Analytical Data Modeling

(With On-Chain Data)

@sha2fiddy

Engineering Manager, Data Analytics

Foundry Digital

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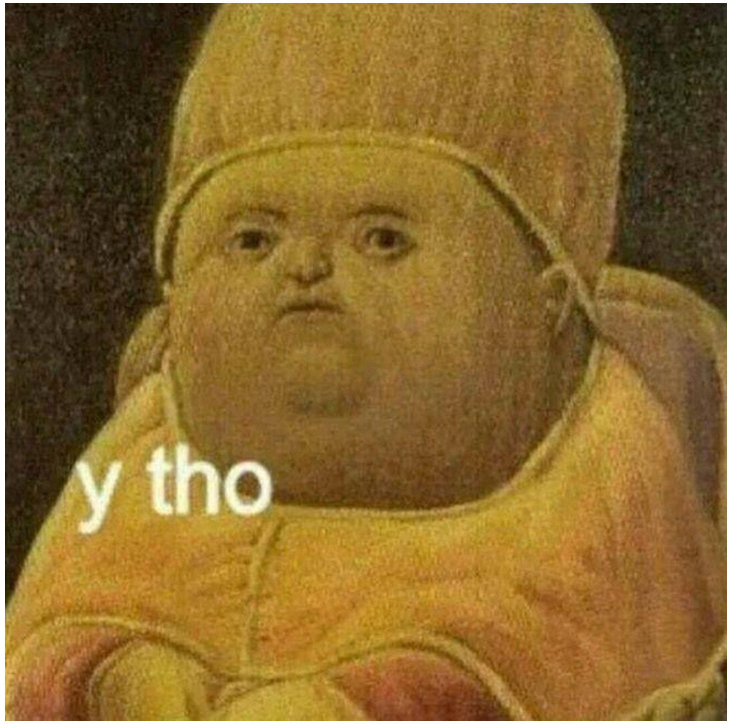
github.com/sha2fiddy/btcpp-demo-2025/

Analytics Engineering



What: transform raw data into clean, reliable data models

Analogy: raw tables are ingredients; models are recipes

Why: productivity, consistency, reusability, & central sources of truth

How: applying software engineering principals and technologies to data modeling & analysis

Data Engineers: build data ingestion pipelines & infrastructure

Data Analysts: create queries, reports, & dashboards

Analytics Engineers: build data transformation pipelines with software engineering best practices, but primarily to enable analytical needs

Data Modeling Concepts

Data Granularity: level of detail of a table or dataset

- *week/day/hour*
- *block/address/transaction*
- *pool/subaccount/worker*

Natural vs Surrogate Key: a unique identifier from the data source vs one generated within the data warehouse

Change Data Capture (CDC): systematically record how & when categorical data changes over time (e.g. name change)

Related: Slowly Changing Dimensions (SCDs)

Normalization vs Denormalization: separating categorical and numerical data vs combining them into flat dataset models

Star Schema Models

Star Schema: a central fact table which joins to one or more dimension tables (**normalized**)

Dimension Model (Dim): categorical data that is used to aggregate, filter, and sort by (one row per dim entity)

- *date, pool, customer, miner model*

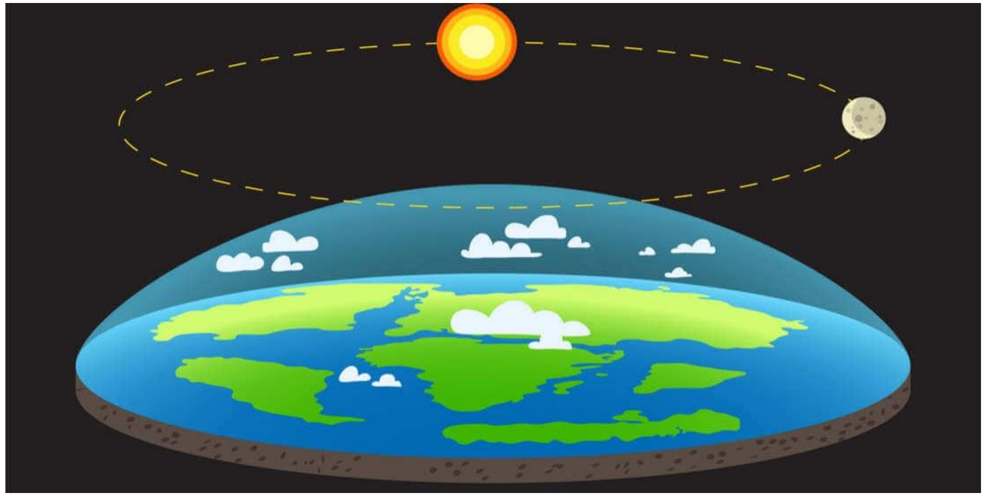
Fact Model: numerical measurements or events to be aggregated (one row per level of detail)

