**Smart Manufacturing Lab- Marelli**

The document is really clear for me, thank you very much.

Hope you can state it clearly in your presentation.

Today, give me some progress on

the data base?

meetings?

questions?

**data processing**: automaticlly process the data in the database.

in each batch, flat or rotate machine is deterministic. we can deal with in batch, but put the setup timeA , set time B inside the batch processing time.

Marelli is a provider for customers.

each customer has many products in each order.

The class of products for each customer may not be the same. one customer can only use SP7.

1. Assignable lines: lines capable of processing the lot

SP lines

SP7 single machine schduling

In each line, there are different stations, once enter, step by step processing.

processing time

1. Dimension of the lot as number of sheets
2. Figures per sheet: it is used to estimate the number of sheets that must be processed to obtain the desired number of parts.

setup time

Re-enter

Number of ink layers: it entails the number of passes the parts will flow through the line for the different layers to be printed

Cycle time: one station or one line?

info needed for the model

data into one table

products/figures/sheets/ lots/parts/layers

Qusetions:

1. cycle time means whole line or..
2. ....
3. ...

Table (Think and add Label field as much as possible):

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| ID | product class | capable lines | setup | Dimension of the lot (number of sheets) | processing  time(if on SP1/2/3) | processing  time(if on SP4/5) | sp 6 needed or not | re-work/  passing stations | objective | .... |
| order 1 |  |  |  |  |  |  |  |  |  |  |
| order 2 |  |  |  |  |  |  |  |  |  |  |
| ... |  |  |  |  |  |  |  |  |  |  |

We can procede in a smarter way.

You guys try to understand the manufacturing environment, and model it.

If you have doubts, leave comments, and ask them when they hold the meeting.

I can provide suggestions after your proposal/model.

we discuss the feasibility and correctness of the prototype of the process flow and formulation.

Feel

Thank you Riccado.

I have re-read the model, and I think the paper is right to use "<=".

before I thought, is there any possiblity that X201=0 while X213=1, in fact, constraint 5 gurantee this won't happen.

while from the theory point of view, if the number of jobs is larger than the number of machines, I think "==" should be correct also. while if the number of jobs is not certainly larger than the number of machines, "==" should be not sure.

So let's keep it "<=", just take this as an exercise to understand the formulation.

with respect to the CPU time, in my laptop, both "==" and "<=" cost about 1 minute, in my experience, some models with tight constraints(==) can accelerate, but not to this model, it's another story, and we won't address it here.

I prefer to delete the constraint 8, since in the gurobi variable definition, we set lb=0, hope it can accelerate little in the future large problems.

Ok, that's all about this model part.

Next is the Gantt chart.

overlay the chart in plotly always use add\_trace, but it seems not applicable to timeline chart.

So I modified the dataFrame to the plotly, i.e. take setup as one job. It's like a small trick. For your reference.

And I have a quesion on your data collection after the model to create machine list.

you use

"for j in range(nJobs):

for k in range(nJobs):"

twice, this is because there at most one reverse order in each machine.

I mean in the final machine list [[0, 10, 7, 9], [0, 6, 3, 5], [0, 1, 2, 4, 8]],

in machine 1, job 10, job 7 in reverse order.

in machine 2, job 6, job 3 in reverse order.

This is why first loop only give

[[0, 10, 7], [0, 6, 3], [0, 1, 2, 4, 8]]

but if we have more jobs, more reverse orders, this approach need more loops, and we don't know how many loops we need in advance, right?

do you agree with me?

Think about some approach more reasonable.

@Riccado, you use this code and generated only two machinlists on your laptop?

That will be stange, maybe you need restart all, the Kernel/out..

although when printAttr('X'), some 0.999997 emerge, no problem, it's ==1 when use in Gurobi.

but only machine list is a problem, clear all and re-try.

Anyway, really great work, guys, proud of you.

Hope this small project work is rewarding for you and hope we can begin some on real industrial case as soon as possible.

Feel free to contact me if you have some other ideas or questions.

Thank you very much for your work and collaboration.

**30 Mar**

Robust makespan minimisation in identical parallel machine scheduling problem with interval data

**regret-maximising scenario for any schedule belongs to a finite set of extreme point scenarios**

**23 Mar**

**Theory:**

1. Organize some sentences on the parallel machine environment, and kinds of setup times.
2. Overview of kinds of models from referred literature, questions?

