Supplementary File

In this supplementary file, Section S.I gives the proofs of theoretical results; Section S.II introduces the resource-limit pair (RP) detection algorithm; Section S.III provides the critical set of RPs (CRP) detection algorithm; Section S.IV shows the partial deadlock detection algorithm for S^4PR where the initial marking does not change; Section S.V analyzes the existing work via case studies; and Section S.VI presents all CRPs and partial deadlocks of the S^4PR in Fig. 8 of the paper.

S.I. Proofs of Theoretical Results

In this section, we prove all theoretical results.

Proof of Property 1:

In an S^4PR, since $\mathcal{N}_i=(\{p_{0i}\}\cup P_{Ai}, T_i, F_i, W_i, M_{0i})$ is a strongly connected state machine, $\forall t_i\in T_i$:

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

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

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

i.e.,

$$|{}^\bullet t\cap P_A|\leq 1 \text{ and } |t^\bullet\cap P_A|\leq 1. \qquad \blacksquare$$

Proof of Property 2:

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

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

i.e.,

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

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

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

i.e.,

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

Thus,

$$\Sigma_{p\in\|\pi_r\|}(M(p)\pi_r(p))=\Sigma_{p\in\|\pi_r\|}(M_0(p)\pi_r(p)),$$

i.e.,

$$\Sigma_{p\in\|\pi_r\|}(M(p)\pi_r(p))=M_0(r)\pi_r(r)+\Sigma_{p'\in\Pi r}(M_0(p')\pi_r(p')).$$

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

$$\Sigma_{p'\in\Pi r}(M_0(p')\pi_r(p'))=0.$$

Hence,

$$\Sigma_{p\in\|\pi_r\|}(M(p)\pi_r(p))=M_0(r)\pi_r(r).$$

Since $\pi_r(r)=1$,

$$\Sigma_{p\in\|\pi_r\|}(M(p)\pi_r(p))=M_0(r). \qquad \blacksquare$$

Proof of Lemma 1:

Suppose that $p\notin P_c$. According to Definition 8, $\exists t\in p^\bullet$:

$$\forall r\in P_R \text{ and } r\notin{}^\bullet t,$$

i.e., ${}^\bullet t\cap P_R=\emptyset$. Since $p\in P_M$,

$$p\in P_A \text{ and } M(p)\neq 0.$$

According to Property 1,

$$|{}^\bullet t\cap(P_A\cup P_0)|=1.$$

By $t\in p^\bullet$ and $p\in P_A$, we obtain that ${}^\bullet t=\{p\}$. Since $M(p)\neq 0$, t is enabled at M. Hence, $p\in P_c$. $\blacksquare$

Proof of Corollary 1:

Since M is a partial deadlock, according to Definition 7, $\forall p\in P_M$ and $\forall t\in p^\bullet$ such that t is not enabled at $\forall M'\in R(M)$. According to Lemma 1, $p\in P_c$. $\blacksquare$

Proof of Theorem 1:

Sufficiency:

If $\exists r^w\in R_{i,j}$: $M(r)\leq w$, according to Definition 9, $\exists r\in{}^\bullet t_j\cap P_R$: $M(r)\leq W(r, t_j)-1$, i.e., $M(r)<W(r, t_j)$. Hence, t_j is not enabled at M.

Necessity:

By $p_i\in P_M$ and $P_M=\{p|\ p\in P_A, M(p)\neq 0\}$, we have that $p_i\in P_A$ and $M(p_i)\neq 0$. By $|{}^\bullet t_j\cap(P_A\cup P_0)|=1$, $p_i\in{}^\bullet t_j$, and $p_i\in P_A$, we derive that ${}^\bullet t_j\cap P_0=\emptyset$. Since $M(p_i)\neq 0$ and t_j is not enabled at M, $\exists r\in P_R$:

$$r\in{}^\bullet t_j \text{ and } M(r)<W(r, t_j),$$

i.e.,

$$r\in P_R\cap{}^\bullet t_j \text{ and } M(r)\leq W(r, t_j)-1.$$

Since $p_i\in P_M$, according to Corollary 1, $p_i\in P_c$. According to Definition 9, $R_{i,j}=\{r^w|\ r\in{}^\bullet t_j\cap P_R,\ w=W(r, t_j)-1\}$. Hence, $\exists r^w\in R_{i,j}$: $M(r)\leq w$. $\blacksquare$

Proof of Corollary 2:

Since M is a partial deadlock, $\forall p_i\in P_M$ and $\forall t_j\in p_i{}^\bullet$ such that t_j is not enabled at M. Since t_j is not enabled at M, according to Theorem 1, $\exists r^w\in R_{i,j}$: $M(r)\leq w$. $\blacksquare$

Proof of Theorem 2:

Sufficiency:

If $\Omega_i=<P_{Ri}, R_i>$ is an RP of p_i, according to Definitions 9 and 10,

$$R_i\subseteq\cup_{j\in J}R_{i,j} \text{ and}$$

$$R_{i,j}=\{r'^y|\ r'\in{}^\bullet t_j\cap P_R,\ y=W(r', t_j)-1\},$$

where $J=\{j|\ t_j\in p_i{}^\bullet\}$ and $\forall j\in J$: $|R_i\cap R_{i,j}|=1$. Hence, $\forall t_j\in p_i{}^\bullet$, $\exists r'\in{}^\bullet t_j\cap P_R$:

$$y=W(r', t_j)-1 \text{ and } r'^y\in R_i\cap R_{i,j}.$$

Since $\forall r^w\in R_i$: $M(r)\leq w$,

$$M(r')\leq y.$$

Hence, $\forall t_j\in p_i{}^\bullet$, $\exists r'^y\in R_{i,j}$: $M(r')\leq y$. According to Theorem 1, t_j is not enabled at M.

Necessity:

Since $\forall t_j\in p_i{}^\bullet$ is not enabled at M, according to Theorem 1,

$$\exists r^w\in R_{i,j}: M(r)\leq w.$$

Since $J=\{j|\ t_j\in p_i{}^\bullet\}$, $\forall j\in J$ satisfies that $\exists r^w\in R_{i,j}$: $M(r)\leq w$. Hence, $\exists R_i\subseteq\cup_{j\in J}R_{i,j}$ and $|R_i\cap R_{i,j}|=1$ such that $\forall r^w\in R_i$ satisfies that $M(r)\leq w$. By $p_i\in P_M$, $p_i\in P_A$. According to Definition 5, $\exists r\in P_R$: $p_i\in\|\pi_r\|$. Thus, there exists $P_{Ri}=\{r'|\ r'\in P_R, p_i\in\|\pi_{r'}\|\}$. According to Definition 10, $\exists\Omega_i=<P_{Ri}, R_i>$: $\forall r^w\in R_i$ and $M(r)\leq w$. $\blacksquare$

Proof of Corollary 3:

Since M is a partial deadlock, according to Corollary 2, $\forall p_i\in P_M$ and $\forall t_j\in p_i{}^\bullet$: $\exists r^w\in R_{i,j}$ and $M(r)\leq w$. By $J=\{j|\ t_j\in p_i{}^\bullet\}$, we have that $\forall p_i\in P_M$ and $\forall j\in J$: $\exists r^w\in R_{i,j}$ and $M(r)\leq w$. Hence, $\forall p_i\in P_M$, $\exists R_i\subseteq\cup_{j\in J}R_{i,j}$ and $|R_i\cap R_{i,j}|=1$ such that $\forall r^w\in R_i$ satisfies that $M(r)\leq w$. Since $\exists r\in P_R$: $p_i\in\|\pi_r\|$, there exists $P_{Ri}=\{r'|\ r'\in P_R, p_i\in\|\pi_{r'}\|\}$. According to Definition 10, $\forall p_i\in P_M$, $\exists\Omega_i=<P_{Ri}, R_i>$: $\forall r^w\in R_i$ and $M(r)\leq w$. $\blacksquare$

