TECH VAULT

# DATABASE SHARDING

## Including: Consistent Hashing



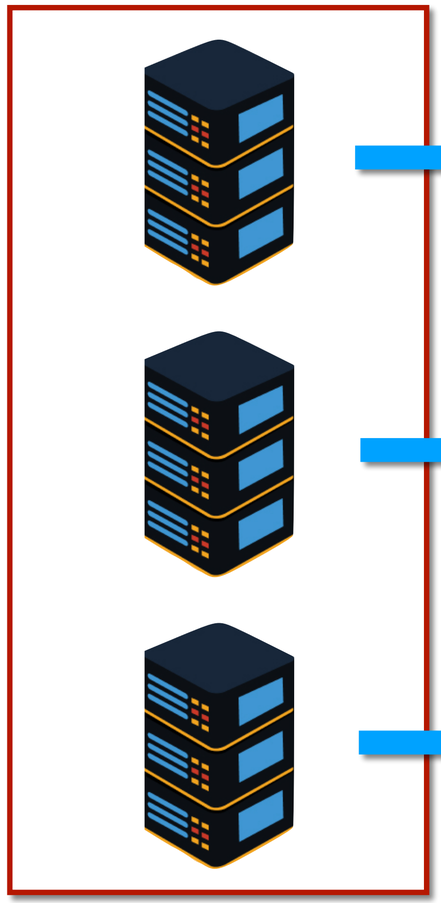
AMR ELHELW

# Sharding

## Data Set

| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 1573 | 2022-05-28 | 16 | 648 |
| 1574 | 2023-01-26 | 10 | 921 |
| 1575 | 2023-09-25 | 3 | 810 |
| 1576 | 2022-01-25 | 18 | 1063 |
| 1577 | 2022-06-28 | 8 | 753 |
| 1578 | 2021-01-28 | 13 | 548 |
| 1579 | 2021-02-07 | 2 | 572 |
| 1580 | 2023-03-23 | 11 | 953 |
| 1581 | 2023-09-11 | 16 | 734 |
| 1582 | 2022-09-12 | 19 | 1070 |
| 1583 | 2023-04-07 | 12 | 385 |
| 1584 | 2023-07-31 | 16 | 930 |
| 1585 | 2023-09-22 | 9 | 716 |
| 1586 | 2023-07-17 | 15 | 766 |
| 1587 | 2022-12-20 | 8 | 1000 |
| 1588 | 2022-11-28 | 2 | 595 |
| 1589 | 2022-06-30 | 20 | 949 |
| 1590 | 2023-04-05 | 11 | 297 |
| 1591 | 2022-07-01 | 2 | 640 |
| 1592 | 2023-05-18 | 2 | 596 |
| 1593 | 2023-03-10 | 8 | 280 |
| 1594 | 2022-06-16 | 8 | 971 |
| 1595 | 2022-07-07 | 18 | 796 |
| 1596 | 2021-06-05 | 17 | 796 |

## Distributed Database

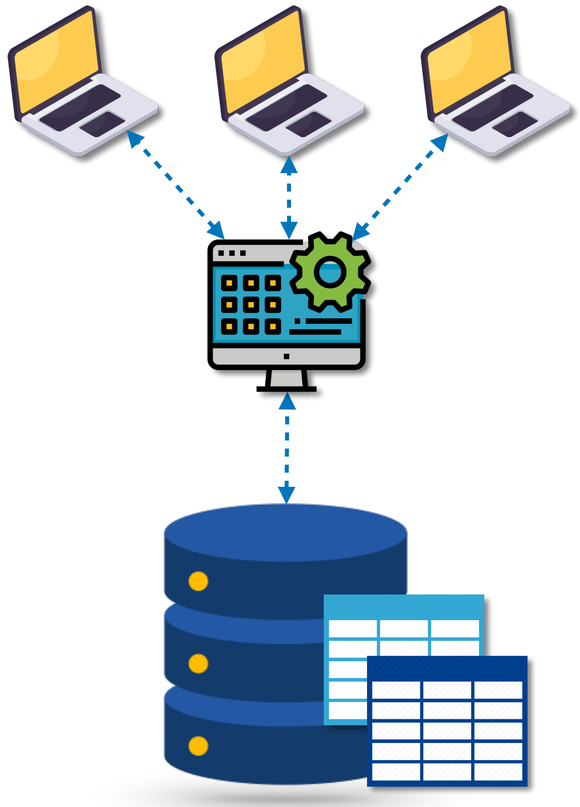


| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 177 | 2021-01-11 | 9 | 581 |
| 181 | 2021-03-15 | 14 | 931 |
| 191 | 2021-03-11 | 13 | 445 |
| 207 | 2021-01-06 | 20 | 553 |
| 210 | 2021-01-13 | 17 | 471 |
| 260 | 2021-01-20 | 11 | 620 |
| 273 | 2021-01-20 | 12 | 444 |
| 289 | 2021-01-20 | 12 | 590 |

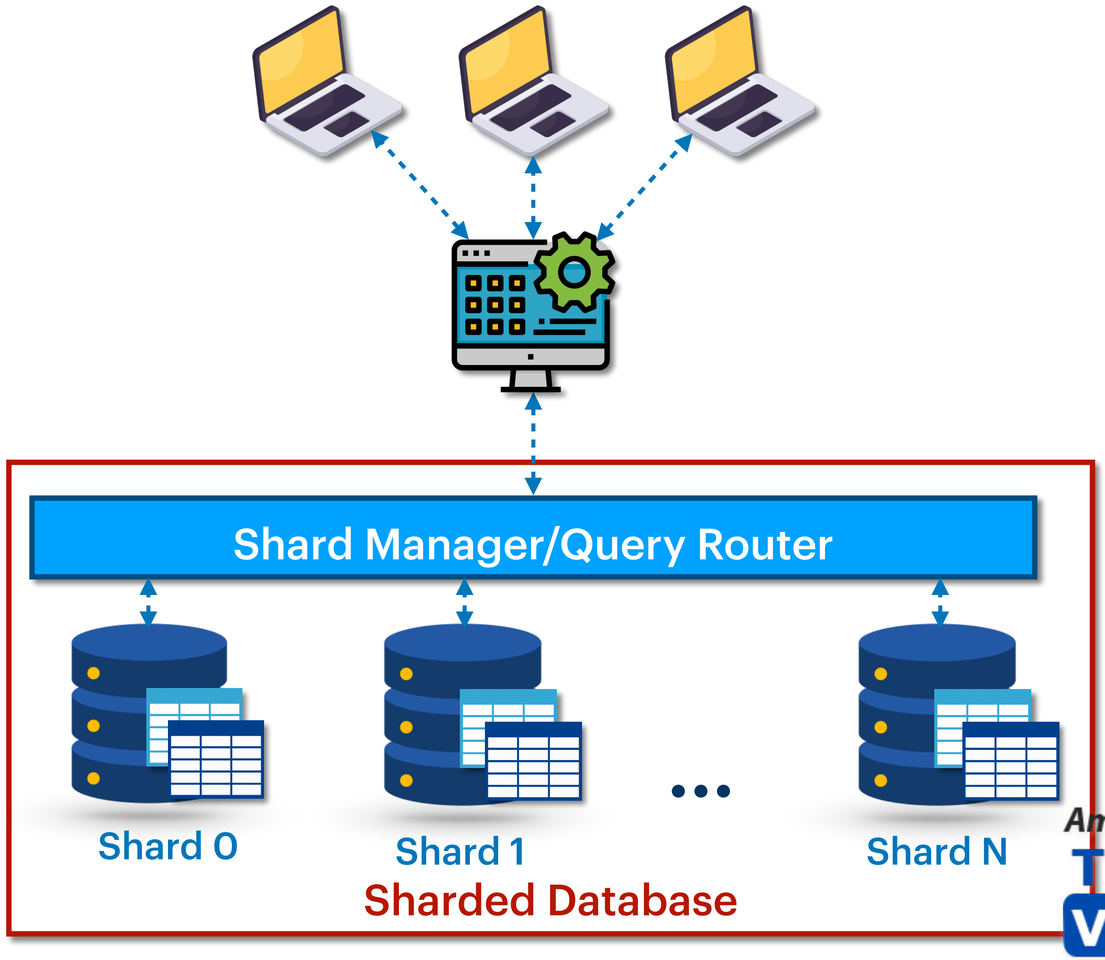
| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 150 | 2021-06-24 | 19 | 1302 |
| 159 | 2021-05-10 | 7 | 192 |
| 162 | 2021-04-10 | 6 | 767 |
| 175 | 2021-06-21 | 8 | 764 |
| 183 | 2021-05-11 | 12 | 1079 |
| 187 | 2021-05-20 | 12 | 444 |

| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 229 | 2021-08-04 | 14 | 1093 |
| 231 | 2021-08-15 | 7 | 167 |
| 251 | 2021-09-12 | 19 | 145 |
| 269 | 2021-08-26 | 19 | 458 |
| 317 | 2021-09-10 | 11 | 413 |
| 339 | 2021-08-23 | 19 | 303 |
| 340 | 2021-07-17 | 5 | 706 |
| 351 | 2021-08-17 | 14 | 144 |

# Sharding



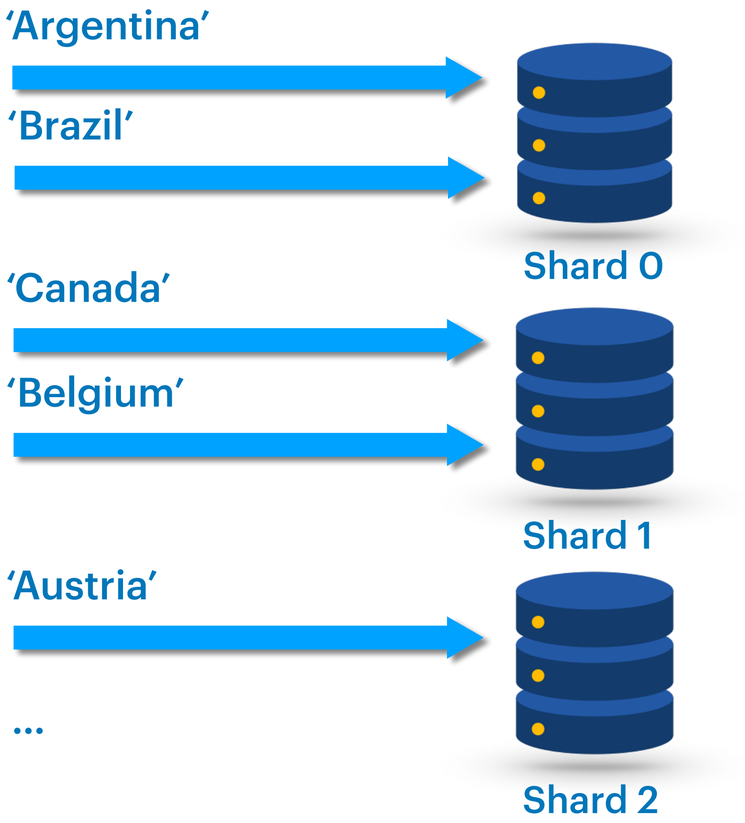
Unsharded Database



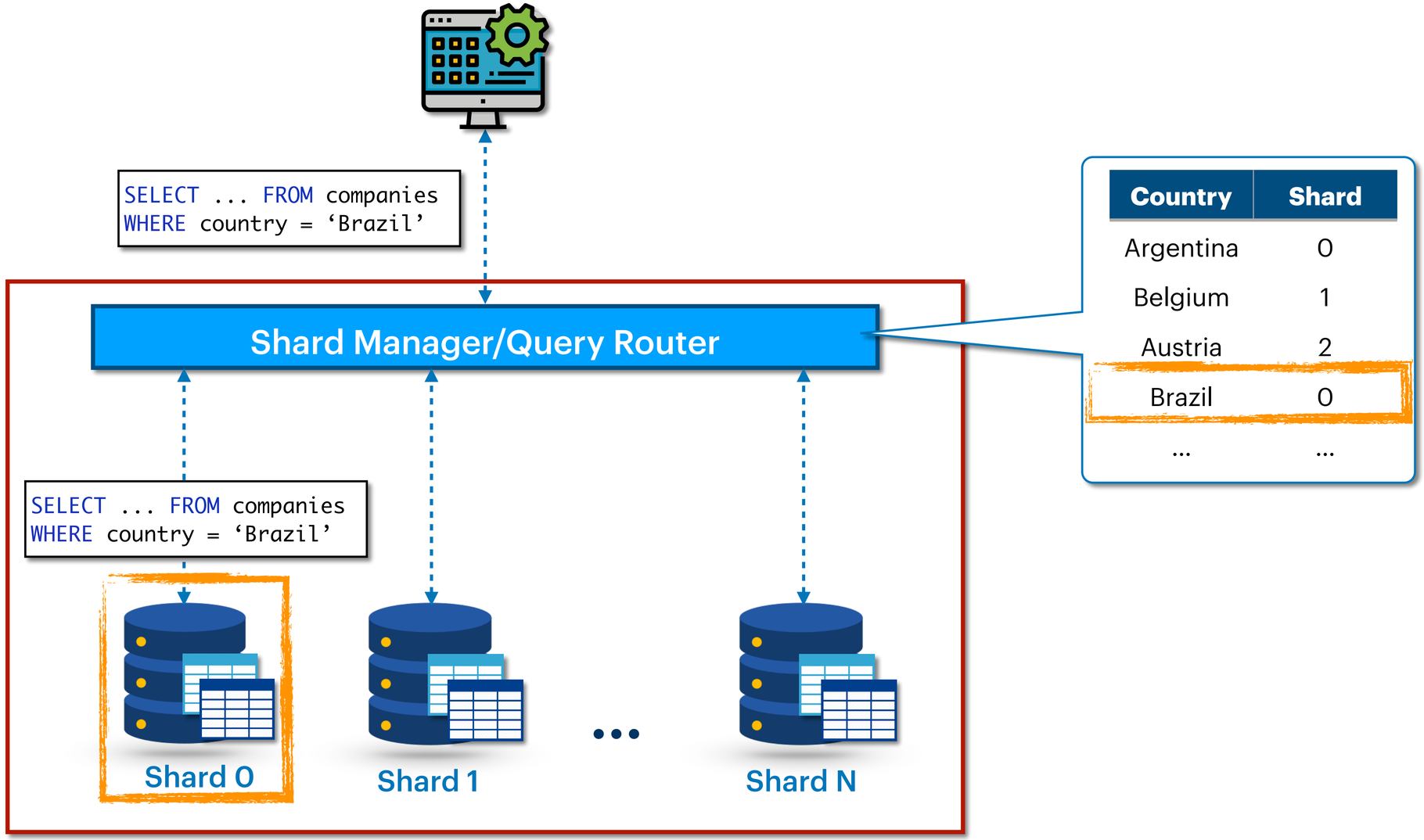
# Directory-based Sharding

Companies

| | company_name | country | region |
|---|---|---|---|
| 1 | Cactus Comidas para llevar | Argentina | [NULL] |
| 2 | Océano Atlántico Ltda. | Argentina | [NULL] |
| 3 | Rancho grande | Argentina | [NULL] |
| 4 | Ernst Handel | Austria | [NULL] |
| 5 | Piccolo und mehr | Austria | [NULL] |
| 6 | Maison Dewey | Belgium | [NULL] |
| 7 | Suprêmes délices | Belgium | [NULL] |
| 8 | Comércio Mineiro | Brazil | SP |
| 9 | Familia Arquibaldo | Brazil | SP |
| 10 | Gourmet Lanchonetes | Brazil | SP |
| 11 | Hanari Carnes | Brazil | RJ |
| 12 | Que Delícia | Brazil | RJ |
| 13 | Queen Cozinha | Brazil | SP |
| 14 | Ricardo Adocicados | Brazil | RJ |
| 15 | Tradição Hipermercados | Brazil | SP |
| 16 | Wellington Importadora | Brazil | SP |
| 17 | Bottom-Dollar Markets | Canada | BC |
| 18 | Laughing Bacchus Wine Cellars | Canada | BC |



# Directory-based Sharding



# Range-based Sharding

## Orders

| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 1573 | 2022-05-28 | 16 | 648 |
| 1574 | 2023-01-26 | 10 | 921 |
| 1575 | 2023-09-25 | 3 | 810 |
| 1576 | 2022-01-25 | 18 | 1063 |
| 1577 | 2022-06-28 | 8 | 753 |
| 1578 | 2021-01-28 | 13 | 548 |
| 1579 | 2021-02-07 | 2 | 572 |
| 1580 | 2023-03-23 | 11 | 953 |
| 1581 | 2023-09-11 | 16 | 734 |
| 1582 | 2022-09-12 | 19 | 1070 |
| 1583 | 2023-04-07 | 12 | 385 |
| 1584 | 2023-07-31 | 16 | 930 |
| 1585 | 2023-09-22 | 9 | 716 |
| 1586 | 2023-07-17 | 15 | 766 |
| 1587 | 2022-12-20 | 8 | 1000 |
| 1588 | 2022-11-28 | 2 | 595 |
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| 1590 | 2023-04-05 | 11 | 297 |
| 1591 | 2022-07-01 | 2 | 640 |
| 1592 | 2023-05-18 | 2 | 596 |
| 1593 | 2023-03-10 | 8 | 280 |
| 1594 | 2022-06-16 | 8 | 971 |
| 1595 | 2022-07-07 | 18 | 796 |
| 1596 | 2021-06-05 | 17 | 796 |