- *revenue, hashrate, price, miner count*

Pros: reduced duplication of code & data storage, modularity

Cons: requires joins, less intuitive for business users

OBT Models



OBT Model: Operational BI Table (aka ‘One Big Table’)

Flat standalone models (**denormalized**), containing all attributes that would otherwise be broken into dims & facts

Pros: fewer joins required, more intuitive for business users

Cons: increased storage, code duplication, can introduce many categorical flags or partitions needed for filters

Best of Both: build star schemas for primary dims & facts, and application-specific OBTs which read from those dims & facts

Data Warehouse Tools & Tips

Data Build Tool (dbt): data modeling framework that brings automation, testing, & jinja templating to data transformation (core product is open source)

Analogy: like a frontend application framework, but for analytics engineering

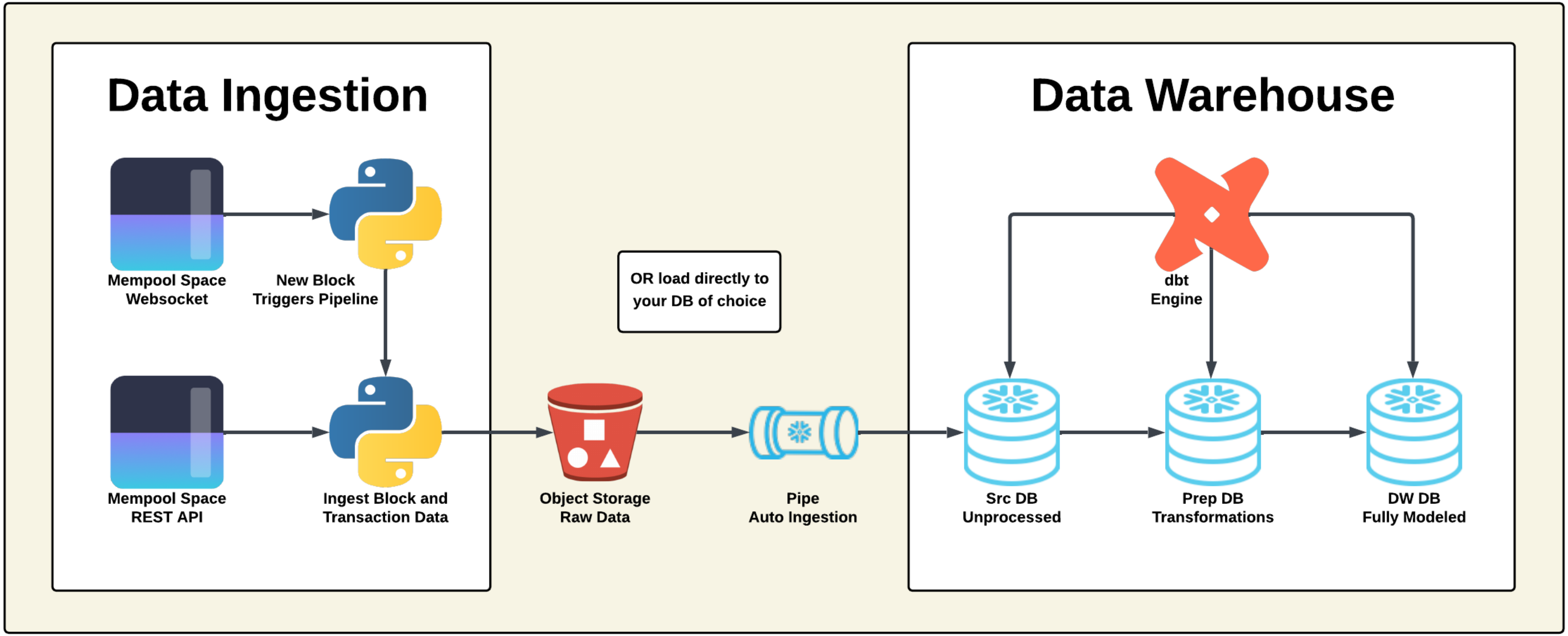
Columnar Databases: column-oriented databases are optimized for aggregating large volumes of data (vs traditional RDS systems which are transactional)

- **SaaS**: Snowflake, BigQuery, Databricks
- **Open Source**: DuckDB, ClickHouse, TimescaleDB