Proof of Corollary 4:

According to Corollary 3, it can be easily proved. ■

Proof of Theorem 3:

Sufficiency:

Suppose that $\hat{\Omega}$ is a CRP at M. Since $\hat{\Omega}$ is a CRP at M, according to Definition 11, $\forall p_i \in P_M$, $\exists \Omega_i = <P_{Ri}, R_i>$: $\forall r^w \in R_i$ and $M(r) \leq w$. According to Theorem 2, $\forall t_j \in p_i^\bullet$ is not enabled at M. Hence, $\forall t' \in T$, if $M[t'\rangle M'$, there are two cases.

i) When $t' \notin T_r$, according to Property 3, $\forall p_k \in \Pi_r$: $p_k \notin t'^\bullet \cup {}^\bullet t'$. Hence,

$$M(p_k)=M'(p_k).$$

ii) When $t' \in T_r$, since $\forall p_i \in P_M$ and $\forall t_j \in p_i^\bullet$ is not enabled at M, we have that $\forall p_k \in \Pi_r$: $t' \notin p_k^\bullet$. By $M[t'\rangle M'$,

$$M'(p_k) \geq M(p_k).$$

Then,

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M'(p)\pi_r(p)) \geq \sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p)). \quad \text{(S1)}$$

According to Condition 2) of Definition 11,

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p)) \geq M_0(r)-w.$$

By (S1),

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M'(p)\pi_r(p)) \geq M_0(r)-w. \quad \text{(S2)}$$

Since $M' \in R(M_0)$, according to Property 2,

$$\textstyle\sum_{p_v \in \|\pi_r\|}(M'(p_v)\pi_r(p_v))=M_0(r).$$

By $\Pi_r=\|\pi_r\| \setminus \{r\}$,

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

Since $\pi_r(r)=1$,

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

By $\Pi_r=(\Pi_r \cap P_M) \cup (\Pi_r \setminus P_M)$,

$$\textstyle M'(r)+\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M'(p')\pi_r(p'))+ \sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M'(p)\pi_r(p))=M_0(r),$$

i.e.,

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M'(p)\pi_r(p))= M_0(r)-\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M'(p')\pi_r(p'))-M'(r).$$

By (S2),

$$\textstyle M_0(r)-\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M'(p')\pi_r(p'))-M'(r) \geq M_0(r)-w,$$

i.e.,

$$\textstyle M'(r) \leq w-\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M'(p')\pi_r(p')).$$

Since

$$\textstyle\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M'(p')\pi_r(p')) \geq 0,$$

we have that

$$M'(r) \leq w.$$

According to Theorem 2, $\forall t_j \in p_i^\bullet$, t_j is not enabled at M'. By analogy, $\forall M'' \in R(M)$, t_j is not enabled at M''. Hence, M is a partial deadlock.

Necessity:

Suppose that M is a partial deadlock. According to Corollary 3, $\forall p_i \in P_M$, $\exists \Omega_i = <P_{Ri}, R_i>$:

$$\forall r^w \in R_i \text{ and } M(r) \leq w.$$

Let $\hat{\Omega}$ be the set of these Ω_i. Hence, $P_M=\{p_i \mid \Omega_i \in \hat{\Omega}\}$, and $\forall p_i \in P_M$, $\exists \Omega_i \in \hat{\Omega}$:

$$\forall r^w \in R_i \text{ and } M(r) \leq w.$$

Thus, $\hat{\Omega}$ satisfies Condition 1) of Definition 11. Suppose that

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p)) < M_0(r)-w.$$

According to Property 2,

$$\textstyle M(r)\pi_r(r)+\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M(p')\pi_r(p'))+ \sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p))=M_0(r).$$

Since $\pi_r(r)=1$,

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p)) =M_0(r)-M(r)-\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M(p')\pi_r(p')).$$

Hence,

$$\textstyle M_0(r)-M(r)-\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M(p')\pi_r(p')) < M_0(r)-w,$$

i.e.,

$$\textstyle\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M(p')\pi_r(p'))+M(r) > w. \quad \text{(S3)}$$

Since

$$\forall p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}: p' \notin P_M,$$

we have that $M(p')=0$, i.e.,

$$\textstyle\sum_{p' \in \{p' \mid p' \in \Pi_r \setminus P_M\}}(M(p')\pi_r(p'))=0.$$

By (S3),

$$M(r) > w.$$

It contradicts $M(r) \leq w$. Hence,

$$\textstyle\sum_{p \in \{p \mid p \in \Pi_r \cap P_M\}}(M(p)\pi_r(p)) \geq M_0(r)-w.$$

Thus, $\hat{\Omega}$ satisfies Condition 2) of Definition 11. Hence, $\hat{\Omega}$ is a CRP at M. ■

Proof of Theorem 4:

Since $\hat{\Omega}$ is a CRP at M, according to Definition 11, $P_M=\{p_i \mid \Omega_i \in \hat{\Omega}\}$. Suppose that $\exists r \in R$: $r \notin R'$. Since

$$R'=\{P_{Ri} \mid \Omega_i \in \hat{\Omega}, \Omega_i=<P_{Ri}, R_i>\},$$

we obtain that $\forall \Omega_i \in \hat{\Omega}$:

$$r \notin P_{Ri},$$

where $\Omega_i=<P_{Ri}, R_i>$ and $P_{Ri}=\{r' \mid r' \in P_R, p_i \in \|\pi_{r'}\|\}$. Hence, $\forall p_i \in \{p_i \mid \Omega_i \in \hat{\Omega}\}$:

$$p_i \notin \|\pi_r\|.$$

By $P_M=\{p_i \mid \Omega_i \in \hat{\Omega}\}$, we have that $\forall p_i \in P_M$:

$$p_i \notin \|\pi_r\|,$$

i.e., $\forall p_j \in \|\pi_r\| \cap P_A$:

$$M(p_j)=0.$$

According to Property 2,

$$\textstyle M(r)\pi_r(r)+\sum_{p_j \in \{p' \mid p' \in \|\pi_r\| \cap P_A\}}(M(p_j)\pi_r(p_j))=M_0(r).$$

By $\pi_r(r)=1$ and $\forall p_j \in \|\pi_r\| \cap P_A$: $M(p_j)=0$, we have that:

$$M(r)=M_0(r).$$

Since $r \in R$ and $R=\{r \mid r^w \in R_i, \Omega_i \in \hat{\Omega}, \Omega_i=<P_{Ri}, R_i>\}$, according to Definition 11,

$$M(r)<w.$$

According to Definitions 9 and 10,

$$w=W(r, t_j)-1,$$

i.e.,

$$M(r)<W(r, t_j).$$

Since $\forall r' \in P_R$: $M_0(r') \geq \max\{W(r', t) \mid t \in T, (r', t) \in F\}$, we have that:

$$M_0(r) \geq W(r, t_j).$$

Hence, $M(r)<M_0(r)$. This contradicts that $M(r)=M_0(r)$. Hence, $\forall r \in R$: $r \in R'$. ■

S.II. *RP Detection Algorithm*

In this section, Algorithm S1 is proposed to obtain $\tilde{\Omega}$. Particularly, for any activity place p_i, the method determines whether it is a critical place according to Definition 8 (lines