From 2021-01-01 to 2021-03-31

Shard 0

From 2021-04-01 to 2021-06-30

Shard 1

From 2021-07-01 to 2021-09-30

Shard 2

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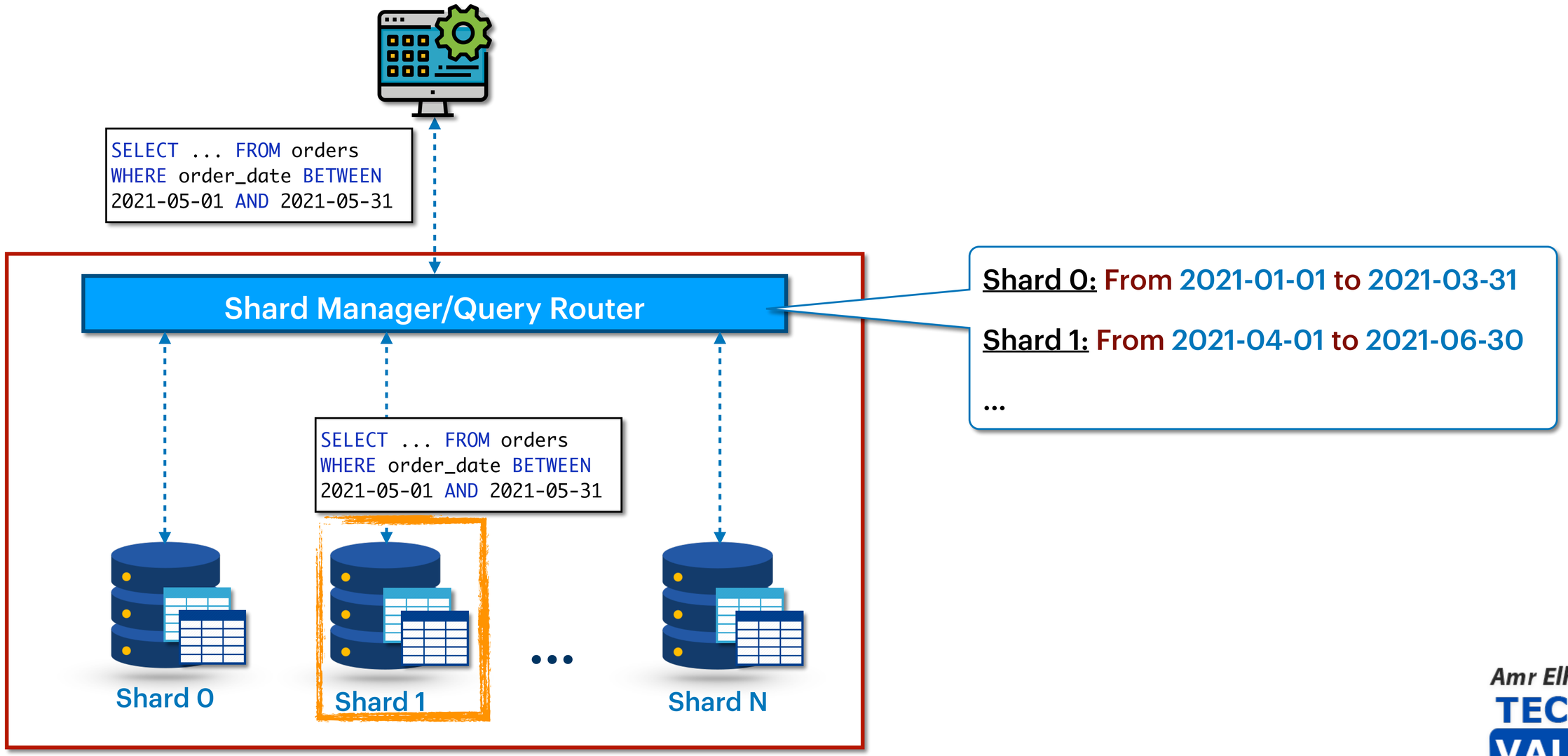
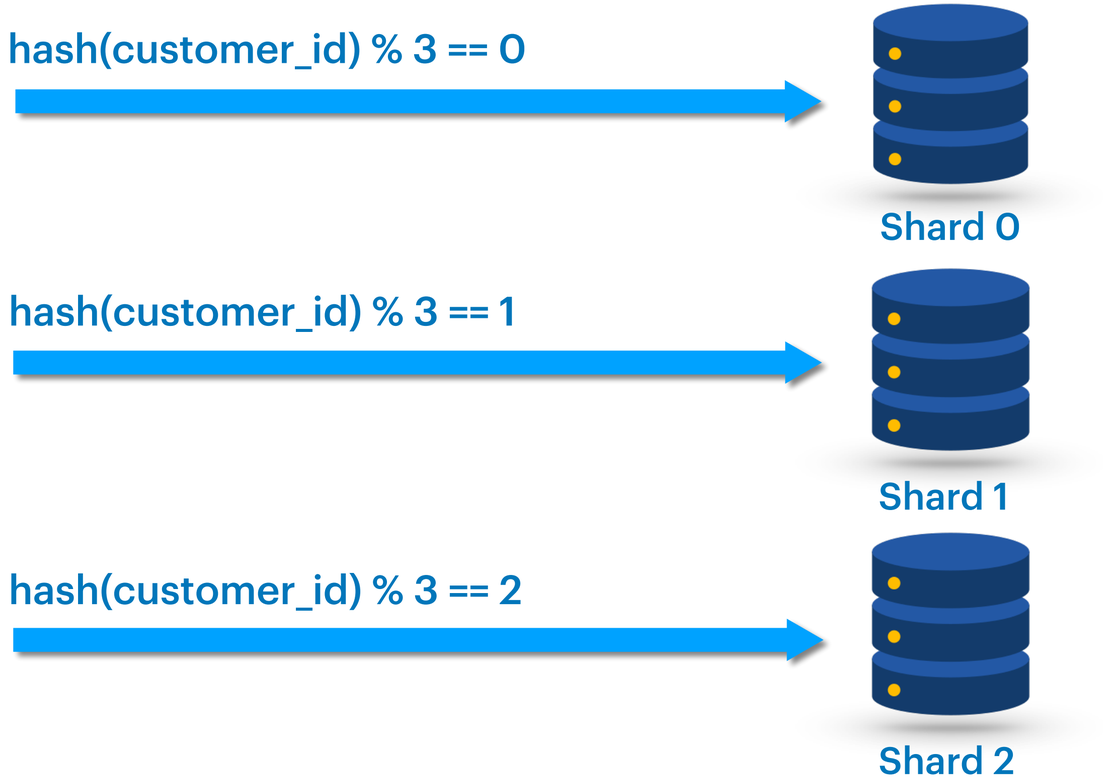
# Range-based Sharding



# Hash-based Sharding

## Orders

| order_id | order_date | customer_id | amount |
|---|---|---|---|
| 1573 | 2022-05-28 | 16 | 648 |
| 1574 | 2023-01-26 | 10 | 921 |
| 1575 | 2023-09-25 | 3 | 810 |
| 1576 | 2022-01-25 | 18 | 1063 |
| 1577 | 2022-06-28 | 8 | 753 |
| 1578 | 2021-01-28 | 13 | 548 |
| 1579 | 2021-02-07 | 2 | 572 |
| 1580 | 2023-03-23 | 11 | 953 |
| 1581 | 2023-09-11 | 16 | 734 |
| 1582 | 2022-09-12 | 19 | 1070 |
| 1583 | 2023-04-07 | 12 | 385 |
| 1584 | 2023-07-31 | 16 | 930 |
| 1585 | 2023-09-22 | 9 | 716 |
| 1586 | 2023-07-17 | 15 | 766 |
| 1587 | 2022-12-20 | 8 | 1000 |
| 1588 | 2022-11-28 | 2 | 595 |
| 1589 | 2022-06-30 | 20 | 949 |
| 1590 | 2023-04-05 | 11 | 297 |
| 1591 | 2022-07-01 | 2 | 640 |
| 1592 | 2023-05-18 | 2 | 596 |
| 1593 | 2023-03-10 | 8 | 280 |
| 1594 | 2022-06-16 | 8 | 971 |
| 1595 | 2022-07-07 | 18 | 796 |