**Codes exercise:**

1. The first MIP model "identical parallel machine scheduling", you have in hand (make sure you can run it successfully).
2. Unrelated parallel machine scheduling, with excel data, with visualization Gantt chart.

This should be easy, slightly modify the identical model. Right?

1. (optional) If you have time, add sequence dependent setup time data in the formulation, and have a try.

We will say setup time will increase the complexity of the problem (model construction and CPU running time)

the model proposed in " A genetic algorithm for the unrelated parallel machine scheduling problem with sequence dependent setup times"

pay attention to the index of parameters.

I slightly modified the excel sheet of setup time.

I prefer to change the constraint 4 to "==1"

a source data file for you.

The first sheet is processing times and the second sheet is set up times, note that here it's only job sequence dependent. So you can use binary variable Xij to represent it, no need the machine index for this moment.

As you know, pandas library is popular in excel data processing. We use read\_excel or read\_csv function, pay attention to the first row and first column, is it data or name, need parameter to control this(see the online documentation).

Then now it's a dataframe in the code.

we can get/read the data of a dataframe or transform the dataframe to a list.

Now data is yours, use it as you want.

If we don't have any further information from the company, let's put aside the industrial case for a moment, I hope you can organize the work/results clearly before next Tuesday, in case Professor will attend the meeting and you can show to him step by step.

**Codes exercise:**

The first MIP model "identical parallel machine scheduling", you have in hand (make sure you can run it successfully).

Unrelated parallel machine scheduling, with excel data, with visualization Gantt chart.

(optional) If you have time, add sequence dependent setup time data in the formulation, and have a try.

**Theory :**

Organize some sentences on the parallel machine environment, and kinds of setup times.

That's enough.

I know this is the first experience on python, it will be a little frustrating sometimes.

Feel free to contact me even simple python debug problems.

If you still feel hard to hands on this, let me know and we can prepare a webinar on this, spend 1 hour to learn this.

Definitely you are expecting the company to re-start this project as soon as possible, while waiting, I hope you can enjoy the preliminary work, it's also interesting and useful.

best regards,

Lei

**identical parallel machine scheduling**



*Biskup, Dirk, Jan Herrmann, and Jatinder ND Gupta. "Scheduling identical parallel machines to minimize total tardiness." International Journal of Production Economics 115.1 (2008): 134-142.*

**uniform parallel machine scheduling**

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*Xu, Xiaoqing, Jun Lin, and Wentian Cui. "Hedge against total flow time uncertainty of the uniform parallel machine scheduling problem with interval data." International Journal of Production Research 52.19 (2014): 5611-5625.*

**unrelated parallel machine scheduling with dependent set-up time, MIP formulation**



*Vallada, Eva, and Rubén Ruiz. "A genetic algorithm for the unrelated parallel machine scheduling problem with sequence dependent setup times." European Journal of Operational Research 211.3 (2011): 612-622.*

Hi everyone. I hope this email finds you well.

Here I want to update something about the Smart manufacturing lab course work.

I communicated with Prof. Urgo, and he suggested that waiting for the company in this week was not a good idea. We should begin with some preliminary work. As Riccardo said on Tuesday.

**First thing** is about the parallel machine scheduling environment, there are several forms of parallel machine scheduling environments (identical, uniform, unrelated..), I hope you to learn and understand this.

Then **second thing** is about the setup time, it is always classified as sequence-dependent/ sequence-independent. I can't remember this Tuesday's meeting, in your slides, you presented this or not. Anyway, you will use it in this project.

The **third one** is about the uncertainty in parallel machine scheduling environment. I don't know if you have some knowledge on risk measures (VaR, CVaR..). If not, I suggest you begin from minimax regret for interval processing time.

In this project, your Mixed Integer Programming formulation will on

* deterministic parallel machine scheduling without setup time
* deterministic parallel machine scheduling with setup time
* Robust parallel machine scheduling with setup time

Step by step, then you can fulfill the aim.

I attached several papers on these for your reference, for the references, you can ignore the algorithm part, only focus on the problem environment and MIP formulation part. Of course you can search more.

About the meeting, Professor fixed the Tuesday morning 9:00-10:00, he will be there maybe every 2-3 weeks, but I will be there every week, so that we can discuss the progress and questions.

Before next Tuesday, I hope you can finish some study on the different kinds of parallel machine scheduling, and setup time. Also, begin MIP formulation/coding work on the simple deterministic version problem.

Thanks for your work.

Again, feel free to contact me if there is anything confusing.

Best regards,

Lei