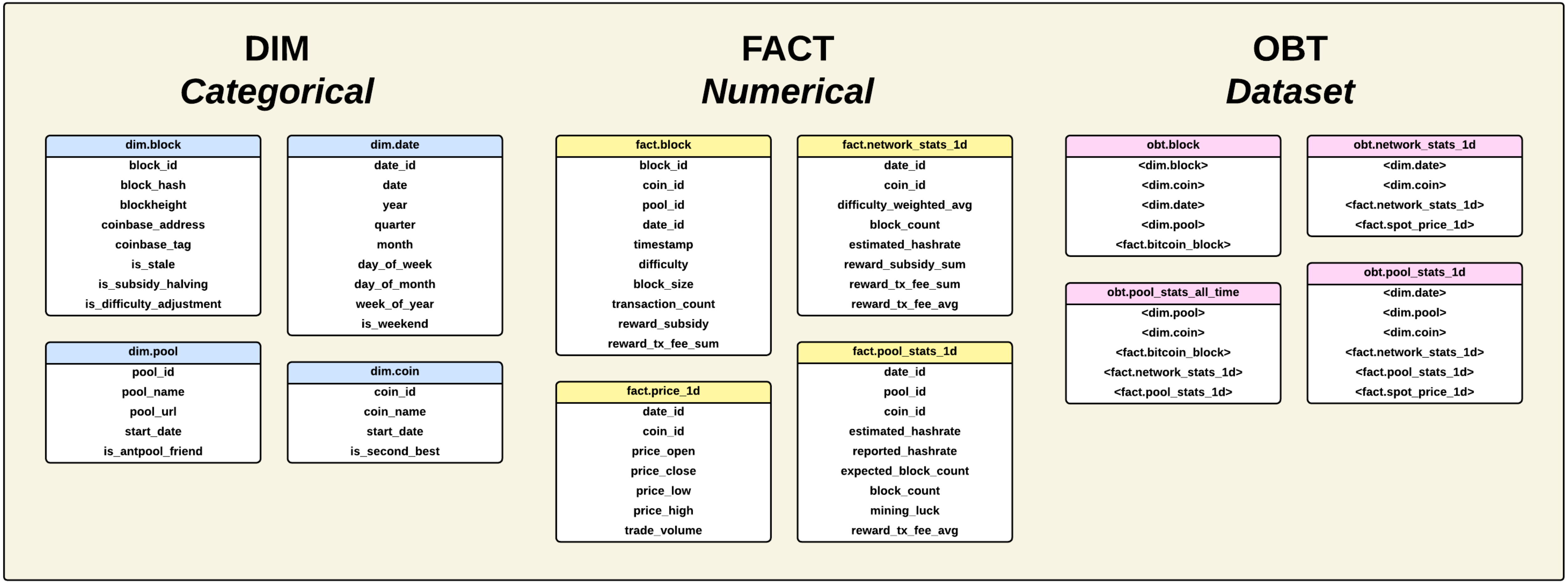
Extract, Load, Transform (ELT): ingest all raw data to a central storage layer first, then perform transformations (vs traditional ETL approach)

Data Validation: automated tests & audits on both raw and modeled data layers help ensure data integrity & reliability

Architecture Example



Model Examples



DIM
Categorical

dim.block
- block_id
- block_hash
- blockheight
- coinbase_address
- coinbase_tag
- is_stale
- is_subsidy_halving
- is_difficulty_adjustment

dim.date
- date_id
- date
- year
- quarter
- month
- day_of_week
- day_of_month
- week_of_year
- is_weekend

dim.pool
- pool_id
- pool_name
- pool_url
- start_date
- is_antpool_friend

dim.coin
- coin_id
- coin_name
- start_date
- is_second_best

FACT
Numerical

fact.block
- block_id
- coin_id
- pool_id
- date_id
- timestamp
- difficulty
- block_size
- transaction_count
- reward_subsidy
- reward_tx_fee_sum

fact.network_stats_1d
- date_id
- coin_id
- difficulty_weighted_avg
- block_count
- estimated_hashrate
- reward_subsidy_sum
- reward_tx_fee_sum
- reward_tx_fee_avg

fact.price_1d
- date_id
- coin_id
- price_open
- price_close
- price_low
- price_high
- trade_volume

fact.pool_stats_1d
- date_id
- pool_id
- coin_id
- estimated_hashrate
- reported_hashrate
- expected_block_count
- block_count
- mining_luck
- reward_tx_fee_avg

