Dial-a-Ride

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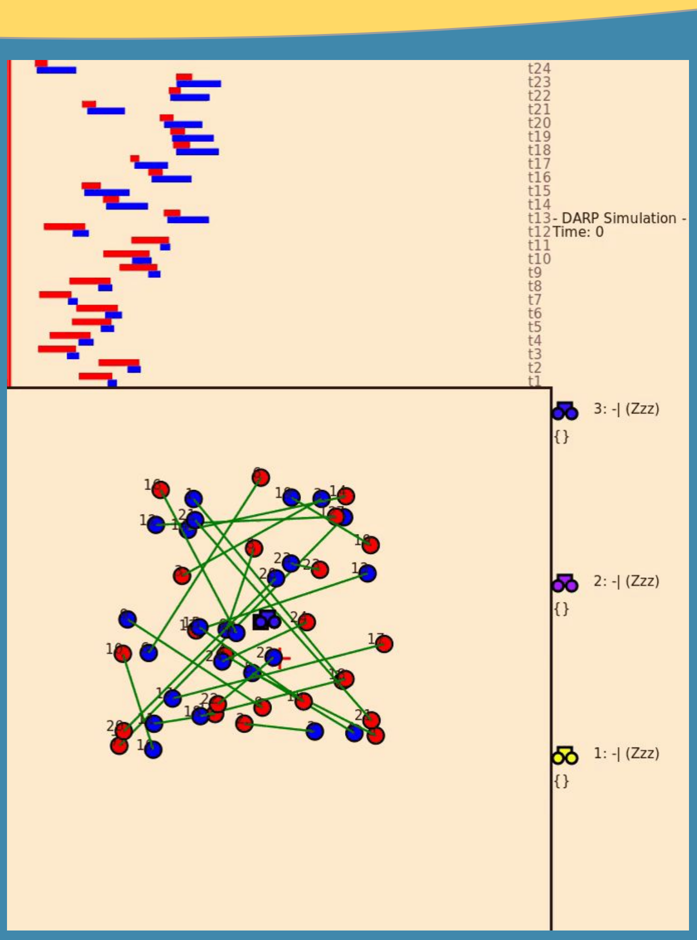
Combinatorial Problems with Transformers

The Dial a Ride Problem

- Complex **routing Problem**
- Pick-up and Drop of Targets
- **Constraints**:
  - Time & Space
  - Capacity
  - Service time
- **NP-Hard**:
  - DARP > VRP > TSP



Background

- DaRP Survey paper in 2018:

  A survey of dial-a-ride problems: Literature review and recent developments, C. Ho (2018)
  - Only **Operational Research**
  - No learning solutions
- DARP state-of-the-art:
  - Branch-and-Cut algorithms

    A new formulation for the dial-a-ride problem, Y. Rist (2021)
  - **Optimal** solutions on *cordeau2006*
- Use of **Transformer** in TSP
  - Get **optimality** with n=100

    The Transformer Network for the TSP, X. Bresson (2021)

