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# MltAuxTSP: a unified benchmark for deep learning-based traffic state prediction with multi-source auxiliary data

**Key words:** Traffic prediction; Benchmark platform; Deep learning; Multi-source auxiliary data

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# Motivation

- Existing traffic prediction models rely solely on traffic-related data, limiting performance.
- Multi-source auxiliary data (weather, temporal features) are underutilized due to poor generality and scalability of integration methods.
- Lack of a unified benchmark hinders fair model comparison and quantification of auxiliary data benefits.

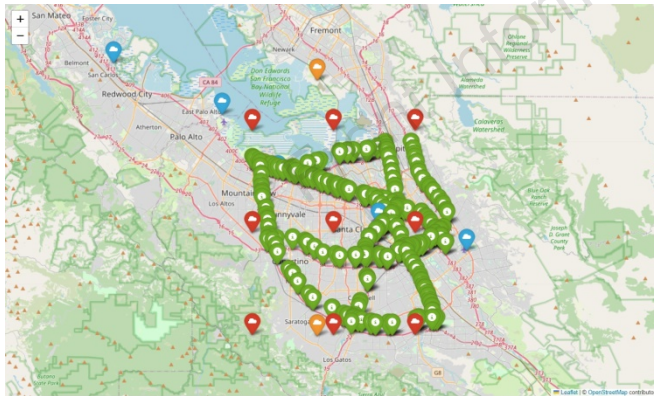
# Main idea

- Propose MltAuxTSP, a **general and scalable** framework integrating **multi-source auxiliary data**.
- Design a **unified data container (UDC)** to standardize heterogeneous data storage and management.
- Develop **fusion embedding modules** to convert multi-source data into unified hidden representations for downstream models.
- Augment classic datasets (METR-LA, PEMS-BAY) with weather and temporal features for standardized evaluation.

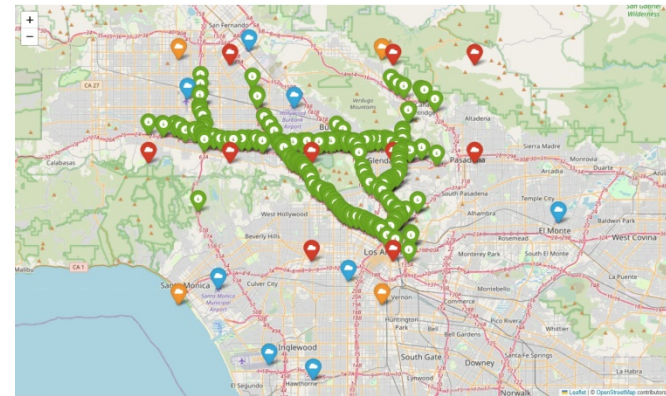
# Method

## 1. Data processing

- Augment METR-LA and PEMS-BAY with three weather datasets (ERA5-Land, ERA5-HEAT, GH-ISD) and three temporal features (minute of the hour, MoH; hour of the day, HoD; day of the week, DoW).
- Preprocessing: temporal interpolation (5-min frequency), spatial alignment, and Z-score normalization.



