

SUPPLEMENTARY FILE

In this supplementary file, Section S.I gives the proofs of Properties 1 and 2; Section S.II introduces the resource-limit pair (RP) detection algorithm; Section S.III provides the critical set of RPs (CRP) detection algorithm; and Section S.VI presents all CRPs and partial deadlocks of the S⁴PR in Fig. 3 of the paper.

S.I. PROOFS OF THEORETICAL RESULTS

In this section, we prove all theoretical results.

Proof of Property 1:

In an S⁴PR, since $\mathcal{N}_i = (\{p_{0i}\} \cup P_{Ai}, T_i, F_i, W_i, M_{0i})$ is a strongly connected state machine, $\forall t_i \in T_i$:

$$|t_i \cap (P_{Ai} \cup \{p_{0i}\})| = |t_i \cap (P_{Ai} \cup \{p_{0i}\})| = 1.$$

According to Definition 5, $\forall t \in T$:

$$|t \cap (P_A \cup \{p_0\})| = |t \cap (P_A \cup \{p_0\})| = 1,$$

i.e.,

$$|t \cap P_A| \leq 1 \text{ and } |t \cap P_A| \leq 1. \quad \blacksquare$$

Proof of Property 2:

$\forall M \in R(M_0)$, $A^T X = M - M_0$. Hence,

$$(A^T X)^T \pi_r = (M - M_0)^T \pi_r,$$

i.e.,

$$X^T (A \pi_r) = (M - M_0)^T \pi_r.$$

By $A \pi_r = \mathbf{0}$,

$$(M - M_0)^T \pi_r = \mathbf{0},$$

i.e.,

$$M^T \pi_r = M_0^T \pi_r.$$

Thus,

$$\sum_{p \in \Pi_r} (M(p) \pi_r(p)) = \sum_{p \in \Pi_r} (M_0(p) \pi_r(p)),$$

i.e.,

$$\sum_{p \in \Pi_r} (M(p) \pi_r(p)) = M_0(r) \pi_r(r) + \sum_{p' \in \Pi_r} (M_0(p') \pi_r(p')).$$

Since $\Pi_r \subseteq P_A$ and $\forall p_i \in P_A$: $M_0(p_i) = 0$,

$$\sum_{p' \in \Pi_r} (M_0(p') \pi_r(p')) = 0.$$

Hence,

$$\sum_{p \in \Pi_r} (M(p) \pi_r(p)) = M_0(r) \pi_r(r).$$

Since $\pi_r(r) = 1$,

$$\sum_{p \in \Pi_r} (M(p) \pi_r(p)) = M_0(r). \quad \blacksquare$$

S.II. RP Detection Algorithm

In this section, Algorithm S1 is proposed to obtain Ω . Particularly, for any activity place p_i , the method determines whether it is a critical place according to Definition 8 (line 4 of Algorithm S1). If the above is fulfilled, P_{Ri} (line 5) and L_{i-a} (lines 6-9) are computed according to Definition 10. Given an S⁴PR, the maximum number of input resource places for transitions is $\hat{n} = \max(\{x \mid x = |t \cap P_R|, t \in T\})$, and the maximum number of output transitions for activity places is $\bar{n} = \max(\{y \mid y = |p \cap T|, p \in P_A\})$. Hence, when executing the for-loop in lines 2-15 each time, lines 6-7 repeat at most \bar{n} times, where the obtained $R_{i,j}$ has at most \hat{n} elements. Hence, $b = \prod_{j \in J} |R_{i,j}| \leq \hat{n}^{\bar{n}}$. We then have that the for-loop in

