1 Introduction: Ordinator v0.2.2

This memo is for the Ordinator scheduling project with the goal of getting primary stakeholders in sync.

2 Status Update

- Writing to SAP
- Coding on the server side
- Academic Papers
- External Stay
- Problems and Issues

3 Writing to SAP

I have had discussions with people in Paris about writing to SAP. Specifically asked if it would be possible to write to table AFVC column ABLAD which is the column called ”Unloading Point”. This is possible but it will require all my source code to be uploaded to Total Energies servers, which I are a little reluctant to do as I will lose control over the research project.

4 Coding on the server side

Since out last meeting I have done a significant amount of coding on the server side of the application, most of it is related to the tactical model, the algorithm that schedules on the days, to make it dynamic and provide results that are satisfactory.

To reiterate the long term goal here refer to figure 1, 2, and 3. Figure 1 holds all the data needed to make the system function as well as capture all the changes that the end-users make based on the results of the algorithms.

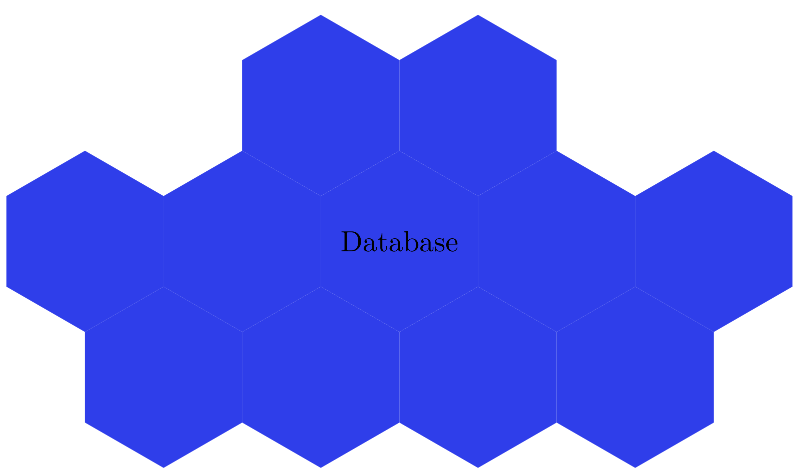

Figure 1: Common database layer for all algorithms in the system. The database layer is initialized from the **SAP**, and the also receives inputs from the user for **Resources** and **Timehorizons**.

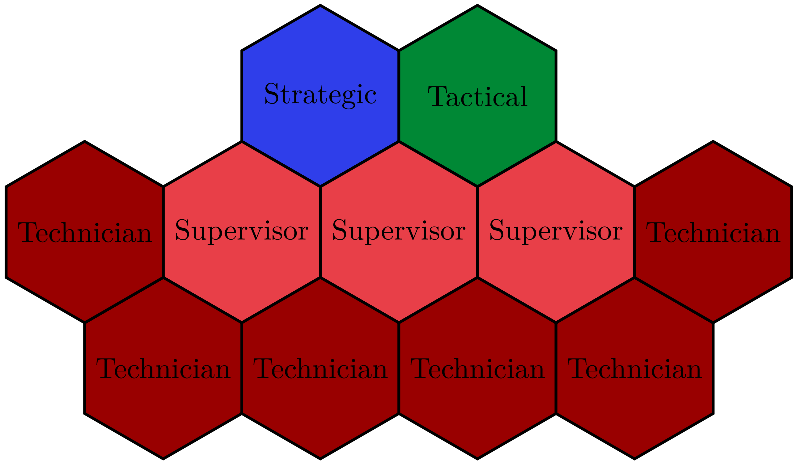

Figure 2: The proposed model setup. The server creates one **Strategic** algorithm as shown in section 8.3, on **Tactical** algorithm as shown in section 8.4, and one for each **Supervisor** as shown in section 8.5, finally there one model for each **Technician** as shown in section 8.6

Figure 2 shows the setup where each hexagon is a mathematical algorithm that is optimizing a certain part of the scheduling process. Here you both have seen the **Strategic** and the **Tactical**. These models will never be able of their own to model the scheduling process therefore user-interfaces are created for each of these stakeholders which is illustrated in figure 3.