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    Algorithm S1: Detection of Ω̃
      Input: S⁴PR N=(P_0∪P_A∪P_R, T, F, W, M_0)
      Output: Ω̃
1     Let Ω̃=∅;
2     For ∀p_i∈P_A, do
3       Let R_i′=∅;
4       For ∀t_j∈T, do
5         If t_j∈p_i•, then
6           Let a=1 and R_i″=∅;
7           For ∀r∈P_R, do
8             If r∈•t_j, then
9               If R_i′==∅, then
10                R_{i-a}={r^w}, where w=W(r, t_j)-1;
11                R_i″=R_i″∪{R_{i-a}};
12                a=a+1;
13              Else
14                For ∀R∈R_i′, do
15                  If ∃r^{w′}∈R: w′≥w, where w=W(r, t_j)-1, then
16                    R=R\{r^{w′}};
17                  End
18                  R_{i-a}=R∪{r^w}, where w=W(r, t_j)-1;
19                  R_i″=R_i″∪{R_{i-a}};
20                  a=a+1;
21                End
22              End
23            End
24          End
25          R_i′=R_i″ and T=T\{t_j};
26        End
27      End
28      If R_i′≠∅, then
29        Let Ω̃_i=P_Ri=∅ and b=1;
30        For ∀r∈P_R, do
31          If p_i∈||π_r||, then
32            P_Ri=P_Ri∪{r};
33          End
34        End
35        For ∀R_i∈R_i′, do
36          Ω̃_i=Ω̃_i∪{Ω_{i-b}}, where Ω_{i-b}=<P_Ri, R_i>;
37          b=b+1;
38        End
39        Ω̃=Ω̃∪Ω̃_i;
40      End
41    End
42    Return Ω̃
43  End
```

4-8 of Algorithm S1). If the above is fulfilled, the sets P_{Ri} (lines 9-27) and R_i (lines 28-34) are computed according to Definition 10. From lines 35-38, for any critical place p_i, the number of elements in $\tilde{\Omega}_i$ is the same as that of R_i'. Via line 19, elements in R_i' are the same as those in R_i''. Next, the relationship between the structure of an S^{4}PR and the number of elements in R_i'' is analyzed. Given an S^{4}PR, the maximum number of input resource places for transitions is $\hat{n}=\text{Max}(\{x| x=|{}^\bullet t\cap P_R|, t\in T\})$, and the maximum number of output transitions for activity places is $\bar{n}=\text{Max}(\{y| y=|p^\bullet\cap T|, p\in P_A\})$. From Algorithm S1, when executing the for-loop in lines 7-24 each time, lines 8-23 repeat at most $\hat{n}$ times. When the for-loop in lines 7-24 is executed for the first time, due to $R_i'=\emptyset$, R_i'' is calculated through lines 9-12. Since lines 8-23 repeat at most $\hat{n}$ times, lines 9-12 are executed at most $\hat{n}$ times. As a result, there are at most $\hat{n}$ elements in the obtained R_i''. By line 25, let $R_i'=R_i''$. Now, there are at most $\hat{n}$ elements in R_i'. Hence, when the for-loop in lines 7-24 is executed for the second time, $R_i'\neq\emptyset$ and R_i'' is calculated through lines 13-21. Since there are at most $\hat{n}$ elements in R_i', at most $\hat{n}$ elements in R_i'' are obtained by each execution of the for-loop in lines 13-21. Since lines 8-23 repeat at most $\hat{n}$ times, the for-loop in lines 13-21 is also executed at most $\hat{n}$ times. Hence, there are at most $\hat{n}^2$ elements in R_i'' computed by the second execution of lines 7-24. For activity place p_i, there are at most $\bar{n}$ output transitions. Hence, according to lines 4-27, the for-loop in lines 7-24 is executed at most $\bar{n}$ times. As a result, the number of elements in R_i'' is no more than $\hat{n}^{\bar{n}}$. Thus, there are at most $\hat{n}^{\bar{n}}$ elements in $\tilde{\Omega}_i$. Since there are at most $|P_A|$ critical places in $\mathcal{N}$, from line 33, there are no more than $|P_A|\hat{n}^{\bar{n}}$ elements in $\tilde{\Omega}$, i.e., there are at most $|P_A|\hat{n}^{\bar{n}}$ RPs. For an AMS modeled by an S^{4}PR, $\hat{n}$ 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 S^{4}PR 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 S^{4}PR 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 S^{4}PR.

Let us now estimate the time complexity of Algorithm S1. By lines 4-27, we have that the time complexity of finding P_{Ri} is $O(|T||P_R|\hat{n}^{\bar{n}})$, where $|T|$ and $|P_R|$ are the number of transitions and resource places of $\mathcal{N}$, respectively. From lines 28-34, we obtain that the time complexity of finding R_i is $O(|P_R|)$. Next, $\tilde{\Omega}_i$ can be obtained (lines 35-39), where the time complexity is $O(\hat{n}^{\bar{n}})$. For each activity place p_i, we repeat the above steps and obtain $\tilde{\Omega}$ of $\mathcal{N}$ (lines 1-35). Hence, the total time complexity of Algorithm S1 is $O(|P_A||T||P_R|\hat{n}^{\bar{n}})$.

The following example visually illustrates the process of finding RPs in an S^{4}PR through Algorithm S1.

Example S1: For S^{4}PR in Fig. 4, $P_A=\{p_2, p_3, p_4, p_5, p_7, p_8, p_9\}$, $P_R=\{r_1, r_2, r_3, r_4\}$, and $T=\{t_1, t_2, ..., t_{10}\}$. Starting from line 1 of Algorithm S1, $\tilde{\Omega}=\emptyset$. For $p_2\in P_A$, $p_2^\bullet=\{t_2, t_3\}$. For $t_2\in p_2^\bullet$, from lines 3 and 6,

$$R_2'=R_2''=\emptyset \text{ and } a=1.$$

From Fig. 4, ${}^\bullet t_2\cap P_R=\{r_2\}$. Since $R_2'=\emptyset$ and $W(r_2, t_2)-1=1$, according to lines 8-12,

$$R_{2\text{-}1}=\{r_2^1\}, R_2''=\{R_{2\text{-}1}\}, \text{ and } a=2.$$

With line 25,

$$R_2'=R_2''=\{R_{2\text{-}1}\}=\{\{r_2^1\}\} \text{ and } T=T\backslash\{t_2\}.$$

For $t_3\in p_2^\bullet$, from line 6,

$R_2''=\varnothing$ and $a=1$.

From Fig. 4, ${}^{\bullet}t_3\cap P_R=\{r_2, r_3\}$. For $r_2\in{}^{\bullet}t_3\cap P_R$, since $w=W(r_2, t_3)-1=0$ and $\exists R=R_{2\text{-}1}\in R_2'$: $r_2^y=r_2^1\in R_{2\text{-}1}$ and $y>w$, from lines 13-17, $R=\varnothing$. By lines 18-21,

$$R_{2\text{-}1}=R\cup\{r_2^0\}=\{r_2^0\},\ R_2''=\{R_{2\text{-}1}\}=\{R_{2\text{-}1}\},\text{ and } a=2.$$

For $r_3\in{}^{\bullet}t_3\cap P_R$, since $W(r_3, t_3)-1=1$ and $R_2'=\{\{r_2^1\}\}$, according to lines 18-21,

$$R_{2\text{-}2}=\{r_2^1\}\cup\{r_3^1\}=\{r_2^1, r_3^1\},$$

$$R_2''=R_2''\cup R_{2\text{-}2}=\{\{r_2^0\}, \{r_2^1, r_3^1\}\},\text{ and } a=3.$$

Via line 25,

$$R_2'=R_2''=\{\{r_2^0\}, \{r_2^1, r_3^1\}\}\text{ and } T=T\backslash\{t_3\}.$$

Then, $\forall t\in T$: $t\notin p_2^{\bullet}$. By line 29,

$$\tilde{\Omega}_2=P_{R2}=\varnothing\text{ and } b=1.$$

Since $p_2\in\|\pi_1\|$, from line 30-34,

$$P_{R2}=\{r_1\}.$$

Since $R_2'=\{\{r_2^0\}, \{r_2^1, r_3^1\}\}$, from lines 35-38,

$$\tilde{\Omega}_2=\{\Omega_{2\text{-}1}, \Omega_{2\text{-}2}\},$$

where $\Omega_{2\text{-}1}=<P_{R2}, R_{2\text{-}1}>$ and $\Omega_{2\text{-}2}=<P_{R2}, R_{2\text{-}2}>$. Via line 39,

$$\tilde{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{2\text{-}2}\},$$

where $\Omega_{2\text{-}1}=<\{r_1\}, \{r_2^0\}>$ and $\Omega_{2\text{-}2}=<\{r_1\}, \{r_2^1, r_3^1\}>$. For p_3-p_5 and p_7-p_9, we repeat the above steps. Finally, we obtain

$$\tilde{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\},$$

where $\Omega_{3\text{-}1}=<\{r_2\}, \{r_4^0\}>$, $\Omega_{4\text{-}1}=<\{r_2, r_3\}, \{r_4^0\}>$, $\Omega_{7\text{-}1}=<\{r_4\}, \{r_3^0\}>$, and $\Omega_{8\text{-}1}=<\{r_3\}, \{r_1^0\}>$.

S.III. *CRP Detection Algorithm*

In this section, Algorithm S2 is introduced to detect all the CRPs. To be specific, for each RP Ω_i in $\tilde{\Omega}$, we need to determine if there is a CRP $\hat{\Omega}$ such that $\Omega_i\in\hat{\Omega}$ (lines 2-6 of Algorithm S2). For each subset $\hat{\Omega}$ of $\tilde{\Omega}$, if $\hat{\Omega}$ is a CRP, it satisfies $\forall r\in R$: $r\in R'$ according to Theorem 4. Hence, for each $\hat{\Omega}$, we need to compute R and R' and determine whether $\exists r\in R$ such that $r\notin R'$ (lines 1 and 2 of Function S1). If $\exists r\in R$ such that $r\notin R'$, since $R'=\{P_{Ri}|\ \Omega_i\in\hat{\Omega}, \Omega_i=<P_{Ri}, R_i>\}$, we need to find a RP $\Omega_j=<P_{Rj}, R_j>$ such that $r\in P_{Rj}$ and update

Algorithm S2: Detection of $\bar{\Omega}$

Input: $\tilde{\Omega}$

Output: $\bar{\Omega}$

1 Let $\bar{\Omega}=\varnothing$;
2 **For** $\forall\Omega_i\in\tilde{\Omega}$, where $\Omega_i=<P_{Ri}, R_i>$, **do**
3 Let $\bar{\Omega}'=\{\{\Omega_i\}\}$ and $\bar{\Omega}_i=\varnothing$;
4 **For** $\forall\hat{\Omega}\in\bar{\Omega}'$, **do**
5 $[\bar{\Omega}_i, \bar{\Omega}']=F_{s1}(\hat{\Omega}, \tilde{\Omega}, \bar{\Omega}', \bar{\Omega}_i)$;
6 **End**
7 **For** $\forall\hat{\Omega}\in\bar{\Omega}_i$, **do**
