ?user :posts ?x } }
GROUP BY ?user
```

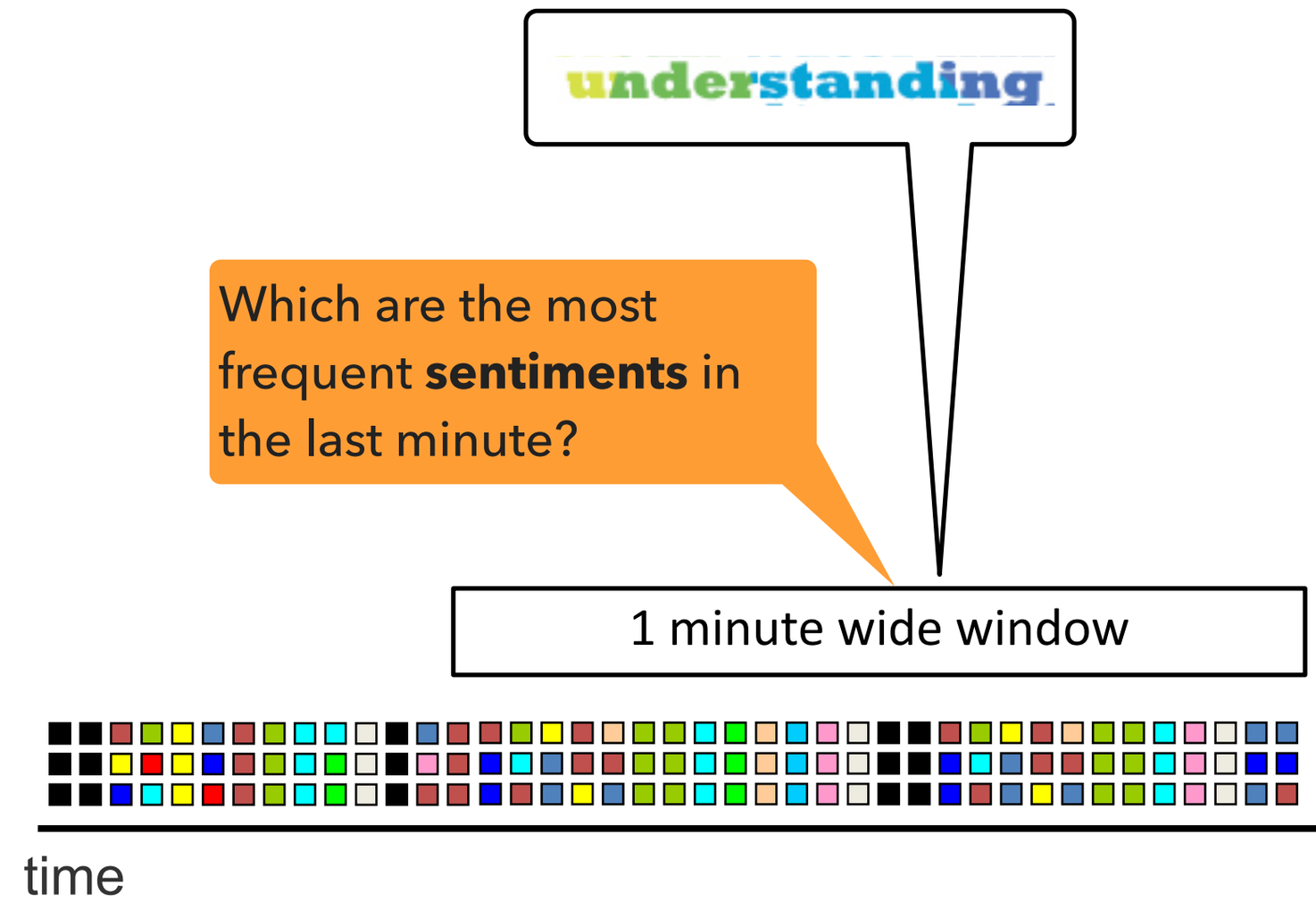
HOW RQLQL EXTENDS SPARQL TO PROCESS RDF STREAMS



WEB STREAM PROCESSING

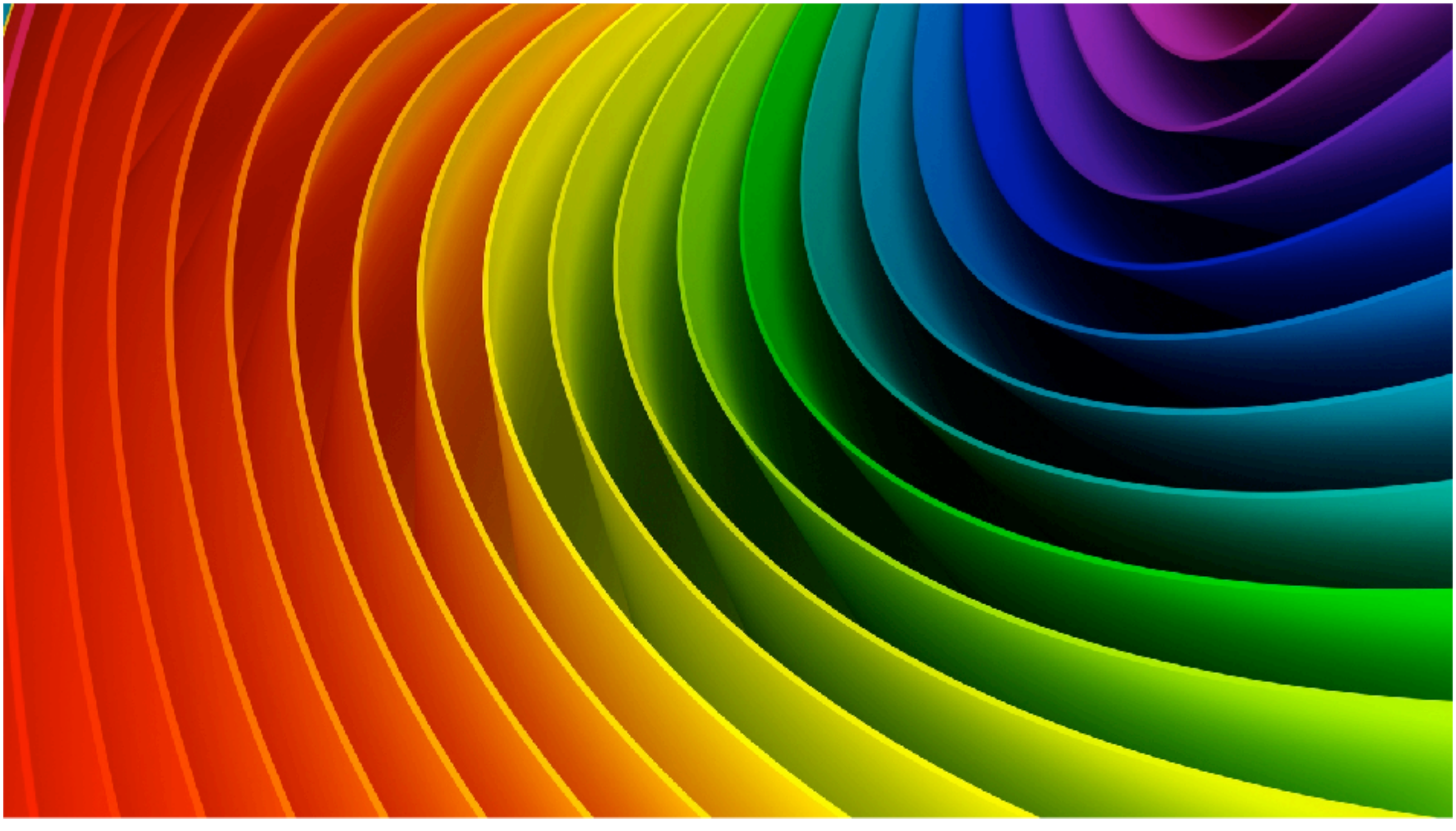
WEB STREAM PROCESSING A USER PERSPECTIVE

The **better** is the **ontology** (of the colors) we are using
the **more expressive** are the **queries** we can register



A **better**
ontology (of colors)

COLORWAVE!



