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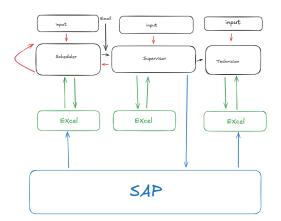
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1 Project Overview

1.1 Stakeholders

- Brian Friis Nielsen (Total)
- Valentin Ispas (GMC Norspie)
- Anne-Laure Debar (Total)
- Baptiste Dubillaud (Total)

1.2 Highlevel Work Flow



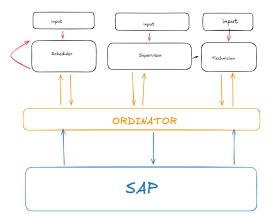


Figure 1: Schematic difference between the current way of doing things versus how it could be done in the future. Each stakeholder can immediately sees an optimized schedule based on the state in the optimization algorithms. This means that the moment that a **Scheduler**, **Supervisor**, or **Technician** sees that there is something wrong his part of the schedule it can be handled immediately. After an excel file has been sent in the as-is example the remaining stakeholders are working blind

Issues:

- Manually sending email around: Manual process leads to long iteration time on schedules
- State duplication: Information on the same work order is found in many places at any one time
- SAP is not made for optimization workflows: You copy the current SAP state to excel and continue working from there.
- Ordinator is a layer between SAP and the **scheduler** and **supervisor**: Ordinator holds all state which can be manipulated and optimizes it (scheduling, optimizations etc.).