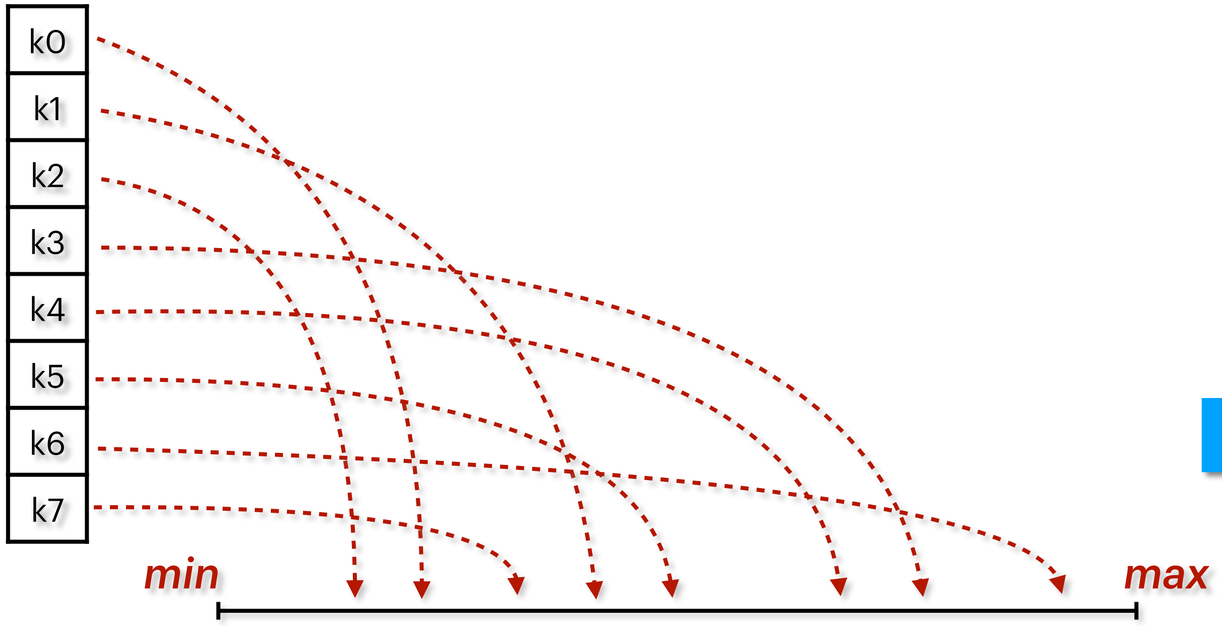


# Simple Hashing

Sharding Key *k* → hash(k) % N → Shard id

k → hash(k) → [min, max] → % N → {0, 1, 2, ..., N-1}

*(Hash space)*




% 3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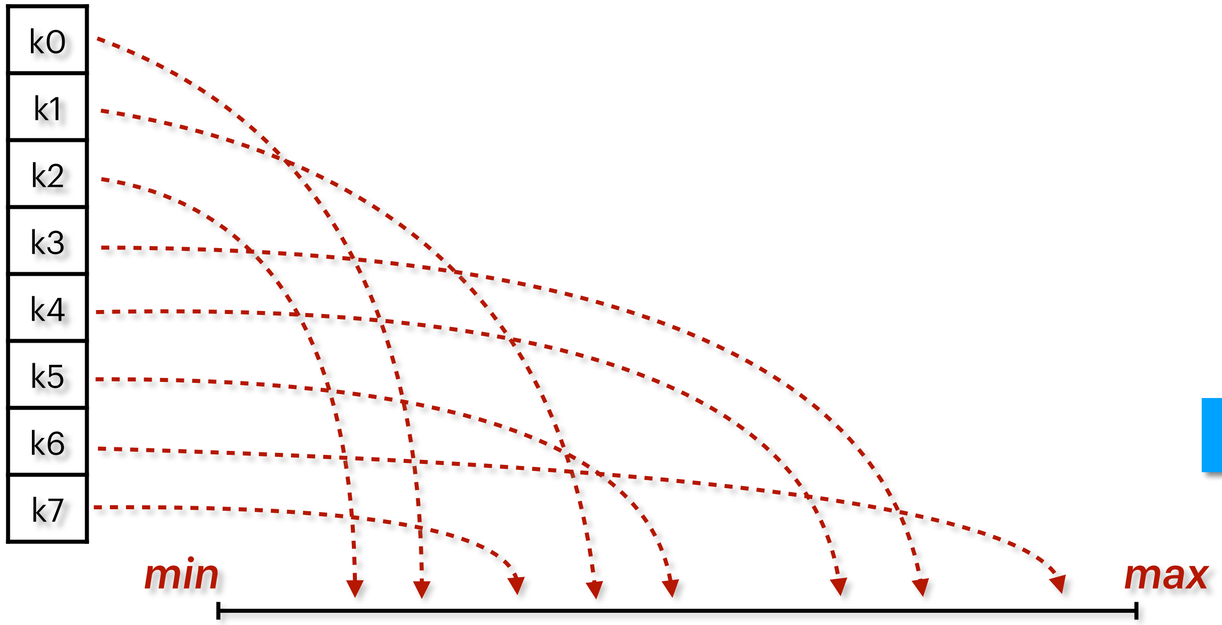
# Simple Hashing

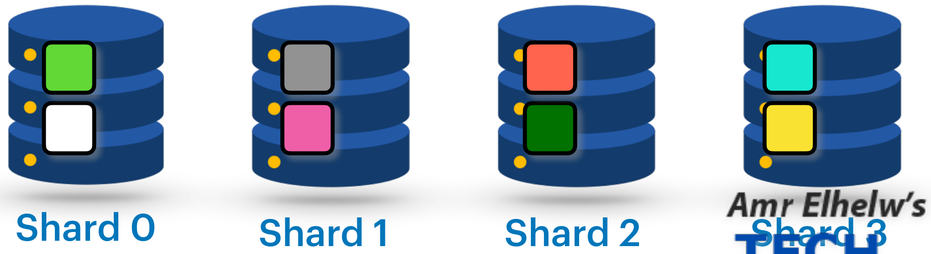
Sharding Key *k* → hash(k) % N → Shard id