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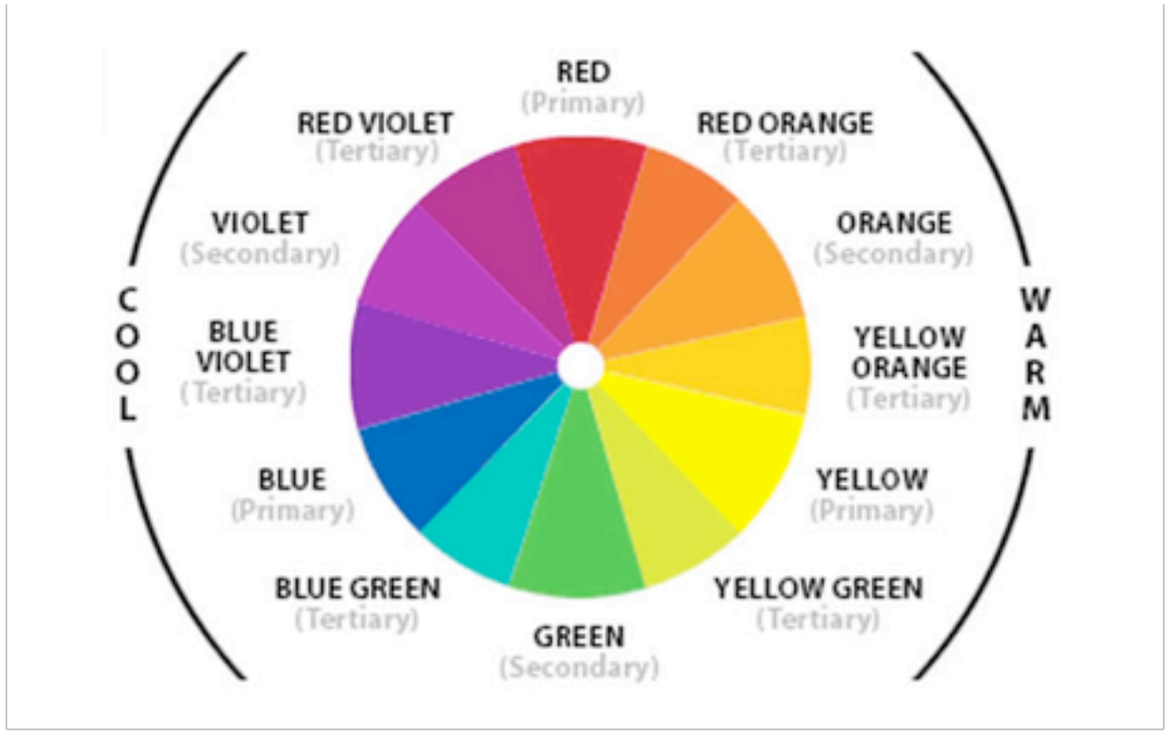
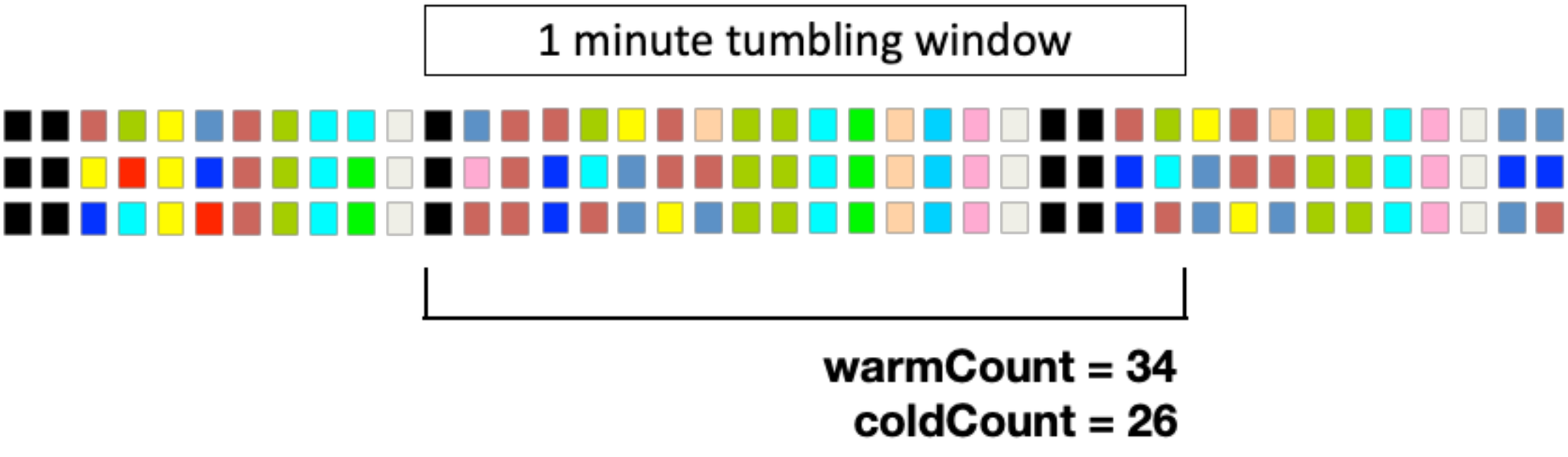
