3.1 From Tensors Mathematical Object to a Data Model

Most Used tensor products

- Kronecker product
- Khatri-Rao product
- Hadamard product
- External product
- N-mode

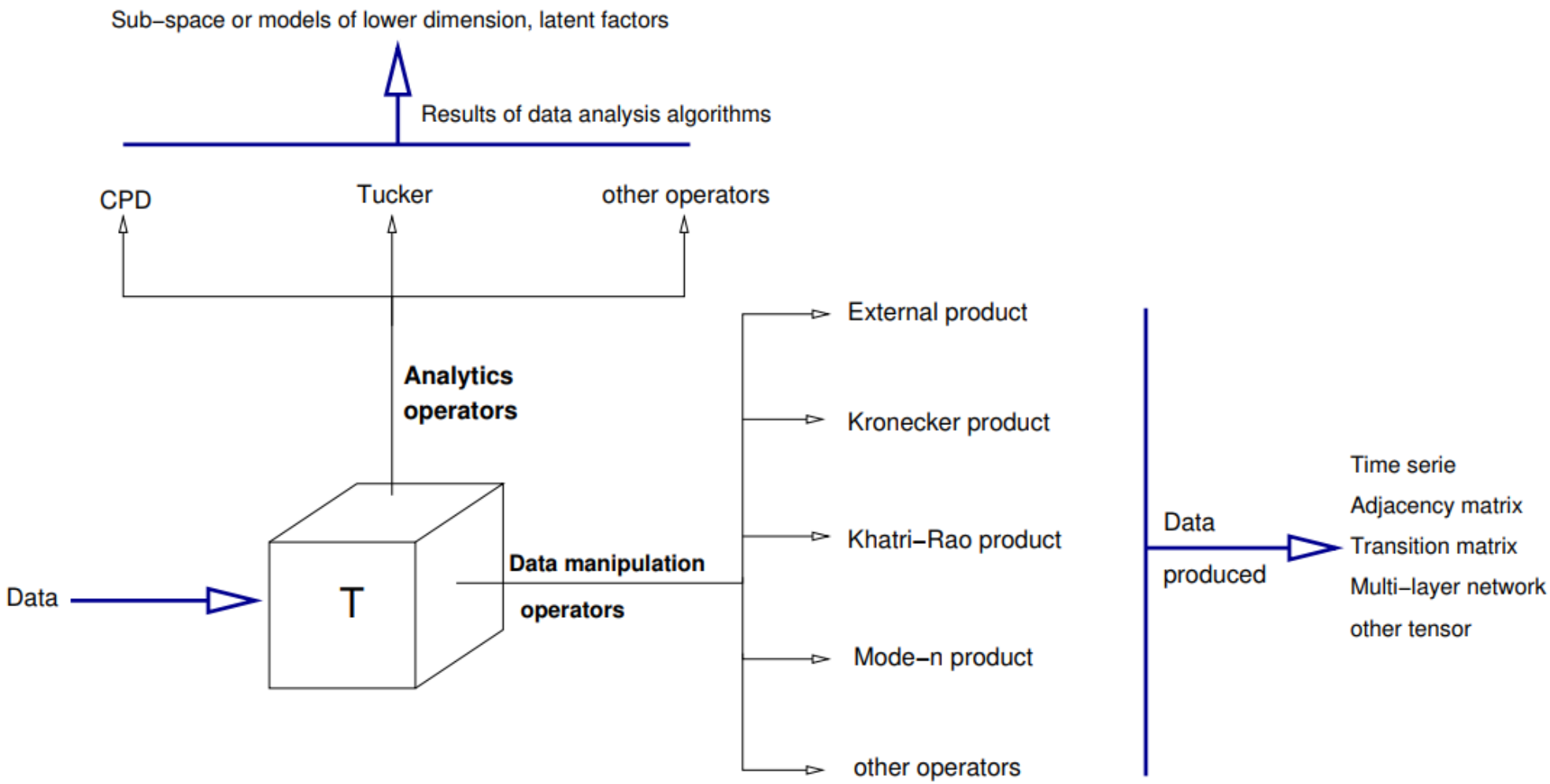


Figure 2: Tensor Model and operations

3.2 Architecture

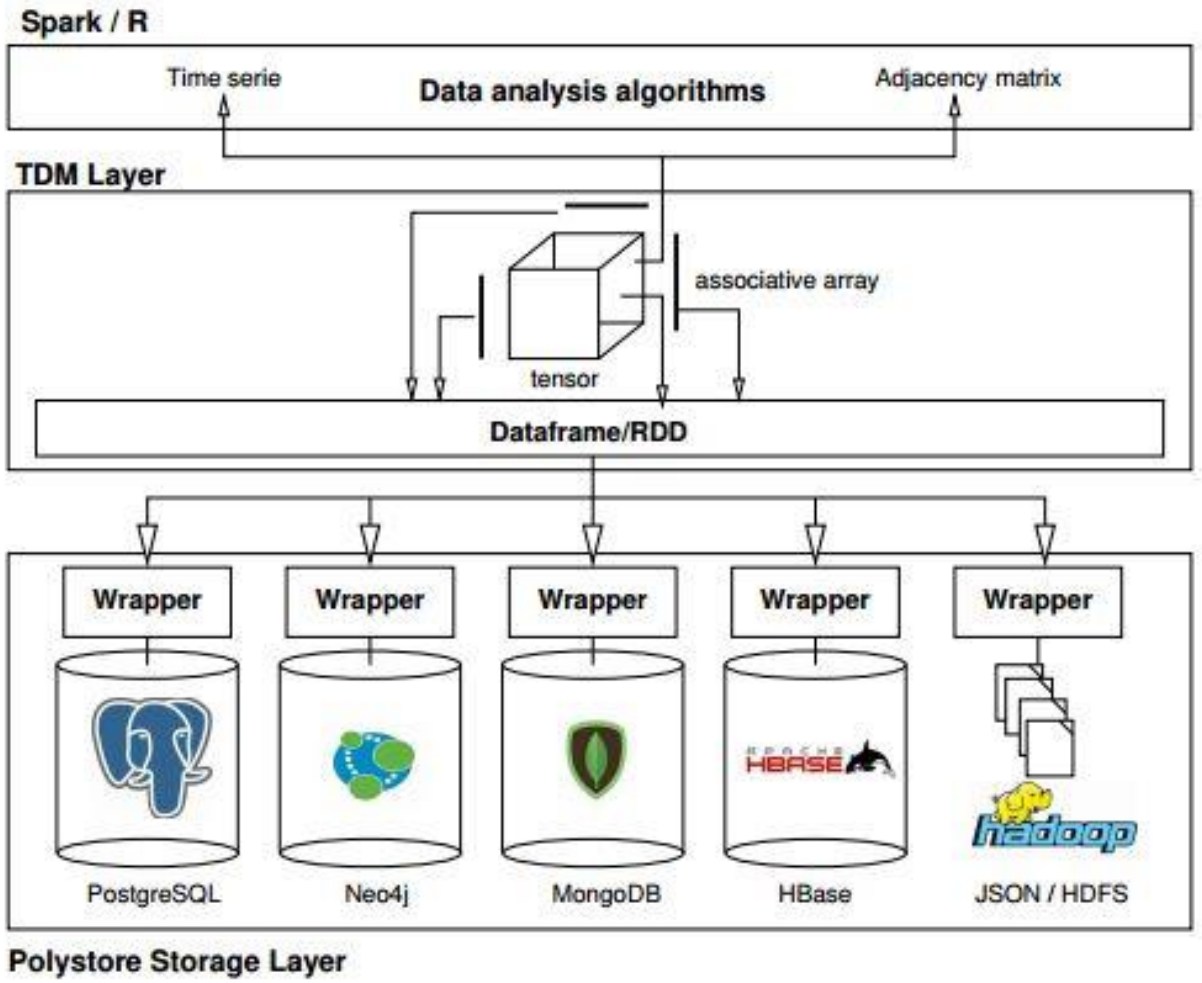
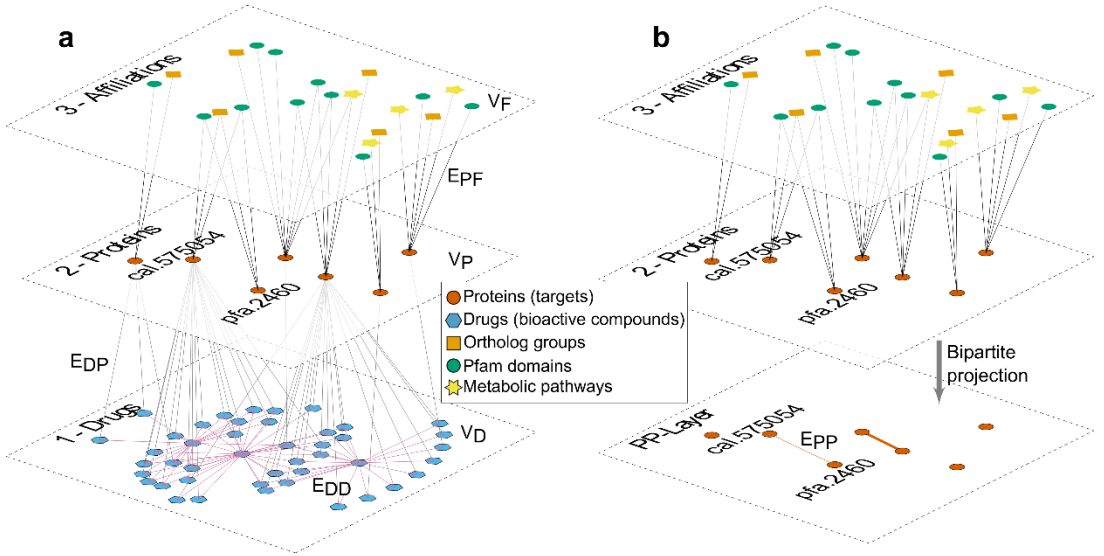