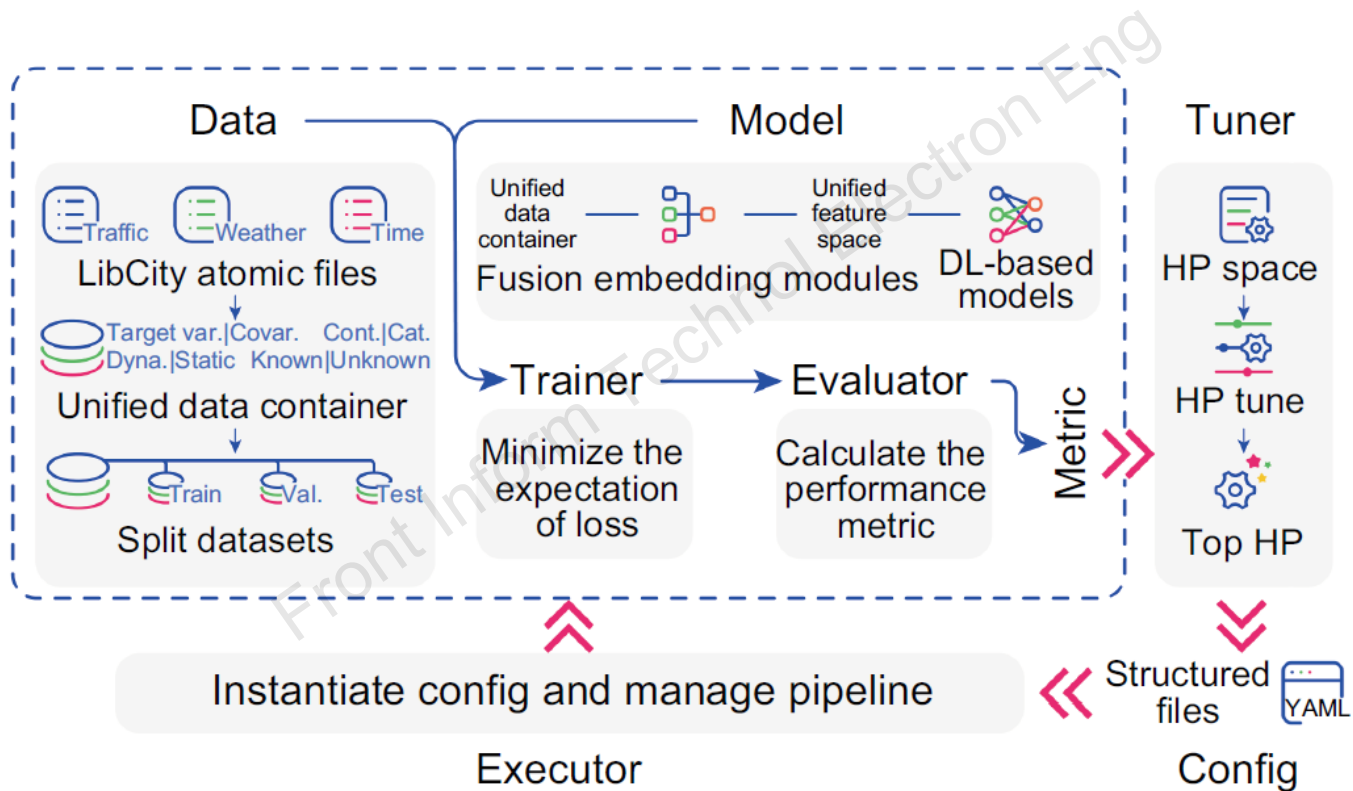
(a) PEMS-BAY



(b) METR-LA

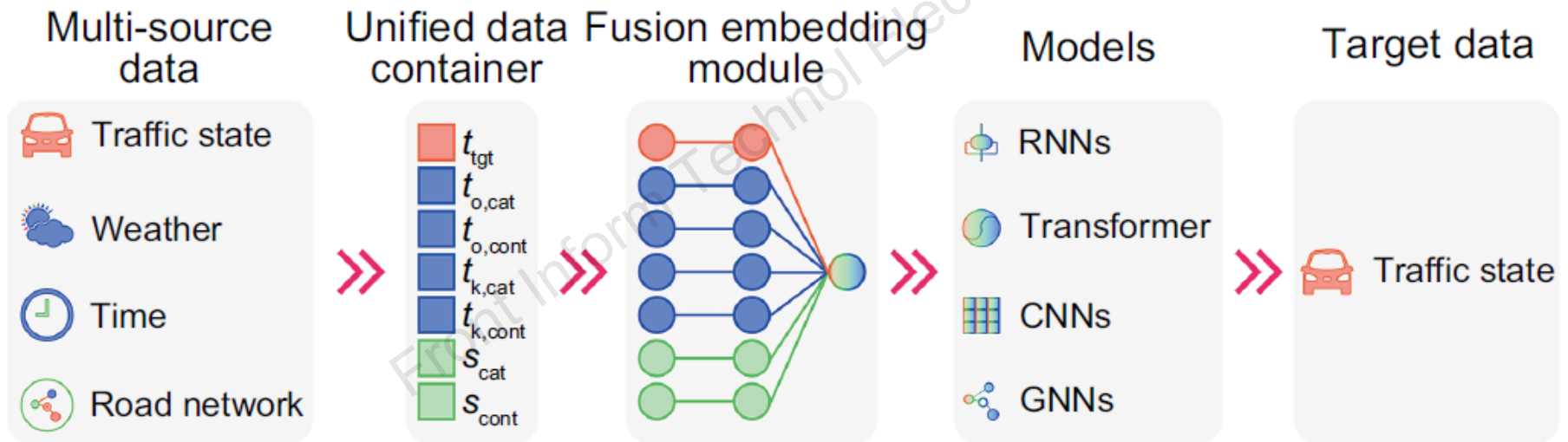
# Method

## 2. Benchmarking system



# Method

## 3. Multi-source auxiliary data fusion framework for traffic state prediction



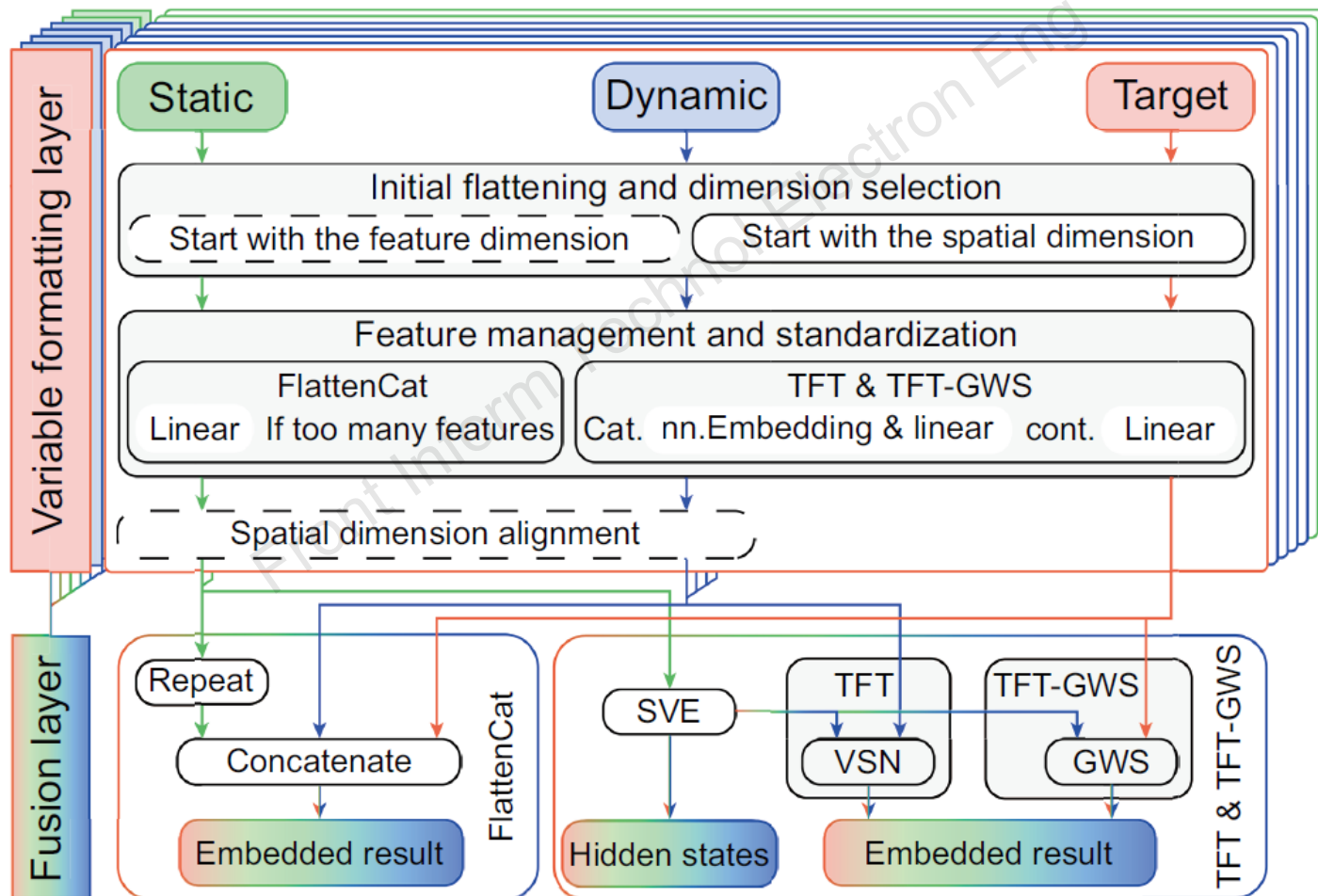
# Method

## 4. UDC

Component	Source	Temporal	Observation	Data type
$t_{tgt}$	Target	Dynamic	Unknown	Continuous, categorical
$s_{cont}$	Covariates	Static	Known	Continuous
$s_{cat}$			Known	Categorical
$t_{k,cont}$		Dynamic	Known	Continuous
$t_{k,cat}$			Known	Categorical
$t_{o,cont}$			Unknown	Continuous
$t_{o,cat}$			Unknown	Categorical