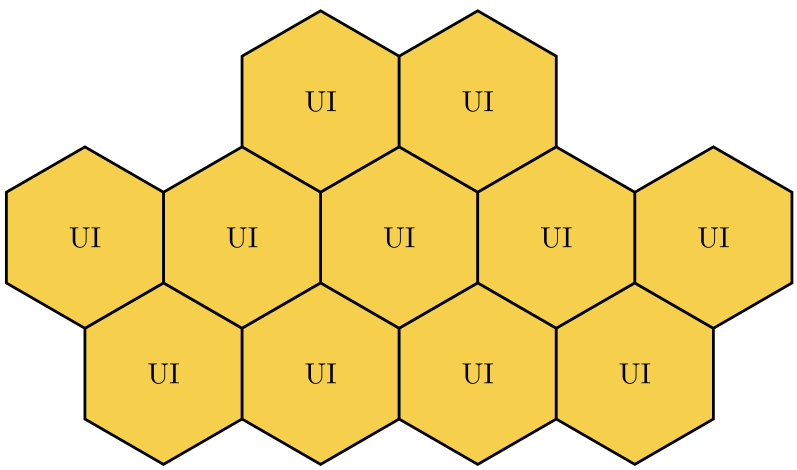

Figure 3: Every algorithm has its own user interface. This means that there will be a view into the system that is unique for each kind of stakeholder.

There are more than these three layers, they serve to provide a high level visualization of what the code is aiming to do.

4.1 Separating Responsibilities

Brian mentioned at the previous meeting that for this kind of system it would be crucial that each stakeholder that we want to be part of the system has clearly defined boundaries for what they can and cannot change. In appendix 8.1 I have taken out some code that makes the server only accept changes to certain status codes from the Strategic model (Scheduler). This means that there are internally in the server, clear boundaries for what each user of the system can change, for which work orders.

5 Academic Papers

I have to write academic papers even though we do not have solid results yet. The first paper is titled **Actor-based Large Neighborhood Search**. I am trying to complete it as soon as possible so that we can get back to testing.

6 External Stay

I am going of external stay in Paris at a company called **Decision Brain** it is a company that creates maintenance scheduling software that resembles the kind of system that we are trying to develop. It is my intention to learn how to best proceed with implementing the system that we are developing.

7 Problems and Issues

- Getting in sync with stakeholders
- Frontend development

7.1 Getting in sync with stakeholders

The success of this project relies on convincing you two that it could work. The issue that I am having is that I cannot develop all the frontends myself that will show a complete user experience.

Currently my priorities are:

- Backend: Make the tactical algorithm dynamic and functioning respect constraints
- Frontend: Let you manually upload resources
- Frontend: Let you see live updating of the currect resource profile of the schedule that the algorithm is generating.

So questions for you if you disagree with the priorities:

- **What aspects of the program does each of you think should be prioritized now?**
- **I believe that making this program work without any involvement of a offshore supervisor (the person responsible for assigning names to the technicians) will be very difficult. Do you aggee or disagree?**

7.2 Frontend Development

My background is in solving scheduling problems, and it is my judgement that the kind of scheduling problem that we are facing cannot be solved without the user interactions from the **Scheduler**, **Supervisor** and the **Technician** (we will skip them for now). That means that I cannot simply rely on my skills in coding scheduling systems, we need frontends to provide you (and supervisors) with the **schedules** that the system generates so that each scheduler (and supervisor) and quickly iterate on the schedules.