k → hash(k) → [min, max] → % N → {0, 1, 2, ..., N-1}

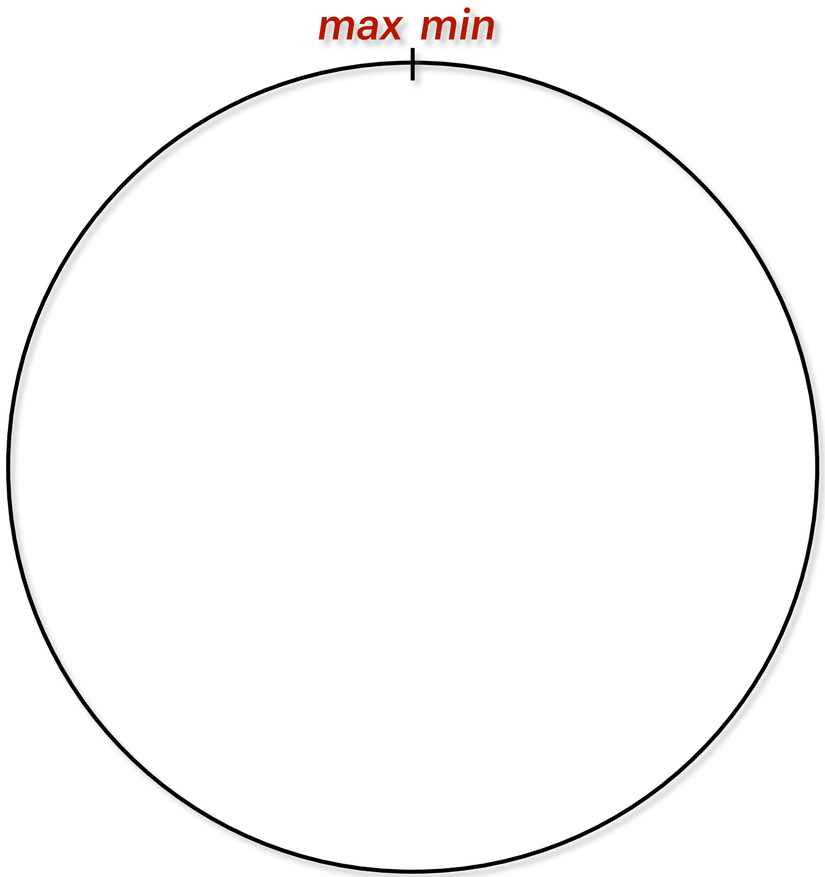
*(Hash space)*




% 4

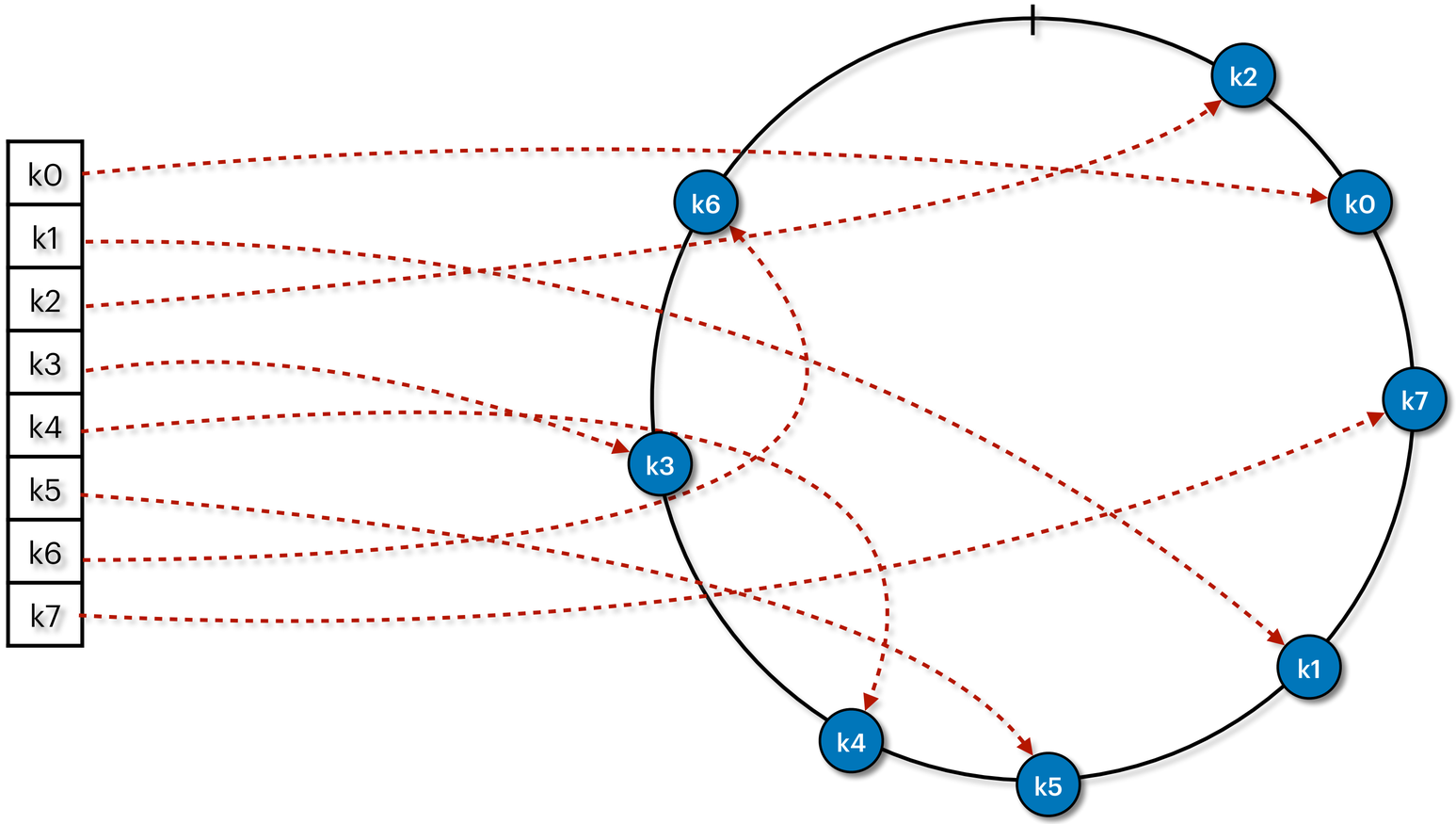


# Consistent Hashing

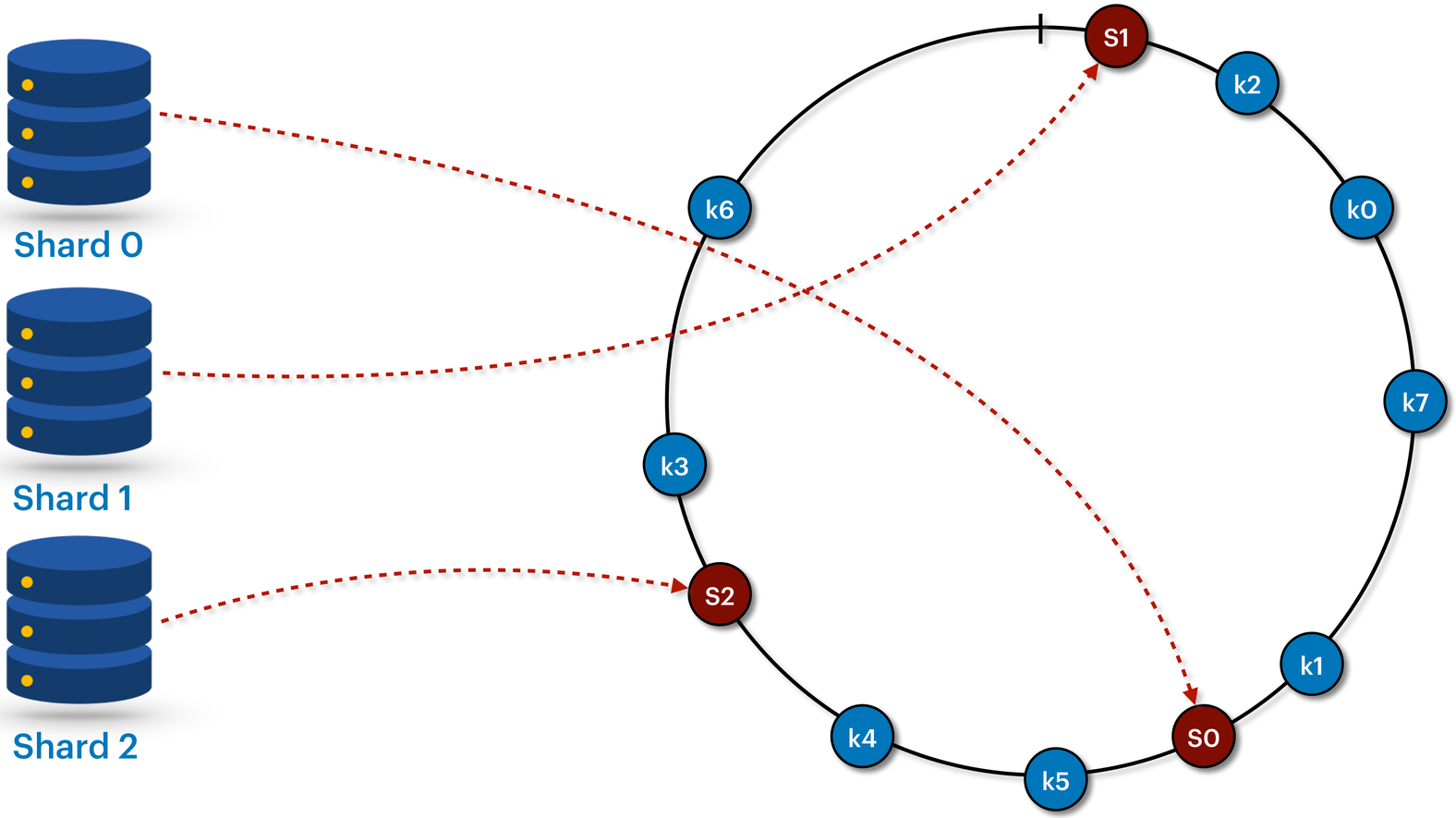