1.3 Excel Examples

В	C	D	Ε		;	н			K	L M	N
Revision *		Main Work	Oper.WorkCent ~			Opr. short text	 System status 		* Wor * A	ctual we Unloading Point	 Bas, start d
NOSD	WDF	MTN-MECH	MTN-SCAF	2100074609 ANOS Timerelay for door		Scaffold assistance/step-up scaff.	REL GMPS MANC PRC SETC	APPR WTA SMAT AWDO RDBL RFRZ ROUT	8,0	0,000 W09-W10	2024-09-03
NOSD	WDF	MTN-MECH		2100074609 ANOS Timerelay for door		Replice Door Time-delay VIv.	REL GMPS MANC PRC SETC	APPR WTA SMAT AWDO RDBL RFRZ ROUT	8,0	0,000 W09-W10	2024-09-03
NE	WDF	MTN-INST	MTN-INST	2100098684 Online vibration data col		Online vibration data collection stopped	REL MANC PRC SETC	APPR WTA RDBL	32,0	0,000 NA	2024-09-1
NOSD	WGN	VEN-MECH	VEN-MECH	2200007060 Handheld vib meas. on r	otating Equipment	Handheld vib meas, on rotating Equipment	REL PONF MANC PRC SETC	APPR WTA RDBL	0,0	0,000	2023-12-1
NOSD	WGN	VEN-MECH	VEN-MECH	2200007060 Handheld vib meas. on r	otating Equipment	Make sure equipment is operating stable	REL PONF MANC PRC SETC	APPR WTA RDBL	12,0	0,000	2023-12-1
NOSD	WGN	VEN-MECH		2200007060 Handheld vib meas. on r		Take vib meas with handheld data collect	REL PONF MANC PRC SETC	APPR WTA RDBL	24,0	112,000	2023-12-
NOSD	WGN	VEN-MECH	VEN-MECH	2200007060 Handheld vib meas, on r		Data Analysis, db optimization	REL PCNF MANC PRC SETC	APPR WTA RDBL	0,0	0,000	2023-12-1
NOSD	WGN	VEN-MECH	VEN-MECH	2200007060 Handheld vib meas. on r		Additional measurements	REL PCNF MANC PRC SETC	APPR WTA RDBL	0,0	0,000	2023-12-
NOSD	WGN	VEN-MECH	VEN-MECH	2200007818 Handheld vib meas, on r	otating Eq R2	Handheld vib meas, on rotating Eq R2	REL MANC PRC SETC	APPR WTA RDBL	0,0	0,000	2023-03-
NOSD	WGN	VEN-MECH	VEN-MECH	2200007818 Handheld vib meas, on r		Make sure equipment is operating stable	REL MANC PRC SETC	APPR WTA RDBL	0,0	0,000	2023-03-
NOSD	WGN	VEN-MECH	VEN-MECH	2200007818 Handheld vib meas. on r		Take vib meas with handheld EX data coll	REL MANC PRC SETC	APPR WTA RDBL	50,0	0,000	2023-03-
NOSD	WGN	VEN-MECH	VEN-MECH	2200007818 Handheld vib meas. on r	otating Eq R2	Data analysis, db optimization	REL MANCPRC SETC	APPR WTA RDBL	10,0	0,000	2023-03-
HD-DIFF	WDF	MTN-PIPF	MTN-PIPF	2100023866 2 stk HCV L.G. blowdown	line HDA29	Spool og Erct finde frem og tjekkes.	REL MANC PRC SETC	APPR WMAT RDBL	2,7	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPE	MTN-SCAF	2100023866 2 stk HCV L.G. blowdown		Stillads/skamle stilles til rådighed	REL MANC PRC SETC	APPR WMAT RDBL	6,7	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPE	MTN-SCAF	2100023866 2 stk HCV L.G. blowdown	line HDA29	Rigger ass ophæng af spool/ventiler	REL MANC PRC SETC	APPR WMAT RDBL	8,0	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPE	PRODTECH	2100023866 2 stk HCV L.G. blowdown		Safing udføres. Prod tilstede ved Fig ad	REL MANC PRC SETC	APPR WMAT RDBL	2,0	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPF	MTN-PIPF	2100023866 2 stk HCV L.G. blowdown		Ventiler udskiftes til nye. Vær agtpågiv	REL MANC PRC SETC	APPR WMAT RDBL	6,7	0,000	2025-01
HD-DIFF	WDF	MTN-PIPF	PRODTECH	2100023866 2 stk HCV L.G. blowdown		Desafing/Leaktest udføres.	REL MANC PRC SETC	APPR WMAT RDBL	2,0	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPF	MTN-SCAF	2100023866 2 stk HCV L.G. blowdown		Stillads/skamle/rigger udstyr demonteres	REL MANCPRC SETC	APPR WMAT RDBL	4,0	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPE	MTN-PIPF	2100023866 2 stk HCV L.G. blowdown	line HDA29	Området opryddes.	REL MANC PRC SETC	APPR WMAT RDBL	1,3	0,000	2025-01-
HD-DIFF	WDF	MTN-PIPE	CON-WELD	2100023866 2 stk HCV L.G. blowdown		new valve orded	REL MANC PRC SETC	APPR WMAT RDBL	0,0	0,000	2025-01-
HBAPWELL	WDF	MTN-INST	MTN-INST	2100043868 HCV upstream PIT-30106	is blocked	HCV upstream PIT-30106 is blocked	REL MANC PPRT PRC SETC	APPR WMAT RDBL	0,0	0,000	2025-01-
HBAPWELL	WDF	MTN-INST	PRODTECH	2100043868 HCV upstream PIT-30106		Isolate the line	REL MANC PPRT PRC SETC	APPR WMAT RDBL	1,0	0,000 Oceam team do the job	2025-01-
HBAPWELL	WDF	MTN-INST	MTN-INST	2100043868 HCV upstream PIT-30106		Isolate Pressure transmitter	REL MANC PPRT PRC SETC	APPR WMAT RDBL	0,5	0,000	2025-01
HBAPWELL		MTN-INST	MTN-MECH	2100043868 HCV upstream PIT-30106		Install new SDBB valve	REL MANC PPRT PRC SETC	APPR WMAT RDBL	2,5	0,000	2025-01-
HBAPWELL	WDF	MTN-INST	MTN-INST	2100043868 HCV upstream PIT-30106	is blocked	De-Isolate Pressure transmitter	REL MANC PPRT PRC SETC	APPR WMAT RDBL	0,5	0,000	2025-01-
HBAPWELL	WDF	MTN-INST	MTN-INST	2100043868 HCV upstream PIT-30106	is blocked	Test Pressure transmitter	REL MANC PPRT PRC SETC	APPR WMAT RDBL	1,5	0,000	2025-01-
HBAPWELL	WDF	MTN-INST	PRODTECH	2100043868 HCV upstream PIT-30106	is blocked	De-isolate line	REL MANC PPRT PRC SETC	APPR WMAT RDBL	1,0	0,000	2025-01-
HDADEG A	WDF	MTN-MECH	MTN-SCAF	2100050877 HCV to LT upper seal stud		Prepare permit/rectify Scaffolding	REL MANC PRC SETC	APPR WMAT RDBL	24,0	0,000	2025-01-
HDADEG A	WDF	MTN-MECH		2100050877 HCV to LT upper seal stud		Prepare matr/tools/permit	REL MANC PRC SETC	APPR WMAT RDBL	2,0	0,000	2025-01-
HDADEG A	WDF	MTN-MECH	PRODTECH	2100050877 HCV to LT upper seal stud		Production Isolation/Permit	REL MANC PRC SETC	APPR WMAT RDBL	3,0	0,000	2025-01
HDADEG A	WDF	MTN-MECH	MTN-MECH	2100050877 HCV to LT upper seal stud	k in open pos.	Replace 2" valve	REL MANC PRC SETC	APPR WMAT RDBL	4,0	0,000	2025-01
HDADEG A	WDF	MTN-MECH	MTN-INST	2100050877 HCV to LT upper seal stud		Recalibrate ESD LIT-50166A	REL MANC PRC SETC	APPR WMAT RDBL	4,0	0,000	2025-01
HDADEG A	WDF	MTN-MECH	PRODTECH	2100050877 HCV to LT upper seal stud	k in open pos.	Production Deisolate w leak/test	REL MANC PRC SETC	APPR WMAT RDBL	3,0	0,000	2025-01-
HDADEG A	WDF	MTN-MECH	MTN-MECH	2100050877 HCV to LT upper seal stud	k in open pos.	Housekeeping	REL MANC PRC SETC	APPR WMAT RDBL	1,0	0,000	2025-01-
HDADEG A	WDF	MTN-MECH	MTN-SCAF	2100050877 HCV to LT upper seal stud	k in open pos.	Scaffold removal	REL MANC PRC SETC	APPR WMAT RDBL	18,0	0,000	2025-01-
HBA09-GL	WDF	MTN-INST	PRODTECH	2100063712 Cable and Glant is not co	onnect proberly	Isolate the well and CVA valve	REL MANC PRC SETC	APPR WMAT RDBL	1,0	0,000	2025-01-
HBA09-GL	WDF	MTN-INST	MTN-INST	2100063712 Cable and Glant is not co		Replace cable glands	REL MANC PRC SETC	APPR WMAT RDBL	2,0	0,000	2025-01-
HBA09-GL	WDF	MTN-INST	PRODTECH	2100063712 Cable and Glant is not co	nnect proberly	De-isolate the valve	REL MANC PRC SETC	APPR WMAT RDBL	0,5	0,000	2025-01-
HBA23-GL	WDF	MTN-INST	MTN-INST	2100064728 Synergi 650656 FIT-29233	bolt failure	Synergi 650656 FIT-29233 bolt failure	REL MANC PPRT PRC SETC	APPR WMAT RDBL	0.0	0.000	2025-01-0