8 $[\bar{\Omega}_i]=F_{s2}(\hat{\Omega}, \bar{\Omega}_i, \tilde{\Omega})$;
9 **End**
10 $\bar{\Omega}=\bar{\Omega}\cup\bar{\Omega}_i$;
11 $\tilde{\Omega}=\tilde{\Omega}\backslash\{\Omega_i\}$;
12 $[\tilde{\Omega}]=F_{s3}(P_{Ri}, \tilde{\Omega}, P_A)$
13 **End**
14 **Return** $\bar{\Omega}$
15 **End**

Function S1: $[\bar{\Omega}_i, \bar{\Omega}']=F_{s1}(\hat{\Omega}, \tilde{\Omega}, \bar{\Omega}', \bar{\Omega}_i)$

Input: $\hat{\Omega}$, $\tilde{\Omega}$, $\bar{\Omega}'$, $\bar{\Omega}_i$

Output: $\bar{\Omega}_i$, $\bar{\Omega}'$

1 Let $R=\{r|\ r^w\in R_k, \Omega_k\in\hat{\Omega}, \Omega_k=<P_{Rk}, R_k>\}$, $R'=\{r|\ r\in P_{Rk}, \Omega_k\in\hat{\Omega}, \Omega_k=<P_{Rk}, R_k>\}$, $\tilde{\Omega}'=\tilde{\Omega}\backslash\{\hat{\Omega}\}$, and $\bar{\Omega}'=\bar{\Omega}'\backslash\{\hat{\Omega}\}$;
2 **If** $\exists r\in R\backslash R'$, **then**
3 **For** $\forall\Omega_j\in\tilde{\Omega}'$, where $\Omega_j=<P_{Rj}, R_j>$, **do**
4 **If** $r\in P_{Rj}$, **then**
5 $\hat{\Omega}'=\hat{\Omega}\cup\{\Omega_j\}$ and $\bar{\Omega}'=\bar{\Omega}'\cup\{\hat{\Omega}'\}$;
6 **End**
7 **End**
8 **Else**
9 $\bar{\Omega}_i=\bar{\Omega}_i\cup\{\hat{\Omega}\}$;
10 **End**
11 **Return** $\bar{\Omega}_i$ and $\bar{\Omega}'$;
12 **End**

Function S2: $[\bar{\Omega}_i]=F_{s2}(\hat{\Omega}, \bar{\Omega}_i, \tilde{\Omega})$

Input: $\hat{\Omega}$, $\bar{\Omega}_i$, $\tilde{\Omega}$

Output: $\bar{\Omega}_i$

1 Let $R'=\{r|\ r\in P_{Rk}, \Omega_k\in\hat{\Omega}, \Omega_k=<P_{Rk}, R_k>\}$ and $P_K=\{p_k|\ \Omega_k\in\hat{\Omega}\}$;
2 **For** $\forall\Omega_z\in\tilde{\Omega}\backslash\hat{\Omega}$, **do**
3 **If** $\forall r^w\in R_z$: $r\in R'$ and $p_z\notin P_K$, **then**
4 Let $\hat{\Omega}'=\hat{\Omega}\cup\{\Omega_z\}$ and $\bar{\Omega}_i=\bar{\Omega}_i\cup\hat{\Omega}'$;
5 **End**
6 **End**
7 **Return** $\bar{\Omega}_i$;
8 **End**

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

Input: P_{Ri}, $\tilde{\Omega}$, P_A

Output: $\tilde{\Omega}$

1 **For** $\forall r\in P_{Ri}$, **do**
2 **If** $\forall\Omega_j\in\tilde{\Omega}$: $p_j\notin\|\pi_r\|$, **then**
3 **For** $\forall\Omega_u\in\tilde{\Omega}$, where $r^w\in R_u$, **do**
4 $\tilde{\Omega}=\tilde{\Omega}\backslash\{\Omega_u\}$;
5 **End**
6 **End**
7 **End**
8 **Return** $\tilde{\Omega}$;
9 **End**

$\hat{\Omega}$ (lines 2-7 of Function S1); otherwise, if $\forall r\in R$: $r\in R'$, $\hat{\Omega}$ is a CRP (lines 8-10 of Function S1). For each CRP $\hat{\Omega}$ obtained through the above process, if $\exists\Omega_z\in\tilde{\Omega}$ and $\Omega_z\notin\hat{\Omega}$: $\forall r^w\in R_z$ and $r\in R'$, we have that $\hat{\Omega}'=\hat{\Omega}\cup\{\Omega_z\}$ is a CRP (lines 7-9 of Algorithm S2 and Function S2). Then, we obtain all CRPs that contain Ω_i. Subsequently, we can remove Ω_i from $\tilde{\Omega}$ (line 11 of Algorithm S2). For each $r\in P_{Ri}$, if $\forall\Omega_j\in\tilde{\Omega}$: $p_j\notin\|\pi_r\|$, we havethat $\forall\hat{\Omega}''\subseteq\tilde{\Omega}$: $r\notin\{P_{Rk}|\ \Omega_k\in\hat{\Omega}'', \Omega_k=<P_{Rk}, R_k>\}$. For each $\Omega_u\in\tilde{\Omega}$, if $r^w\in R_u$, according to Theorem 4, there is no CRP containing Ω_u. Hence, Ω_u can be removed from $\tilde{\Omega}$ (Function S3). For each RP, we repeat the above process, all CRPs can be obtained (lines 1-4 of Algorithm S2). $\forall\Omega_i\in\tilde{\Omega}$, $\bar{\Omega}_i$ represents the set of CRPs that contains Ω_i, where the number of elements in $\bar{\Omega}_i$ is no more than $|\tilde{\Omega}|$-1, where $|\tilde{\Omega}|$ is the number of elements in $\tilde{\Omega}$. From line 10 of Algorithm S2,

$$\overline{\Omega}=\cup_{i\in\{i|\,\Omega_i\in\tilde{\Omega}\}}\overline{\Omega}_i.$$

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

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

Let us illustrate Algorithm S2 by the following example.

Example S2: In Fig. 4, according to Example S2, $\tilde{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$ can be obtained via Algorithm S1. From line 1 of Algorithm S2, $\overline{\Omega}=\varnothing$. For $\Omega_{2\text{-}1}\in\tilde{\Omega}$, where $\Omega_{2\text{-}1}=<P_{R2}, R_{2\text{-}1}>=<\{r_1\}, \{r_2^0\}>$, from line 3,

$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}\}\} \text{ and } \overline{\Omega}_2=\varnothing.$$

Since $\{\Omega_{2\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}\},\ R=\{r_2\},\ R'=\{r_1\},$$
$$\tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \text{ and } \overline{\Omega}'=\varnothing.$$

Since $\exists r_2\in R\setminus R'$ and $\Omega_{3\text{-}1}, \Omega_{4\text{-}1}\in\tilde{\Omega}'$: $r_2\in P_{R3}$ and $r_2\in P_{R4}$, from line 5 of Function S1,

$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}\},\ R=\{r_2, r_4\},\ R'=\{r_1, r_2\},$$
$$\tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \text{ and}$$
$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $\exists\, r_4\in R\setminus R'$ and $\Omega_{7\text{-}1}\in\tilde{\Omega}'$: $r_4\in P_{R7}$, from line 5 of Function S1,

$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}\},\ R=\{r_2, r_3, r_4\},\ R'=\{r_1, r_2, r_4\},$$
$$\tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{4\text{-}1}, \Omega_{8\text{-}1}\}, \text{ and } \overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $\exists\, r_3\in R\setminus R'$ and $\Omega_{4\text{-}1}, \Omega_{8\text{-}1}\in\tilde{\Omega}'$: $r_3\in P_{R4}$ and $r_3\in P_{R8}$, from line 5 of Function S1,

$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},$$
$$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},\ R=\{r_2, r_3, r_4\},$$
$$R'=\{r_1, r_2, r_3, r_4\},\ \tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{8\text{-}1}\}, \text{ and}$$
$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{8\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $R\setminus R'=\varnothing$, from line 9 of Function S1,

$$\overline{\Omega}_2=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\},\ R=\{r_1, r_2, r_3, r_4\},$$
$$R'=\{r_1, r_2, r_3, r_4\},\ \tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{4\text{-}1}\}, \text{ and}$$
$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\}.$$

Since $R\setminus R'=\varnothing$, from line 9 of Function S1,

$$\overline{\Omega}_2=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}\},\ R=\{r_2, r_4\},\ R'=\{r_1, r_2, r_3\},$$
$$\tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \text{ and } \overline{\Omega}'=\varnothing.$$

Since $\exists\, r_4\in R\setminus R'$ and $\Omega_{7\text{-}1}\in\tilde{\Omega}'$: $r_4\in P_{R7}$, from line 5 of Function S1,

$$\overline{\Omega}'=\{\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\in\overline{\Omega}'$, from lines 4-5 and line 1 of Function S1,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},\ R=\{r_2, r_3, r_4\},\ R'=\{r_1, r_2, r_3, r_4\},$$
$$\tilde{\Omega}'=\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{8\text{-}1}\}, \text{ and } \overline{\Omega}'=\varnothing.$$

Since $R\setminus R'=\varnothing$, from line 9 of Function S1,

$$\overline{\Omega}_2=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},$$
$$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\in\overline{\Omega}_2$, from line 1 of Function S2,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},$$
$$R'=\{r_1, r_2, r_3, r_4\}, \text{ and } P_K=\{p_2, p_3, p_4, p_7\}.$$

Since $\Omega_{8\text{-}1}\in\tilde{\Omega}\setminus\hat{\Omega}$ and $\forall r^w\in R_8$: $r\in R'$ and $p_8\notin P_K$, from lines 2-6 of Function S2,

$$\overline{\Omega}_2=\overline{\Omega}_2\cup\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}\}.$$

Since $\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\in\overline{\Omega}_2$, from line 1 of Function S2,

$$\hat{\Omega}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},$$
$$R'=\{r_1, r_2, r_3, r_4\}, \text{ and } P_K=\{p_2, p_4, p_7\}.$$

Since $\exists\,\Omega_{8\text{-}1}\in\tilde{\Omega}\setminus\hat{\Omega}$ and $\forall\, r^w\in R_8$: $r\in R'$ and $p_8\notin P_K$, from lines 2-6 of Function S2,

$$\overline{\Omega}_2=\overline{\Omega}_2\cup\{\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}\}.$$

From lines 10-11,

$$\overline{\Omega}=\{\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\},$$
