

# Solving the Capacitated Vehicle Routing Problem with Dynamic Graph Transformers

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**Abstract:** This paper presents a novel approach to solving the Capacitated Vehicle Routing Problem (CVRP) using Dynamic Graph Transformers. We leverage the power of deep reinforcement learning to train an agent that can dynamically construct high-quality routes for a fleet of vehicles. Our model is evaluated on a set of well-known CVRP benchmarks, and we show that it outperforms existing methods in terms of both solution quality and computational time.

## 1 INTRODUCTION

### 2 Model settings

#### 2.1 Instances

#### 2.2 GAT

#### 2.3 GT

### 3 Optimal and suboptimal benchmarks

Your paper will be part of the conference proceedings therefore we ask that authors follow the guidelines explained in this example in order to achieve the highest quality possible (?).

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## 4 MANUSCRIPT PREPARATION

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Please remember that all the papers must be in English and without orthographic errors.

Do not add any text to the headers (do not set running heads) and footers, not even page numbers, because text will be added electronically.

For a best viewing experience the used font must be Times New Roman, except on special occasions, such as program code 4.4.8.

### 4.1 Manuscript Setup

The template is composed by a set of 7 files, in the following 2 groups:


**Group 1.** To format your paper you will need to copy into your working directory, but NOT edit, the following 4 files:


- apalike.bst
- apalike.sty
- article.cls
- scitepress.sty


**Group 2.** Additionally, you may wish to copy and edit the following 3 example files:

- example.bib

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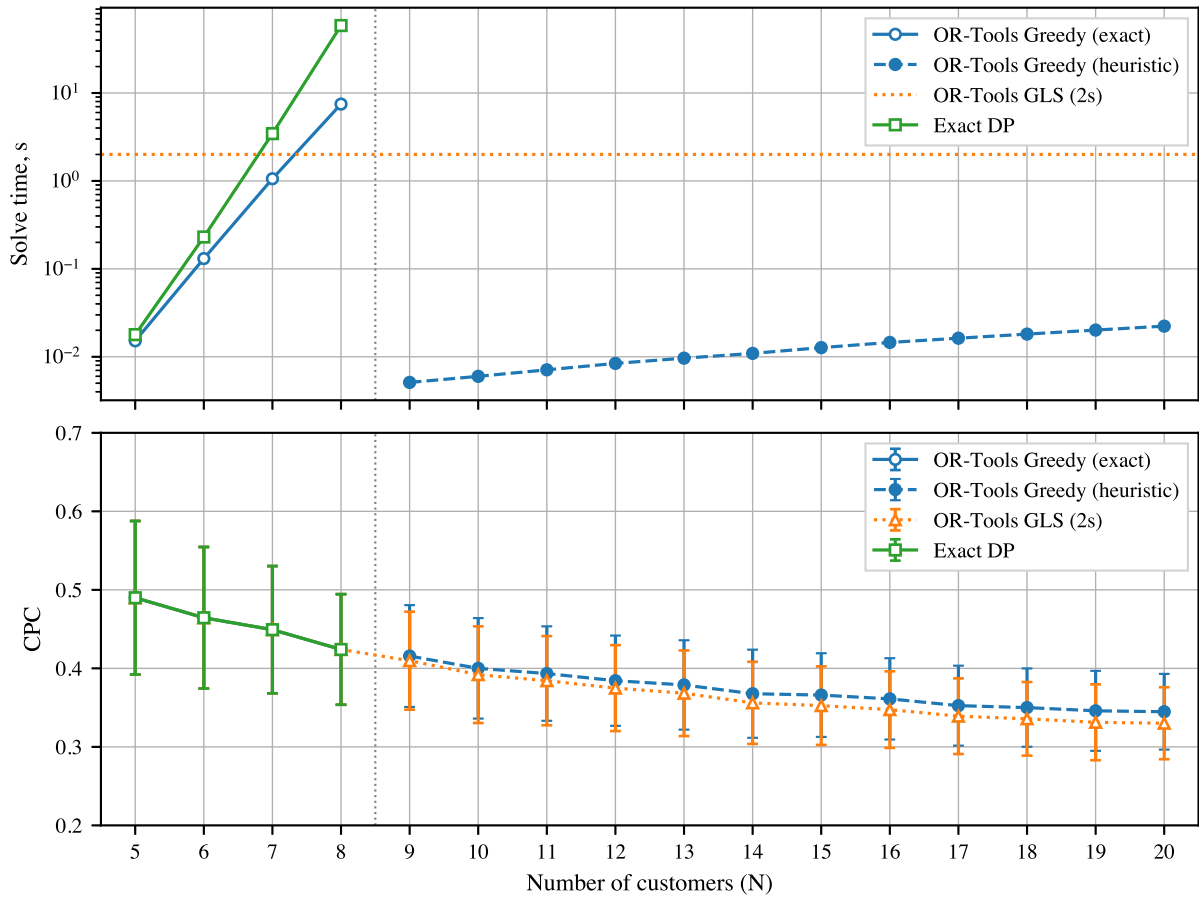