Hashing Ring

# Consistent Hashing



# Consistent Hashing

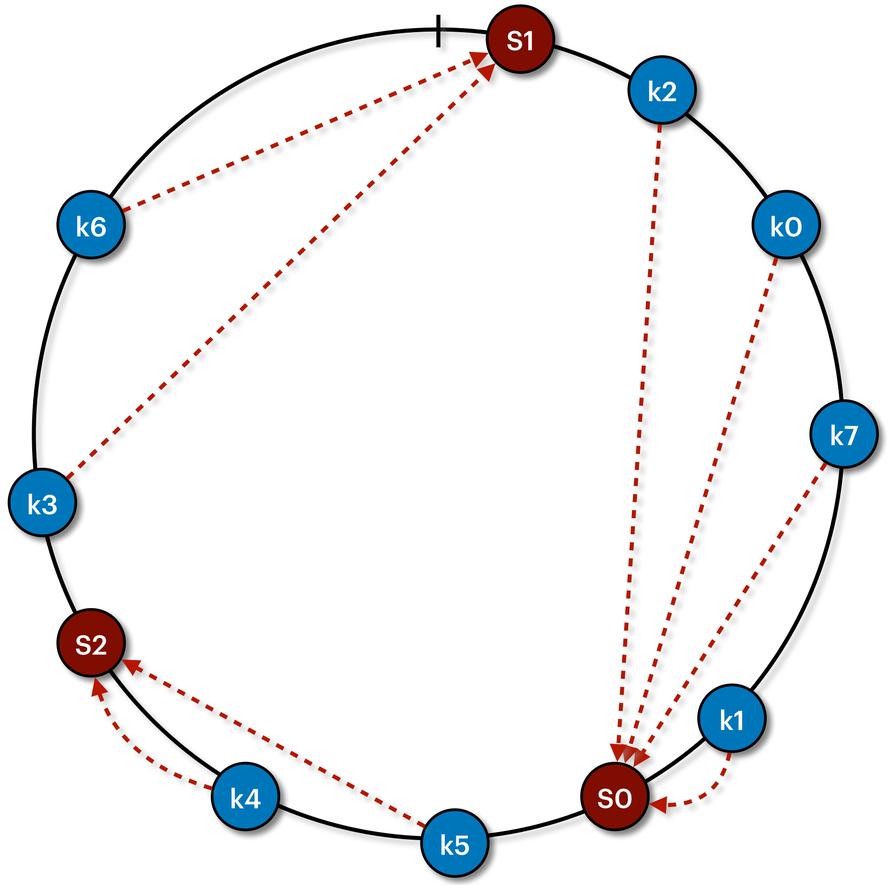


# Consistent Hashing

Shard 0

Shard 1

Shard 2

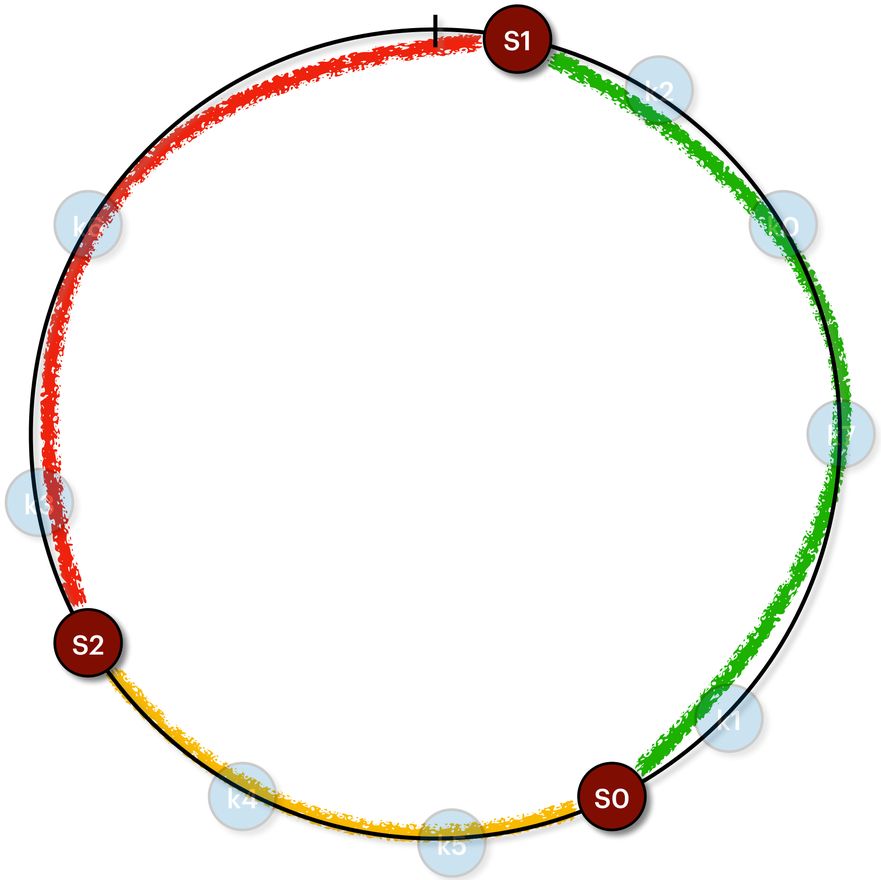