8 Appendix

8.1 Illustrative Code Parts

8.1.1 All user status codes

$$
\begin{array}{l}
struct\ UserStatusCodes \\
\quad appr : bool, \\
\quad smat : bool, \\
\quad init : bool, \\
\quad rdbl : bool, \\
\quad qcap : bool, \\
\quad rfrz : bool, \\
\quad wmat : bool, \\
\quad cmat : bool, \\
\quad pmat : bool, \\
\quad ... \\
\quad dfrj : bool, \\
\quad vpas : bool, \\
\quad dfcr : bool, \\
\quad ireq : bool, \\
\quad atvd : bool, \\
\quad awmd : bool, \\
\quad dfex : bool, \\
\quad dfap : bool, \\
\quad awpr : bool, \\
\}
\end{array}
$$

8.1.2 User status codes that the Strategic Algorithms can modify

$$
\begin{array}{l}
struct\ StrategicUserStatusCodes\ \{ \\
\quad work\_order\_numbers : Vec < WorkOrderNumber >, \\
\quad sch : Option < bool >, \\
\quad awsc : Option < bool >, \\
\quad cmat : Option < bool >, \\
\quad wmat : Option < bool >, \\
\quad pmat : Option < bool >, \\
\quad smat : Option < bool >, \\
\}
\end{array}
$$

8.2 Mathematical Models

I have put the mathematical models in here only if you should find them interesting.

When designing scheduling systems, mathematical models should be seen as somewhat similar to an architectural drawing when constructing a house. They set a high level blueprint of what the whole system should achieve and what outcomes it should produce.

Everytime that I have had an interview with either of you, I have cross checked the material and insights that I got from the interview and extended the models. Then I implement the model changes into the scheduling system code.

8.3 Strategic Model: A Knapsack Variant

Meta variables:

$$s \in S \tag{1}$$

$$\beta(\tau) \tag{2}$$

$$\tau \in [0, \infty] \tag{3}$$

Minimize:

$$\begin{aligned} &- \sum_{w \in W(\tau)} \sum_{p \in P(\tau)} strategic\_value_{wp}(\tau) \cdot \alpha_{wp}(\tau) \\ &+ \sum_{p \in P(\tau)} \sum_{r \in R(\tau)} strategic\_penalty \cdot \epsilon_{pr}(\tau) \\ &- \sum_{p \in P(\tau)} \sum_{w1 \in W(\tau)} \sum_{w2 \in W(\tau)} clustering\_value_{w1,w2} \cdot \alpha_{w1p}(\tau) \cdot \alpha_{w2p}(\tau) \end{aligned} \tag{4}$$

Subject to:

$$\begin{aligned} &\sum_{w \in W(\tau)} work\_order\_work_{wr} \cdot \alpha_{wp}(\tau) \leq \; resource_{pr}(\tau, \beta(\tau)) + \epsilon_{pr}(\tau) \\ &\quad \forall p \in P(\tau) \quad \forall r \in R(\tau) \end{aligned} \tag{5}$$

$$\sum_{w \in W(\tau)} \alpha_{wp}(\tau) = 1 \quad \forall p \in P(\tau) \tag{6}$$

$$\alpha_{wp}(\tau) = 0, \quad if \quad exclude_{wp}(\tau) \;\; \forall w \in W(\tau) \quad \forall p \in P(\tau) \tag{7}$$

$$\alpha_{wp}(\tau) = 1, \quad if \quad include_{wp}(\tau) \;\; \forall w \in W(\tau) \quad \forall p \in P(\tau) \tag{8}$$

$$\alpha_{wp}(\tau) \in \{0, 1\} \quad \forall w \in W(\tau) \quad \forall p \in P(\tau) \tag{9}$$

$$\epsilon_{pr}(\tau) \in \mathbb{R}^+ \quad \forall p \in P(\tau) \quad \forall r \in R(\tau) \tag{10}$$