lines 9-12 repeat at most $\hat{n}^{\bar{n}}$ times. As a result, at most $\hat{n}^{\bar{n}}$ elements in Ω are obtained. Since there are at most $|P_A|$ critical places, the for loop in lines 2-15 is repeated no more than $|P_A|$ times. Thus, there are no more than $|P_A| \hat{n}^{\bar{n}}$ elements in Ω , i.e., there are at most $|P_A| \hat{n}^{\bar{n}}$ RPs. For an AMS modeled by an S⁴PR, \hat{n} represents the maximum number of resource types required for a single-step processing operation within the system, and \bar{n} denotes the maximum number of parallel processes when machining the same type of part. For example, in the AMS modeled by the S⁴PR in Fig. 4, the processing operation represented by t_3 requires two types of resources (r_2 and r_3), while the other operations require only one type. Hence, we have that $\hat{n} = 2$. In addition, the job type represented in the left subnet allows two parallel sequential processes to process the same type of part, while the job type shown in the right subnet can only be completed by one sequential process. Hence, we obtain that $\bar{n} = 2$. Notice that the number of RPs is $|P_A| \hat{n}^{\bar{n}}$ only if there are \hat{n} input resource places for each transition and \bar{n} output transitions for each activity place. In general, the number of RPs is much smaller than $|P_A| \hat{n}^{\bar{n}}$. For example, for the S⁴PR in Fig. 4, $|P_A| = 7$ and $\hat{n} = \bar{n} = 2$. Hence, $|P_A| \hat{n}^{\bar{n}} = 28$. However, from Table IV, there are only 6 RPs in this S⁴PR.

Let us now estimate the time complexity of Algorithm S1. Suppose that $|T|$ and $|P_R|$ are the number of transitions and resource places, respectively. By line 5, the time complexity of obtaining P_{Ri} is $O(|P_R|)$. From lines 6-8, we have that the time complexity of finding $R_{i,j}$ is $O(|T||P_R|)$. For lines 9-12, the time complexity is $O(\hat{n}^{\bar{n}})$. For each activity place p_i , we repeat the above steps (lines 2-15). Hence, the total time complexity of Algorithm S1 is $O(|P_A|(|T||P_R| + \hat{n}^{\bar{n}}))$.

Algorithm S1: Detection of Ω

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Input: S4PR  $\mathcal{N} = (P_0 \cup P_A \cup P_R, T, F, W, M_0)$ 
Output:  $\Omega$ 
1   Let  $\Omega = \emptyset$ ;
2   For each  $p_i \in P_A$ , do
3     If  $p_i$  is a critical place, then
4       Let  $P_{Ri} = \{r \mid r \in P_R, p_i \in \Pi_r\}$ ;
5       For each  $t_j \in p_i^*$ , do
6         Let  $R_{i,j} = \{r^w \mid r \in t_j \cap P_R, w = W(r, t_j) - 1\}$ ;
7       End
8       For  $a=1$  to  $b$ , where  $b = \prod_{j \in J} |R_{i,j}|$ , do
9         Let  $L_{i-a}$  be a unique set containing one element of each
10         $R_{i,j}$ , where  $\forall r^w, r^{w'} \in L_{i-a}$ , if  $w < w'$ , then  $L_{i-a} = L_{i-a} \setminus \{r^{w'}\}$ ;
11        Let  $\omega_{i-a} = < P_{Ri}, L_{i-a} >$  and  $\Omega = \Omega \cup \{\omega_{i-a}\}$ ;
12      End
13    End
14  End
15 End
16 Return  $\Omega$ ;
17 End

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S.III. CRP Detection Algorithm

In this section, Algorithm S2 is introduced to detect all CRPs. For each RP ω_{i-a} in Ω , we need to determine if there is