Figure 2: Schedulers view of the scheduling process

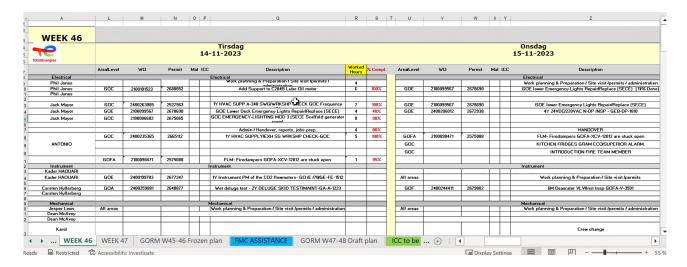


Figure 3: Supervisors and Technicians view of the scheduling process

2 Product Vision

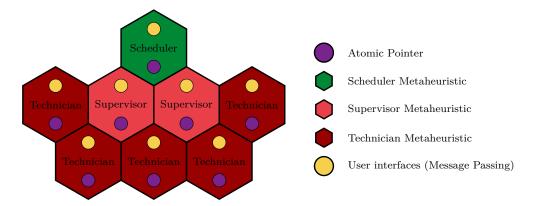


Figure 4: Each model represents a distinct stakeholder with its own UI (yellow) and their solution spaces are tied together with lock-free atomic pointer swaps (purple)

