SSE and SSD:

Page-Efficient Searchable Symmetric Encryption

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- Raphael Bost — DGA
- Pierre-Alain Fouque — Université de Rennes
- Brice Minaud — ENS — CNRS — PSL University — INRIA
- Michael Reichle — ENS — CNRS — PSL University — INRIA

Motivation

Outsource confidential information

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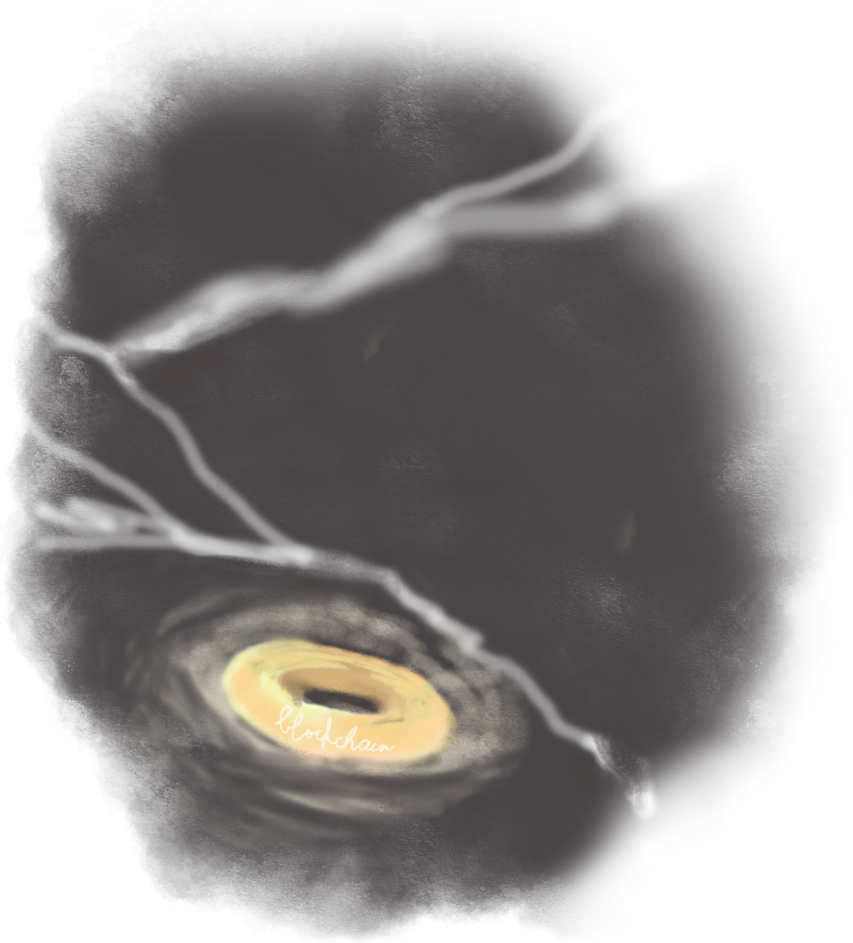

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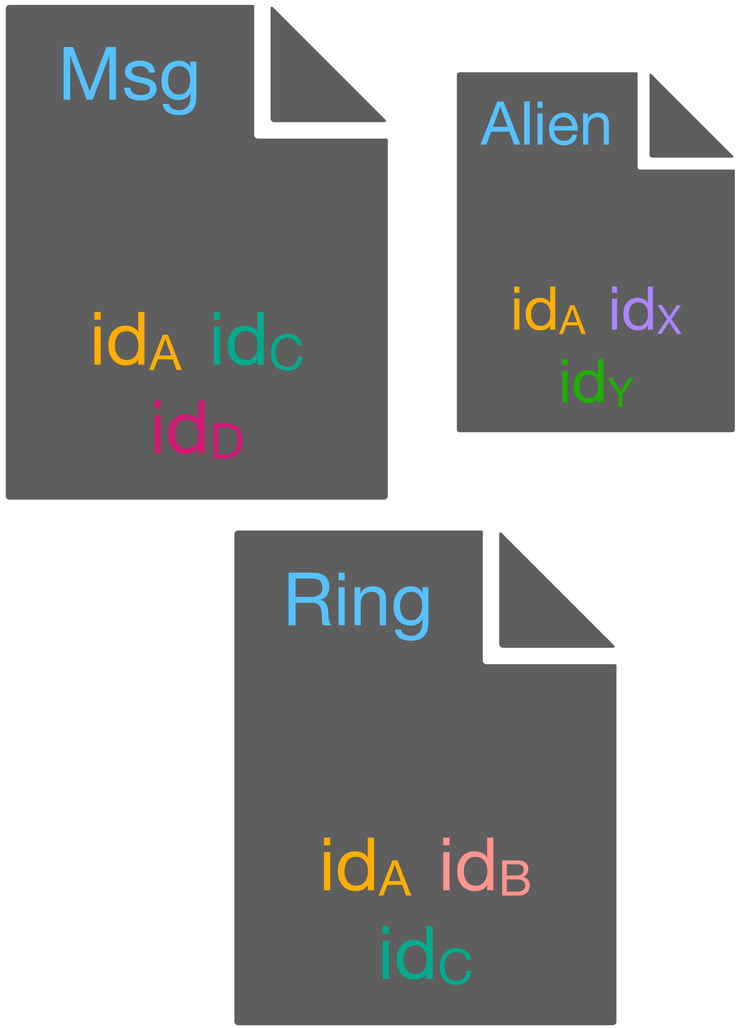

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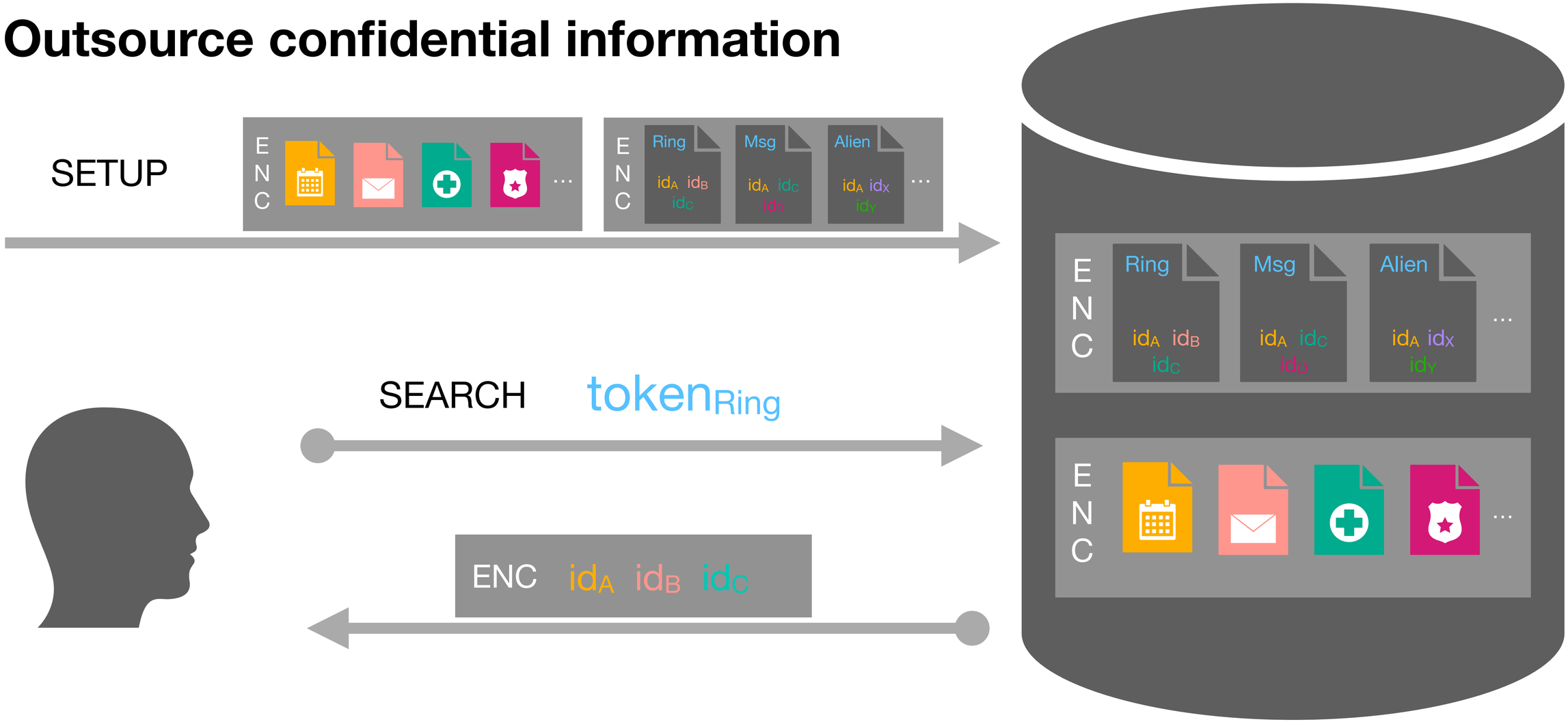

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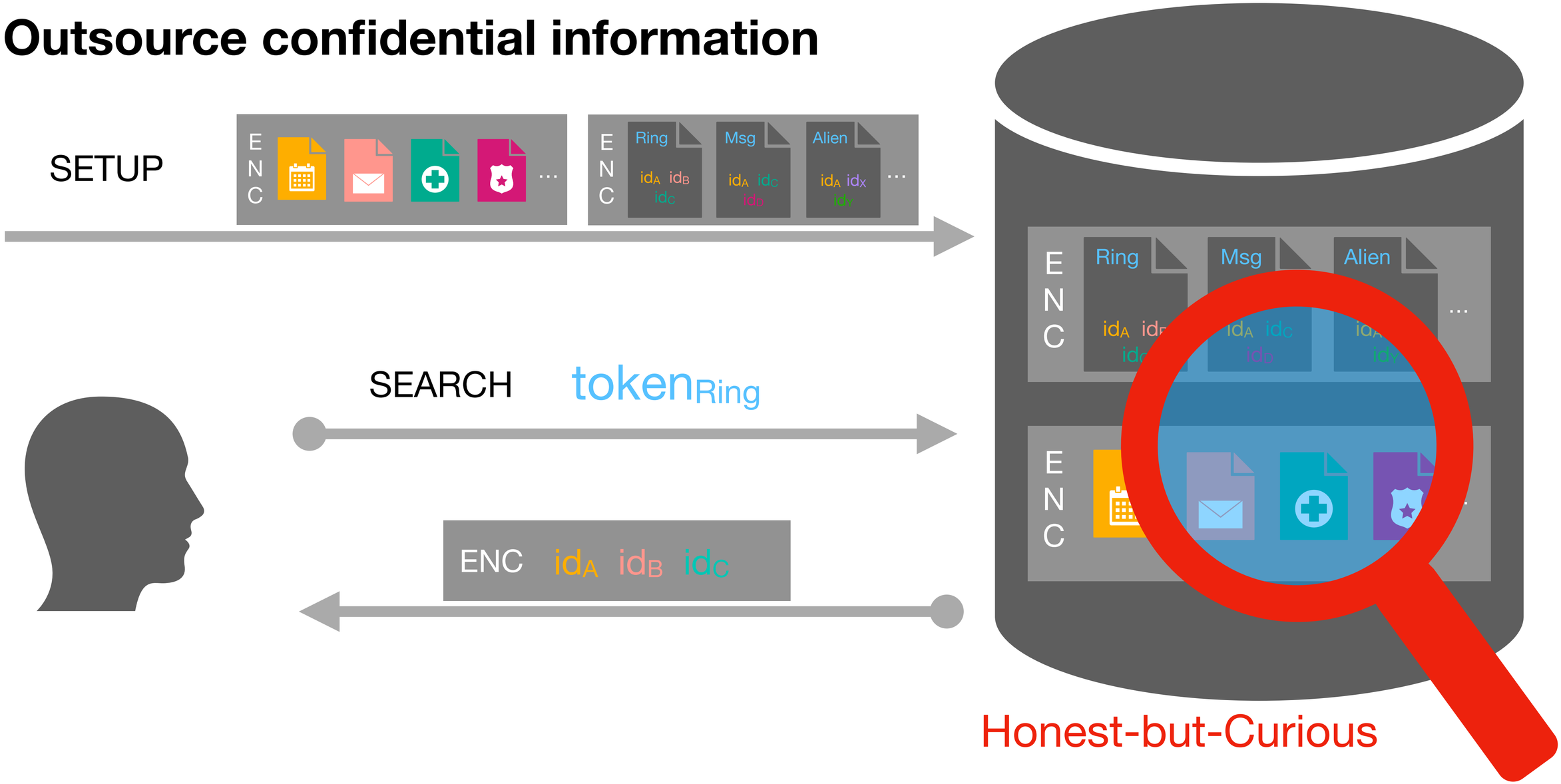
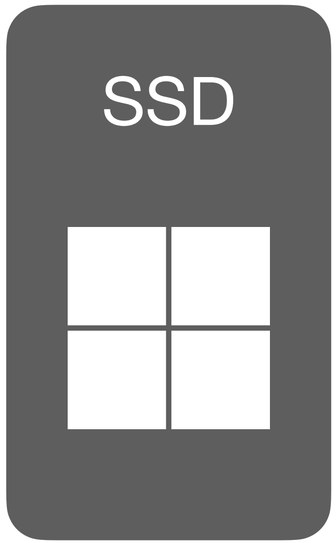


HDDs vs SSDs

Locality:

Number of Read
(non-adjacent)
Memory Locations

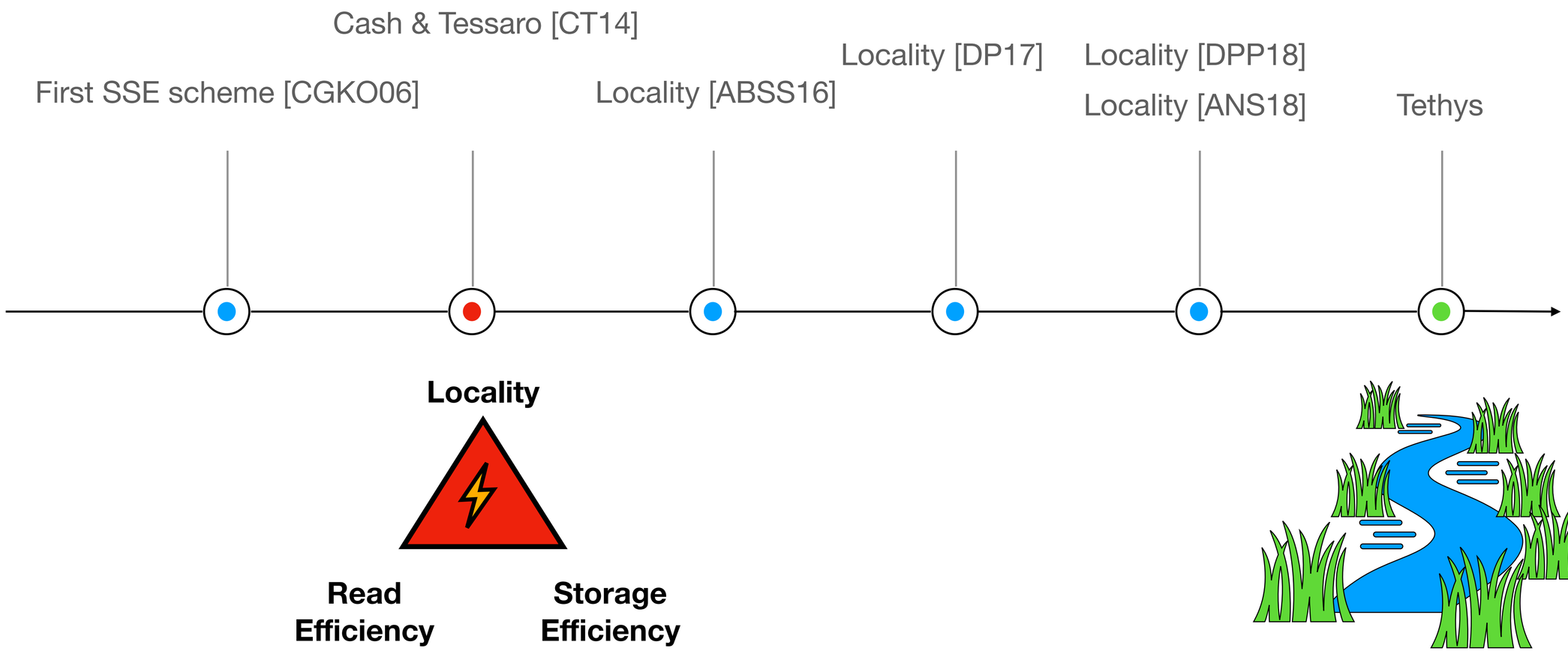


Page Efficiency:

Number of Read
Pages per Query

SSE Research Progress

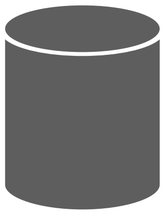
selected articles



Goals

Efficient SSE

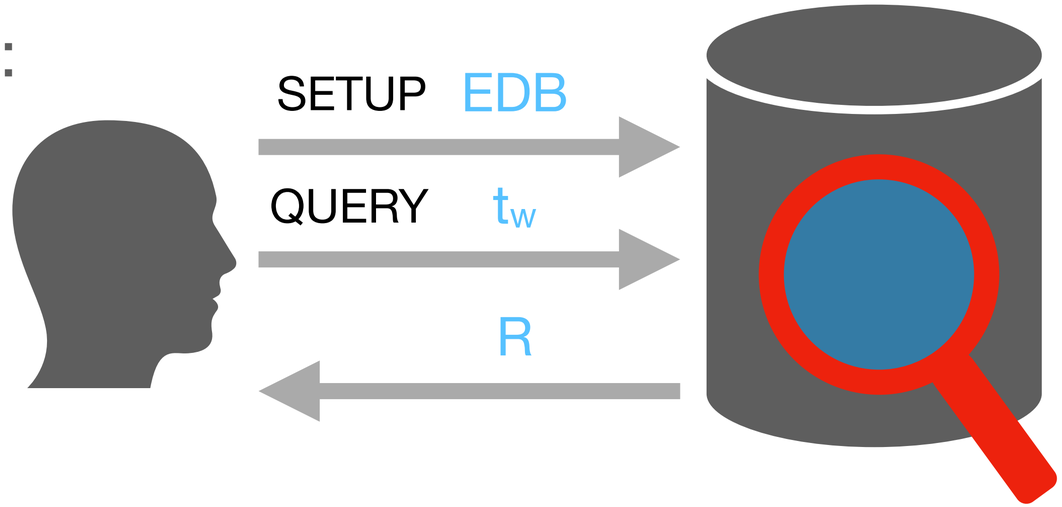
- Page Efficiency:
  - Minimize Page Accesses per Query
- Storage Efficiency:
  - Minimize Server Storage
- Security:
  - Guarantees on Leaked Information



Security

Static SSE

- Game:

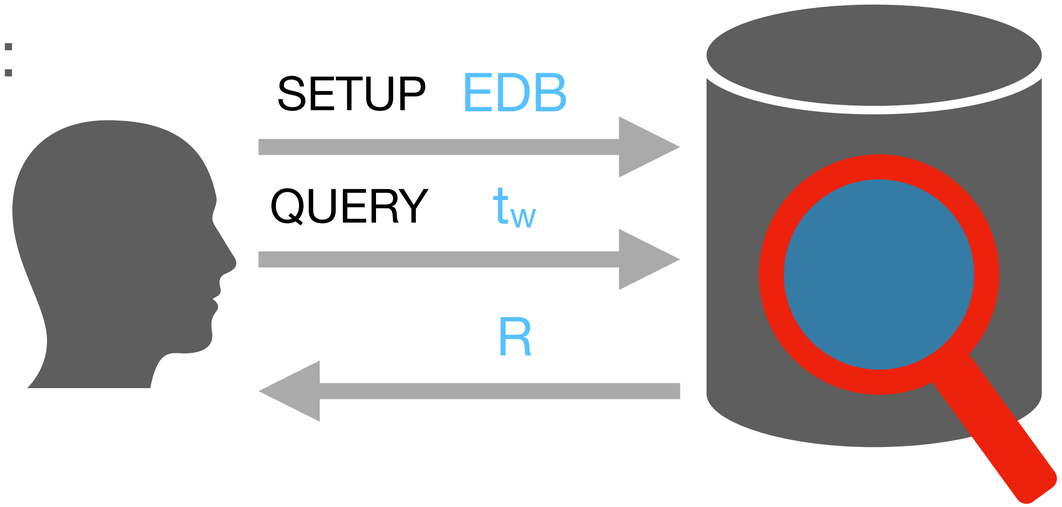


- EDB = SSE.Setup(DB)
- t_w = SSE.Search(DB, w)

Security

Static SSE

- Game:



- $EDB = SSE.Setup(L_{setup}(DB))$
- $t_w = SSE.Search(L_{query}(DB, w))$

- Leakage Function $L = (L_{setup}, L_{query})$:
  - $L_{setup}(DB)$ size(DB)
  - $L_{query}(DB, w)$ size(ids_w), search pattern

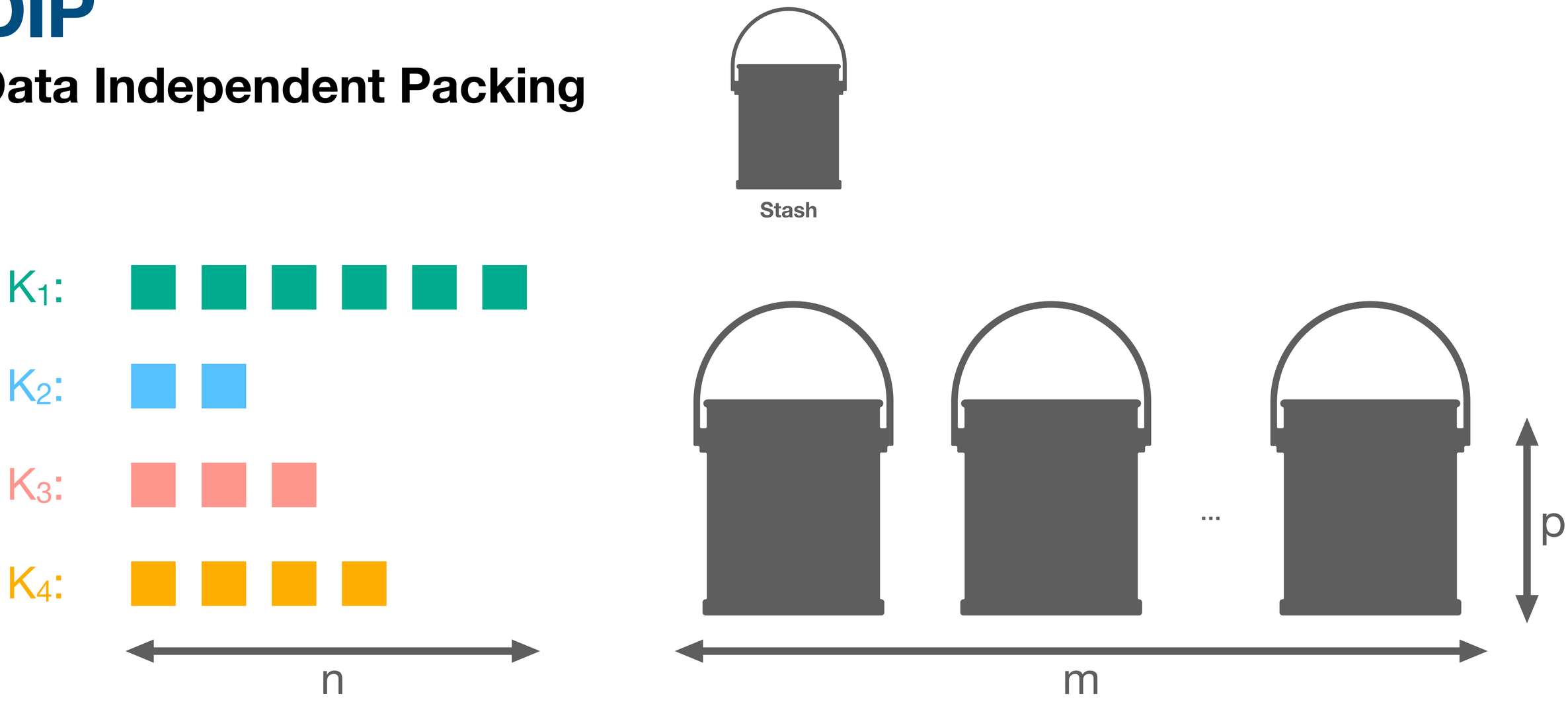
Contribution

This Work

- Page Efficiency:
  - Definition
- Data Independent Packing (DIP):
  - Framework: SSE from DIP
- Tethys:
  - Efficient DIP scheme
  - Based on Cuckoo-Hashing for Weighted Items
  - SSE: optimal page and storage efficiency

DIP

Data Independent Packing



DIP

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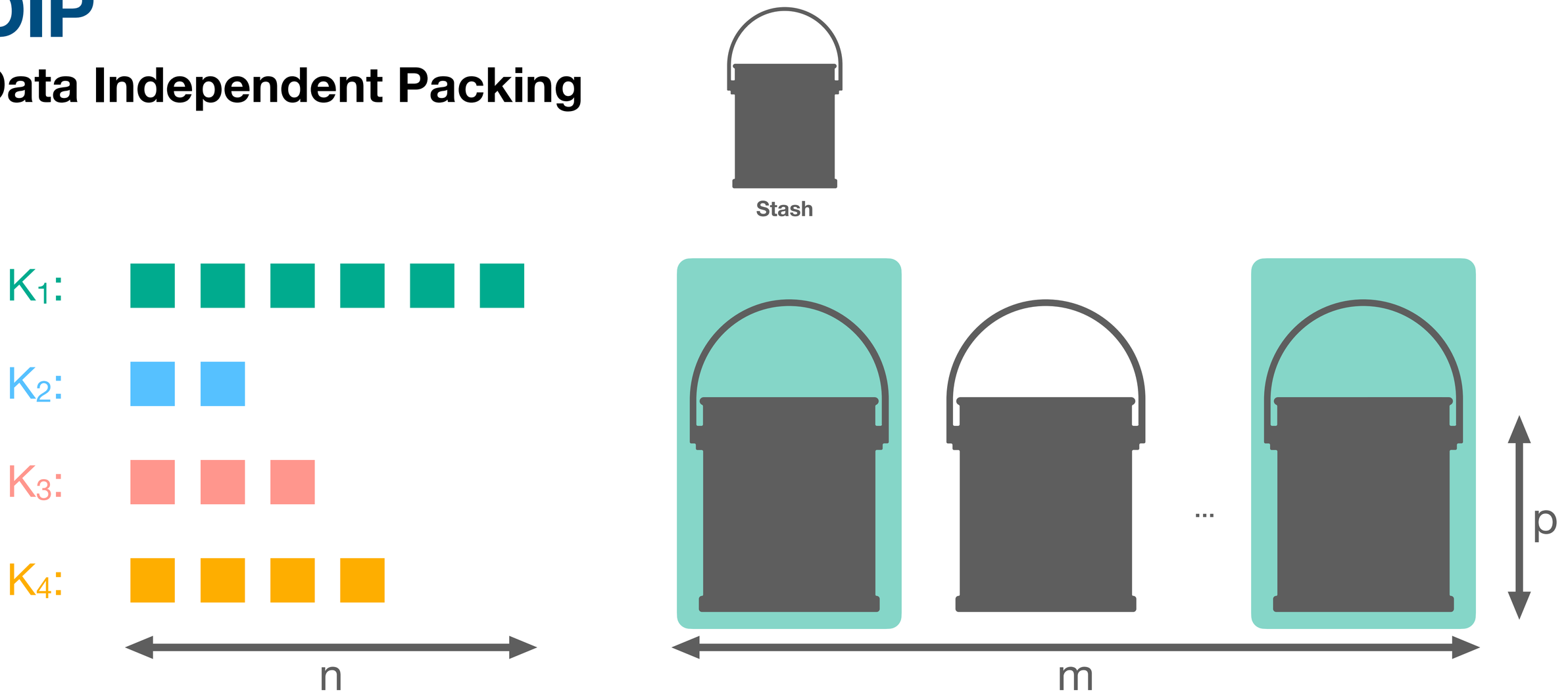