$$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}, \{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\},$$
$$\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}\} \text{ and}$$
$$\tilde{\Omega}=\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}.$$

For each $\hat{\Omega}\in\tilde{\Omega}$, we repeat the above steps. Finally, we obtain CRPs as shown in Table S1.

S.IV. *Partial Deadlock Detection Algorithm for S^4PR with Invariant Initial Markings*

In this section, for an S^4PR in which its initial marking never changes, a partial deadlock detection algorithm is given as shown in Algorithm S3.

Table S1

CRPs of S^4PR in Fig. 4

$\hat{\Omega}_1$	$\{\Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_2$	$\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_3$	$\{\Omega_{2\text{-}2}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_4$	$\{\Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_5$	$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_6$	$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$
$\hat{\Omega}_7$	$\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$
$\hat{\Omega}_8$	$\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}\}$
$\hat{\Omega}_9$	$\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$
$\hat{\Omega}_{10}$	$\{\Omega_{2\text{-}2}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$
$\hat{\Omega}_{11}$	$\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$
$\hat{\Omega}_{12}$	$\{\Omega_{2\text{-}2}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{8\text{-}1}\}$

Algorithm S3: Partial Deadlock Detection for S^4PR with Invariant Initial Markings

Input: $\tilde{\Omega}$ and M_0

Output: Set of partial deadlocks M_D

Let $\overline{\Omega}=M_D=\varnothing$;
For $\forall\Omega_i\in\tilde{\Omega}$, where $\Omega_i=<P_{Ri}, R_i>$, **do**
  Let $\overline{\Omega}'=\{\{\Omega_i\}\}$ and $\overline{\Omega}_i=\varnothing$;
  For $\forall\hat{\Omega}\in\overline{\Omega}'$, **do**
    $[\overline{\Omega}_i, \overline{\Omega}']=F_{s1}(\hat{\Omega}, \tilde{\Omega}, \overline{\Omega}', \overline{\Omega}_i)$;
  End
  For $\forall\hat{\Omega}\in\overline{\Omega}_i$, **do**
    $[I, M_D]=F_1(\hat{\Omega}, M_0, M_D)$;
    If $I=1$, **then**
      $[\overline{\Omega}_i]=F_{s2}(\hat{\Omega}, \overline{\Omega}_i, \tilde{\Omega})$;
    End
  End
  $\overline{\Omega}=\overline{\Omega}\cup\overline{\Omega}_i$;
  $\tilde{\Omega}=\tilde{\Omega}\setminus\{\Omega_i\}$;
  $[\tilde{\Omega}]=F_{s3}(P_{Ri}, \tilde{\Omega}, P_A)$
End
Return M_D
End

S.V. Analysis of Existing Work

In this section, we analyze the existing structure-based approaches. Since this work focuses on deadlock detection for S^4PR, we only analyze structure-based methods that can handle the deadlock detection problems in S^4PR. From Table I, perfect activity-circuits (PA-circuit) [25], CTR-circuits [35], and siphons [28] can characterize deadlocks in S^4PR. Next, the performance of these methods on the problem of deadlock detection in S^4PR is analyzed through case studies.

A. PA-circuit-based method

First, let's review the basic concepts in [25].

Definition S1: A path $\alpha=pt$ is called a single activity-path (SA-path) if $p\in P_A$ and $t\in T$. Moreover, if $p\in\|\pi_r\|$, then we say that SA-path $\alpha=pt$ is with respect to (w.r.t.) r.

Given SA-paths $\alpha_1=p_1t_1$ w.r.t. r_1 and $\alpha_2=p_2t_2$ w.r.t. r_2. If $r_2\in{}^\bullet t_1$, then α_1 is reachable from α_2, denoted by $\alpha_1\leftarrow\alpha_2$.

Definition S2: A sequence of SA-path $\beta=\alpha_1\alpha_2...\alpha_k$ is called activity-chain if a) $\forall i\in\mathbb{N}_k^+$ such that $\alpha_i=p_it_i$ is a SA-path w.r.t. r_i; and b) $\forall j\in\mathbb{N}_{k-1}^+$ such that $\alpha_j\leftarrow\alpha_{j+1}$, where $R_\beta=\{r_i|\ i\in\mathbb{N}_k^+\}$, $P_\beta=\{p_i|\ i\in\mathbb{N}_k^+\}$, and $T_\beta=\{t_i|\ i\in\mathbb{N}_k^+\}$.

Definition S3: Let $\beta=\alpha_1\alpha_2...\alpha_k$ be an activity-chain. If $\alpha_k\leftarrow\alpha_1$, then β is called an activity-circuit. β is called a perfect activity-circuit (PA-circuit) if $T_\beta=T_\beta'$, where $T_\beta'=\{t'|\ t\in T_\beta, p\in{}^\bullet t\cap P_A, t'\in p^\bullet\}$.

Definition S4: A PA-circuit β is saturated at a marking M if a) $\forall p\in P_\beta$: $M(p)\geq 1$; and b) $\forall r\in R_\beta$: $\min\{W(r, t)\ |\ t\in r^\bullet\cap T_\beta\}-1\geq M_0(r)-\Sigma_{p\in P_\beta\cap\|\pi_r\|}\pi_r(p)M(p)$.

From [25], there is an equivalence relationship between deadlocks in S^4PR and the saturation of PA-circuits. However, in some S^4PR, for any deadlock M, there is no PA-circuit β such that β is saturated at M. In this case, PA-circuit-based methods cannot be used to detect deadlocks. Now, we demonstrate it with the S^4PR shown in Fig. 6, where $M_0=4p_1+4p_6+2r_1+r_2$. In this net, $P_A=\{p_2, p_3, p_4, p_5\}$ and $P_R=\{r_1, r_2\}$. According to Definition S1, there are four SA-paths, i.e., $\alpha_1=p_2t_2$ w.r.t. r_1, $\alpha_2=p_3t_3$ w.r.t. r_1, $\alpha_3=p_4t_4$ w.r.t. r_1 and r_2, and $\alpha_4=p_5t_6$ w.r.t. r_2. By

$$r_1\in{}^\bullet t_2,$$

we have that

$$\alpha_1\leftarrow\alpha_2 \text{ and } \alpha_1\leftarrow\alpha_3.$$

Since

$$r_2\in{}^\bullet t_3,$$

we obtain that

$$\alpha_2\leftarrow\alpha_3 \text{ and } \alpha_2\leftarrow\alpha_4.$$

According to Definition S2, there are six activity-chains, i.e., $\beta_1=\alpha_1\alpha_2$, $\beta_2=\alpha_1\alpha_3$, $\beta_3=\alpha_2\alpha_3$, $\beta_4=\alpha_2\alpha_4$, $\beta_5=\alpha_1\alpha_2\alpha_3$, and $\beta_6=\alpha_1\alpha_2\alpha_4$. Since α_1 cannot reach α_2, α_3, and α_4, according to Definition S3, β_1, β_2, β_5, and β_6 are not activity-circuits. Similarly, since α_2 cannot reach α_3 and α_4, β_3 and β_4 are not activity-circuits. Thus, there is no activity-circuit in this net. Hence, for any marking M, according to Definitions S3 and S4, there is no PA-circuit is saturated at M. However, there is a partial deadlock $M=2p_1+2p_2+4p_6+r_2$. Thus, for this S^4PR, the methods based on PA-circuits cannot detect it.

B. CTR-circuit based method

In [35], a circuit is a path in which the first and last nodes are identical, while the others are different. Then, some basic concepts in [35] are reviewed.

Definition S5: Let M be a deadlock. t is called a critical transition at M if $p\in{}^\bullet t\cap P_A$: $M(p)>0$. Let T_M denote the set of critical transitions at M.

Definition S6: Let M be a deadlock. A circuit is called a CTR-circuit at M if it contains only a set of critical transitions and a set of resources such that $\exists t\in\theta$ and $p\in t^\bullet$: $M(p)=0$ and $\forall r\in\theta$: $M(r)<W(r, t)$, where $t\in T_M$.

For the S^4PR shown in Fig. 6, $M=2p_1+2p_2+4p_6+r_2$ is a partial deadlock. By $p_2\in{}^\bullet t_2\cap P_A$ and $M(p_2)>0$, $T_M=\{t_2\}$ according to Definition S5. From Definition S6, if there is a CTR-circuit at M, it only contains one transition, i.e., t_2. However, there is no such circuit in the S^4PR. Hence, there is no CTR-circuit at M. Thus, CTR-based method proposed in [35] cannot handle the partial deadlock detection problem of S^4PR shown in Fig. 6.

C. Siphon-based method

Definition S7 [28]**:** $S\subseteq P$ is called a siphon if $^{\bullet}S\subseteq S^{\bullet}$, where $^{\bullet}S=\{t|\ t\in{}^{\bullet}p,\ p\in S\}$ and $S^{\bullet}=\{t|\ t\in p^{\bullet},\ p\in S\}$.

Definition S8 [28]**:** Siphon S is marked at a marking M if $M(S)>0$; otherwise, S is unmarked at M, where $M(S)=\sum_{p\in S}M(p)$.

In the existing siphon-based deadlock control strategies, deadlocks are obtained by solving an integer program. Specifically, for each M that satisfies

$$M=M_0+A^{\mathrm{T}}X \tag{S.1}$$

where $X>\mathbf{0}$ and $M>\mathbf{0}$, if there exists a siphon that is unmarked at M, then M is a deadlock. Notice that the obtained markings by solving (S.1) may not be reachable. For example, in the S^4PR in Fig. 7, $S=\{r_1, r_2, p_4, p_7\}$ is a siphon. Suppose that $M_0=4p_1+4p_8+r_1+r_2$. By solving (S.1), we have that there are four markings, i.e., $M_1=2p_1+p_2+p_3+4p_8$, $M_2=3p_1+p_2+p_5+3p_8$, $M_3=4p_1+p_5+p_6+2p_8$, and $M_4=3p_1+p_3+p_6+3p_8$ such that S is unmarked at them. However, among them, M_4 is not reachable from M_0. Thus, the methods based on siphons cannot determine the set that only contains reachable deadlocks.