a CRP $\hat{\Omega}$ such that $\omega_{i-a} \in \hat{\Omega}$ (lines 2-6 of Algorithm S2), where Function S1 is used to recursively determine elements in $\hat{\Omega}$. Specifically, suppose that there is a CRP $\hat{\Omega}$ such that $\omega_{i-a} \in \hat{\Omega}$. According to Theorem 4, $\hat{\Omega}$ satisfies that $\forall r \in \mathcal{R}: r \in \Phi$. Hence, we first initialize $\hat{\Omega} = \{\omega_{i-a}\}$. Then, we need to compute \mathcal{R} and Φ and determine whether $\exists r \in \mathcal{R}$ such that $r \notin \Phi$ (lines 1 and 2 of Function S1). If $\exists r \in \mathcal{R}$ such that $r \notin \Phi$, since $\Phi = \{P_{Rj} | \omega_{i-a} \in \hat{\Omega}, \omega_{i-a} = \langle P_{Rj}, L_{i-a} \rangle\}$, we need to find a RP $\omega_{j-c} = \langle P_{Rj}, L_{j-c} \rangle$ such that $r \in P_{Rj}$ and update $\hat{\Omega}$ (lines 2-7 of Function S1); otherwise, if $\forall r \in \mathcal{R}: r \in \Phi$, $\hat{\Omega}$ is a CRP (lines 8-10 of Function S1). For each CRP $\hat{\Omega}$ obtained through the above process, if $\exists \omega_{z-c} \in \Omega$ and $\omega_{z-c} \notin \hat{\Omega}$: $\forall r^w \in L_{z-c}, r \in \Phi$, we have that $\hat{\Omega}' = \hat{\Omega} \cup \{\omega_{z-c}\}$ is a CRP (lines 7-9 of Algorithm S2 and Function S2). Hence, Function 2 is proposed to determine new CRPs by adding RPs to a obtained CRP. Then, we obtain all CRPs that contain ω_{i-a} . Subsequently, we can remove ω_{i-a} from Ω (line 11 of Algorithm S2). For each $r \in P_{Ri}$, if $\forall \omega_{j-a} \in \Omega: p_j \notin \|\pi_r\|$, we have that $\forall \hat{\Omega}' \subseteq \Omega: r \notin \{P_{Rk} | \omega_{k-c} \in \hat{\Omega}', \omega_{k-c} = \langle P_{Rk}, L_{k-c} \rangle\}$. For each $\omega_{u-c} \in \Omega$, if $r \in \{r' | r'^w \in L_{u-c}, \omega_{u-c} = \langle P_{Ru}, L_{u-c} \rangle\}$, according to Theorem 4, there is no CRP containing ω_{u-c} . Thus, Function

Algorithm S2: Detection of Θ

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1   Input:  $\Omega$ 
2   Output:  $\Theta$ 
3   Let  $\Theta = \emptyset$ ;
4   For  $\forall \omega_{i-a} \in \Omega$ , where  $\omega_{i-a} = \langle P_{Ri}, L_{i-a} \rangle$ , do
5     Let  $\Theta' = \{\omega_{i-a}\}$  and  $\Theta_{i-a} = \emptyset$ ;
6     For each  $\hat{\Omega} \in \Theta'$ , do
7        $[\Theta_{i-a}, \Theta'] = F_{s1}(\hat{\Omega}, \Omega, \Theta', \Theta_{i-a})$ ;
8     End
9     For each  $\hat{\Omega} \in \Theta_{i-a}$ , do
10       $[\Theta_{i-a}] = F_{s2}(\hat{\Omega}, \Theta_{i-a}, \Omega)$ ;
11    End
12     $\Theta = \Theta \cup \Theta_{i-a}$ ;
13     $\Omega = \Omega \setminus \{\omega_{i-a}\}$ ;
14     $[\Omega] = F_{s3}(P_{Ri}, \Omega, P_A)$ 
15  End
16  Return  $\Theta$ 