# Consistent Hashing

Shard 0

Shard 1

Shard 2



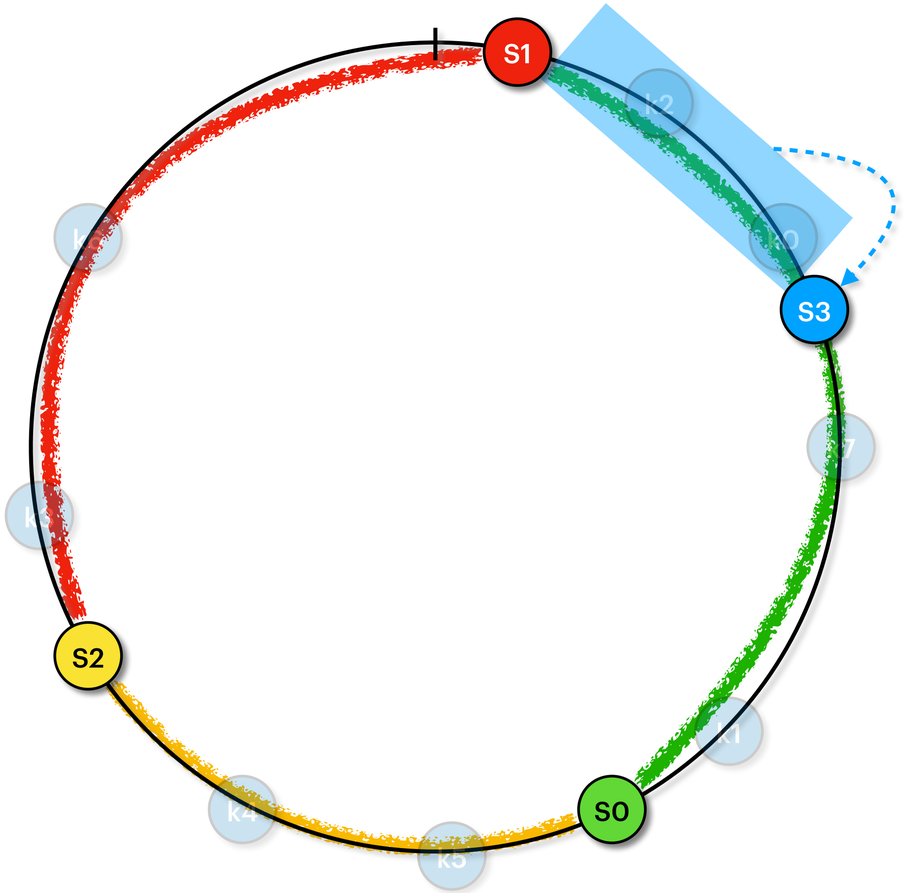
# Consistent Hashing

Shard 0

Shard 1

Shard 2

Shard 3



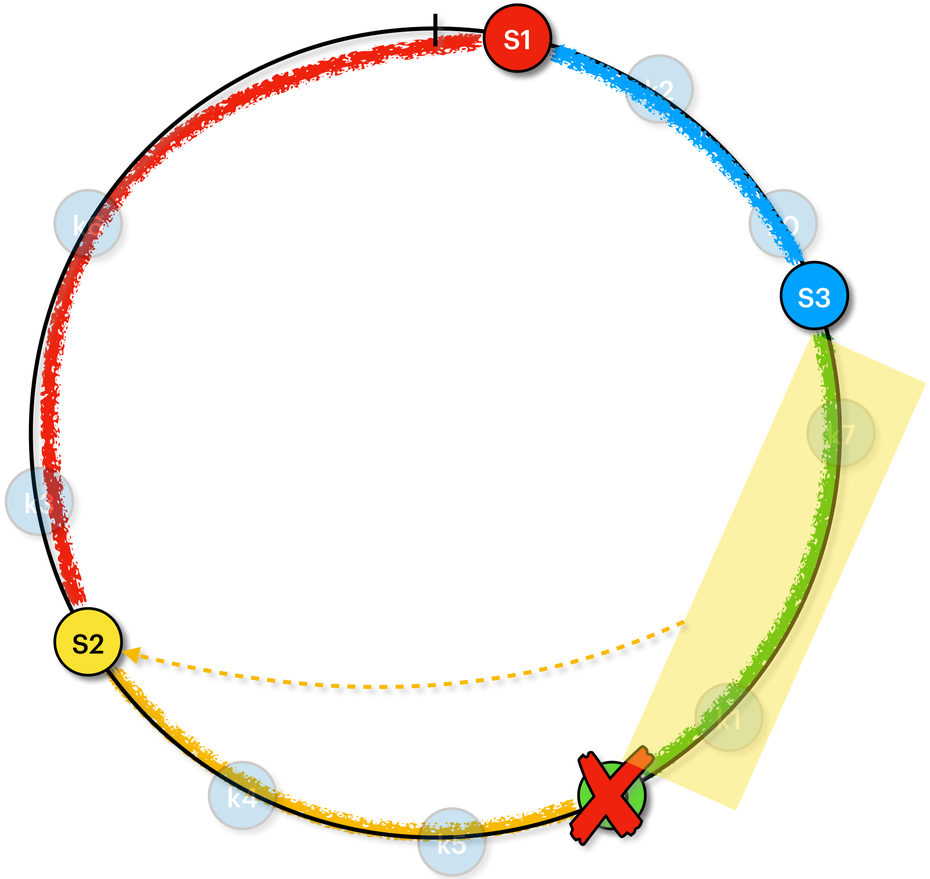
# Consistent Hashing

Shard 0