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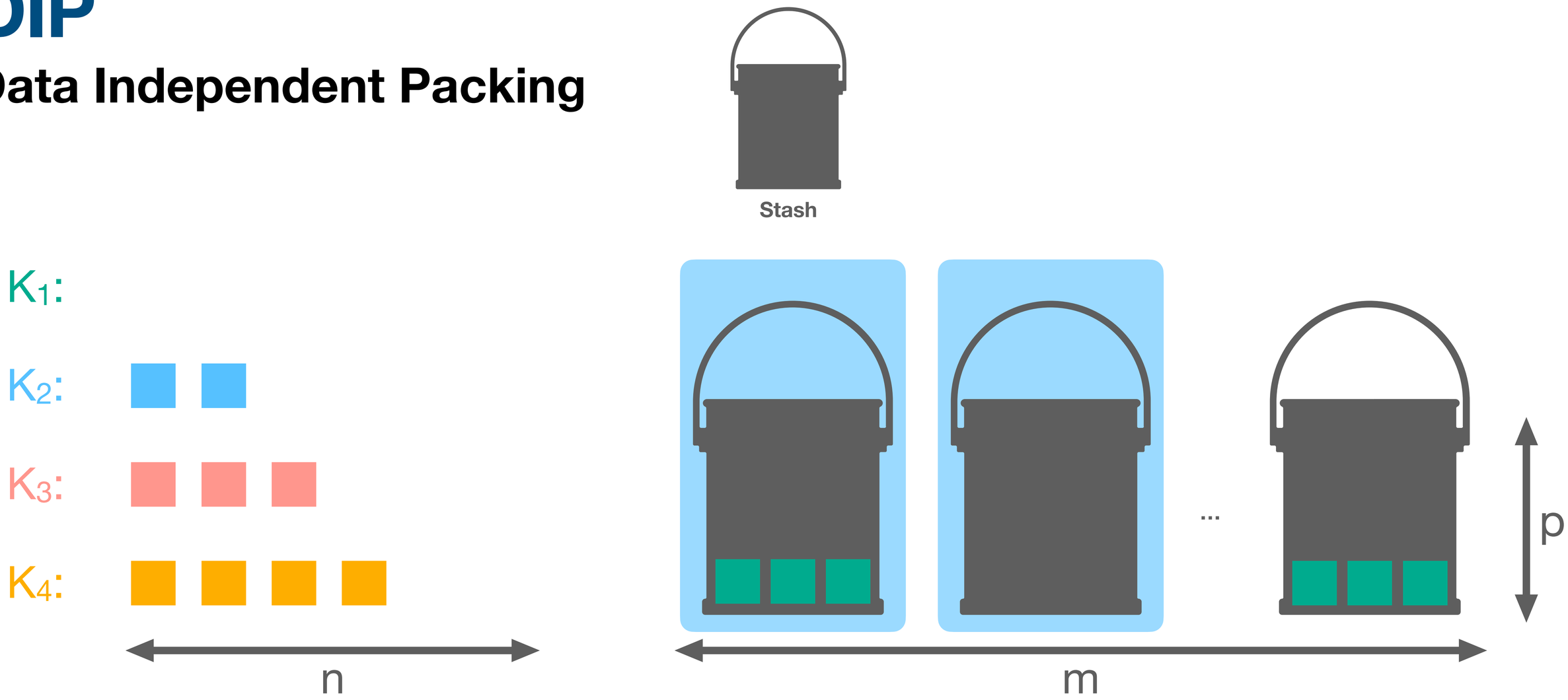

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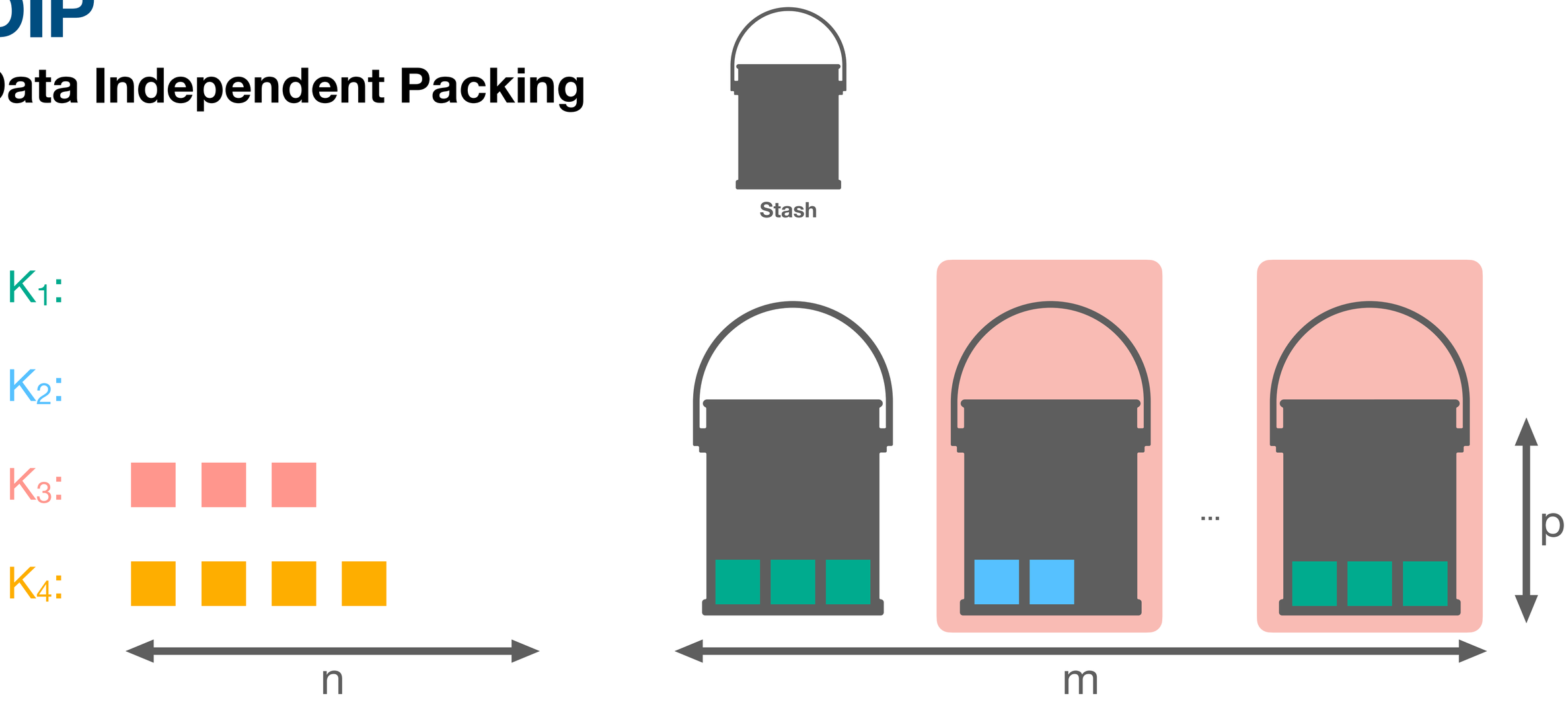

DIP

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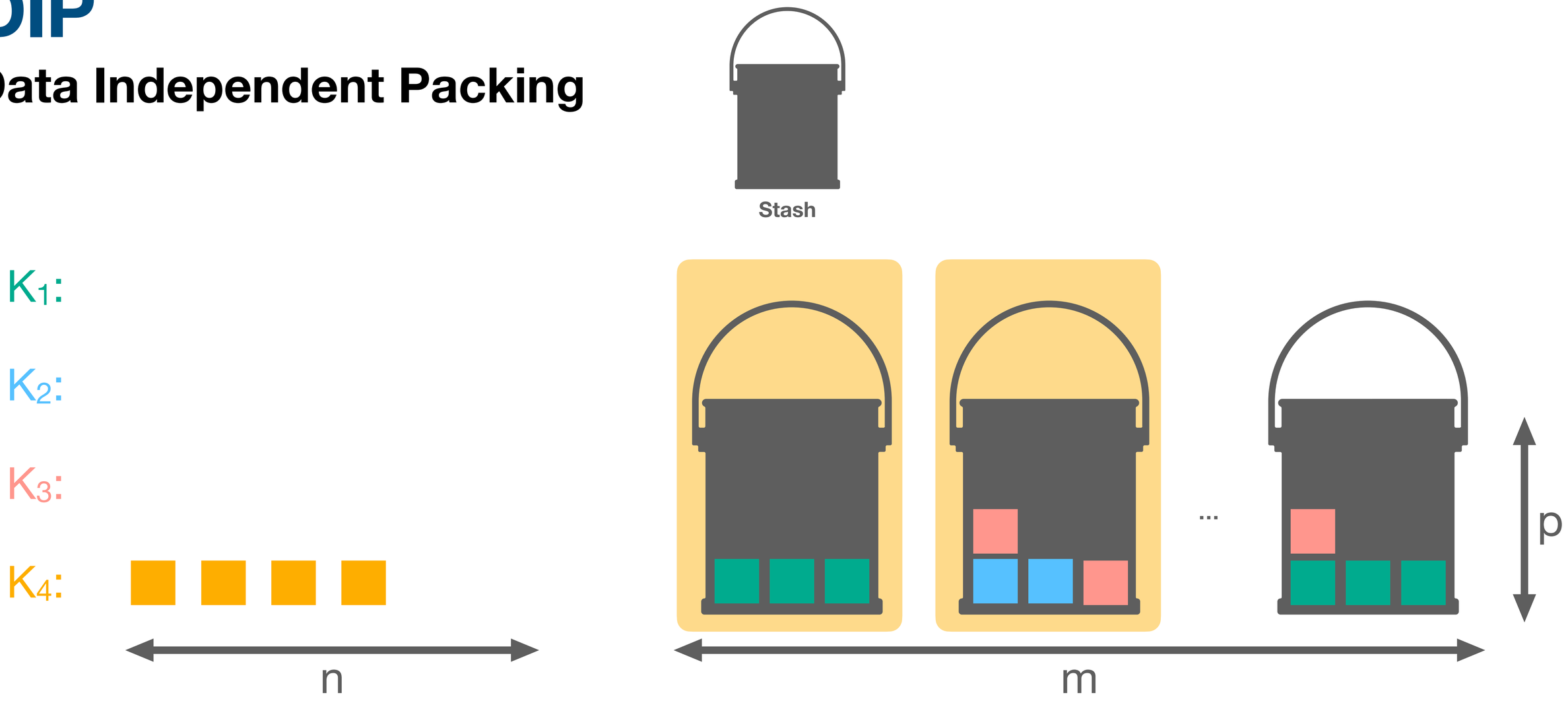


DIP

Definition

Size(n):

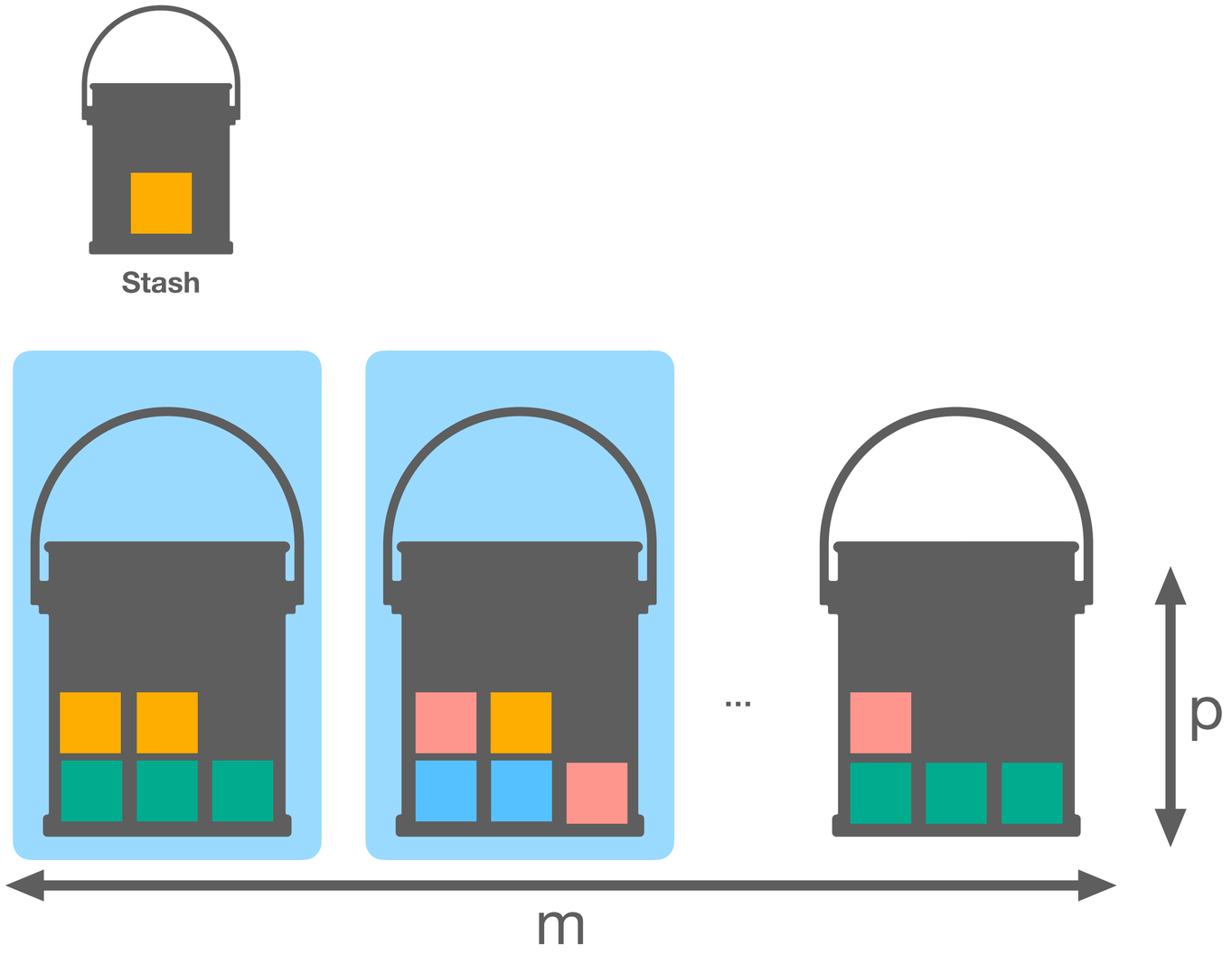
- Return m, the Number of Buckets

Build(M):

- Returns Buckets filled with Items from Multi-Map M
- Allows for Stash S

Lookup(m, K_i, ℓ_i):

- Return Bucket Indices



DIP

Efficiency

Lookup Efficiency:

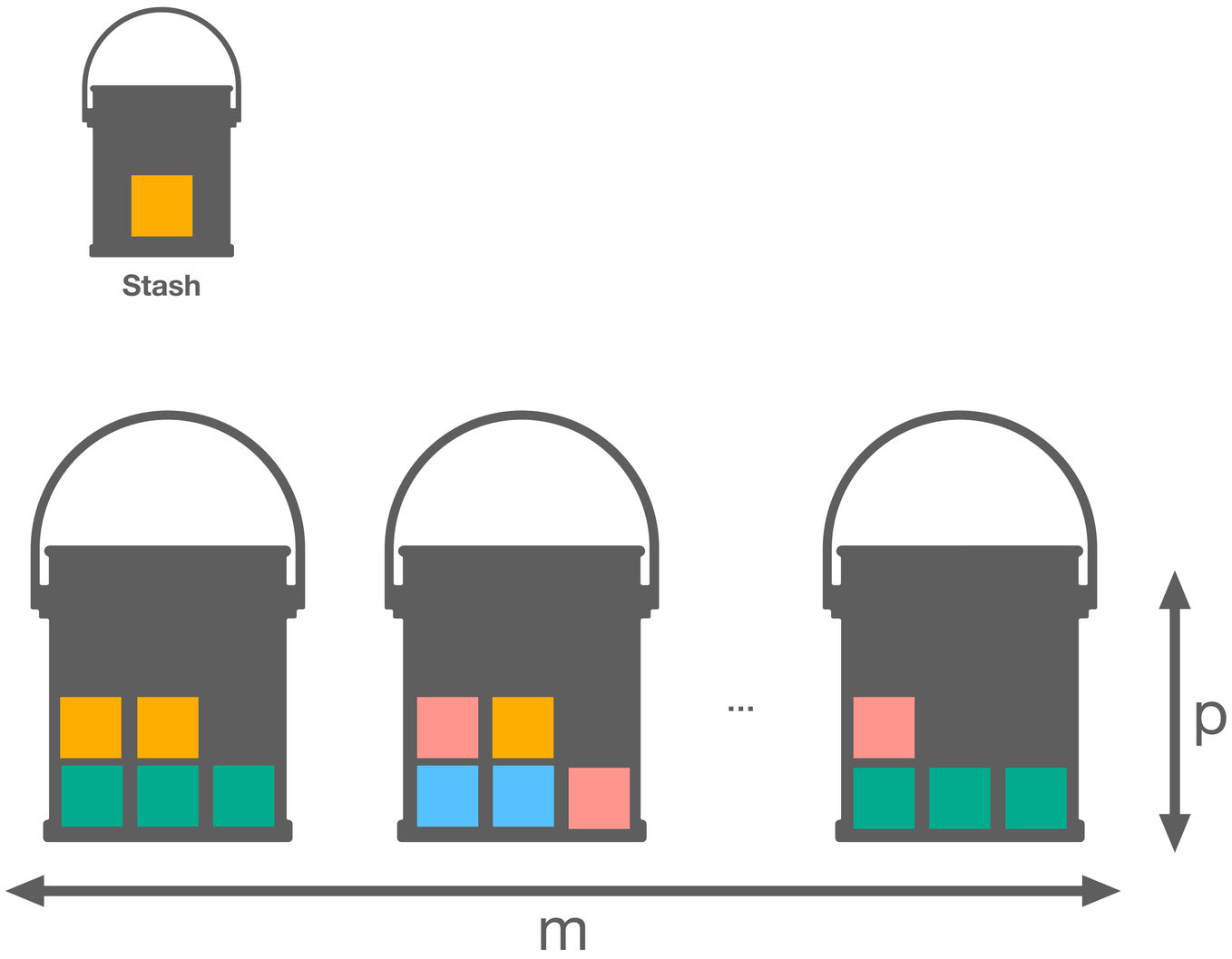
- number of buckets per keyword

Storage Efficiency:

- (m•p) / n

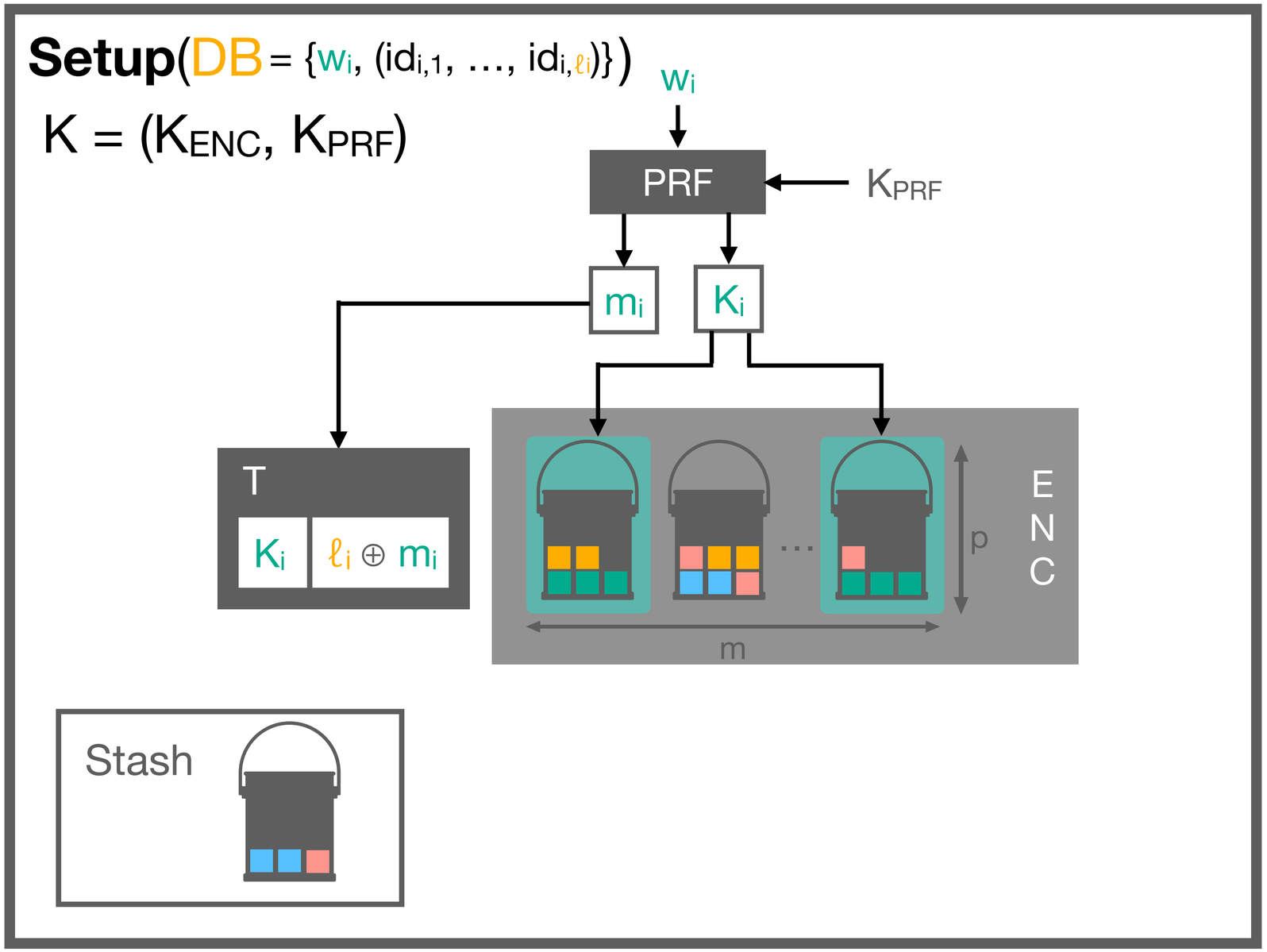
Stash Size:

- Size of Stash S



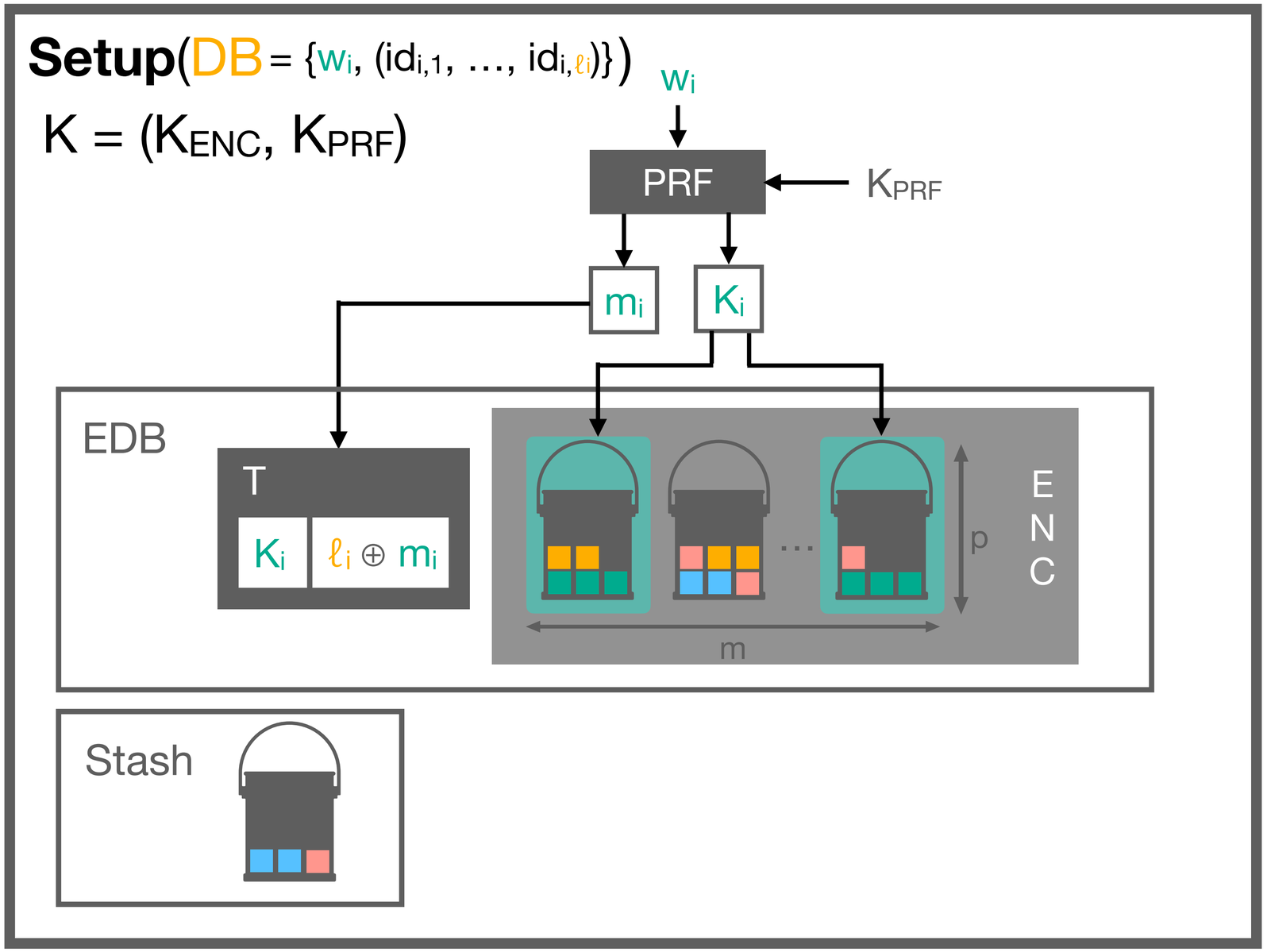
DIP ⇒ SSE

Framework



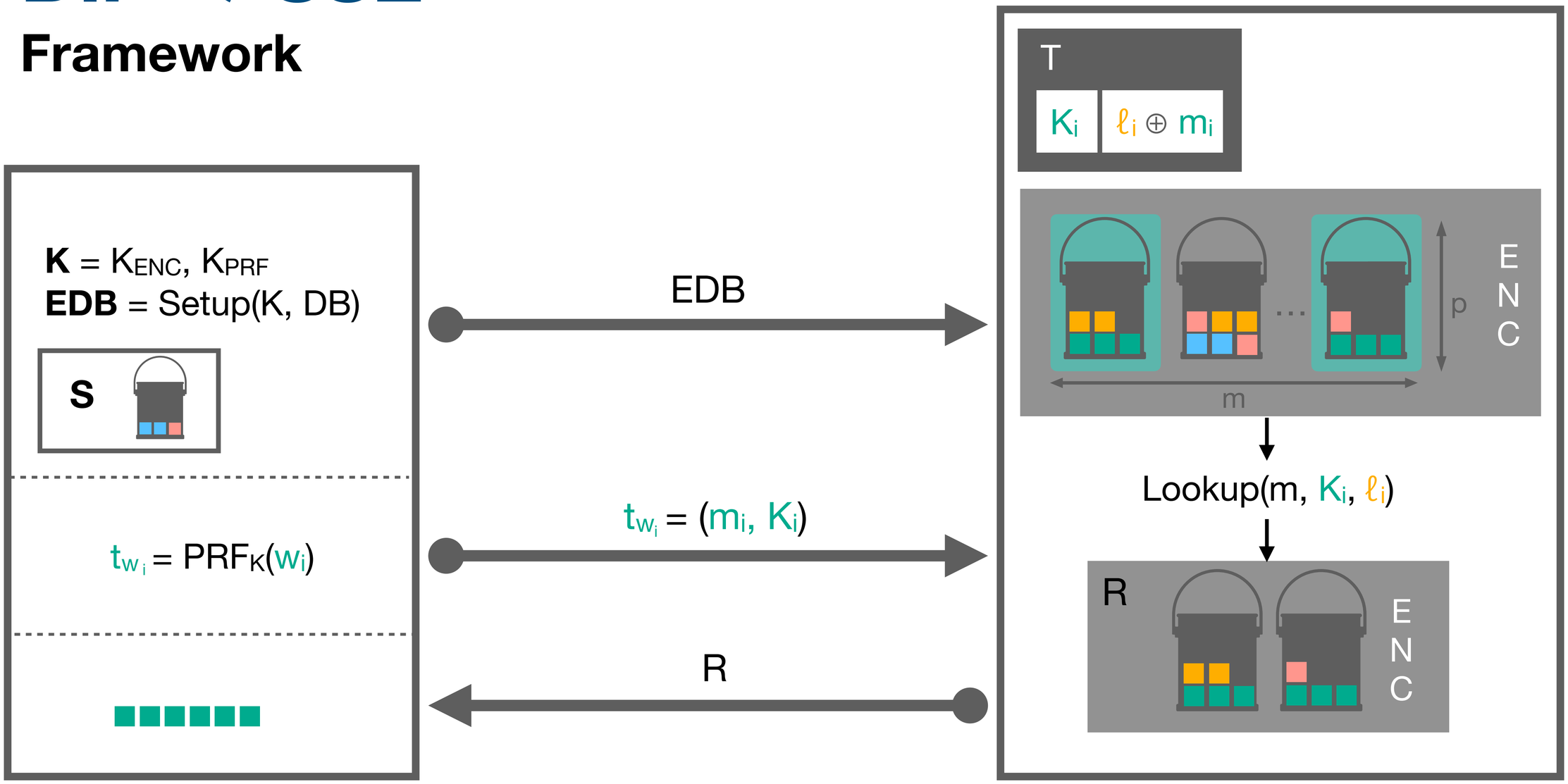
DIP ⇒ SSE

Framework



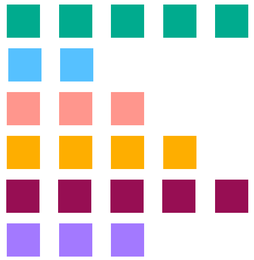
DIP ⇒ SSE

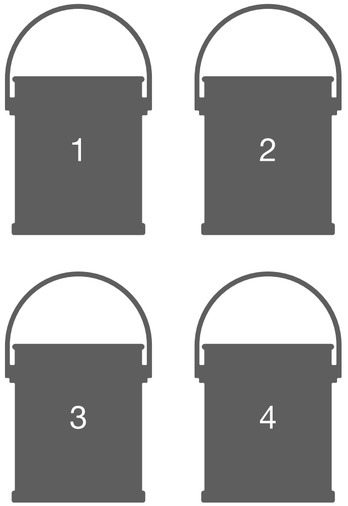
Framework



Tethys

Efficient DIP





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1

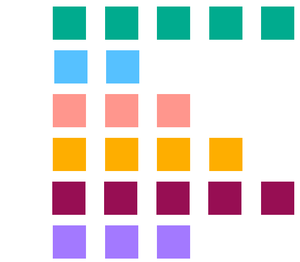
2

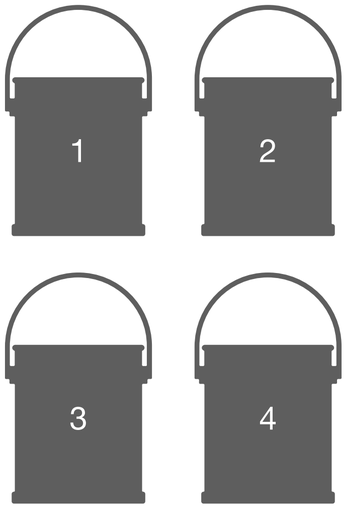
4

3

Tethys

Efficient DIP





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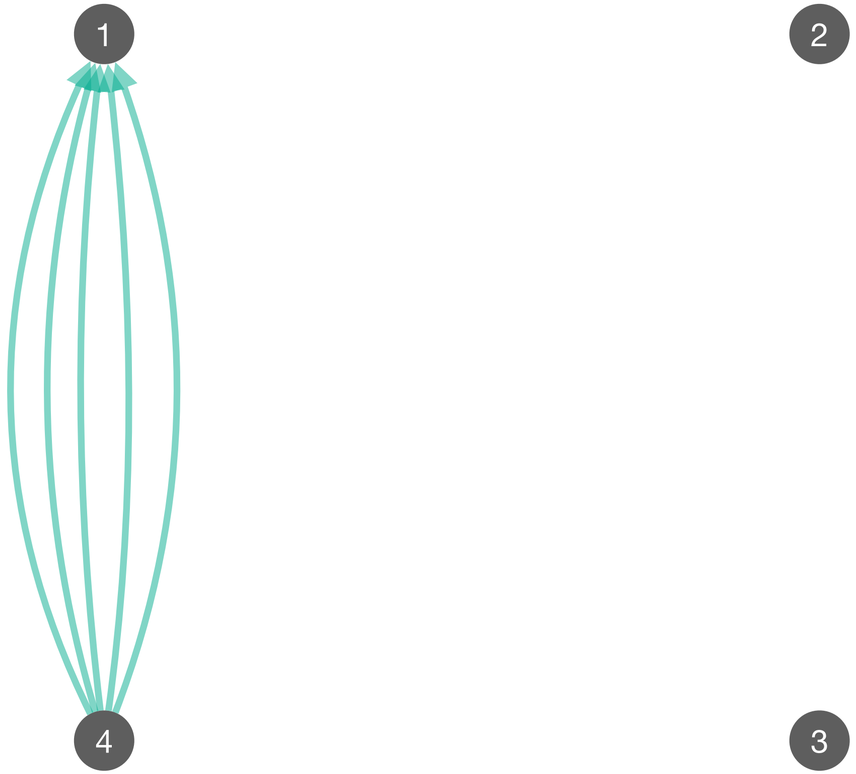

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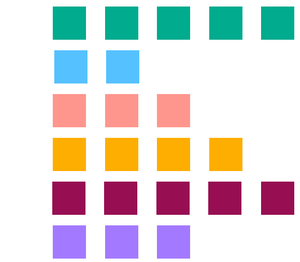

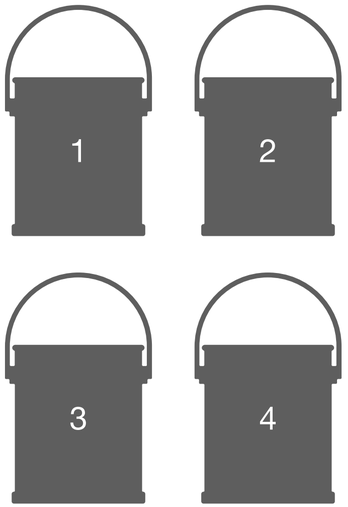

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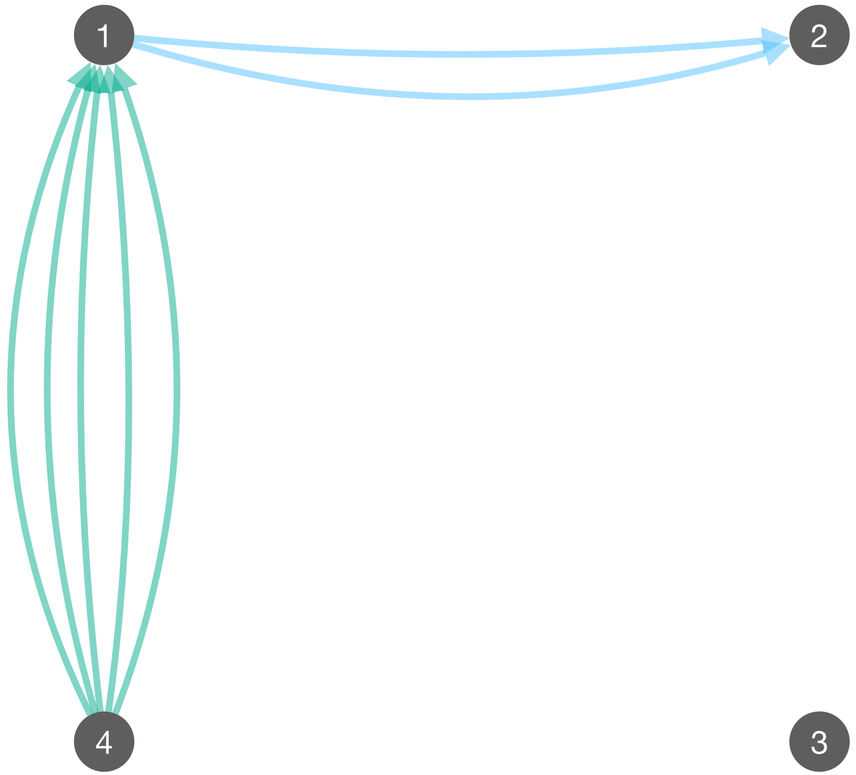

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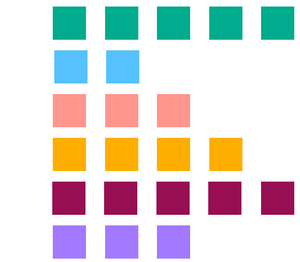

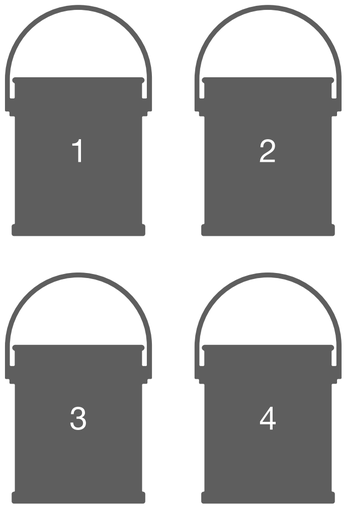

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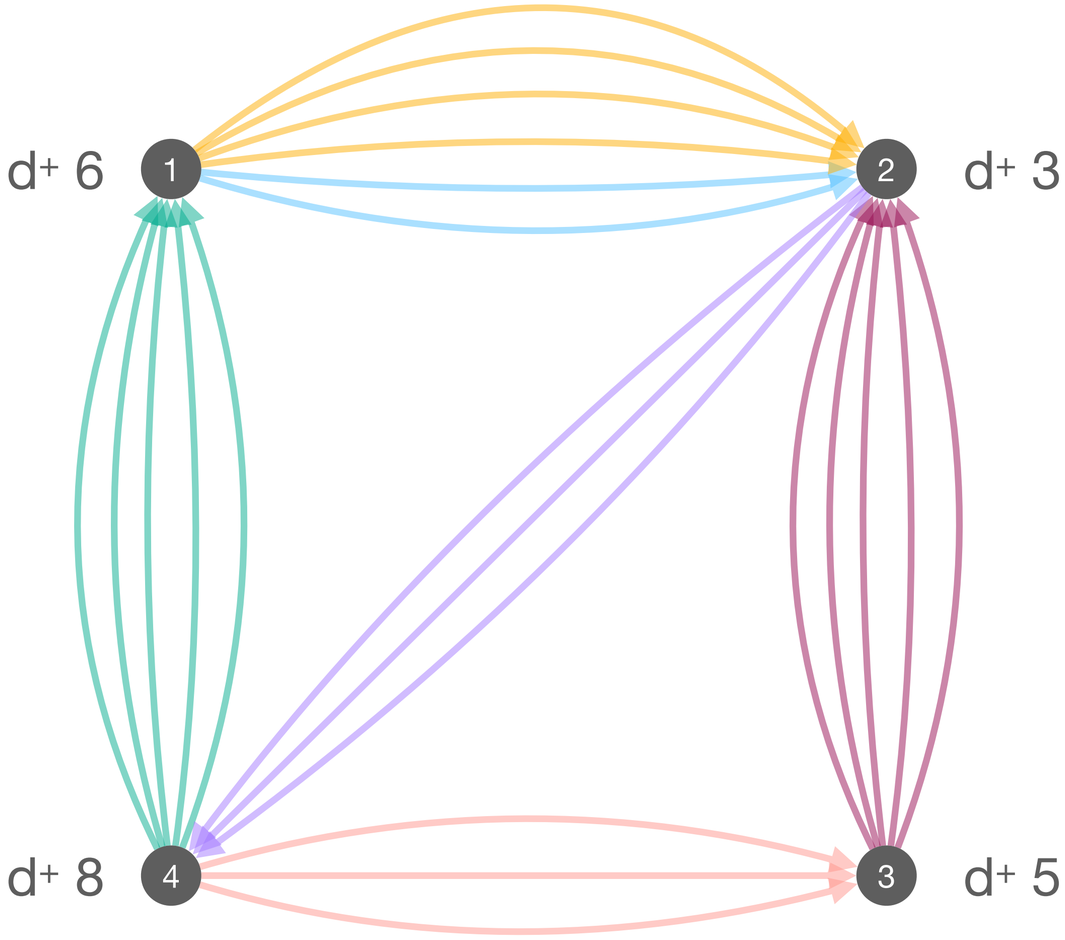

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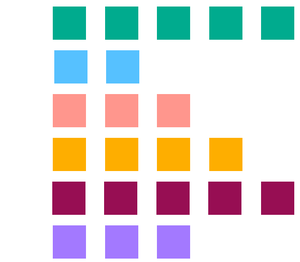

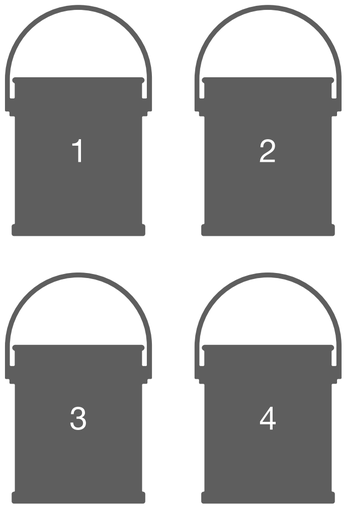

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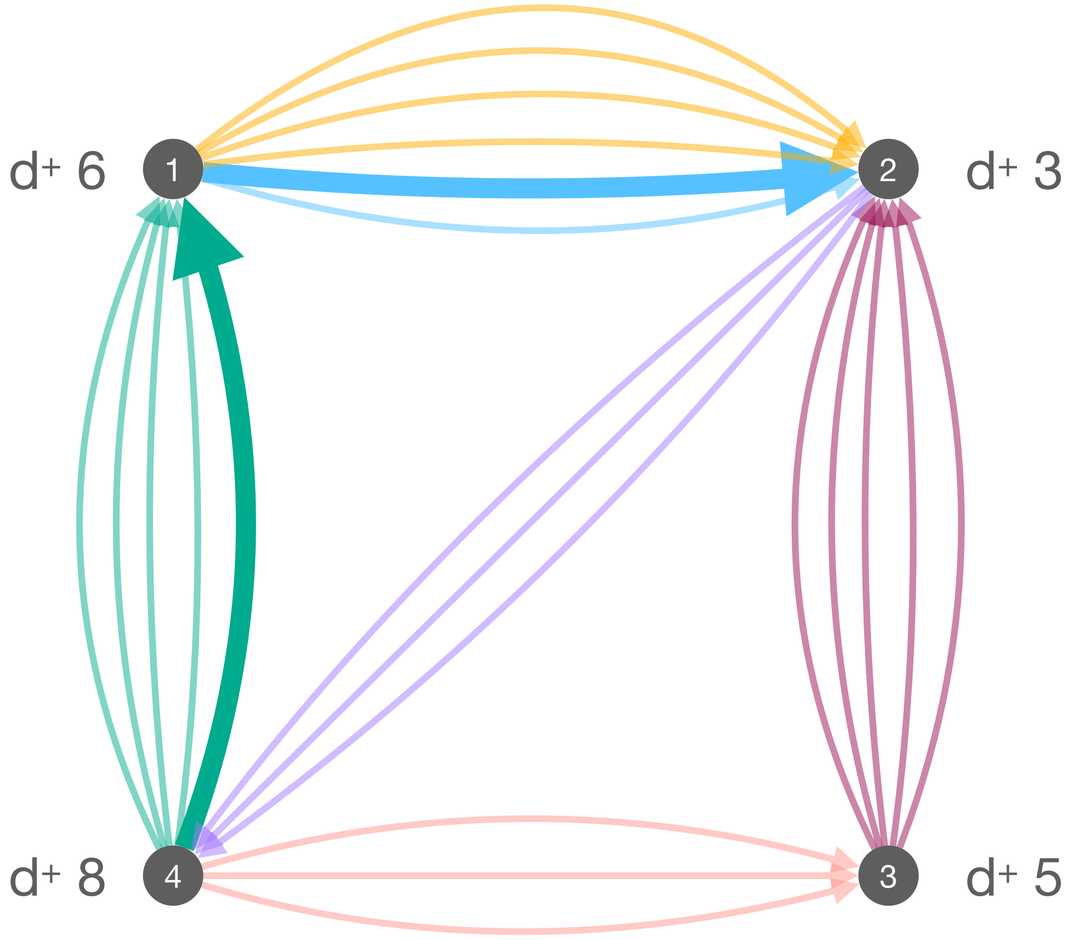

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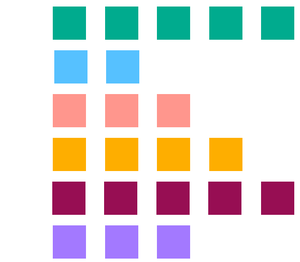