3 Product Architecture

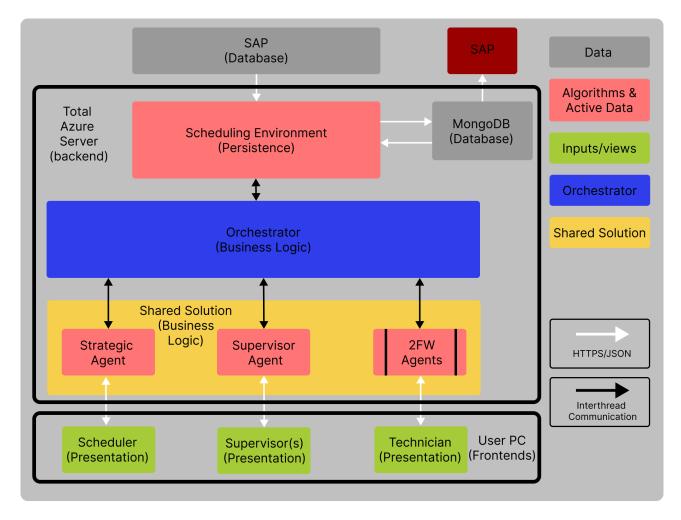


Figure 5: Software architecture of the Ordinator application. Databases are shown in **grey**, with either SAP or Mongodb based on the data requirements, SchedulingEnvironment holds all the needed data for the application to run and saves all the user interactions with the system, these interaction are held in the MongoDB database, the Orchestrator is shown in **blue** and is responsible for managing the whole system while it is running, the Shared Solution is shown in **yellow** and holds fast mutable state that is needed for the algorithms to optimize across the different stakeholders, each optimization algorithms themselves is shown in **light red**, where each models and optimizes the scheduling process for that specific stakeholder, finally the presentation views for each of the stakeholders which are shown in **green**

4 Project going forward

4.1 Collaboration

Main issues:

- $\bullet\,$ I will need time in Esbjerg to further develop the project
 - I have family in Esbjerg that I might be able to stay with
- I lack the project management skill to run the whole project by myself
- There is one year left of the project, so the collaboration will have to depend on project scope
- The project will require developer time from Loic
- The project will require developer time from GMC and the maintenance department

Main questions:

• What do you think that it would take to convince Total to further the project?

• The project could save the company a lot of money. Which steps should be taken to gain the best kind of support?

4.2 Milestones

- 1. Make the first iteration of Ordinator that can schedule for each kind of stakeholder
- 2. Providing each stakeholder with high quality excel exports
- 3. Host the program with both a **Scheduler** and **Supervisor** frontend
- 4. Create frontends together with Total

4.3 Company: Scipo

Would a company setup be an option if the project gains financial support. This may be a long short. I have a good and competent friend and I think that the two of us together would be able to deliver you a product of high quality. This kind of collaboration would go along the lines:

- 1. Develop Ordinator so mature that Total gains confidence in its likely success
- 2. Drafting a budget, specifying how many hours there is needed to deliver certain milestones.
- 3. Shared ownership of the product or open-source the code.