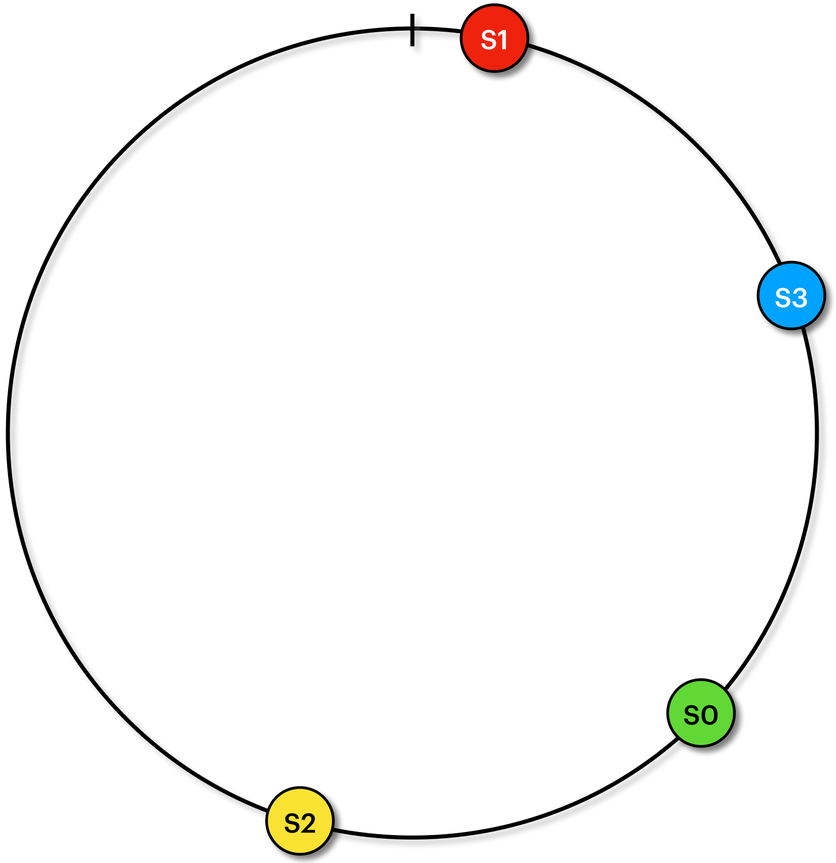
Shard 1

Shard 2

Shard 3



# Consistent Hashing



- Indexing
- Transaction Management
  - Single-Shard Transactions
  - Cross-Shard Transactions
- Fault Tolerance
  - Replication