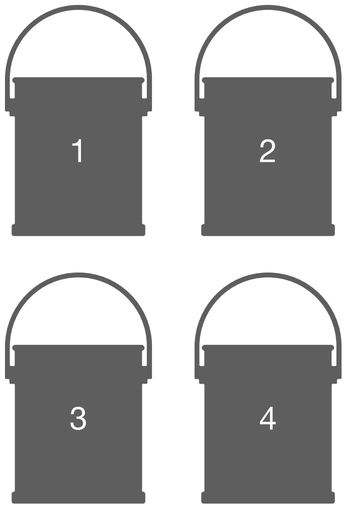

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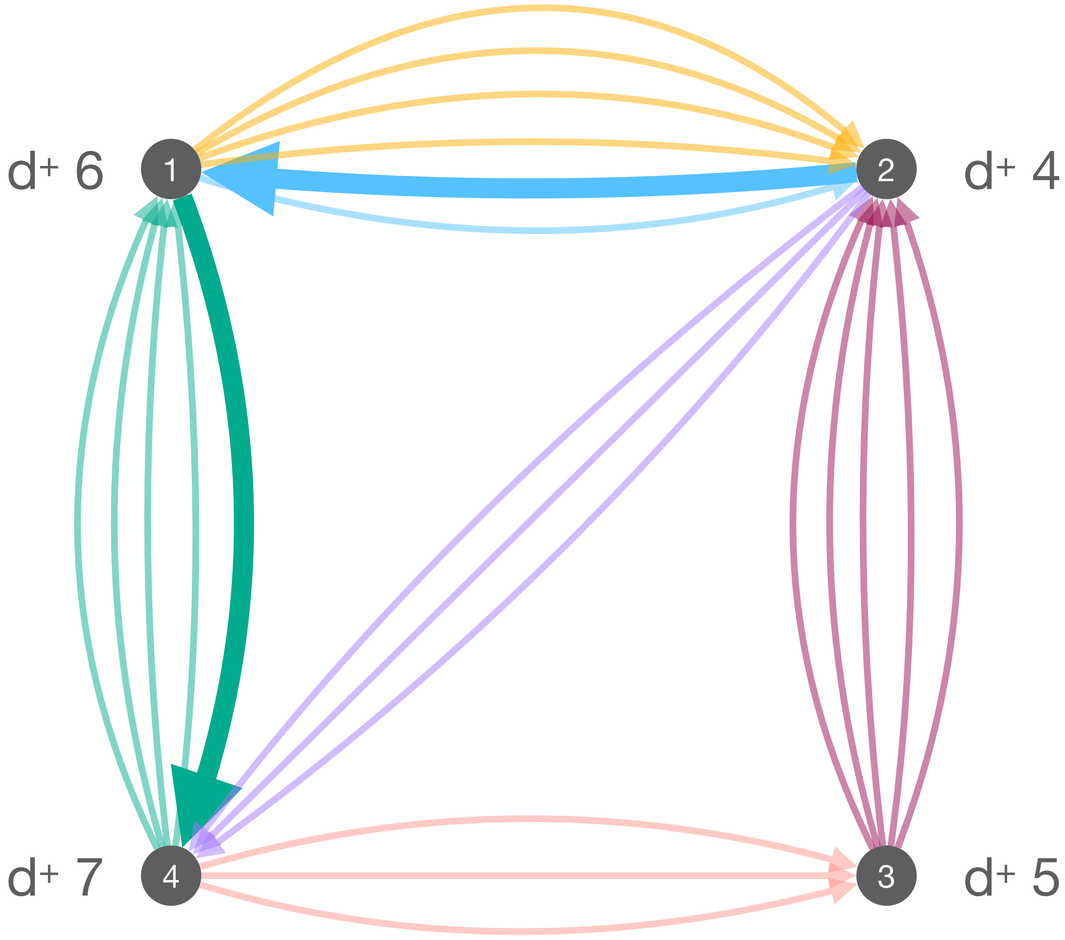

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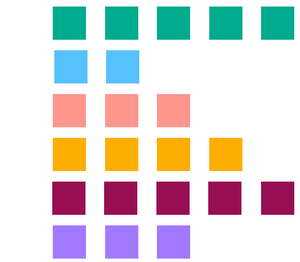

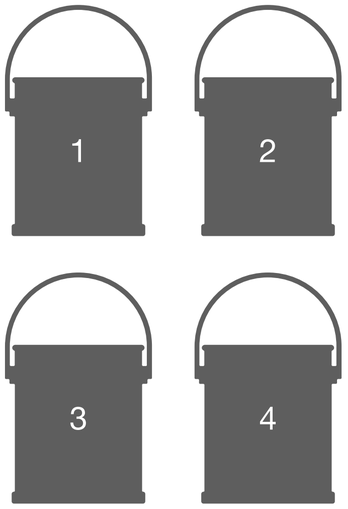

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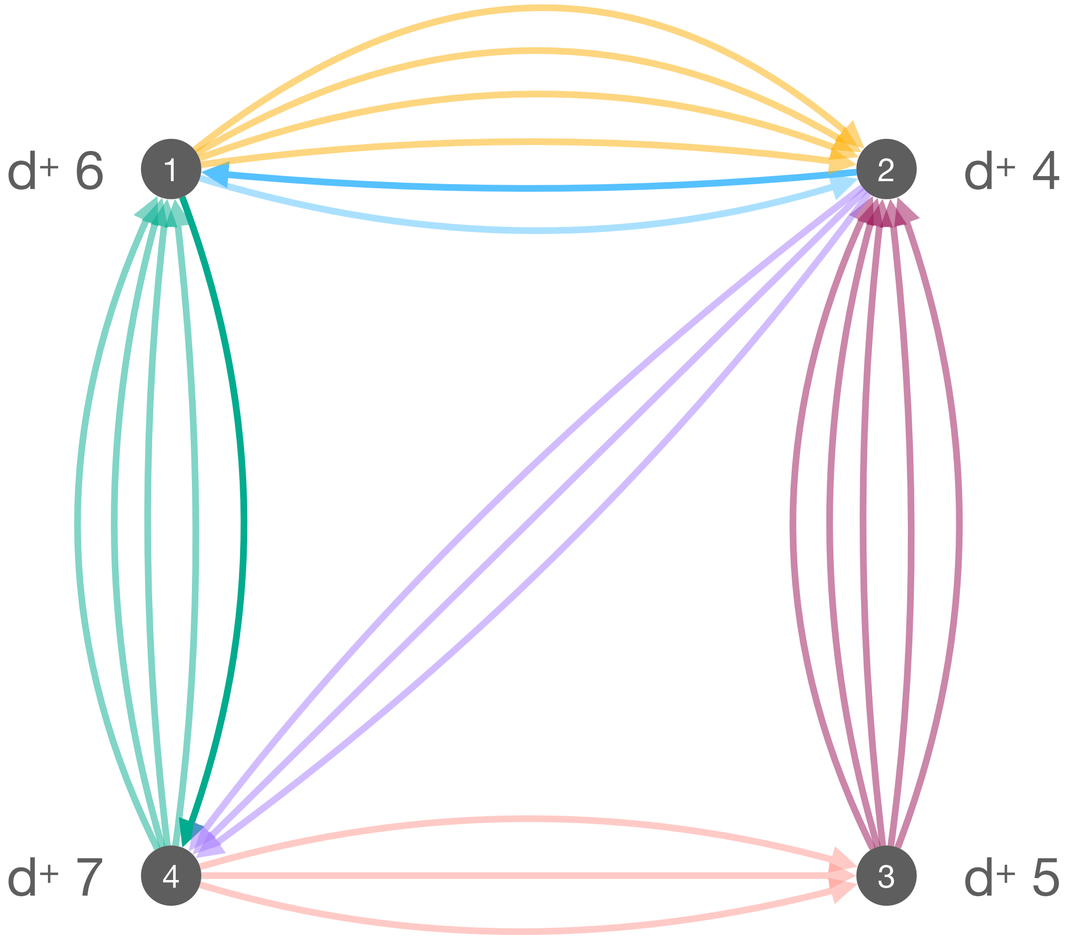

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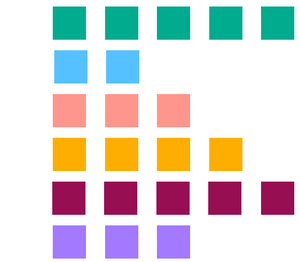

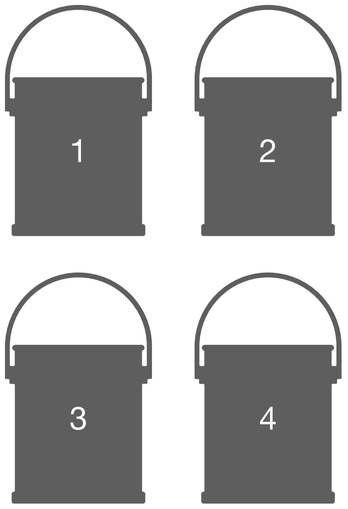

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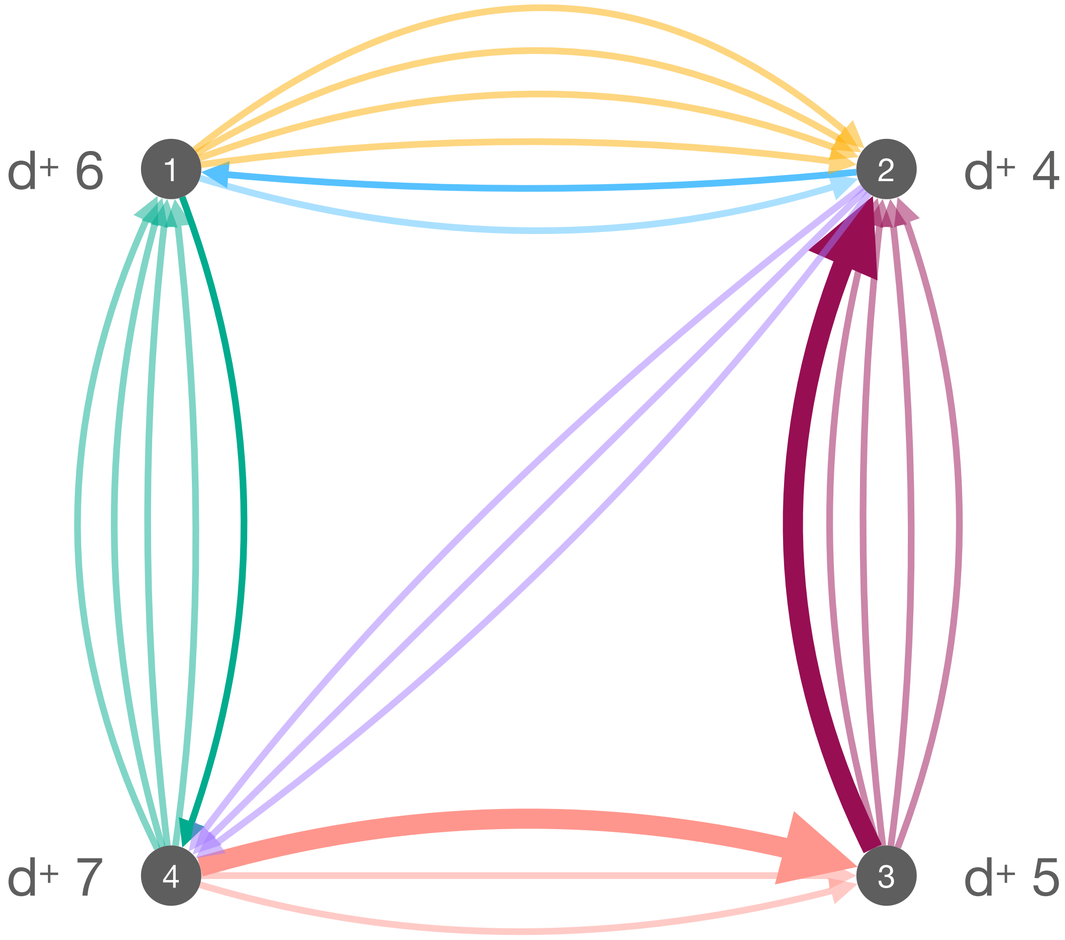

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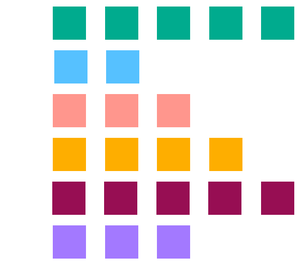

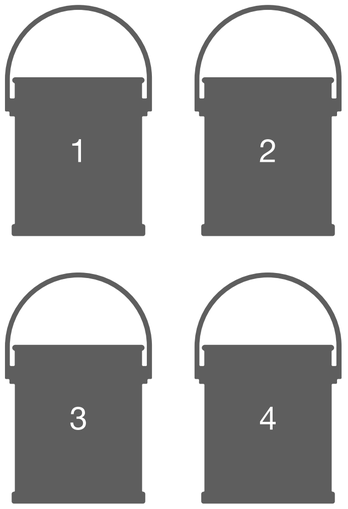

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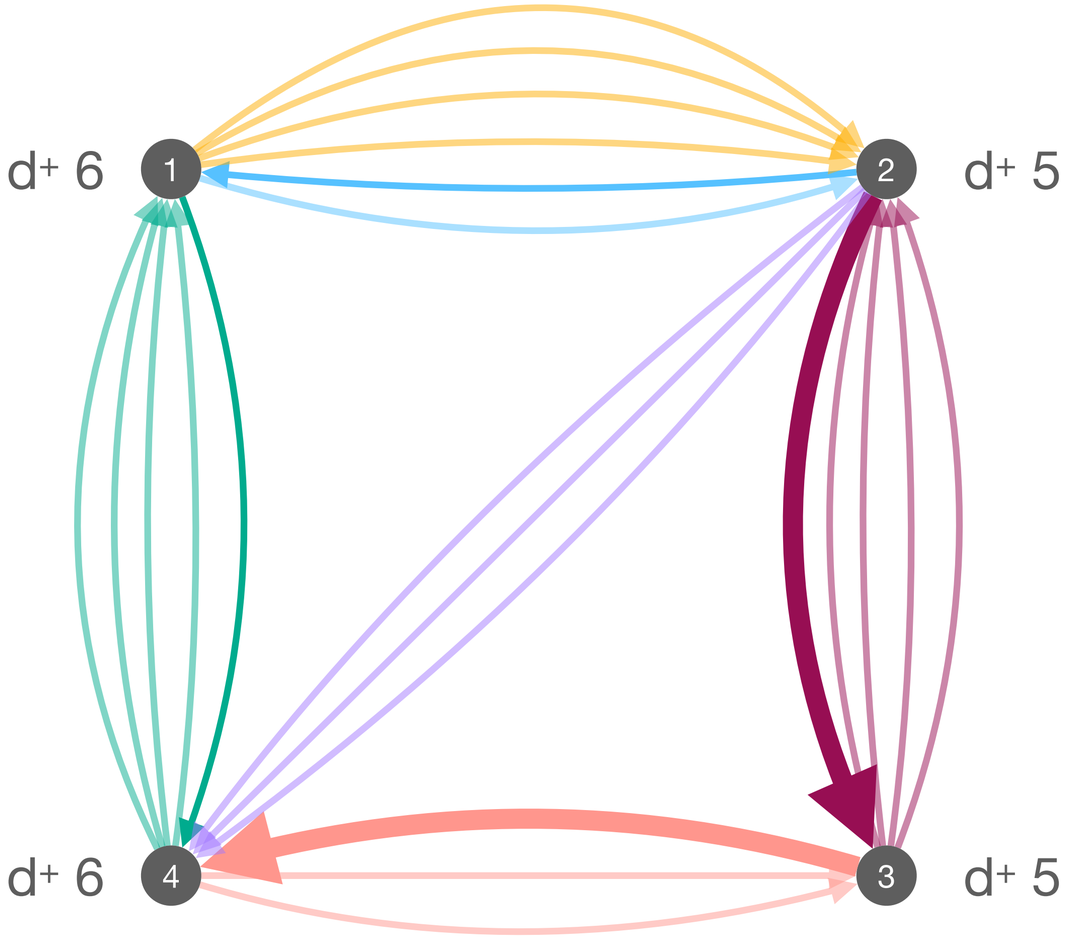

