Time-Series Databases for Telemetry

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Telemetry in TimescaleDB — hypertables, time_bucket, gap filling, continuous aggregates, columnstore, retention, ingestion — plus InfluxDB 3.

Video walkthrough — scan the code to watch.

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Mental model

Telemetry is append-mostly data whose primary dimension is time, and almost every query asks about a recent window or a coarse summary of an old one. So partition by time, aggregate ahead of time, and let old data get cheaper as it ages — first compressed, then summarized, then dropped. TimescaleDB does all three inside PostgreSQL; this sheet assumes the PostgreSQL sheet for everything else.

Hypertables and chunks

Setting	Default
`tsdb.hypertable`	Turns `CREATE TABLE` into a hypertable
`tsdb.partition_column`	First timestamp column
`tsdb.chunk_interval`	`7 days`
`tsdb.segmentby`	Picked from statistics
Columnstore policy	Created automatically

A hypertable looks like one table but is stored as chunks, one per time range; queries with a time predicate skip chunks outside it. Size the chunk interval so the indexes of the chunks being written fit in about 25% of memory — the docs' rule, not a default.

```
CREATE TABLE readings (
  time      timestamptz NOT NULL,
  device_id int NOT NULL,
  metric    text NOT NULL,
  value     double precision,
  UNIQUE (device_id, metric, time)
) WITH (
  tsdb.hypertable,
  tsdb.partition_column = 'time',
  tsdb.chunk_interval = '1 day',
  tsdb.segmentby = 'device_id',
  tsdb.orderby = 'time DESC'
);
```

> **Gotcha:** a unique index on a hypertable "must contain all the partitioning columns". `UNIQUE (device_id)` or a surrogate `id` primary key alone is rejected; uniqueness always includes `time`.

Modeling series

Choice	Use
Narrow: `(time, device, metric, value)`	Many sparse metrics
Wide: one column per metric	Fixed sensor set, read together
Separate `devices` table	Site, model, tags — join on read
`segmentby` the series id	Compression and per-device scans

A series is one device (and metric) over time. Keep slowly changing metadata — site, firmware, location —

in an ordinary table keyed by device id rather than repeating it on every row. Segment the columnstore by the column you filter on most, and keep its cardinality low: the docs note lower `segmentby` cardinality compresses better.

```
CREATE TABLE devices (
  device_id int PRIMARY KEY,
  site      text NOT NULL,
  model     text
);
SELECT d.site, avg(r.value)
FROM readings r JOIN devices d USING (device_id)
WHERE r.metric = 'power_kw'
  AND r.time > now() - interval '1 hour'
GROUP BY d.site;
```

Time buckets and latest values

Function	Returns
`time_bucket('15 min', time)`	Bucket start for each row
`last(value, time)`	Latest value within a group
`first(value, time)`	Earliest value within a group
`DISTINCT ON (device_id)`	Latest row per device

`time_bucket` is `date_trunc` with arbitrary widths; group by it to downsample at query time. `first` and `last` pick a value by another column inside a `GROUP BY`.

```
SELECT time_bucket('15 minutes', time) AS bucket,
       device_id,
       avg(value) AS avg_kw,
       last(value, time) AS last_kw
FROM readings
WHERE metric = 'power_kw'
```

```
  AND time > now() - interval '1 day'
GROUP BY bucket, device_id
ORDER BY bucket;
```

> **Gotcha:** `last()` and `first()` "do not use indexes"; they scan the whole group. For "current value per device" use `SELECT DISTINCT ON (device_id) … ORDER BY device_id, time DESC`.

Gap filling

Function	Fills a missing bucket with
`time_bucket_gapfill(w, time)`	A row with `NULL` aggregate
`locf(agg)`	Last observation carried forward
`interpolate(agg)`	Linear interpolation

Sensors drop out, and charts need a row for every bucket. `time_bucket_gapfill` emits the missing buckets; wrap the aggregate in `locf` or `interpolate` to fill them. The range comes from the `WHERE` clause, so give it explicit lower and upper bounds on `time`.

```
SELECT time_bucket_gapfill('5 minutes', time) AS
t,
       device_id,
       locf(avg(value)) AS kw
FROM readings
WHERE metric = 'power_kw'
  AND time >= now() - interval '6 hours'
  AND time <  now()
GROUP BY t, device_id
ORDER BY t;
```

> **Note:** the aggregate goes inside `locf`, never the other way round — `locf(avg(value))`, not `avg(locf(value))`.