8.4 Tactical Model: A Resource Constrained Project Scheduling Problem Variant

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Meta variables:

$$s \in S \tag{11}$$

$$\alpha(\tau) \tag{12}$$

$$\tau \in [0, \infty] \tag{13}$$

Minimize:

$$\sum_{o \in O(\tau,\alpha(\tau))} \sum_{d \in D(\tau)} tactical\_value_{do}(\tau) \cdot \beta_{do}(\tau) + \sum_{r \in R(\tau)} \sum_{d \in D(\tau)} tactical\_penalty \cdot \mu_{rd}(\tau) \tag{14}$$

Subject to:

$$\sum_{o \in O(\tau,\alpha(\tau))} work_o(\tau) \cdot \beta_{do}(\tau) \leq tactical\_resource_{dr}(\tau) + \mu_{rd}(\tau) \forall d \in D(\tau) \quad \forall r \in R(\tau) \tag{15}$$

$$\sum_{d=earliest\_start_o(\tau)}^{latest\_finish_o(\tau)} \sigma_{do}(\tau) = duration_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{16}$$

$$\sum_{d^* \in D_{duration_o(\tau)}(\tau)} \sigma_{d^*o}(\tau) = duration_o(\tau) \cdot \eta_{do}(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \quad \forall d \in D(\tau) \tag{17}$$

$$\sum_{o \in O(\tau,\alpha(\tau))} \eta_{do}(\tau) = 1, \quad \forall d \in D(\tau)$$

$$\sum_{d \in D(\tau)} d \cdot \sigma_{do1}(\tau) + \Delta_o(\tau) = \sum_{d \in D(\tau)} d \cdot \sigma_{do2}(\tau) \quad \forall (o1, o2) \in finish\_start_{o1,o2} \tag{18}$$

$$\sum_{d \in D(\tau)} d \cdot \sigma_{do1}(\tau) = \sum_{d \in D(\tau)} d \cdot \sigma_{do2}(\tau) \quad \forall (o1, o2) \in start\_start_{o1,o2} \tag{19}$$

$$\beta_{do}(\tau) \leq number_o(\tau) \cdot operating\_time_o \quad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{20}$$

$$\beta_{do}(\tau) \in \mathbb{R} \qquad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{21}$$

$$\mu_{rd}(\tau) \in \mathbb{R} \qquad \forall r \in R(\tau) \quad \forall d \in D(\tau) \tag{22}$$

$$\sigma_{do}(\tau) \in \{0, 1\} \qquad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{23}$$

$$\eta_{do}(\tau) \in \{0, 1\} \qquad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{24}$$

$$\Delta_o(\tau) \in \{0, 1\} \quad \forall o \in O(\tau, \alpha(\tau)) \tag{25}$$

8.5 Supervisor Model: An Assignment Problem Variant

Meta variables:

$$z \in Z \tag{26}$$

$$\alpha(\tau) \tag{27}$$

$$\theta(\tau) \tag{28}$$

$$\tau \in [0, \infty] \tag{29}$$

Maximize:

$$\sum_{a \in A(\tau,\alpha(\tau))} \sum_{t \in T(\tau)} supervisor\_value_{at}(\tau, \lambda_t(\tau), \Lambda_t(\tau)) \cdot \gamma_{at}(\tau) \tag{30}$$

Subject to:

$$\sum_{a \in A_o(\tau,\alpha(\tau))} \rho_a(\tau) = work_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{31}$$

$$\sum_{t \in T(\tau)} \sum_{a \in A_o(\tau,\alpha(\tau))} \gamma_{at}(\tau) = \phi_o(\tau) \cdot number_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \tag{32}$$

$$\sum_{o \in O_w(\tau,\alpha(\tau))} \phi_o(\tau) = |O_w(\tau, \alpha(\tau))| \quad \forall w \in W(\tau, \alpha(\tau)) \tag{33}$$

$$\sum_{a \in A_o(\tau,\alpha(\tau))} \gamma_{at}(\tau) \leq 1 \quad \forall o \in O(\tau, \alpha(\tau)) \quad \forall t \in T(\tau) \tag{34}$$

$$\gamma_{at}(\tau) \leq feasible_{at}(\theta(\tau)) \quad \forall o \in O(\tau, \alpha(\tau)) \quad \forall t \in T(\tau) \tag{35}$$

$$\gamma_{at}(\tau) \in \{0, 1\} \quad \forall o \in O(\tau, \alpha(\tau)) \quad \forall t \in T(\tau) \tag{36}$$

$$\rho_a(\tau) \in [lower\_activity\_work_a(\tau), work_a(\tau)] \quad \forall a \in A(\tau, \alpha(\tau)) \tag{37}$$