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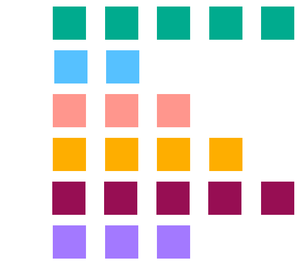

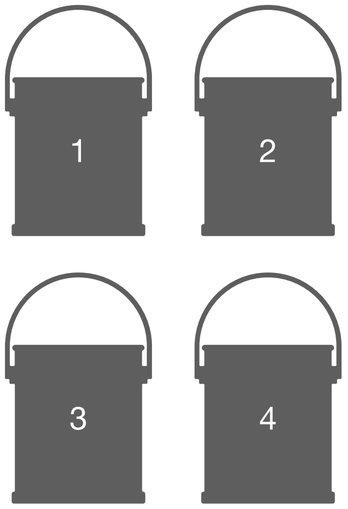

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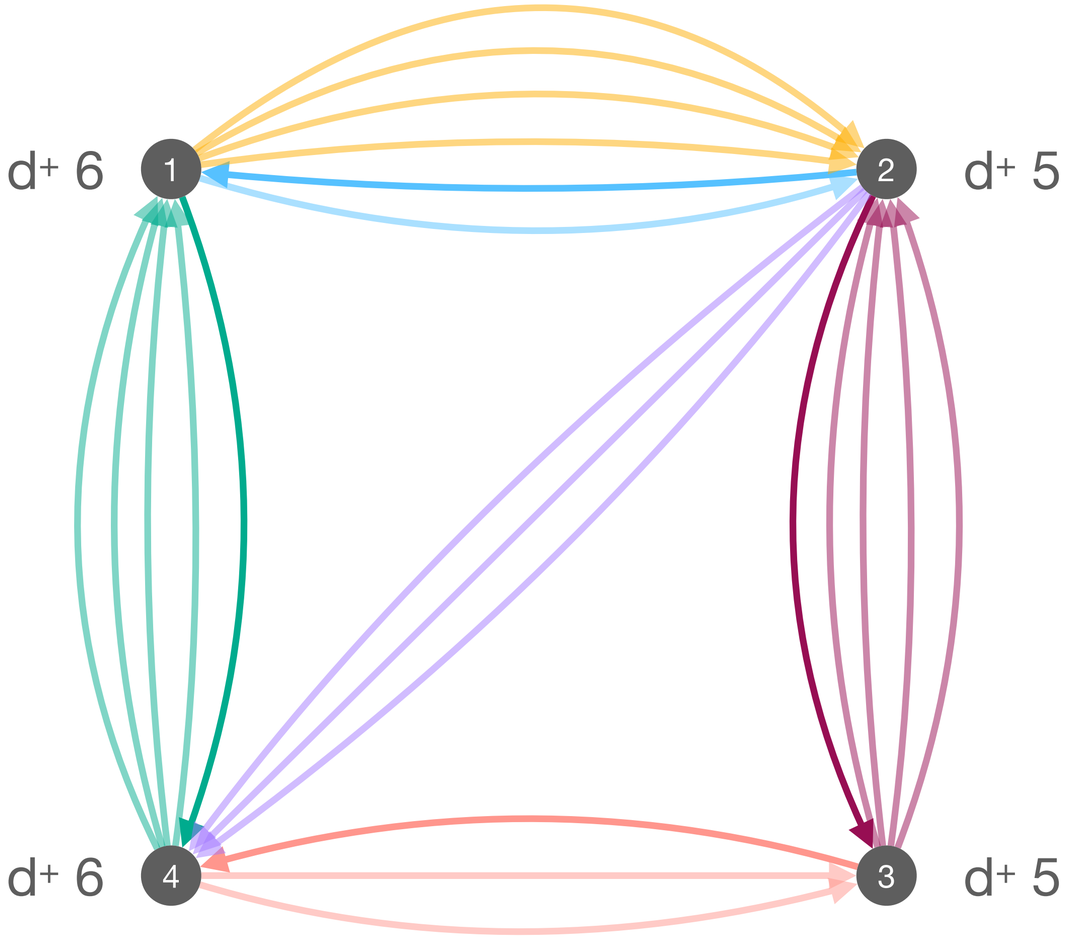

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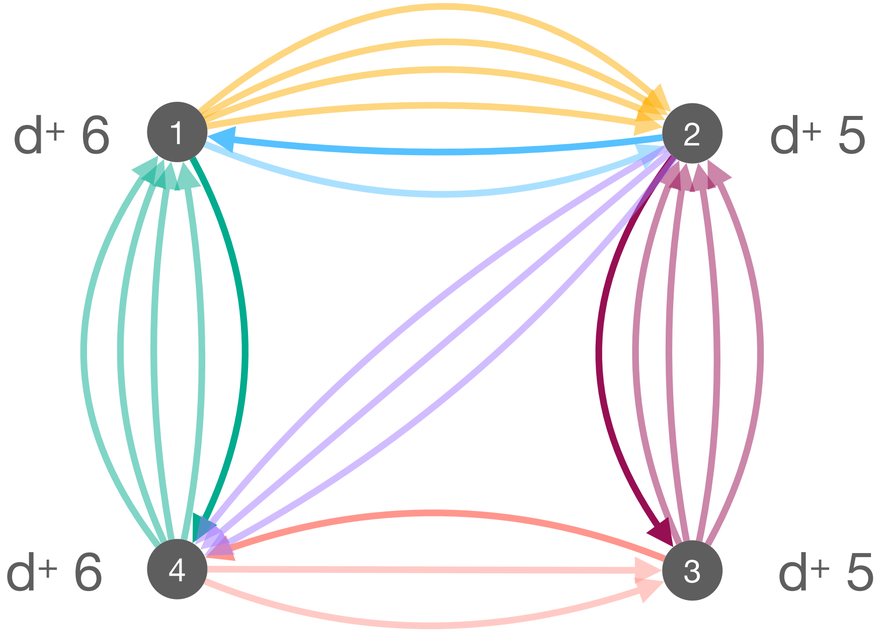

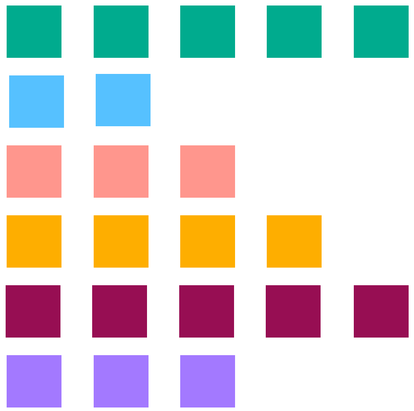

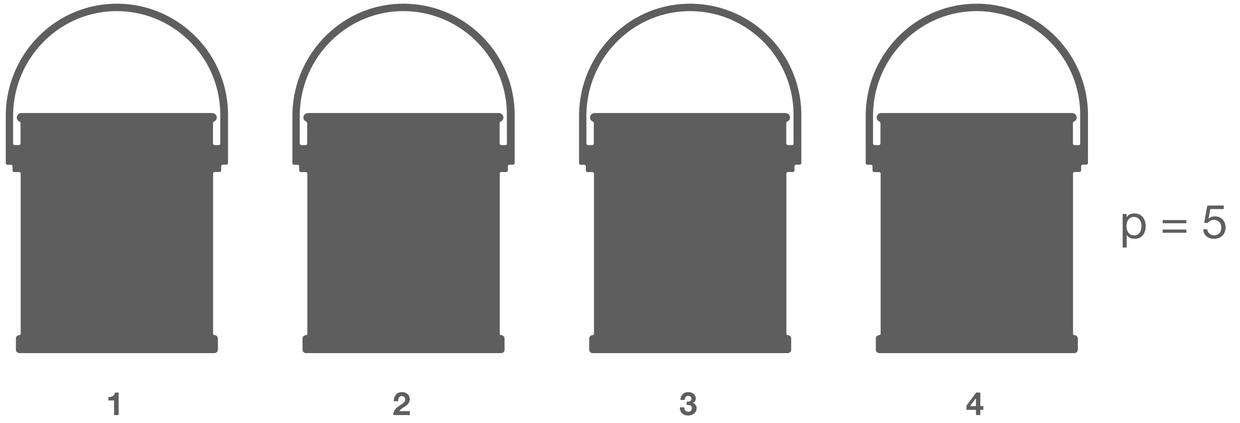

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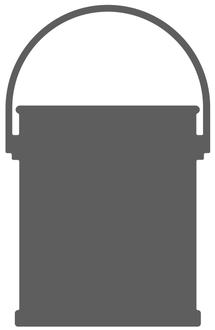

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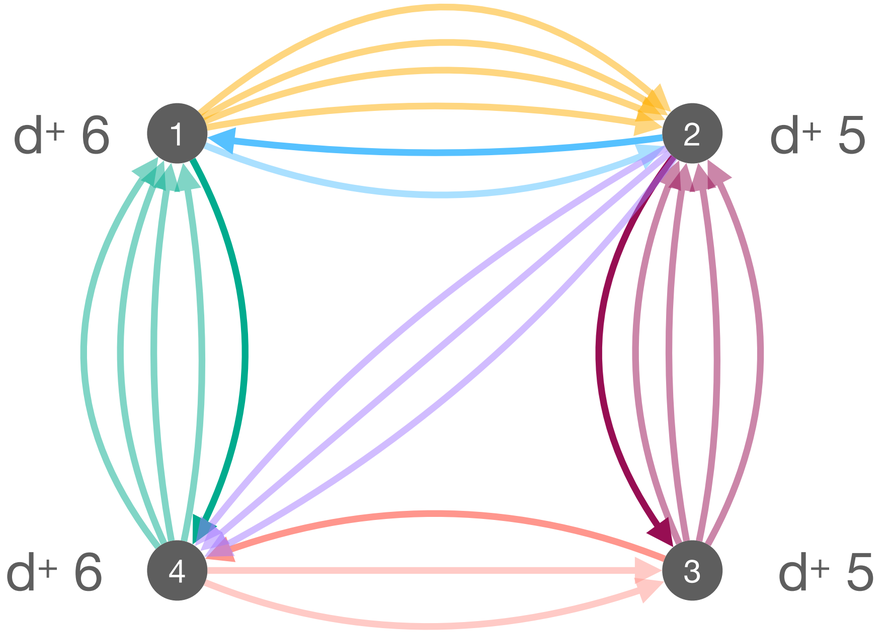

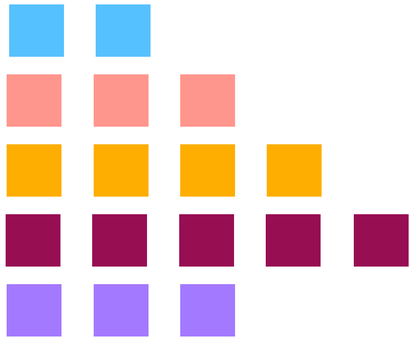

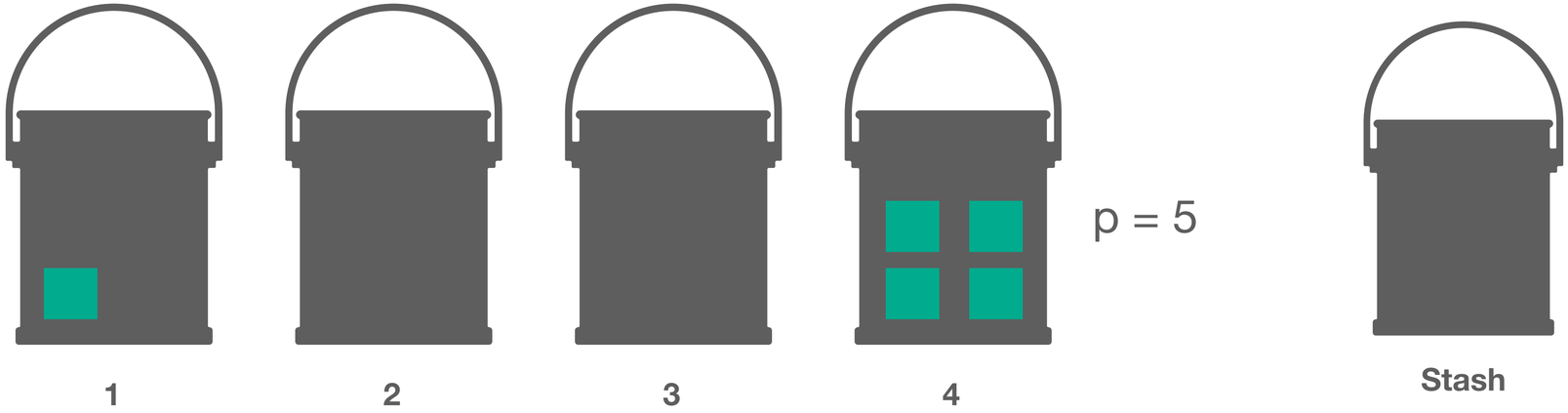

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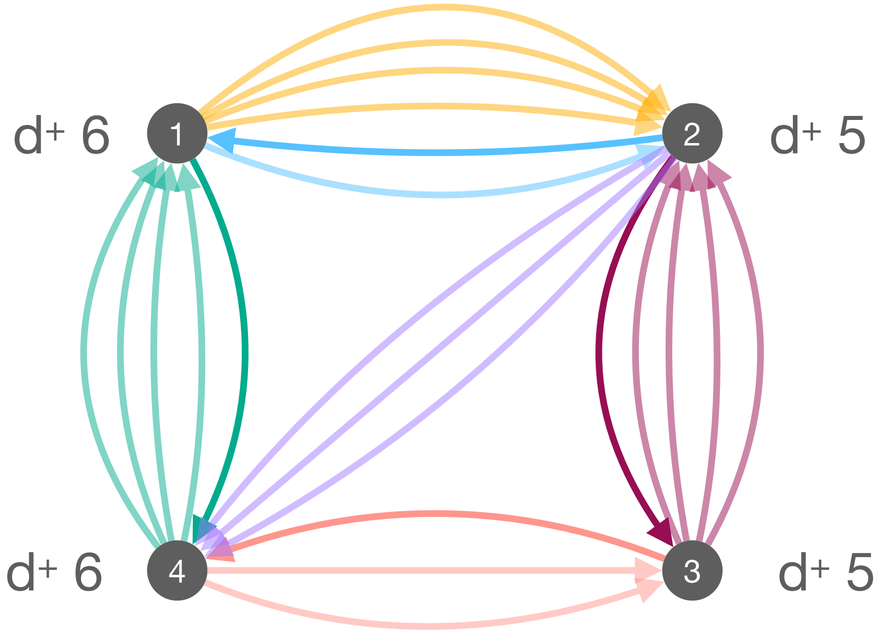
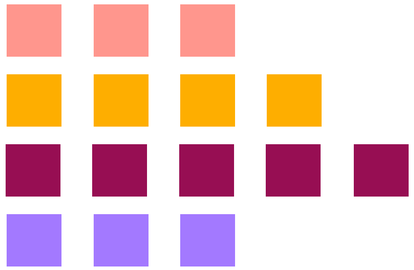
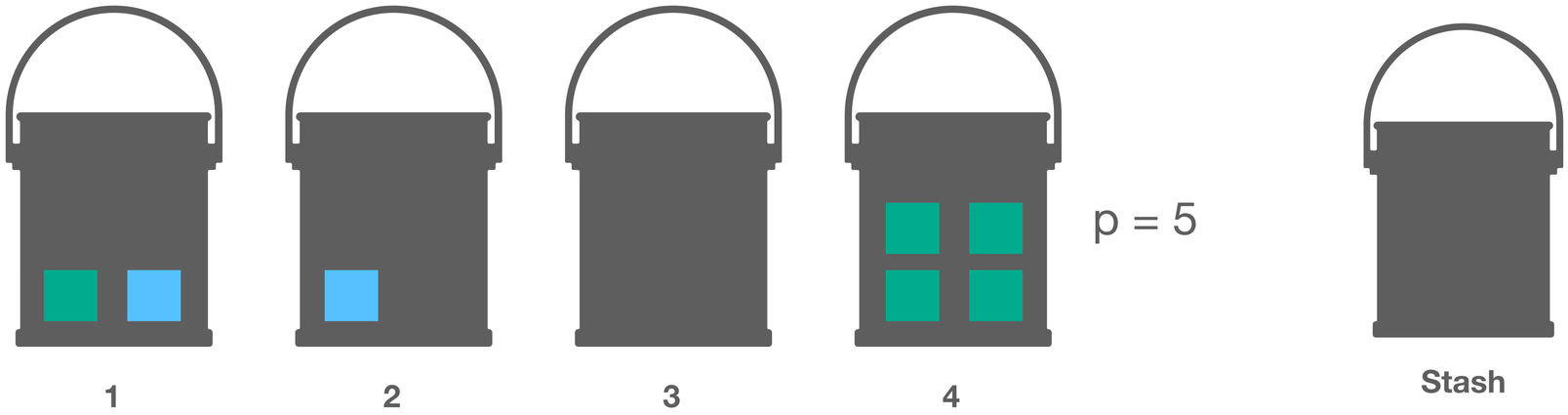
Efficient DIP

