An Template of Research Papers

Peng Cheng
Hong Kong University of Science and Technology
Hong Kong, China
pchengaa@connect.ust.hk

Example
Example University
Earth, Universe
example@example.edu

ABSTRACT

"Usually write this section when are creating an entry in the system, which means that leave this section at the end."
Sentence1: Background of this paper.
Sentence2: What is your point? What is the novelty of your paper? The key point! Say it clearly!
Sentence3: What problem you modeled? Briefly introduce your problem.
Sentence4: What is the challenge in your problem?
Sentence5: How you solve it? Any heuristic algorithms or approximation algorithms proposed? If your algorithms have some interesting or theory results, show them here! For example, good approximation ratios, low time complexities, and efficient structures.
Sentence6: Introduce that the experiments have demonstrated your algorithms. For example, "Through extensive experiments, we demonstrate the efficiency and effectiveness of our XXX approaches on both real and synthetic data sets."

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1. INTRODUCTION

Before introduce how to write a good introduction, I want first emphasize the important of introduction section as below (for the details, see the slides in "Slides" folder of this project):

Spend some time to pick a good title for your paper!!! If your paper later has 1000 hundred of readers, 1000 will read your title, 100 read abstract, 100 read introduction, 10 read your problem definition, 10 read related work, maybe just 10 or less than 10 will read your solutions and only 5 read the details of your solution at the end.

Usually, you should write the introduction section two times! 1) Write it first: tell a clear story; 2) write it last: make sure it is telling what you really do in your finished paper.

Here is a good structure for introduction section:

Paragraph 1: Context. What is the background? At most 4 sentences please!

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Paragraph 2: Problem area. Some related studies. What is the problem in this area? Don't tell too detailed about the related studies, which is what "Related Work" will do. About 3 sentences are enough.

Paragraph 3-4: What you do in this paper? What is the key point of this paper? You can have a motivation example to show your niche! Usually, people can understand example better than what you explained. Better to draw an interesting figure for you problem. Like the example [1] below:

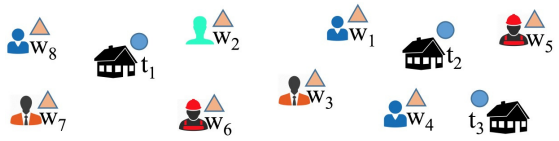


Figure 1: An Example of Motivation Example.

Paragraph 5: challenges in this novel problem. Why it is hard? Why existing solutions cannot solve it?

Paragraph 6: What you have done on solving it? Similar to the introduction, but more details. Brief summary of results.

Paragraph 7: Outline of this paper. You can modify the example below:

To summarize, we make the following contributions in the paper:

- We propose a XXXX problem and prove it is NP-hard in Section 2.
- We proposed solution1 and solution2 in Section 3 and 4, respectively.
- We have conducted extensive experiments on real and synthetic data sets, to show the efficiency and effectiveness of our XXX framework/algorithm in Section 5.

In addition, the remaining sections of the paper are arranged as follows. We review and compare previous studies on queueing theory and vehicle dispatching in Section 6 and conclude the work in Section 7.

2. PROBLEM DEFINITION

Three tasks to do in this section: 1) define the small components in this paper; 2) formally define the problem with your components; 3) prove the hardness of the proposed problem through a theorem.

Theorem 2.1. *(Hardness of the XX Problem) The problem of the Example Problem (XX) is NP-hard.*

To learn how to prove NP-hardness, read the example [2].

Usually, at the end of this section, add a table to list the important variables used in this paper as a reference.

Table 1: Symbols and Descriptions.

Symbol	Description
R	a set of m time-constrained riders
r_i	a rider r_i sending ride request q_i
s_i	the source location of ride request q_i
e_i	the destination location of ride request q_i

3. SOLUTION1

Paragraph 1: what is the general idea of the solution1? Greedy based? DP? Generally introduce solution1.

3.1 some properties

Do you have any properties about the problem to use to develop the algorithm? Show them in this subsection with lemmas.