Figure 1: Performance comparison of CVRP solvers on CPU benchmarks. **Top panel:** Solve time (log scale) versus problem size for different solvers. Exact DP provides optimal solutions but is limited to small instances ( $N \leq 8$ ). OR-Tools Greedy operates in exact mode for  $N \leq 8$  (solid line) and switches to heuristic mode for larger instances (dashed line). OR-Tools GLS with 2-second time limit maintains consistent performance across all problem sizes (dotted line). **Bottom panel:** Cost per customer (CPC) showing solution quality with error bars indicating standard deviation across 1000 instances per problem size. The vertical line at  $N=8.5$  marks the transition point between exact and heuristic approaches for OR-Tools Greedy.

- example.tex  
- scitepress.eps

## 4.2 Page Setup

The paper size must be set to A4 (210x297 mm). The document margins must be the following:

- Top: 3,3 cm;
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- Left: 2,6 cm;
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It is advisable to keep all the given values because any text or material outside the aforementioned margins will not be printed.

## 4.3 First Section

This section must be in one column.

### 4.3.1 Title and Subtitle

Use the command `\title` and follow the given structure in "example.tex". The title and subtitle must be with initial letters capitalized (titlecased). The separation between the title and subtitle is done by adding a colon ":" just before the subtitle beginning. In the title or subtitle, words like "is", "or", "then", etc. should not be capitalized unless they are the first word of the title or subtitle. No formulas or special characters of any form or language are allowed in the title or subtitle.

Table 1: GPU CVRP Performance with Log-normal Statistics and Normality Tests

Method	N	Cap.	GM	GSD	95% Range	95% CI	KS	D'Agost.	JB	AD
Exact (100k)	10	20	0.4735	1.2012	[0.3306, 0.6782]	[0.4730, 0.4741]	0.19	<0.001	<0.001	1.405*
Exact (10k)	10	20	0.4737	1.1996	[0.3316, 0.6767]	[0.4720, 0.4754]	0.93	0.37	0.37	0.295
Heuristic	10	20	0.4831	1.2064	[0.3344, 0.6978]	[0.4813, 0.4849]	0.87	0.44	0.44	0.353
Heuristic*	20	30	0.3319	1.1514	[0.2518, 0.4376]	[0.3310, 0.3328]	1.00	0.85	0.86	0.093
Heuristic*	50	40	0.2303	1.1291	[0.1815, 0.2921]	[0.2297, 0.2308]	0.73	0.29	0.28	0.400
OR-Tools GLS	100	50	0.1811	1.1058	[0.1487, 0.2206]	[0.1776, 0.1847]	0.47	0.39	0.49	0.521

GM: Geometric Mean, GSD: Geometric Standard Deviation

95% Range: Individual value range  $GM \times [GSD^{-1.96}, GSD^{+1.96}]$

95% CI: Confidence interval for the geometric mean

KS: Kolmogorov-Smirnov, D'Agost.: D'Agostino, JB: Jarque-Bera (p-values for log(CPC) normality)

AD: Anderson-Darling test statistic (critical value at 5% = 0.787; \* indicates rejection)

\* Based on partial benchmark data from GPU heuristic

OR-Tools GLS: 100 instances with 1s time limit per instance

Table 2: GPU Improved Heuristic Performance (10,000 instances)

N	Capacity	Mean CPC	Std CPC	SEM	2×SEM/Mean(%)
10	20	0.4815	0.0886	0.0003	0.12%
10	20	0.4816	0.0881	0.0008	0.37%
10	20	0.4916	0.0929	0.0009	0.38%
20	30	0.3353	0.0476	0.0005	0.28%
50	40	0.2316	0.0283	0.0003	0.24%
100	50	0.1753	0.0208	0.0002	0.24%