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Function S1: $[\Theta_{i-a}, \Theta'] = F_{s1}(\hat{\Omega}, \Omega, \Theta', \Theta_{i-a})$

```

1   Input:  $\hat{\Omega}, \Omega, \Theta', \Theta_{i-a}$ 
2   Output:  $\Theta_{i-a}, \Theta'$ 
3   Let  $\mathcal{R} = \{r | r^w \in L_{k-a}, \omega_{k-a} \in \hat{\Omega}, \omega_{k-a} = \langle P_{Rk}, L_{k-a} \rangle\}$ ,
4    $\Phi = \{r | r \in P_{Rk}, \omega_{k-a} \in \hat{\Omega}, \omega_{k-a} = \langle P_{Rk}, L_{k-a} \rangle\}$ ,
5    $\Omega' = \Omega \setminus \{\hat{\Omega}\}$ , and  $\Theta' = \Theta \setminus \{\hat{\Omega}\}$ ;
6   If  $\exists r \in \mathcal{R} \setminus \Phi$ , then
7     For each  $\omega_{j-c} \in \Omega'$ , where  $\omega_{j-c} = \langle P_{Rj}, L_{j-c} \rangle$ , do
8       If  $r \in P_{Rj}$ , then
9          $\hat{\Omega}' = \hat{\Omega} \cup \{\omega_{j-c}\}$  and  $\Theta' = \Theta' \cup \{\hat{\Omega}'\}$ ;
10      End
11    End
12  Else
13     $\Theta_{i-a} = \Theta_{i-a} \cup \{\hat{\Omega}\}$ ;
14  End
15  Return  $\Theta_{i-a}$  and  $\Theta'$ ;

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Function S2: $[\Theta_{i-a}] = F_{s2}(\hat{\Omega}, \Theta_{i-a}, \Omega)$

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1   Input:  $\hat{\Omega}, \Theta_{i-a}, \Omega$ 
2   Output:  $\Theta_{i-a}$ 
3   Let  $\Phi = \{r | r \in P_{Rk}, \omega_{k-a} \in \hat{\Omega}, \omega_{k-a} = \langle P_{Rk}, L_{k-a} \rangle\}$  and
4    $P_K = \{p_k | \omega_{k-a} \in \hat{\Omega}\}$ ;
5   For each  $\omega_{z-c} \in \Omega \setminus \hat{\Omega}$ , do
6     If  $\forall r^w \in L_{z-c}: r \in \Phi$  and  $p_z \notin P_K$ , then
7       Let  $\hat{\Omega}' = \hat{\Omega} \cup \{\omega_{z-c}\}$  and  $\Theta_{i-a} = \Theta_{i-a} \cup \hat{\Omega}'$ ;
8     End
9   End
10  Return  $\Theta_{i-a}$ ;
11 End

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Function S3: $[\Omega] = F_{s3}(P_{Ri}, \Omega, P_A)$

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1   Input:  $P_{Ri}, \Omega, P_A$ 
2   Output:  $\Omega$ 
3   For each  $r \in P_{Ri}$ , do
4     If  $\forall \omega_{j-a} \in \Omega: p_j \notin \|\pi_r\|$ , then
5       For each  $\omega_{u-c} \in \Omega$ , where  $r \in \{r' | r'^w \in L_{u-c}, \omega_{u-c} = \langle P_{Ru}, L_{u-c} \rangle\}$ ,
6         do
7            $\Omega = \Omega \setminus \{\omega_{u-c}\}$ ;
8       End
9     End
10   End
11  Return  $\Omega$ ;
12 End

```

S3 is given to remove ω_{u-c} from Ω , thereby reducing the computational complexity of detecting CRPs. For each RP, we repeat the above process, all CRPs can be obtained (lines 1-4 of Algorithm S2). Θ_{i-a} represents the set of CRPs that contains ω_{i-a} , where the number of elements in Θ_{i-a} is no more than $|\Omega|-1$, where $|\Omega|$ is the number of elements in Ω . From line 10 of Algorithm S2,

$$\Theta = \bigcup_{\omega_{i-a} \in \Omega} \Theta_{i-a}.$$

Since there are at most $|\Omega|$ elements in Ω , the number of CRPs is no greater than $|\Omega|(|\Omega|-1)$. According to Algorithm S1, $|\Omega| \leq |P_A| \bar{n}^{\bar{n}}$.

Next, we evaluate the time complexity of Algorithm S2. From line 1 of Function S1, $\Omega' = \Omega \setminus \{\hat{\Omega}\}$, i.e., $|\Omega'| \leq |\Omega|$. Hence, the time complexity of Function S1 is $O(|\Omega|)$. In the worst case, $\forall \omega_{j-a}, \omega_{k-c} \in \Omega$: $\hat{\Omega} = \{\omega_{j-a}, \omega_{k-c}\}$ is a CRP. In this case, Function S1 needs to be repeated $|\Omega|$ times and there are $|\Omega|-1$ elements in Θ_{i-a} . Thus, the complexity of lines 4-6 of Algorithm S2 is $O(|\Omega|^2)$. According to line 2 of Function S2, $\omega_{z-a} \in \Omega \setminus \hat{\Omega}$. Hence, the time complexity of Function S2 is $O(|\Omega|)$. Since there $|\Omega|-1$ elements in Θ_{i-a} , the time complexity of lines 7-9 of Algorithm S2 is $O(|\Omega|^2)$. For Function S3, since $P_{Ri} \subseteq P_R$ and $\omega_{u-c} \in \Omega$, the time complexity of Function S3 is $O(|P_{Ri}| |\Omega|)$. Thus, the time complexity of lines 3-12 of Algorithm S2 is $O(|\Omega|^2 + |P_{Ri}| |\Omega|)$. From lines 2-13, the above steps need to be repeated $|\Omega|$ times. Hence, the total time complexity of Algorithm S2 is $O(|\Omega|^3 + |P_{Ri}| |\Omega|^2)$.