Or you need define some special values to ease your algorithm description, do it here!

You may need to write some equations. Here I show some example equations styles.

1. Multiple Equations with numbering:

$$A = B \tag{1}$$
$$B = C. \tag{2}$$

2. Single equation with numbering:

$$A = B \tag{3}$$

3. Simple equation without numbering:

$$A = B$$

4. Align equations:

$$\begin{aligned} & function(A) \\ = \; & A^3 + A^2 + A^1 \end{aligned} \tag{4}$$

5. Equation with more than one conditions:

$$A = \begin{cases} A + 1, & A \neq 0 \\ A, & A = 0 \end{cases} \tag{5}$$

6. Linear Programming:

$$\begin{aligned} \max \quad & \sum \lambda_{ik} \cdot x_{ik} \\ \text{s.t.} \quad & d(u_i, v) \cdot x_{ik} \leq r, \quad i = 1, \ldots, m; k = 1, \ldots, q, \\ & \sum_{k=1}^{q} x_{ik} \leq 1, \qquad i = 1, \ldots, m, \end{aligned} \tag{6}$$

3.2 proposed algorithm

Your algorithm needs a interesting name! Stop simply calling it "the Greedy algorithm" or "the Dynamic Programming Based Algorithm"! Do not use these boring names, please!

Introduce the details of your algorithms with natural language. Below is an example of pseudocode.

3.3 theory analyses

Analyze the approximation ratios, competitive ratios, time complexities here.

4. SOLUTION2

Paragraph1: Explain why you propose solution2. What point will solution2 improve compared with solution1?

The rest is similar to what you have done in solution1 section.

Algorithm 1: ExampleAlgorithm

Input: A set C of n workers, and a set R of m riders
Output: A set of updated scheduling sequences S

```
foreach r_i ∈ R do
    retrieve a list C_i of workers that are valid to r_i
while C_i ≠ ∅ do
    if rider r_i can be arranged in c_j then
        do if.
        break
    else if r_i can replace rider r_i' of c_j then
        do else.
        break
do
    Eample of do-while-loop
while condition
return 𝕊
```

Table 2: Experimental Settings.

Parameters	Values
the number, m, of riders	1K, **3K**, 5K, 8K, 10K
the number, n, of vehicles	100, **200**, 300, 400, 500
the pickup deadline range $[rt^-_{min}, rt^-_{max}]$	**[1, 10]**, [10, 30], [30, 60]
the capacity of vehicles a_j	2, **3**, 4, 5
the balancing parameters (α, β)	(0, 0), (1, 0), (0, 1), **(0.33, 0.33)**
the flexible factor ε	1.2, **1.5**, 1.7, 2
the length δ_j of time frame f_j	30 mins

5. EXPERIMENTAL STUDY

5.1 Data Set

In introduce what data sets you have used in your experimental study. Real dataset first, then synthetic dataset.

5.2 Approaches and Measurements

What approaches tested in the experimental study? Introduce each one with one sentence. Your proposed approaches, the compared existing approaches, random approaches, and so on.

Why need this paragraph? Readers may have forgot your solutions, thus just make them recall your solutions through some simple descriptions.

Then introduce the measures you will compare on, such as running time, memory usage, and so on. Usually, control variate method will be used in the experimental study. Define a default setting, then change one parameter in a set of experiments. Make a table to show the configuration, like the example in Table 2 [2].

Finally, introduce the running environment of your experimental study. Running on what kind of PCs or servers? Using what programming languages?

5.3 Experimental Results

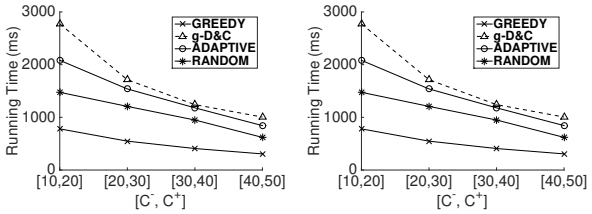
What do you discover or demonstrated in the experimental study? Show the effects of each parameters one by one. Usually, describe results on real dataset first.