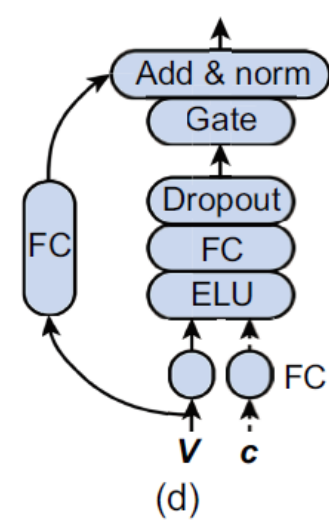
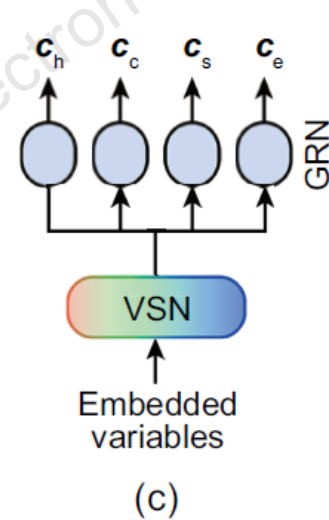
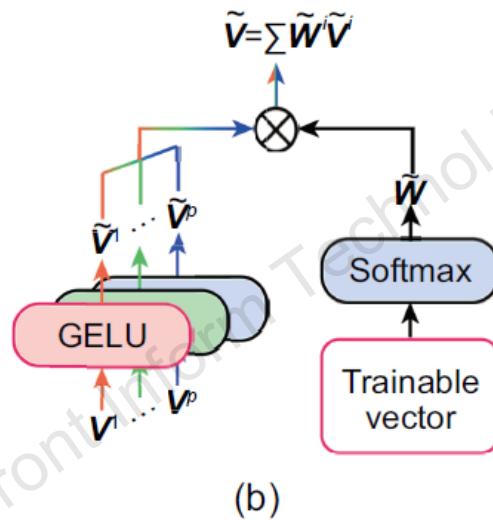
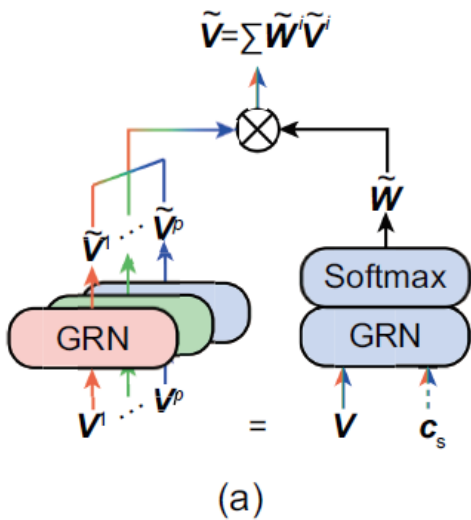
# Method