S.IV. CRPs AND PARTIAL DEADLOCKS OF S⁴PR IN FIG. 3

Table S1 shows all the partial deadlocks and CRPs of the S⁴PR shown in Fig. 3 of this paper.

TABLE S1
CRPs AND PARTIAL DEADLOCKS OF S⁴PR IN FIG. 3.

CRPs	Partial deadlocks
$\hat{\Omega}_1=\{\omega_{1-1}, \omega_{15-1}\}$	$M_1=p_1+9p_8+10p_{12}+2p_{15}+8p_{20}+3p_{22}+p_{23}+3p_{24}+3p_{25}$
$\hat{\Omega}_2=\{\omega_{1-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_2=p_1+9p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+2p_{24}+3p_{25}$
$\hat{\Omega}_3=\{\omega_{1-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_4=\{\omega_{1-1}, \omega_{2-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_5=\{\omega_{1-1}, \omega_{3-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_3=p_1+p_3+8p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{24}+3p_{25}$ $M_4=p_1+2p_3+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_6=\{\omega_{1-1}, \omega_{6-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_7=\{\omega_{1-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_5=p_1+2p_7+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$ $M_6=p_1+p_7+8p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{24}+3p_{25}$
$\hat{\Omega}_8=\{\omega_{1-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_9=\{\omega_{1-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{10}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_7=p_1+2p_3+p_6+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{11}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_8=p_1+p_3+p_6+p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{12}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_9=p_1+p_3+p_6+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{13}=\{\omega_{1-1}, \omega_{3-1}, \omega_{4-2}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{14}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{15}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{16}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{17}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{18}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{10}=p_1+2p_3+p_6+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{19}=\{\omega_{1-1}, \omega_{3-1}, \omega_{4-2}, \omega_{6-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{20}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{21}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{22}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{23}=\{\omega_{1-1}, \omega_{3-1}, \omega_{6-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{24}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{11}=p_1+p_3+p_7+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{25}=\{\omega_{1-1}, \omega_{2-1}, \omega_{3-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{12}=p_1+p_2+p_3+p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{26}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{13}=p_1+p_3+p_7+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{27}=\{\omega_{1-1}, \omega_{3-1}, \omega_{4-2}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{28}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{29}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{30}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{31}=\{\omega_{1-1}, \omega_{3-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{32}=\{\omega_{1-1}, \omega_{3-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{14}=p_1+2p_3+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{33}=\{\omega_{1-1}, \omega_{2-1}, \omega_{3-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{15}=p_1+p_2+2p_3+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{34}=\{\omega_{1-1}, \omega_{2-1}, \omega_{3-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{16}=p_1+p_2+p_3+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{35}=\{\omega_{1-1}, \omega_{3-1}, \omega_{4-2}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{36}=\{\omega_{1-1}, \omega_{3-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{37}=\{\omega_{1-1}, \omega_{3-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{38}=\{\omega_{1-1}, \omega_{3-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{39}=\{\omega_{1-1}, \omega_{3-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{40}=\{\omega_{1-1}, \omega_{6-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{17}=p_1+p_6+2p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{41}=\{\omega_{1-1}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{18}=p_1+p_6+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{42}=\{\omega_{1-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{19}=p_1+2p_7+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{43}=\{\omega_{1-1}, \omega_{2-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	$M_{20}=p_1+p_2+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{44}=\{\omega_{1-1}, \omega_{4-2}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{45}=\{\omega_{1-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{46}=\{\omega_{1-1}, \omega_{7-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{47}=\{\omega_{1-1}, \omega_{7-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{48}=\{\omega_{1-1}, \omega_{7-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{49}=\{\omega_{1-1}, \omega_{10-1}, \omega_{13-1}, \omega_{14-1}, \omega_{15-1}\}$	
$\hat{\Omega}_{50}=\{\omega_{1-1}, \omega_{10-1}, \omega_{14-1}, \omega_{15-1}, \omega_{16-1}\}$	
$\hat{\Omega}_{51}=\{\omega_{1-1}, \omega_{2-1}, \omega_{14-1}\}$	
$\hat{\Omega}_{52}=\{\omega_{1-1}, \omega_{2-1}, \omega_{3-1}, \omega_{4-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{53}=\{\omega_{1-1}, \omega_{2-1}, \omega_{4-1}, \omega_{7-1}, \omega_{13-1}\}$	