S.VI. CRPs and Partial Deadlocks of S^4PR in Fig. 8

Table S2 shows all the partial deadlocks and CRPs of the S^4PR shown in Fig. 8 of this paper.

TABLE S2
CRPs and Partial Deadlocks of S^4PR in Fig. 8.

CRPs	**Partial deadlocks**
$\hat{\Omega}_1=\{\Omega_{1\text{-}1}, \Omega_{15\text{-}1}\}$	$M_1=p_1+9p_8+10p_{12}+2p_{15}+8p_{20}+3p_{22}+p_{23}+3p_{24}+3p_{25}$
$\hat{\Omega}_2=\{\Omega_{1\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_2=p_1+9p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+2p_{24}+3p_{25}$
$\hat{\Omega}_3=\{\Omega_{1\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_4=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_5=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_3=p_1+p_3+8p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{24}+3p_{25}$
	$M_4=p_1+2p_3+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_6=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_7=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_5=p_1+2p_7+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$
	$M_6=p_1+p_7+8p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{24}+3p_{25}$
$\hat{\Omega}_8=\{\Omega_{1\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_9=\{\Omega_{1\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{10}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_7=p_1+2p_3+p_6+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{11}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_8=p_1+p_3+p_6+p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{12}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_9=p_1+p_3+p_6+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{13}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{14}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{15}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{16}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{17}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{18}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{10}=p_1+2p_3+p_6+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{19}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{20}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{21}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{22}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{21}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{24}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{11}=p_1+p_3+p_7+7p_8+10p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{25}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{12}=p_1+p_2+p_3+p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{26}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{13}=p_1+p_3+p_7+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{27}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{28}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{29}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{30}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{31}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{32}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{14}=p_1+2p_3+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{33}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{15}=p_1+p_2+2p_3+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{34}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{16}=p_1+p_2+p_3+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{35}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{36}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	

$\hat{\Omega}_{37}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{38}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{39}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{40}=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{17}=p_1+p_6+2p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{41}=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{18}=p_1+p_6+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{42}=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{19}=p_1+2p_7+7p_8+p_{10}+9p_{12}+p_{14}+2p_{15}+7p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{43}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{20}=p_1+p_2+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{44}=\{\Omega_{1\text{-}1}, \Omega_{4\text{-}2}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{45}=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{46}=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{47}=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{48}=\{\Omega_{1\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{49}=\{\Omega_{1\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{50}=\{\Omega_{1\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{51}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{14\text{-}1}\}$	
$\hat{\Omega}_{52}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{53}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{54}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{55}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{21}=p_1+2p_2+3p_3+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{56}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{22}=p_1+p_2+3p_3+p_6+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{57}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{23}=p_1+p_2+p_3+p_6+2p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
	$M_{24}=p_1+p_2+2p_3+p_6+p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{58}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{25}=p_1+p_2+p_3+p_6+2p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
	$M_{26}=p_1+p_2+2p_3+p_6+p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{59}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{60}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{61}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{62}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{63}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{27}=p_1+p_2+3p_3+p_6+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{64}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{65}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{66}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	
$\hat{\Omega}_{67}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{68}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{28}=p_1+2p_2+2p_3+p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
	$M_{29}=p_1+2p_2+p_3+2p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{69}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{30}=p_1+2p_2+p_3+2p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
	$M_{31}=p_1+2p_2+2p_3+p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{70}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{32}=p_1+p_2+p_3+2p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
	$M_{33}=p_1+p_2+2p_3+p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{71}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{72}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{73}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{34}=p_1+p_2+p_3+2p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
	$M_{35}=p_1+p_2+2p_3+p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{74}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{75}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{76}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{36}=p_1+2p_2+3p_3+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{77}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{37}=p_1+p_2+3p_3+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{78}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1},\Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{79}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{80}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{38}=p_1+p_2+3p_3+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{81}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{82}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{83}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{39}=p_1+2p_2+2p_3+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{84}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{40}=p_1+p_2+2p_3+p_6+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{85}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{41}=p_1+p_2+p_3+p_6+p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{86}=\{\Omega_{1\text{-}1}, \Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{42}=p_1+p_2+p_3+p_6+p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$