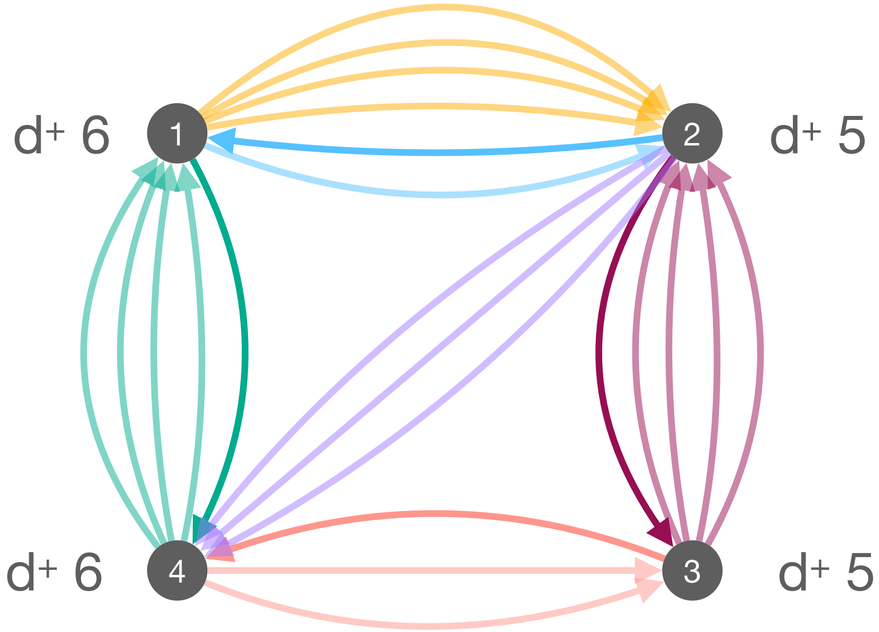


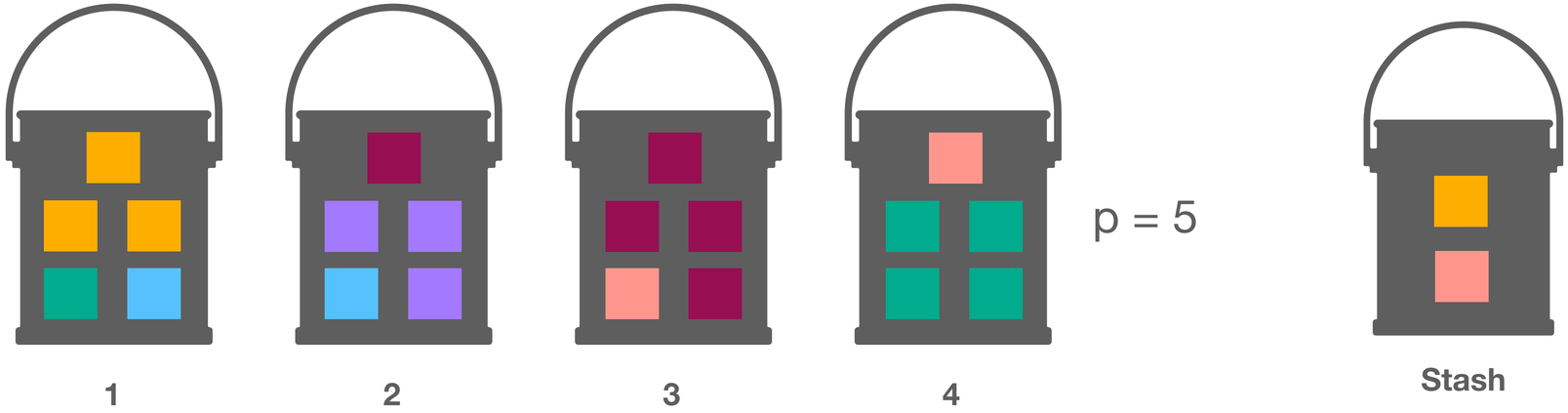




Tethys

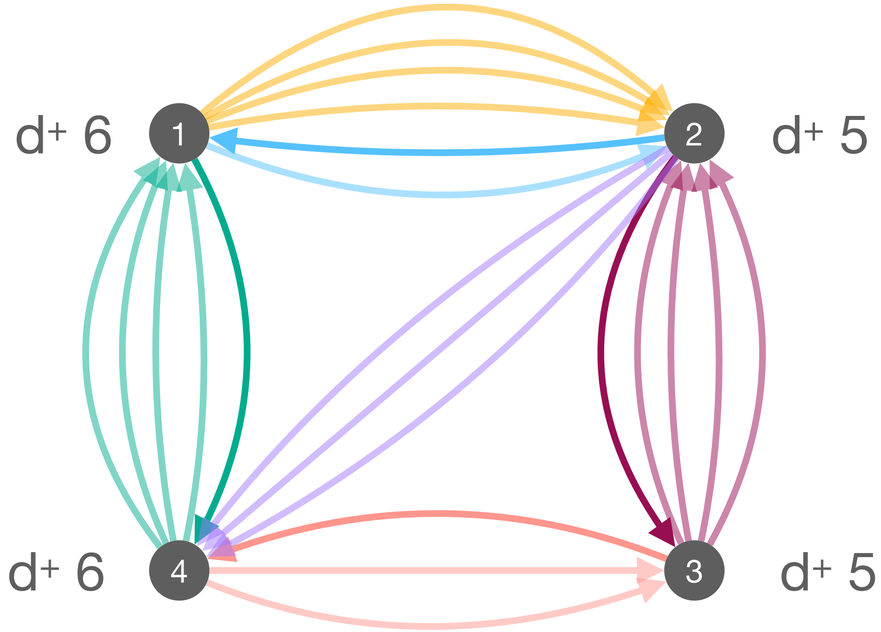
Efficient DIP

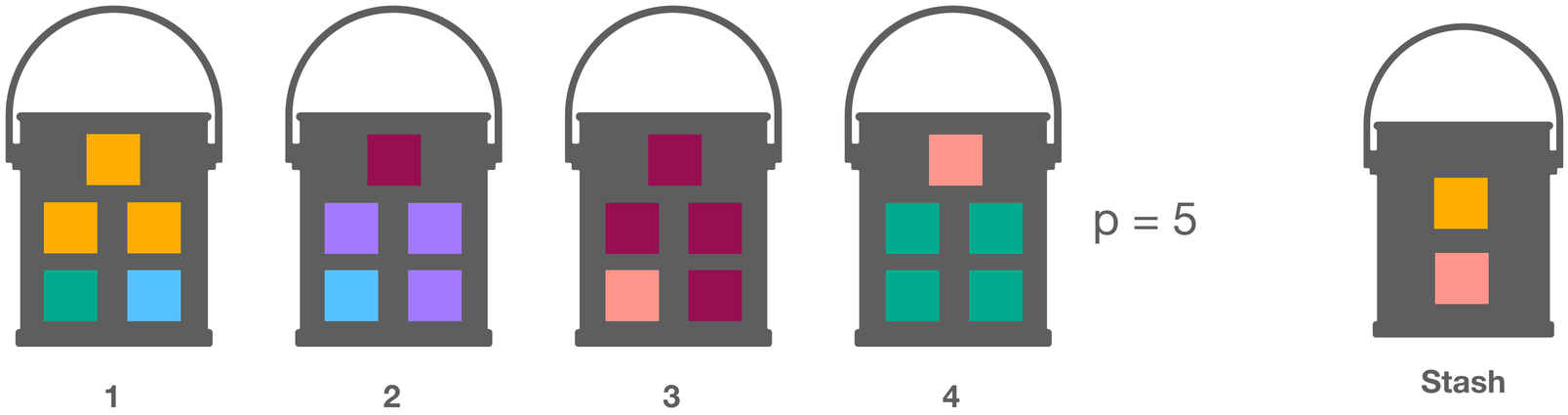




Tethys

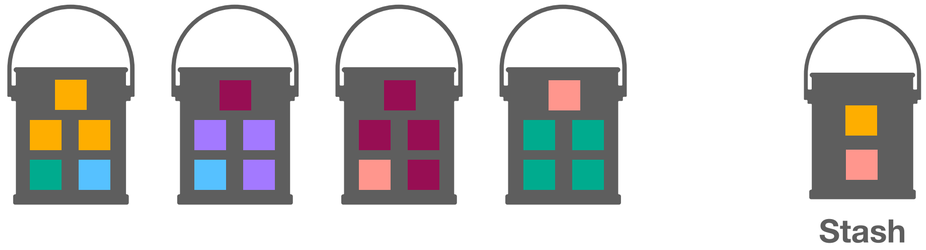
Efficient DIP





Tethys

Efficient DIP



- Main Theorem:
  - There Exists a Valid Assignment w.o.p. such that:
    - **m** = (2 + ε)n/p
    - **Stash**: ω(logλ)/log(n) pages
  - Direct Generalization of Cuckoo-Hashing in the Static Case

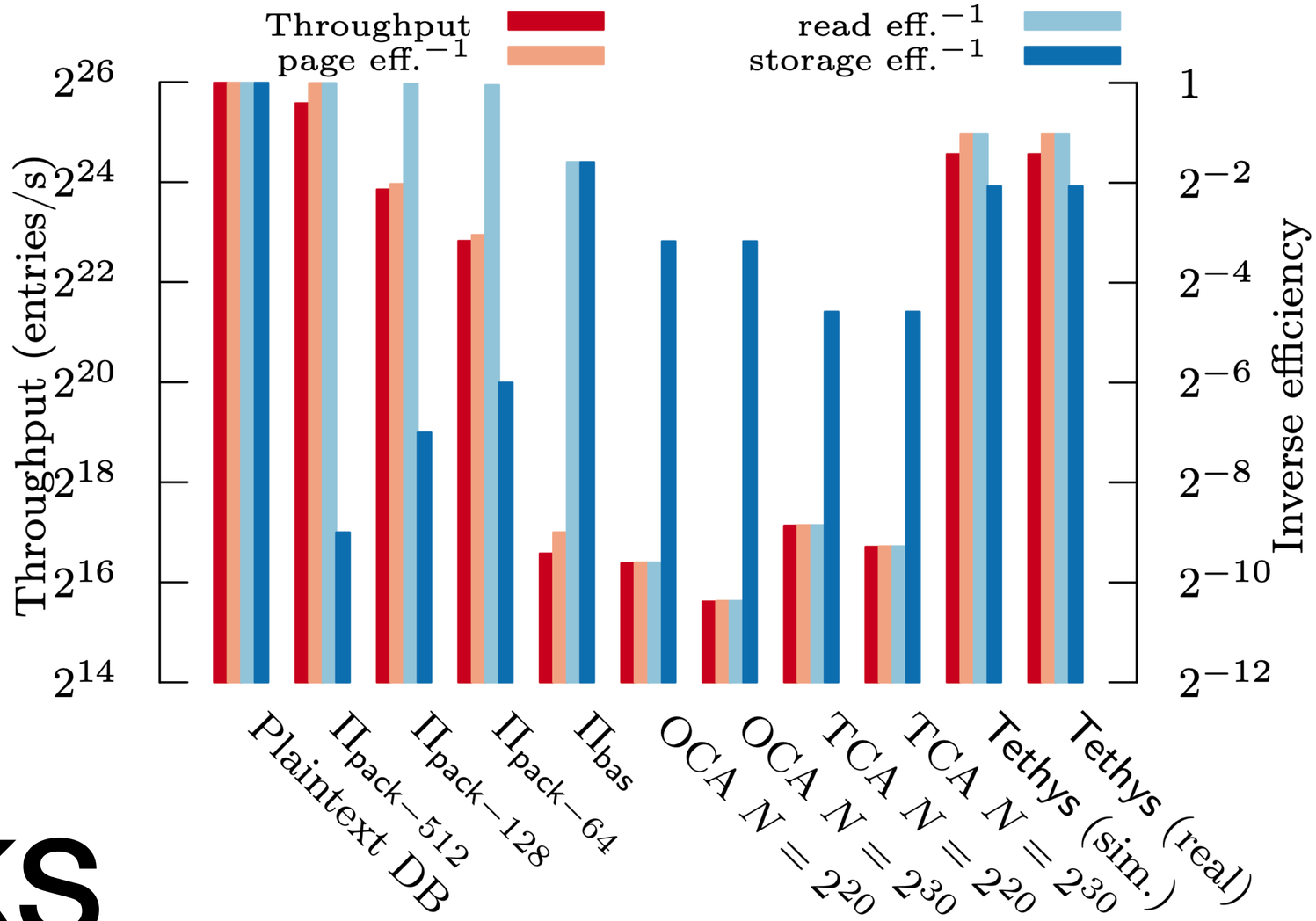
Conclusion

Efficiency

- Cuckoo-Hashing with Stash for Items of Variable Size
- **DIP**: Data-Independent Packing
- **Tethys**: O(1) Storage + Page Efficiency

Conclusion

Efficiency



THANKS