Figure 3: Tensor and associative arrays roles in the architecture of a polystore system

4 TDM: A TENSOR DATA MODEL

4.1 TDM Motivations

- Drawbacks of adjacency matrices.
- Allows to model complex relationships without fine knowledge and understanding.



4.2 TDM Formalization

- Associative array
- Named Typed Associative Array
- Typed Tensor

user	u1	u2	u3	...
i	1	2	3	...

tweetID	t1	t2	t3	t4	...
j	1	2	3	4	...

time	18-03-08	18-03-07	18-02-28	18-02-26	...
k	1	2	3	4	...

Figure 4: Named Typed Associative Arrays representing tensor dimensions

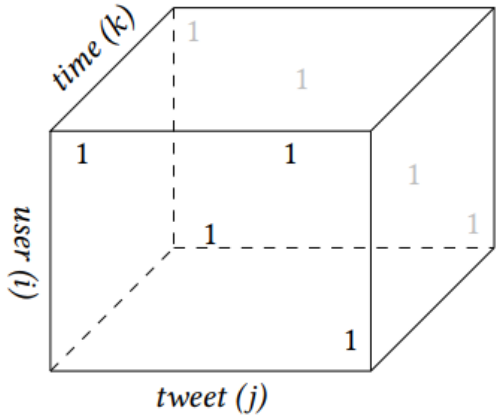


Figure 5: Associated tensor $\mathcal{X}$

4.3 Examples with Twitter Data

- Nodes are heterogeneous (users, tweets, hashtags, etc.)
- Relationships too are heterogeneous(retweet, publish, follow, mention, etc.)
- Different Dimensions like user interactions (retweet, follow), user actions (publish, like), tweet structure (content, mention, hashtag)

Let us denote the set of users by V_1, the set of tweets by V_2

- mention, $R_1 : V_1 \times V_1 \rightarrow \mathbb{N}$
- retweet, $R_2 : V_1 \times V_2 \rightarrow \mathbb{N}$
- retweet_U, $R_3 : V_1 \times V_1 \rightarrow \mathbb{N}$
- publish, $R_4 : V_1 \times V_2 \rightarrow \mathbb{N}$
- follow, $R_5 : V_1 \times V_1 \rightarrow \mathbb{N}$

Using the null value tensor can model both simple and complex relationships, which can contribute to gain in performance by allowing materialized joins.