$\hat{\Omega}_{197} = \{\omega_{3-1}, \omega_{4-2}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{132} = p_3 + p_6 + 2p_7 + 6p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{21} + p_{22} + p_{25}$
$\hat{\Omega}_{198} = \{\omega_{3-1}, \omega_{6-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{133} = 3p_3 + 2p_6 + 5p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{22} + p_{25}$ $M_{134} = 3p_3 + p_6 + 6p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{21} + p_{22} + p_{25}$
$\hat{\Omega}_{199} = \{\omega_{3-1}, \omega_{4-2}, \omega_{6-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{135} = 2p_6 + 3p_7 + 5p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{22} + 3p_{25}$ $M_{136} = p_6 + 3p_7 + 6p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{21} + p_{22} + 3p_{25}$
$\hat{\Omega}_{200} = \{\omega_{6-1}, \omega_{7-1}, \omega_{10-1}\}$	$M_{137} = 2p_6 + 3p_7 + 5p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{22} + p_{25}$ $M_{138} = p_6 + 3p_7 + 6p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + p_{21} + p_{22} + p_{25}$
$\hat{\Omega}_{202} = \{\omega_{4-1}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{203} = \{\omega_{4-2}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{204} = \{\omega_{4-1}, \omega_{6-1}, \omega_{7-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{205} = \{\omega_{3-1}, \omega_{4-2}, \omega_{6-1}, \omega_{10-1}\}$	
$\hat{\Omega}_{206} = \{\omega_{4-2}, \omega_{6-1}, \omega_{7-1}, \omega_{10-1}\}$	
$\hat{\Omega}_{207} = \{\omega_{3-1}, \omega_{4-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{208} = \{\omega_{3-1}, \omega_{4-2}, \omega_{10-1}\}$	
$\hat{\Omega}_{209} = \{\omega_{3-1}, \omega_{13-1}\}$	$M_{139} = 3p_3 + 7p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + 3p_{25}$
$\hat{\Omega}_{210} = \{\omega_{3-1}, \omega_{7-1}, \omega_{13-1}\}$	$M_{140} = 2p_3 + p_7 + 7p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + 3p_{25}$ $M_{141} = p_3 + 2p_7 + 7p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + 3p_{25}$
$\hat{\Omega}_{211} = \{\omega_{3-1}, \omega_{7-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{142} = 2p_3 + p_7 + 7p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + p_{25}$ $M_{143} = p_3 + 2p_7 + 7p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + p_{25}$
$\hat{\Omega}_{212} = \{\omega_{3-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{144} = 3p_3 + 7p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + p_{25}$
$\hat{\Omega}_{213} = \{\omega_{4-1}, \omega_{7-1}, \omega_{13-1}\}$	
$\hat{\Omega}_{214} = \{\omega_{4-2}, \omega_{7-1}, \omega_{10-1}\}$	
$\hat{\Omega}_{215} = \{\omega_{7-1}, \omega_{13-1}\}$	$M_{145} = 3p_7 + 7p_8 + 10p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + 3p_{25}$
$\hat{\Omega}_{216} = \{\omega_{7-1}, \omega_{10-1}, \omega_{13-1}\}$	$M_{146} = 3p_7 + 7p_8 + p_{10} + 9p_{12} + p_{13} + p_{18} + p_{19} + 9p_{20} + 2p_{21} + p_{22} + p_{25}$