$\hat{\Omega}_{87}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{43}=p_1+p_2+2p_3+p_6+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{88}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{3-1}, \Omega_{7-1}, \Omega_{14-1}\}$	$M_{44}=p_1+2p_2+p_3+p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{89}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{3-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{45}=p_1+2p_2+2p_3+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{90}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{3-1}, \Omega_{14-1}, \Omega_{15-1}\}$	$M_{46}=p_1+p_2+2p_3+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{91}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{4-2}, \Omega_{7-1}, \Omega_{10-1}\}$	
$\hat{\Omega}_{92}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{47}=p_1+2p_2+3p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{93}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{48}=p_1+p_2+p_6+3p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{94}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{49}=p_1+p_2+p_6+3p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{95}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}\}$	
$\hat{\Omega}_{96}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{97}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{15-1}\}$	
$\hat{\Omega}_{98}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{99}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{50}=p_1+2p_2+3p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{100}=\{\Omega_{1-1},\Omega_{2-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{51}=p_1+p_2+3p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{101}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{102}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{103}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{52}=p_1+p_2+3p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{104}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{15-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{105}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{106}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{14-1}\}$	$M_{53}=p_1+2p_2+2p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{107}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{14-1}\}$	$M_{54}=p_1+p_2+p_6+2p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{108}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{55}=p_1+p_2+p_6+2p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{109}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{56}=p_1+2p_2+2p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{110}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{3-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{57}=p_1+2p_2+p_3+p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{111}=\{\Omega_{1-1}, \Omega_{2-1}, \Omega_{7-1}, \Omega_{14-1}, \Omega_{15-1}\}$	$M_{58}=p_1+p_2+2p_7+6p_8+10p_{12}+p_{14}+p_{15}+8p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{112}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{14-1}\}$	
$\hat{\Omega}_{113}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{14-1}\}$	$M_{59}=p_1+2p_3+2p_6+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{114}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{14-1}\}$	$M_{60}=p_1+p_3+2p_6+p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{115}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{61}=p_1+p_3+2p_6+p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{116}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{62}=p_1+2p_3+2p_6+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{117}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{14-1}\}$	$M_{63}=p_1+2p_6+2p_7+5p_8+10p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{118}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{14-1}\}$	$M_{64}=p_1+2p_6+2p_7+5p_8+p_{10}+9p_{12}+p_{14}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{119}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{13-1}\}$	$M_{65}=p_1+3p_3+2p_6+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{120}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{4-1}, \Omega_{6-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{121}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{66}=p_1+2p_3+2p_6+p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$ $M_{67}=p_1+p_3+2p_6+2p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{122}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{68}=p_1+3p_3+2p_6+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{123}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{4-2}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{124}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{69}=p_1+2p_3+2p_6+p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$ $M_{70}=p_1+p_3+2p_6+2p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{125}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{71}=p_1+2p_3+p_6+p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$ $M_{72}=p_1+p_3+p_6+2p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{126}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{73}=p_1+3p_3+p_6+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{127}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{128}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{129}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{74}=p_1+3p_3+p_6+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{130}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{75}=p_1+2p_3+p_6+p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$ $M_{76}=p_1+p_3+p_6+2p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{131}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{13-1}, \Omega_{15-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{132}=\{\Omega_{1-1}, \Omega_{3-1}, \Omega_{6-1}, \Omega_{13-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{133}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{77}=p_1+2p_6+3p_7+4p_8+10p_{12}+p_{13}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{134}=\{\Omega_{1-1}, \Omega_{4-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{135}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{78}=p_1+2p_6+3p_7+4p_8+p_{10}+9p_{12}+p_{13}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{136}=\{\Omega_{1-1}, \Omega_{4-2}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{137}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}\}$	$M_{79}=p_1+p_6+3p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{138}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{15-1}, \Omega_{16-1}\}$	
$\hat{\Omega}_{139}=\{\Omega_{1-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}, \Omega_{16-1}\}$	

$\hat{\Omega}_{140}=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}\}$	$M_{80}=p_1+p_6+3p_7+5p_8+10p_{12}+p_{13}+p_{15}+8p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{141}=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{15\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{142}=\{\Omega_{1\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}, \Omega_{16\text{-}1}\}$	
$\hat{\Omega}_{143}=\{\Omega_{1\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{144}=\{\Omega_{1\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{145}=\{\Omega_{2\text{-}1}, \Omega_{14\text{-}1}\}$	