user	u1	u2	u3	...
i	1	2	3	...

tweetID	t1	t2	t3	t4	...
j	1	2	3	4	...

time	18-03-08	18-03-07	18-02-28	18-02-26	...
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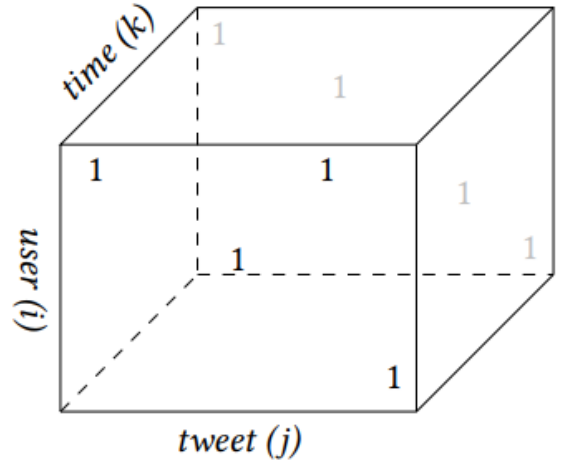

Figure 5: Associated tensor $\mathcal{X}$

5 TDM'S OPERATORS

- Data Manipulation Operators
- Analytical Decomposition Operators

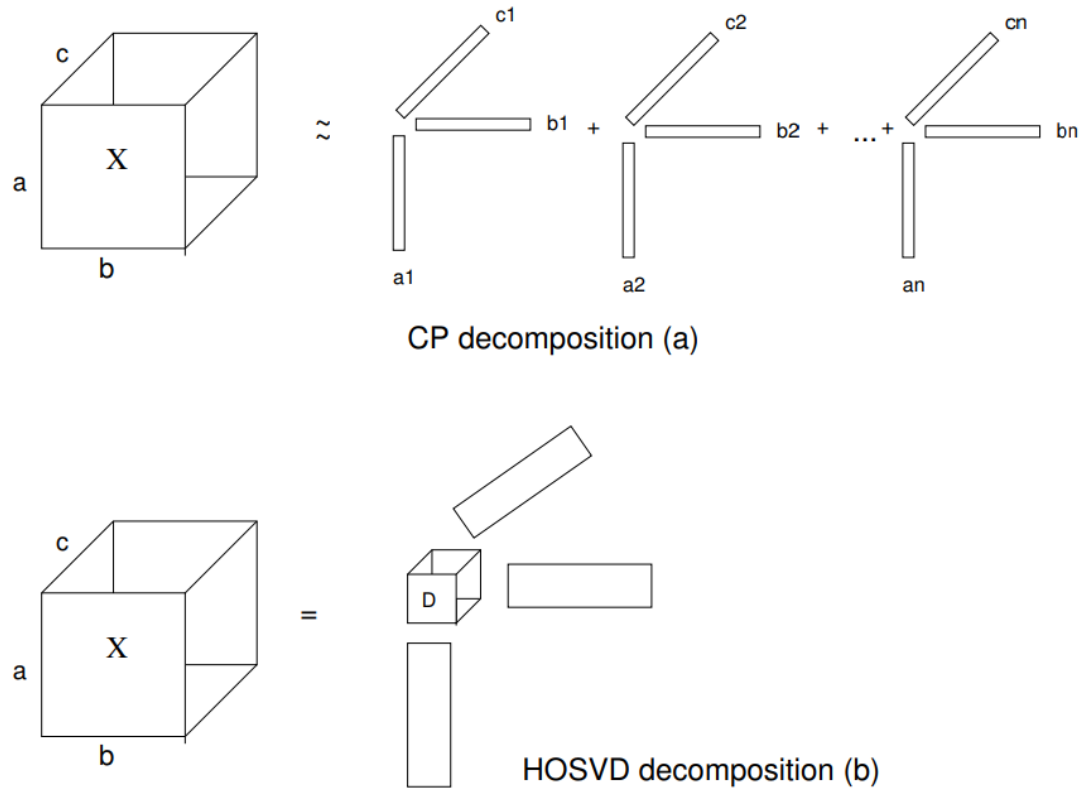

Figure 6: CP and HOSVD decompositions