## 5. Fusion embedding modules



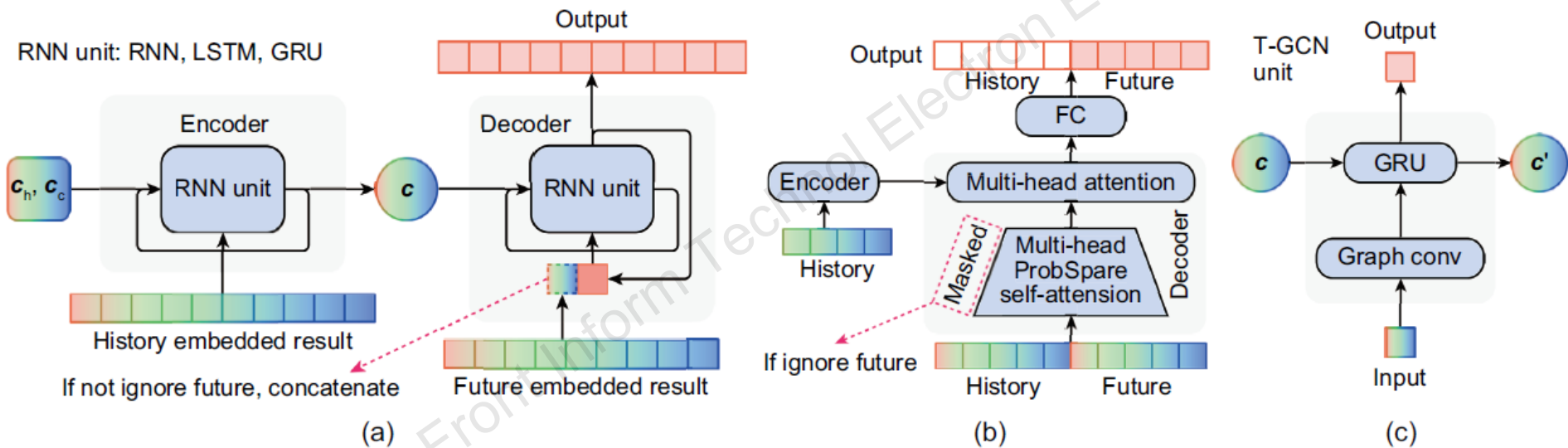
# Method

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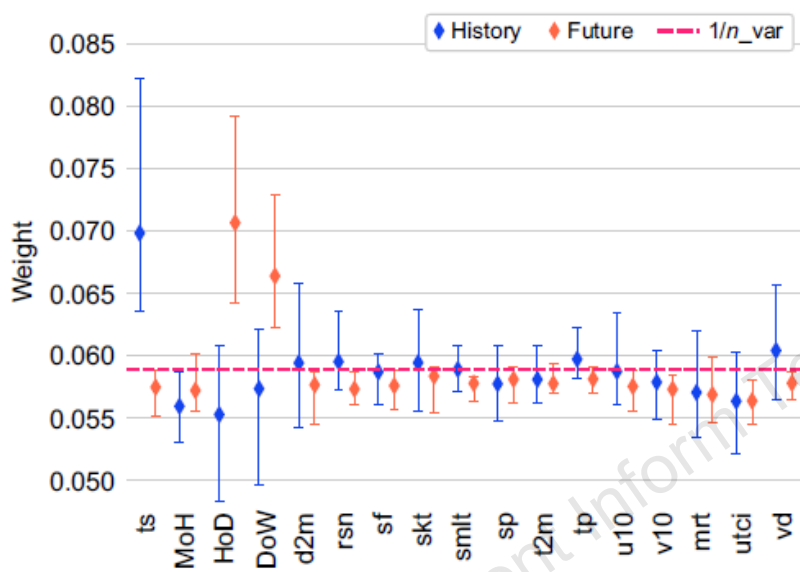


Fusion embedding modules and models: (a) Seq2Seq; (b) Informer; (c) T-GCN unit

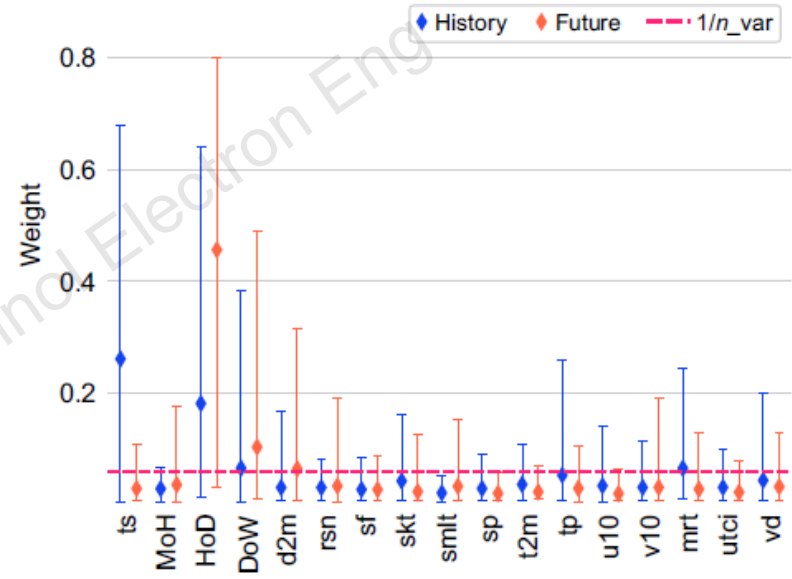
# Major results

- Bandwidth improvement: Auxiliary data enhance long-term (48/96 steps) prediction accuracy (TFT/TFT-GWS).
- Efficiency: TFT-GWS reduces parameters vs. TFT with comparable performance.
- Future information gain: Known future covariates (e.g., HoD/DoW) further boost accuracy.
- Nonlinear fusion modules (TFT/TFT-GWS) outperform linear FlattenCat, especially in long-term forecasting.
- Single-node tasks benefit more from auxiliary data; multi-node models capture spatial interactions effectively.
- Historical traffic speed, future HoD/DoW, and precipitation are top predictive features.

# Major results



(a)



(b)

Variable selection weights in Informer: (a) with TFT-GWS; (b) with TFT

# Conclusions

- MltAuxTSPP provides a unified, scalable platform for multi-source traffic prediction, solving data integration and fair comparison challenges.
- Fusion embedding modules effectively leverage weather and temporal features to improve long-term forecasting robustness.
- The framework serves as a foundation for advancing intelligent transportation system (ITS) research and applications.



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