Continuous aggregates

API	Does
`WITH (timescaledb.continuous)`	Incrementally maintained view
`add_continuous_aggregate_policy`	Refresh a window on a schedule
`materialized_only = false`	Add not-yet-materialized raw rows
Aggregate on an aggregate	Hourly to daily rollups

A continuous aggregate stores the result of a `time_bucket GROUP BY` and refreshes only buckets whose raw data changed. The policy refreshes from `start_offset` to `end_offset` ago; leave the newest, still-busy bucket out of the window.

```
CREATE MATERIALIZED VIEW readings_1h
WITH (timescaledb.continuous) AS
SELECT time_bucket('1 hour', time) AS bucket,
```

```
       device_id, metric,
       avg(value) AS avg, max(value) AS max
FROM readings
GROUP BY bucket, device_id, metric;

SELECT add_continuous_aggregate_policy(
  'readings_1h',
  start_offset => INTERVAL '3 days',
  end_offset => INTERVAL '1 hour',
  schedule_interval => INTERVAL '30 minutes');
```

> **Gotcha:** `timescaledb.materialized_only` defaults to `true`, so the view returns nothing newer than its last refresh. Dashboards look an hour behind until you set it to `false` (real-time aggregation).

Columnstore, retention, downsampling

Policy	Typical age
`add_columnstore_policy(t, after => …)`	Older than a few chunks
`add_retention_policy(t, drop_after => …)`	Raw: weeks to months
`add_retention_policy(cagg, …)`	Rollups: years

The columnstore converts older chunks to compressed columnar form, segmented and ordered as you configured. Retention drops whole chunks, which is far cheaper than `DELETE`. Downsampling is the two combined: keep raw readings for weeks and the hourly aggregate for years.

```
CALL add_columnstore_policy('readings',
  after => INTERVAL '2 days');
SELECT add_retention_policy('readings',
  drop_after => INTERVAL '30 days');
```

```
SELECT add_retention_policy('readings_1h',
  drop_after => INTERVAL '2 years');
```

> **Warning:** if the aggregate's refresh window reaches back past the raw retention, the refresh "sees that the raw data was deleted" and deletes the aggregate rows too. Keep `start_offset` well inside the raw retention period.

Ingesting from MQTT and Kafka

Concern	Do
Throughput	Batch: multi-row `INSERT` or `COPY`
Redelivery	`ON CONFLICT DO NOTHING` on the unique key
Late data	Arrives inside the refresh window
Clock source	Device timestamp, not insert time

Broker consumers deliver at least once, so make writes idempotent with the `(device_id, metric, time)` unique

key. Buffer messages for a few hundred milliseconds and write them in one statement rather than one round trip per reading.

```
INSERT INTO readings
  (time, device_id, metric, value)
VALUES
  ('2026-11-02T10:00:00Z', 7, 'power_kw', 41.2),
  ('2026-11-02T10:00:00Z', 8, 'power_kw', 39.8)
ON CONFLICT (device_id, metric, time) DO NOTHING;
```

> **Gotcha:** a reading older than the aggregate policy's `start_offset` lands in the raw table but never reaches the aggregate. After a device backfills days of buffered data, call `refresh_continuous_aggregate` for that range.

InfluxDB 3 in comparison

	TimescaleDB 2.31	InfluxDB 3.12
Engine	PostgreSQL extension	Own engine, Parquet on object storage
Query	Full SQL, joins	SQL and InfluxQL
Flux	—	Maintenance mode, not supported
Model	Tables you design	Tables with tags, fields, time
Open source	Core is Apache 2.0	InfluxDB 3 Core, single node

InfluxDB 3 is a rewrite: SQL replaces Flux, which is “now in maintenance mode”, and Flux queries must move to SQL or InfluxQL. Core is the free single-node release; Enterprise adds high availability and long-range historical queries. Pick TimescaleDB when telemetry

must join business data in Postgres; pick InfluxDB when it lives on its own.

```
# InfluxDB line protocol: table,tags fields time
power,device=7,site=n kw=41.2 1793613600000000000
```

> **Note:** continuous aggregates, the columnstore, retention policies and gap filling carry TimescaleDB's Community licence, not Apache 2.0. A Postgres service offering only the Apache build lacks them.

Further reading

- Tiger Data docs — Hypertables
- Tiger Data docs — Continuous aggregates
- Tiger Data docs — Hypercore (columnstore)
- TimescaleDB releases on GitHub
- InfluxData docs — InfluxDB 3 Core