Evaluation

- Classical benchmark datasets

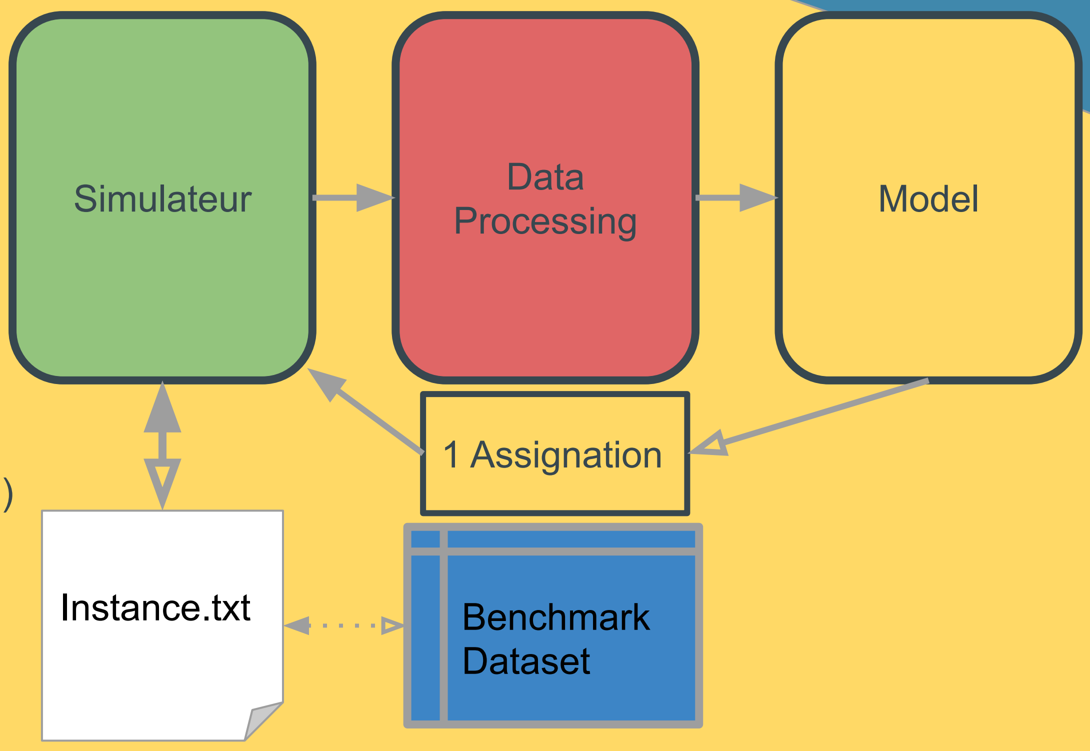
Cordeau2003:
- Heuristics
- Loose constraints

cordeau2006:
- Exact solutions
- Tight constraints

- Metrics:
  - Minimize cost function
  - Cost = Distance
  - GAP = % difference to best known solution
  - CPU = Computation time (min)

General Approach

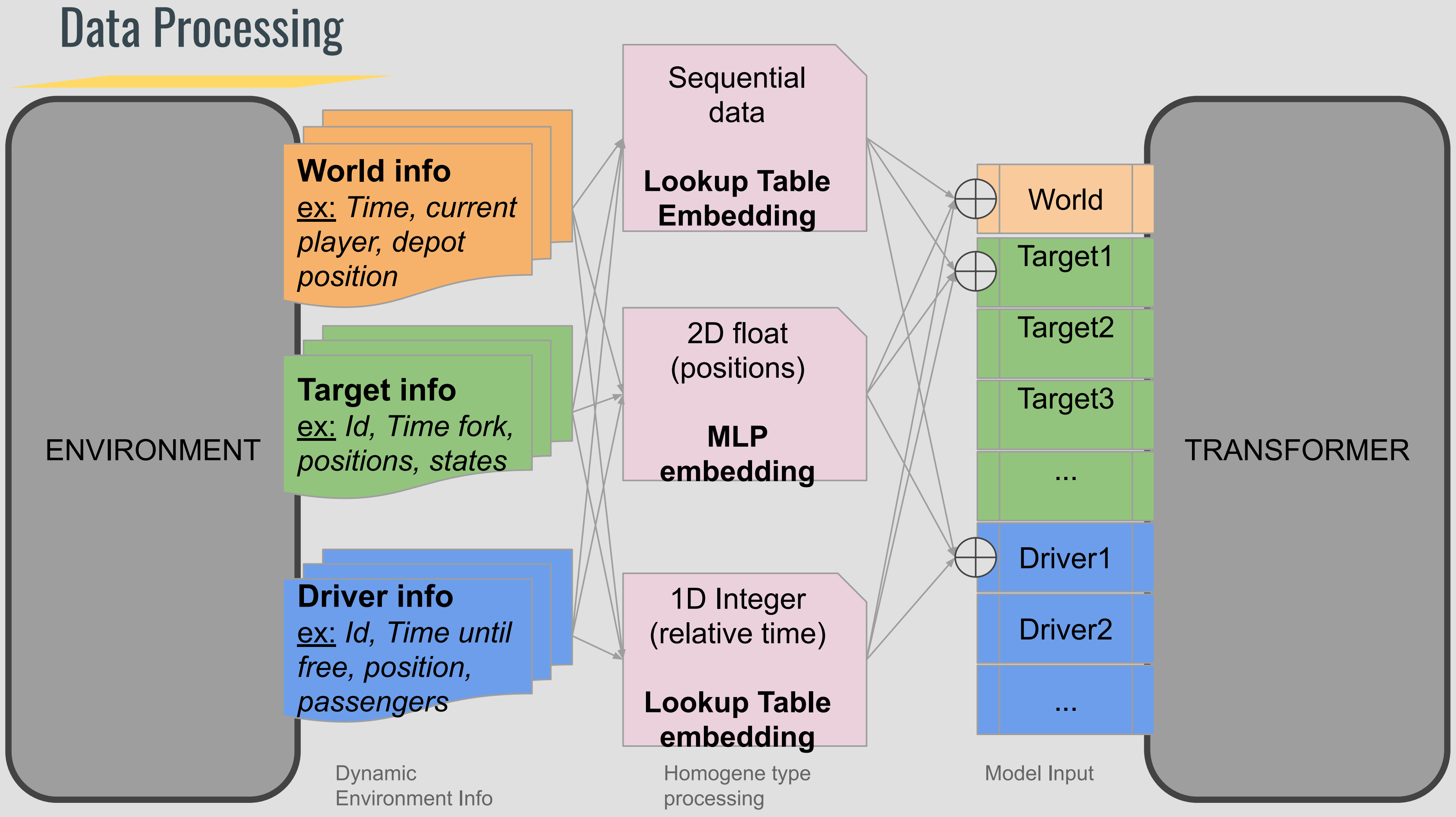
- **Translate the problem** to be understood by the model
- **Clone** an existing policy:
  - **Nearest Neighbor** (NN) (naive strategy)
  - **Restricted Fragment** (RF) (Exact & SotA)
- Learn on top with **RL**
- Evaluate on benchmark datasets