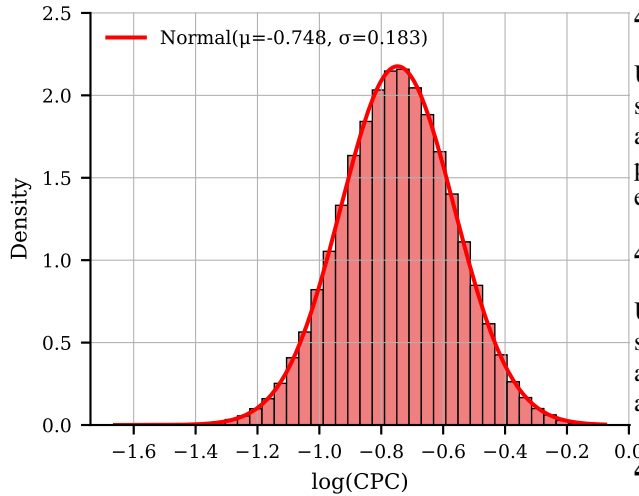


Figure 2: Distribution of log(CPC) for N=10 CVRP instances solved using GPU dynamic programming. The histogram shows 100,000 random instances with the fitted normal distribution overlaid ( $\mu = -0.748$ ,  $\sigma = 0.183$ ). The log-normal fit demonstrates that CPC follows a log-normal distribution (Kolmogorov-Smirnov test,  $p = 0.189$ ).

#### 4.3.2 Authors and Affiliations

Use the command `\author` and follow the given structure in "example.tex". Please note that the name of each author must start with its first name.

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#### 4.3.4 Abstract

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Each column must be 7,5-centimeter wide with a column spacing of 0,8-centimeter.

The section text must be set to 10-point.

Section, subsection and sub-subsection first paragraph should not have the first line indent.

To remove the paragraph indentation (only necessary for the sections), use the command `\noindent` before the paragraph first word.

If you use other style files (.sty) you MUST include them in the final manuscript zip file.

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The heading of a section title should be in all-capitals.

Example: `\section{FIRST TITLE}`

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The heading of a subsection title must be with initial letters capitalized (titlecased).

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Example: `\subsubsection{First Subsubtitle}`

#### 4.4.4 Tables

Tables must appear inside the designated margins or they may span the two columns.

Tables in two columns must be positioned at the top or bottom of the page within the given margins. To span a table in two columns please add an asterisk (\*) to the table *begin* and *end* command.

Example: `\begin{table*}`  
`\end{table*}`

Tables should be centered and should always have a caption positioned above it. The font size to use is 9-point. No bold or italic font style should be used.

The final sentence of a caption should end with a period.

Table 3: This caption has one line so it is centered.

Example column 1	Example column 2
Example text 1	Example text 2

Table 4: This caption has more than one line so it has to be justified.

Example column 1	Example column 2
Example text 1	Example text 2

Please note that the word "Table" is spelled out.

#### 4.4.5 Figures

Please produce your figures electronically, and integrate them into your document and zip file.

Check that in line drawings, lines are not interrupted and have a constant width. Grids and details within the figures must be clearly readable and may not be written one on top of the other.

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`\end{figure*}`

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#### 4.4.6 Equations

Equations should be placed on a separate line, numbered and centered.

The numbers accorded to equations should appear in consecutive order inside each section or within the contribution, with the number enclosed in brackets and justified to the right, starting with the number 1.

Example:

$$a = b + c \quad (1)$$

#### 4.4.7 Algorithms and Listings

Algorithms and Listings captions should have font size 9-point, no bold or italic font style should be used and the final sentence of a caption should end with a period. The separator between the title of algorithms/listings and the name of the algorithm/listing must be a colon. Captions with one line should be centered and if it has more than one line it should be set to justified.

#### 4.4.8 Program Code

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Example of a Computer Program in Pascal:

**Data:** this text

**Result:** how to write algorithm with L<sup>A</sup>T<sub>E</sub>X2e initialization;

```
while not at end of this document do
  read current;
  if understand then
    go to next section;
    current section becomes this one;
  else
    go back to the beginning of current
    section;
  end
end
```

Algorithm 1: How to write algorithms.

```
Begin
  Writeln('Hello World!!');
End.
```

The text must be aligned to the left and in 9-point type.

#### 4.4.9 Reference Text and Citations

References and citations should follow the APA (Author, date) System Convention (see the References section in the compiled manuscript). As example you may consider the citation (?). Besides that, all references should be cited in the text. No numbers with or without brackets should be used to list the references.

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## ACKNOWLEDGEMENTS

If any, should be placed before the references section without numbering. To do so please use the following command: `\section*{ACKNOWLEDGEMENTS}`

## APPENDIX

If any, the appendix should appear directly after the references without numbering, and not on a new page. To do so please use the following command: `\section*{APPENDIX}`