4.4 Example Budget

This is simply an example budget for how a development model could look like between **Total** and **Scipo** (an example company created for solving the scheduling problem for Total)

Scipo	Role	Total Hours	Cost per Hour	Skills	Period
Christian Jespersen	Core Developer	320	250 DKK	Optimization Algorithms	2025-09 to 2025-12
Sebastian Dall	Core Developer	320	250 DKK	API, Frontend, Project	2025-09 to 2025-12
Total	Role	Total Hours	Cost per Hour	Skills	Period
TOTAL_DEVELOPER	Integration	50-70	500 DKK	Azure, IT infrastructure	2025-09 to
Baptiste Dubillaud TOTAL_MAINTENANCE_METHOD Brian Friis Niels	Domain Expert	40	500 DKK	Understanding of Business Flows	2025-12 2025-09 to 2025-12
GMC_SCHEDULER Valentin Ispas	Domain Expert	30	500 DKK	Key Stakeholder	2025-09 to 2025-12
GMC_SUPERVISOR <unknown></unknown>	Domain Expert	20	500 DKK	Key Stakeholder	2025-09 to 2025-12
GMC_TECHNICIAN <unknown></unknown>	Domain Expert	20	500 DKK	Key Stakeholder	2025-09 to 2025-12
Material	Role	Total Hours	Cost per Hour	Skills	Period
Server	-	2000	1-5 DKK	-	2025-09 to 2025-12

page 5 of 10 Recipients: Anne-Laure Debar

```
\begin{aligned} & \text{Total Cost} = (320 \times 250) + (320 \times 250) \\ & + (70 \times 500) + (40 \times 500) + (30 \times 500) \\ & + (20 \times 500) + (20 \times 500) + (2,000 \times 5) \\ & = 80,000 + 80,000 + 35,000 + 20,000 + 15,000 + 10,000 + 10,000 + 10,000 \\ & = 160,000 \quad \text{(Direct cost for Scipo)} \\ & + 100,000 \quad \text{(Indirect cost for Total)} \\ & = 260,000 \quad \text{Total cost DKK} \end{aligned}
```

Total cost per 2 month period 260,000 DKK

5 Appendix

The mathematical model formulations are based on interviews and the handbook (Palmer, 2019).

6 Scheduler: Strategic

Meta variables:

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

$$\tau \in [0, \infty] \tag{2}$$

Minimize:

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

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

$$-\sum_{p\in P(\tau)}\sum_{w1\in W(\tau)}\sum_{w2\in W(\tau)} clustering_value_{w1,w2} \cdot \alpha_{w1p}(\tau) \cdot \alpha_{w2p}(\tau)$$
(3)

Subject to:

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

$$\forall p \in P(\tau) \quad \forall r \in R(\tau) \tag{4}$$

$$\sum_{\tau \in R(\tau)} \psi_{prt}(\tau) \le technician_work_{pt}(\tau, \beta(\tau)) \quad \forall p \in P(\tau) \quad \forall t \in T(\tau)$$
(5)

$$\sum_{p \in P(\tau)} \psi_{prt}(\tau) \le technician_skills_{rt}(\tau) \quad \forall r \in R(\tau) \quad \forall t \in T(\tau)$$
(6)

$$\sum_{w \in W(\tau)} \alpha_{wp}(\tau) = 1 \quad \forall p \in P(\tau)$$
 (7)

$$\alpha_{wp}(\tau) = 0, \quad if \quad exclude_{wp}(\tau) \quad \forall w \in W(\tau) \quad \forall p \in P(\tau)$$
 (8)

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

$$\tag{9}$$

$$\alpha_{wp}(\tau) \in \{0,1\} \quad \forall w \in W(\tau) \quad \forall p \in P(\tau)$$
 (10)

$$\psi_{prt}(\tau) \in \mathbb{R}^+ \quad \forall p \in P(\tau) \quad \forall r \in R(\tau) \quad \forall t \in T(\tau)$$
 (11)

$$\epsilon_{pr}(\tau) \in \mathbb{R}^+ \quad \forall p \in P(\tau) \quad \forall r \in R(\tau)$$
 (12)

Scheduler: Tactical 7

Meta variables:

$$s \in S \tag{13}$$

$$\alpha(\tau)$$
 (14)

$$\tau \in [0, \infty] \tag{15}$$

Minimize:

$$+ \sum_{o \in O(\tau, \alpha(\tau))} \sum_{d \in D(\tau)} tactical_value_{do}(\tau) \cdot \beta_{do}(\tau)$$

$$+ \sum_{r \in R(\tau)} \sum_{d \in D(\tau)} tactical_penalty \cdot \mu_{rd}(\tau)$$
(16)