8.6 Technician Model: Single Machine Scheduling Problem Variant

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Meta variables:

$$t \in T(\tau) \tag{38}$$

$$\alpha(\tau) \tag{39}$$

$$\gamma(\tau) \tag{40}$$

$$\tau \in [0, \infty] \tag{41}$$

Maximize:

$$\sum_{a \in A(\tau, \gamma_t(\tau))} \sum_{k \in K(\gamma(\tau))} \delta_{ak}(\tau) \tag{42}$$

Subject to:

$$\sum_{k \in K(\gamma(\tau))} \delta_{ak}(\tau) \cdot \pi_{ak}(\tau) = activity\_work_a(\tau, \rho(\tau)) \cdot \theta \quad (\tau) \forall a \in A(\tau, \gamma_t(\tau)) \tag{43}$$

$$\lambda_{a21}(\tau) \geq \Lambda_{a1last(a1)}(\tau) + preparation_{a1,a2} \quad \forall a1 \in A(\tau, \gamma_t(\tau)) \quad \forall a2 \in A(\tau, \gamma_t(\tau)) \tag{44}$$

$$\lambda_{ak}(\tau) \geq \Lambda_{ak-1}(\tau) - constraint\_limit \cdot (2 - \pi_{ak}(\tau) + \pi_{ak-1}(\tau))$$
$$\forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{45}$$

$$\delta_{ak}(\tau) = \Lambda_{ak}(\tau) - \lambda_{ak}(\tau) \quad \forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{46}$$

$$\lambda_{ak}(\tau) \geq event_{ie} + duration_{ie} - constraint\_limit \cdot (1 - \omega_{akie}(\tau))$$
$$\forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \quad \forall i \in I(\tau) \quad \forall e \in E(\tau) \tag{47}$$

$$\Lambda_{ak}(\tau) \leq event_{ie} + constraint\_limit \cdot \omega_{akie}(\tau)$$
$$\forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \quad \forall i \in I(\tau) \quad \forall e \in E(\tau) \tag{48}$$

$$\lambda_{a1}(\tau) \geq time\_window\_start_a(\beta(\tau)) \quad \forall a \in A(\tau, \gamma_t(\tau)) \tag{49}$$

$$\Lambda_{alast(a)}(\tau) \leq time\_window\_finish_a(\beta(\tau)) \quad \forall a \in A(\tau, \gamma_t(\tau)) \tag{50}$$

$$\pi_{ak}(\tau) \in \{0, 1\} \quad \forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{51}$$

$$\lambda_{ak}(\tau) \in [availability\_start(\tau), availability\_finish(\tau)]$$
$$\forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{52}$$

$$\Lambda_{ak}(\tau) \in [availability\_start(\tau), availability\_finish(\tau)]$$
$$\forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{53}$$

$$\delta_{ak}(\tau) \in [0, work_{a\_to\_o(a)}(\tau)] \quad \forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \tag{54}$$

$$\omega_{akie}(\tau) \in \{0, 1\} \quad \forall a \in A(\tau, \gamma_t(\tau)) \quad \forall k \in K(\gamma(\tau)) \quad \forall i \in I(\tau) \quad \forall e \in E(\tau) \tag{55}$$

$$\theta_a(\tau) \in \{0, 1\} \quad \forall a \in A(\tau, \gamma_t(\tau)) \tag{56}$$

References