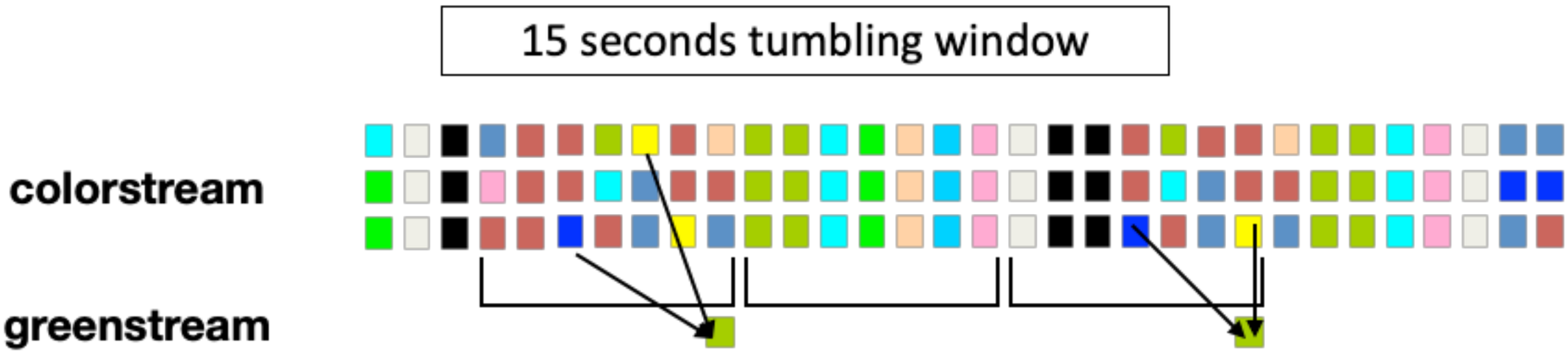
COMPARING WARM AND COLD COLORS





COOKING GREENS FROM YELLOWS AND BLUES



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