Subject to:

$$\sum_{o \in O(\tau, \alpha(\tau))} work_o(\tau) \cdot \beta_{do}(\tau) \le \Psi_{drt}(\tau) + \mu_{rd}(\tau) \quad \forall d \in D(\tau) \quad \forall r \in R(\tau)$$
(17)

$$\sum_{r \in R(\tau)} \Psi_{drt}(\tau) \le tactical_resource_{dr}(\tau) \quad \forall d \in D(\tau) \quad \forall t \in T(\tau)$$
(18)

$$\sum_{d \in D(\tau)} \Psi_{drt}(\tau) \le technician_skills_{rt}(\tau) \quad \forall r \in R(\tau) \quad \forall t \in T(\tau)$$
(19)

$$\beta_{do}(\tau) \le number_o(\tau) \cdot operating_time_o \cdot \sigma_{do}(\tau) \quad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$$
 (20)

 $latest_finish_o(\tau)$

$$\sum_{d=earliest_start_o(\tau)} \sigma_{do}(\tau) = duration_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$$
(21)

$$\sum_{d^* \in D_{duration_o(\tau)}(\tau)} \sigma_{d^*o}(\tau) = duration_o(\tau) \cdot \eta_{do}(\tau) \quad \forall o \in O(\tau, \alpha(\tau)) \quad \forall d \in D(\tau)$$
(22)

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

$$\sum_{d \in D(\tau)} d \cdot \sigma_{do1}(\tau) + \Delta_o(\tau) = \sum_{d \in D(\tau)} d \cdot \sigma_{do2}(\tau) \quad \forall (o1, o2) \in finish_start_{o1, o2}$$
(23)

$$\sum_{d \in D(\tau)} d \cdot \sigma_{do1}(\tau) = \sum_{d \in D(\tau)} d \cdot \sigma_{do2}(\tau) \quad \forall (o1, o2) \in start_start_{o1, o2}$$
(24)

$$\beta_{do}(\tau) \in \mathbb{R} \quad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$$
 (25)

$$\mu_{rd}(\tau) \in \mathbb{R} \qquad \forall r \in R(\tau) \quad \forall d \in D(\tau)$$
 (26)

$$\sigma_{do}(\tau) \in \{0, 1\} \qquad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$$
 (27)

$$\eta_{do}(\tau) \in \{0, 1\} \qquad \forall d \in D(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$$
(28)

$$\Delta_o(\tau) \in \{0, 1\} \quad \forall o \in O(\tau, \alpha(\tau)) \tag{29}$$

 $\Phi_w(\tau) \in \{0,1\} \quad \forall w \in W(\tau,\alpha(\tau))$

 $\rho_a(\tau) \in [lower_activity_work_a(\tau), work_a(\tau)] \quad \forall a \in A(\tau, \alpha(\tau))$

8 Supervisor

Meta variables: (30) $z \in Z$ $\alpha(\tau)$ (31) $\theta(\tau)$ (32) $\tau \in [0, \infty]$ (33)Maximize: $\sum_{a \in A(\tau, \alpha(\tau))} \sum_{t \in T(\tau)} supervisor_value_{at}(\tau, \lambda_t(\tau), \Lambda_t(\tau)) \cdot \gamma_{at}(\tau)$ (34)Subject to: $\sum_{a \in A_o(\tau, \alpha(\tau))} \rho_a(\tau) = work_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$ (35) $\sum_{t \in T(\tau)} \sum_{a \in A_o(\tau, \alpha(\tau))} \gamma_{at}(\tau) = \phi_o(\tau) \cdot number_o(\tau) \quad \forall o \in O(\tau, \alpha(\tau))$ (36) $\sum_{o \in O_w(\tau, \alpha(\tau))} \phi_o(\tau) = |O_w(\tau, \alpha(\tau))| \cdot \Phi_w(\tau) \quad \forall w \in W(\tau, \alpha(\tau))$ (37) $\sum_{a \in A_o(\tau,\alpha(\tau))} \gamma_{at}(\tau) \leq 1 \quad \forall o \in O(\tau,\alpha(\tau)) \quad \forall t \in T(\tau)$ (38) $\gamma_{at}(\tau) \le feasible_{at}(\theta(\tau)) \quad \forall a \in A_o(\tau, \beta) \quad (\tau) \forall o \in O(\tau, \alpha(\tau)) \quad \forall t \in T(\tau)$ (39) $\gamma_{at}(\tau) \in \{0,1\} \quad \forall o \in O(\tau,\alpha(\tau)) \quad \forall t \in T(\tau)$ (40) $\phi_o(\tau) \in \{0,1\} \quad \forall o \in O(\tau, \alpha(\tau))$ (41)