Better to have a summary of the interesting points found in the experimental study at the end of this subsection.

5.4 Adding Figures

In this subsection, some example of adding figures are introduces. Usually, put figures on the top of pages. Put figures close to their description.

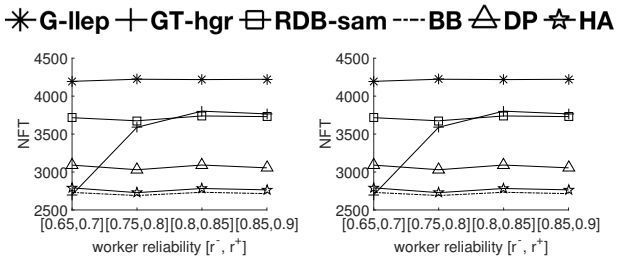
Below is an example of adding two figures together. Modify the related vspace configuration in head.tex to adjust the global setting. To adjust locally, just add your local spacing command behind them. Parameter "h" means "here"; "t" means "top"; "!" means "mandatory". In vspace command, I like to use "ex", which just a unit and you can use others like "px". For other parameters, you can adjust them to see the effects.



(a) Sub Caption1 (b) Sub Caption2

Figure 2: An Example of Figure.

Add a bar on top of a group of subfigures, like in Figure 3.



(a) Sub Caption1 (b) Sub Caption1

Figure 3: An Example of Figure.

To draw a figure crossing two columns, like in Figure 4.
Some suggestions:

- Label subfigures and figures separately. When you describe the particular figure, your can accurately refer to the one you want refer to.
- Use eps files! If you need to convert jpg or png to eps, you can try this website: `https://www.online-convert.com`, which is the most stable one I can find.
- Put figures on the top of pages for better layout.
- Put figures close to their description to ease your readers.

6. RELATED WORK

Half page or $\frac{3}{4}$ pages are enough.

7. CONCLUSION

Just describe what are studied in this paper. Do not talk about related work anymore.

8. ACKNOWLEDGMENT

If you think this template help you on writing research papers and you work on the related topics, please help to cite some of my publications [1, 2, 3, 4, 5, 6, 7, 8, 9, 10]. Thanks a lot!

9. REFERENCES

[1] P. Cheng, X. Lian, L. Chen, J. Han, and J. Zhao, "Task assignment on multi-skill oriented spatial crowdsourcing," *IEEE Transactions on Knowledge and Data Engineering*, vol. 28, no. 8, pp. 2201–2215, 2016.

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[7] P. Cheng, X. Jian, and L. Chen, "An experimental evaluation of task assignment in spatial crowdsourcing," *Proceedings of the VLDB Endowment*, vol. 11, no. 11, pp. 1428–1440, 2018.

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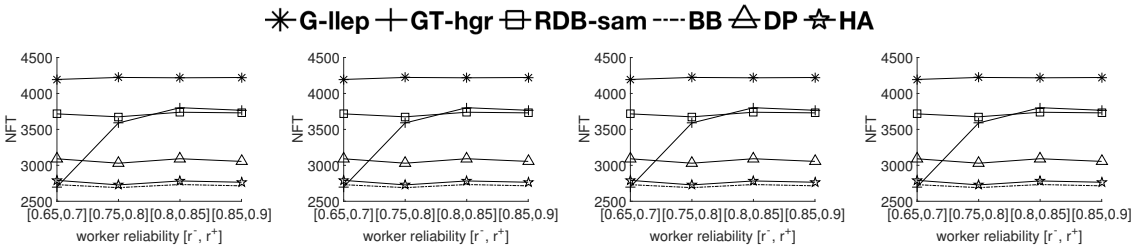

(a) Sub Caption1 (b) Sub Caption2 (c) Sub Caption3 (d) Sub Caption4

Figure 4: An Example of Figure.