1 Introduction

The latest memo on Ordinator version 0.2.4.

2 Status Update

- Clustering in the strategic model
- Latest system architecture
- Next steps

3 Clustering

Hi Brian and Valentin,

A while back, we discussed clustering work orders within the algorithm. My notes indicate that clustering based on either **functional location** or **platform location** appeared to be the most promising approach (as also highlighted in (Palmer, 2019)). Although this wasn't part of the priorities outlined in my previous memo, I ended up implementing this feature in the code for my latest research paper.

To give you a quick overview, I'll explain the general concept focusing on the functional location aspect. The calculations and methodology are based on the diagram in figure 3 that you provided.

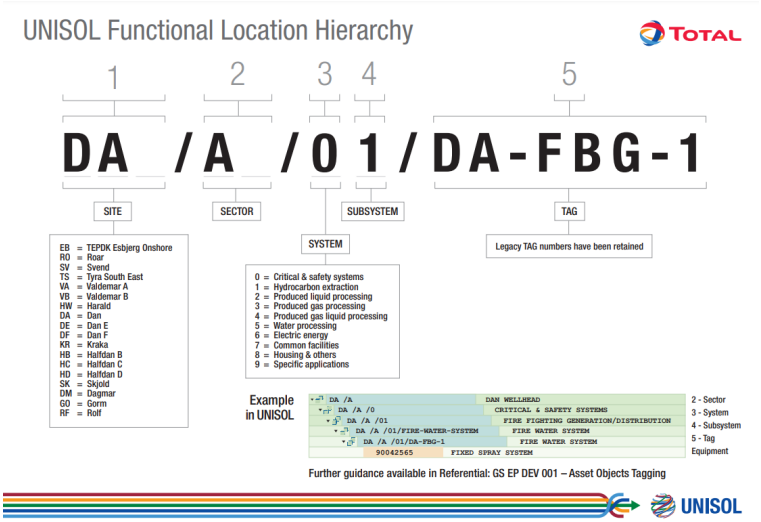

Figure 1: Functional location hierarchy for clustering calculation

Equation 1 defines a similarity measure between work orders based on their functional location as detailed below:

$$
\begin{aligned}
&clustering\_value_{wo1,wo2} = \\
&\quad if \;\; SITE_{wo1} \;\; == \;\; SITE_{wo2} \;\; \{+20\} \\
&+ \; if \;\; SECTOR_{wo1} \;\; == \;\; SECTOR_{wo2} \;\; \{+10\} \\
&+ \; if \;\; SYSTEM_{wo1} \;\; == \;\; SYSTEM_{wo2} \;\; \{+10\} \\
&+ \; if \;\; SUBSYSTEM_{wo1} \;\; == \;\; SUBSYSTEM_{wo2} \;\; \{+10\} \\
&+ \; if \;\; TAG_{wo1} \;\; == \;\; TAG_{wo2} \;\; \{+50\}
\end{aligned}
\tag{1}
$$

This $clustering\_value_{wo1,wo2}$ in equation 1 is then calculated for all **released** work orders for a given asset on which algorithm is initialized. In table 1 will now go through a small example to show how this could look like.

Functional Location	Site	Sector	System	Subsystem	Tag
2100000001	DF	B	3	6	DFBA-FA-4004
2100000002	DF	B	3	6	DFBA-FA-4004
2100000003	DF	B	2	3	DFFA-LIT-500106

Table 1: Functional locations for three different example work orders

Using the data in Table 1 we can calculate the matrix in Table 3 to obtain a similarity between the different work orders.

Work Orders	2100000001	2100000002	2100000003
2100000001	-	100	30
2100000002	100	-	30
2100000003	30	30	-

Table 2: Clustering values between work orders based on functional location. Yellow values are calculated as: 20 + 10 = 30 (same SITE and SECTOR), and the green values have been calculated as: 20 + 10 + 10 + 10 + 50 = 100 (same SITE, SECTOR, SYSTEM, SUBSYSTEM, and TAG)

To see where this goes into the strategic model, refer to **red** part in the model in Section 6.

4 Latest Architecture

I have updated the overall architecture extensively with around 5000 lines of code changes. This is not something that you will see the benefit of directly but it is crucial for the program to perform as intended if scaled up. This change means that we have gone from using message-passing when the algorithms have to share state to using atomic pointer swaps (the purple **Shared Solution** in Figure 2).