OBT
Dataset

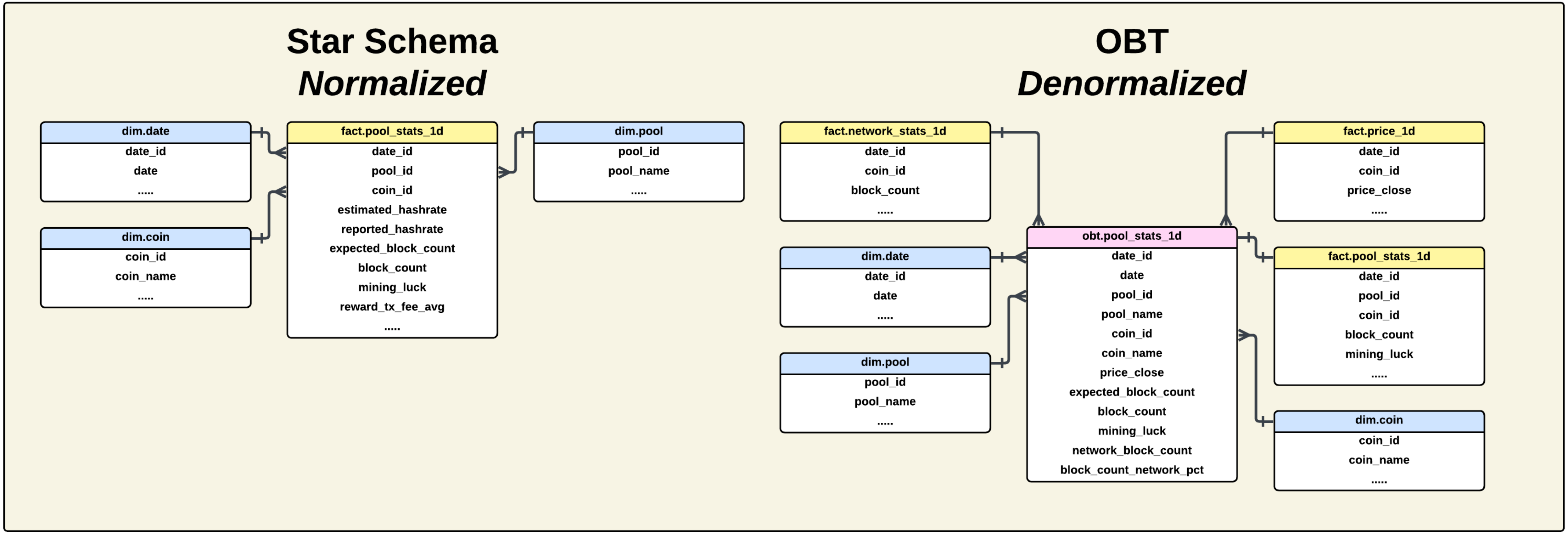
obt.block
- <dim.block>
- <dim.coin>
- <dim.date>
- <dim.pool>
- <fact.bitcoin_block>

obt.network_stats_1d
- <dim.date>
- <dim.coin>
- <fact.network_stats_1d>
- <fact.spot_price_1d>

obt.pool_stats_all_time
- <dim.pool>
- <dim.coin>
- <fact.bitcoin_block>
- <fact.network_stats_1d>
- <fact.pool_stats_1d>

obt.pool_stats_1d
- <dim.date>
- <dim.pool>
- <dim.coin>
- <fact.network_stats_1d>
- <fact.pool_stats_1d>
- <fact.spot_price_1d>

Schema Examples



Star Schema
Normalized

dim.date
date_id
date
.....

dim.coin
coin_id
coin_name
.....

fact.pool_stats_1d
date_id
pool_id
coin_id
estimated_hashrate
reported_hashrate
expected_block_count
block_count
mining_luck
reward_tx_fee_avg
.....

dim.pool
pool_id
pool_name
.....

OBT
Denormalized

fact.network_stats_1d
date_id
coin_id
block_count
.....

dim.date
date_id
date
.....

dim.pool
pool_id
pool_name
.....

obt.pool_stats_1d
date_id
date
pool_id
pool_name
coin_id
coin_name
price_close
expected_block_count
block_count
mining_luck
network_block_count
block_count_network_pct

fact.price_1d
date_id
coin_id
price_close
.....

fact.pool_stats_1d
date_id
pool_id
coin_id
block_count
mining_luck
.....

dim.coin
coin_id
coin_name
.....

Workshop

Star Schemas:

- **Dims**: date, block, pool
- **Facts**: block, network stats, pool stats, price

OBTs: block, network stats, pool stats

Metrics: estimated network hashrate, hashprice, pool mining luck

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