Simulator

- Respect of constraints:
  - Time & Space
  - Capacity
  - Service time
- Dynamic:
  - Online (but offline data..)
  - Continuous time
  - Sparse time step
- Interaction
  - Tour based game
  - Get observation of the environment
  - Action = Assign 1 target to current driver

Data Processing



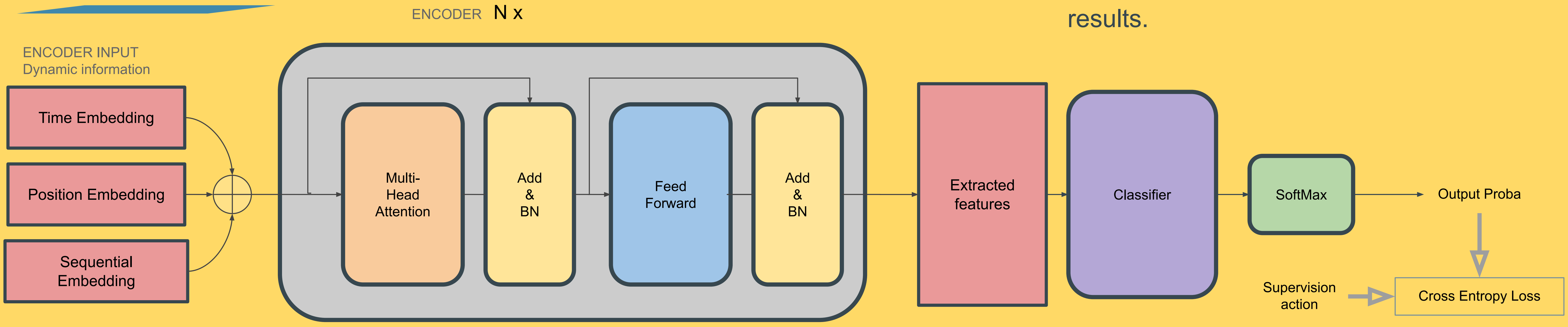
Results

Supervision	Dataset GAP *cordeau2006*	Random instance GAP	Accuracy on test data
RF	2.80%	2.78%	92.4%
NN	-	~100%	99.99%

Conclusion

- Results are **not able to compete** with exact and optimal solutions on *Cordeau2006*
- Although, we show that our approach is able to learn **near optimal solutions**, and understand a complex, multi-type data, combinatorial problem.
- Futures works: **Expand results** to different type of instances. **Train on top** with RL to improve results.

Transformer Model


ENCODER N x
ENCODER INPUT
Dynamic information
Time Embedding
Position Embedding
Sequential Embedding
Multi-Head Attention
Add & BN
Feed Forward
Add & BN
Extracted features
Classifier
SoftMax
Output Proba
Supervision action
Cross Entropy Loss