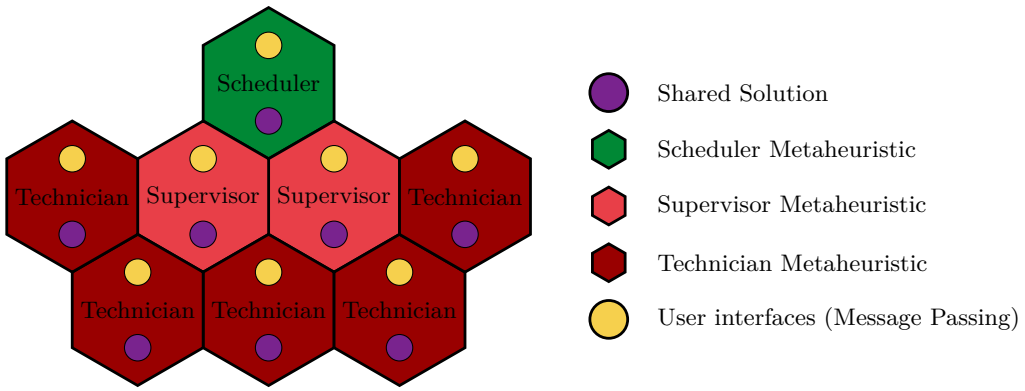

Figure 2: In the system so far, we have three stakeholders, each running an algorithm in perpetuity to optimize their respective schedules. The **purple** dots indicate that the solutions for all algorithms will be shared among them, enabling rapid response to changes once the system is fully implemented. The **yellow** dots highlight points of user interaction. The idea is that the algorithms will handle approximately 60–80 of the work, after which the end-user will manually adjust aspects that the algorithms cannot manage.

5 Next Steps

The last feedback from **Brian** is highlighted in yellow:

- What aspects of the program does each of you think should be prioritized now?
- **Providing some data which can be analyzed to check the output quality.**
- 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 agree or disagree?
- **The end-user is interested in the results and the proof we can give that the output is the best feasible solution. Offshore are not having their mindset on IT solutions in their daily work. They will be able to guide in the direction of how they want it presented as end-user.**

I have unfortunately only made a little further progress on the first point. I wish I had more time to test more intensively but I have to prioritize publishing research to finish the research project on time. I believe that if this project is to be successfully implemented, I will need to work full time on the system rather than splitting my focus with ongoing research.

Without an extension of the research project we have to drop the advanced parts of the frontends. I cannot program that amount of code alone within the current timeline of the project. I hope that you will have the imagination to see how the system could perform if the relevant frontends were actually implemented.

I will prioritize making the **tactical** algorithm work now in line with the first priority that **Brian** highlighted from the last memo.

References

Palmer, R.D., 2019. Maintenance Planning and Scheduling Handbook, 4th Edition , 4th edition ed.. McGraw Hill. chapter 6, pp. 255–288.

6 Appendix: Strategic Model

Meta variables:

$$s \in S \tag{2}$$

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

Minimize:

$$+ \sum_{w \in W(\tau)} \sum_{p \in P(\tau)} strategic\_urgency_{wp}(\tau) \cdot \alpha_{wp}(\tau)$$

$$+ \sum_{p \in P(\tau)} \sum_{r \in R(\tau)} strategic\_resource\_penalty \cdot \epsilon_{pr}(\tau)$$

$$- \sum_{p \in P(\tau)} \sum_{w1 \in W(\tau)} \sum_{w2 \in W(\tau)} clustering\_value_{w1,w2} \cdot \alpha_{w1p}(\tau) \cdot \alpha_{w2p}(\tau) \tag{4}$$

Subject to:

$$\sum_{w \in W(\tau)} work\_order\_workload_{wr} \cdot \alpha_{wp}(\tau) \leq \sum_{t \in T(\tau)} \psi_{prt}(\tau) + \epsilon_{pr}(\tau)$$

$$\forall p \in P(\tau) \quad \forall r \in R(\tau) \tag{5}$$

$$\sum_{r \in R(\tau)} \psi_{prt}(\tau) \leq technician\_work_{pt}(\tau, \beta(\tau)) \quad \forall p \in P(\tau) \quad \forall t \in T(\tau) \tag{6}$$

$$\sum_{p \in P(\tau)} \psi_{prt}(\tau) \leq technician\_skills_{rt}(\tau) \quad \forall r \in R(\tau) \quad \forall t \in T(\tau) \tag{7}$$

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

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

$$\alpha_{wp}(\tau) = 1, \quad if \quad include_{wp}(\tau) \quad \forall w \in W(\tau) \quad \forall p \in P(\tau) \tag{10}$$

$$\alpha_{wp}(\tau) \in \{0, 1\} \quad \forall w \in W(\tau) \quad \forall p \in P(\tau) \tag{11}$$

$$\psi_{prt}(\tau) \in \mathbb{R}^+ \quad \forall p \in P(\tau) \quad \forall r \in R(\tau) \quad \forall t \in T(\tau) \tag{12}$$

$$\epsilon_{pr}(\tau) \in \mathbb{R}^+ \quad \forall p \in P(\tau) \quad \forall r \in R(\tau) \tag{13}$$

Figure 3: The strategic model with the clustering term highlighted. This makes the strategic algorithm cluster work order across all time periods (52 biweekly periods) if there are similarities in the functional locations for the given asset. This means that long term the algorithm will try to make each two week period have work orders that are "close" to each other based on **functional location**.