(42)

(43)

9 Technician

Meta variables:	
$t \in T(\tau)$	(44)
lpha(au)	(45)
$\gamma(au)$	(46)
$ au \in [0, \infty]$	(47)
Maximize:	
$\sum_{a \in A(\tau, \gamma_t(\tau))} \sum_{k \in K(\gamma(\tau))} \delta_{ak}(\tau)$	(48)
Subject to:	
$\sum_{k \in K(\gamma(\tau))} \delta_{ak}(\tau) \cdot \pi_{ak}(\tau) = activity_work_a(\tau, \rho(\tau)) \cdot \theta_a(\tau) \forall a \in A(\tau, \gamma_t(\tau))$	(49)
$\lambda_{a21}(\tau) \ge \Lambda_{a1last(a1)}(\tau) + preparation_{a1,a2} \forall a1 \in A(\tau, \gamma_t(\tau)) \forall a2 \in A(\tau, \gamma_t(\tau))$	(50)
$\lambda_{ak}(\tau) \ge \Lambda_{ak-1}(\tau) - constraint_limit \cdot (2 - \pi_{ak}(\tau) + \pi_{ak-1}(\tau))$	
$\forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(51)
$\delta_{ak}(\tau) = \Lambda_{ak}(\tau) - \lambda_{ak}(\tau) \forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(52)
$\lambda_{ak}(\tau) \ge event_{ie} + duration_{ie} - constraint_limit \cdot (1 - \omega_{akie}(\tau))$	
$\forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau)) \forall i \in I(\tau) \forall e \in E(\tau)$	(53)
$\Lambda_{ak}(\tau) \le event_{ie} + constraint_limit \cdot \omega_{akie}(\tau)$	
$\forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau)) \forall i \in I(\tau) \forall e \in E(\tau)$	(54)
$\lambda_{a1}(\tau) \ge time_window_start_a(\beta(\tau)) \forall a \in A(\tau, \gamma_t(\tau))$	(55)
$\Lambda_{alast(a)}(\tau) \leq time_window_finish_a(\beta(\tau)) \forall a \in A(\tau, \gamma_t(\tau))$	(56)
$\pi_{ak}(\tau) \in \{0,1\} \forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(57)
$\lambda_{ak}(\tau) \in [availability_start(\tau), availability_finish(\tau)]$	
$\forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(58)
$\Lambda_{ak}(\tau) \in [availability_start(\tau), availability_finish(\tau)]$	
$\forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(59)
$\delta_{ak}(\tau) \in [0, work_{a_to_o(a)}(\tau)] \forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau))$	(60)
$\omega_{akie}(\tau) \in \{0,1\} \forall a \in A(\tau, \gamma_t(\tau)) \forall k \in K(\gamma(\tau)) \forall i \in I(\tau) \forall e \in E(\tau)$	(61)
$\theta_a(\tau) \in \{0,1\} \forall a \in A(\tau, \gamma_t(\tau))$	(62)

References

 $\begin{array}{l} {\rm Palmer,\,R.D.,\,2019.\,\,Maintenance\,\,Planning\,\,and\,\,Scheduling\,\,Handbook,\,4th\,\,Edition\,\,.\,\,4th\,\,edition\,\,ed.,\,McGraw\,\,Hill.} \end{array}$