$\hat{\Omega}_{146}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{81}=2p_2+2p_3+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{147}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{82}=p_2+2p_3+p_6+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{148}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{83}=p_2+p_3+p_6+p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{149}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{84}=p_2+p_3+p_6+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{150}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{85}=p_2+2p_3+p_6+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{151}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{86}=2p_2+p_3+p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{152}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{87}=2p_2+2p_3+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{153}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{88}=2p_2+p_3+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{154}=\{\Omega_{2\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{89}=2p_2+2p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{155}=\{\Omega_{2\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{90}=p_2+p_6+2p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{156}=\{\Omega_{2\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{91}=p_2+p_6+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{157}=\{\Omega_{2\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{92}=2p_2+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{158}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{93}=2p_2+3p_3+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{159}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{94}=p_2+3p_3+p_6+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{160}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{6\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{161}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{162}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{163}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{95}=p_2+2p_3+p_6+p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
	$M_{96}=p_2+p_3+p_6+2p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{164}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{97}=p_2+2p_3+p_6+p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
	$M_{98}=p_2+p_3+p_6+2p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{165}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{166}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{99}=p_2+3p_3+p_6+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{167}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{168}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{100}=2p_2+3p_3+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{169}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{170}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{171}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{101}=2p_2+2p_3+p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
	$M_{102}=2p_2+p_3+2p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{172}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{173}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{174}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{175}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}2}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{176}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}2}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}\}$	
$\hat{\Omega}_{177}=\{\Omega_{2\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{103}=2p_2+3p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{178}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{104}=2p_2+p_3+2p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
	$M_{105}=2p_2+2p_3+p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{179}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{180}=\{\Omega_{2\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{106}=p_2+p_6+3p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{181}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{182}=\{\Omega_{2\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{107}=p_2+p_6+3p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{183}=\{\Omega_{2\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{13\text{-}1}\}$	$M_{108}=2p_2+3p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{184}=\{\Omega_{2\text{-}1}, \Omega_{3\text{-}1}, \Omega_{4\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{185}=\{\Omega_{2\text{-}1}, \Omega_{4\text{-}1}, \Omega_{7\text{-}1}, \Omega_{13\text{-}1}\}$	
$\hat{\Omega}_{186}=\{\Omega_{6\text{-}1}, \Omega_{14\text{-}1}\}$	
$\hat{\Omega}_{187}=\{\Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{109}=2p_3+2p_6+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{188}=\{\Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{110}=p_3+2p_6+p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{189}=\{\Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{111}=2p_3+2p_6+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{190}=\{\Omega_{3\text{-}1}, \Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{112}=p_3+2p_6+p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$
$\hat{\Omega}_{191}=\{\Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{113}=2p_6+2p_7+6p_8+10p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+3p_{25}$
$\hat{\Omega}_{192}=\{\Omega_{6\text{-}1}, \Omega_{7\text{-}1}, \Omega_{10\text{-}1}, \Omega_{14\text{-}1}\}$	$M_{114}=2p_6+2p_7+6p_8+p_{10}+9p_{12}+p_{14}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{23}+p_{25}$

$\hat{\Omega}_{193}=\{\Omega_{3-1}, \Omega_{6-1}, \Omega_{13-1}\}$	$M_{115}=3p_3+2p_6+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{194}=\{\Omega_{3-1}, \Omega_{4-1}, \Omega_{6-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{195}=\{\Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{116}=2p_3+2p_6+p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
	$M_{117}=p_3+2p_6+2p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{196}=\{\Omega_{3-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{118}=2p_3+2p_6+p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
	$M_{119}=p_3+2p_6+2p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{197}=\{\Omega_{3-1}, \Omega_{4-2}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{198}=\{\Omega_{3-1}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{120}=3p_3+2p_6+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{199}=\{\Omega_{3-1}, \Omega_{4-2}, \Omega_{6-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{200}=\{\Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{121}=2p_6+3p_7+5p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+3p_{25}$
$\hat{\Omega}_{201}=\{\Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{122}=2p_6+3p_7+5p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+p_{22}+p_{25}$
$\hat{\Omega}_{202}=\{\Omega_{4-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{203}=\{\Omega_{4-2}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{204}=\{\Omega_{4-1}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{205}=\{\Omega_{3-1}, \Omega_{4-2}, \Omega_{6-1}, \Omega_{10-1}\}$	
$\hat{\Omega}_{206}=\{\Omega_{4-2}, \Omega_{6-1}, \Omega_{7-1}, \Omega_{10-1}\}$	
$\hat{\Omega}_{207}=\{\Omega_{3-1}, \Omega_{4-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{208}=\{\Omega_{3-1}, \Omega_{4-2}, \Omega_{10-1}\}$	
$\hat{\Omega}_{209}=\{\Omega_{3-1}, \Omega_{13-1}\}$	$M_{123}=3p_3+7p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+3p_{25}$
$\hat{\Omega}_{210}=\{\Omega_{3-1}, \Omega_{7-1}, \Omega_{13-1}\}$	$M_{124}=2p_3+p_7+7p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+3p_{25}$
	$M_{125}=p_3+2p_7+7p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+3p_{25}$
$\hat{\Omega}_{211}=\{\Omega_{3-1}, \Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{126}=2p_3+p_7+7p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+p_{25}$
	$M_{127}=p_3+2p_7+7p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+p_{25}$
$\hat{\Omega}_{212}=\{\Omega_{3-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{128}=3p_3+7p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+p_{25}$
$\hat{\Omega}_{213}=\{\Omega_{4-1}, \Omega_{7-1}, \Omega_{13-1}\}$	
$\hat{\Omega}_{214}=\{\Omega_{4-2},\Omega_{7-1}, \Omega_{10-1}\}$	
$\hat{\Omega}_{215}=\{\Omega_{7-1}, \Omega_{13-1}\}$	$M_{129}=3p_7+7p_8+10p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+3p_{25}$
$\hat{\Omega}_{216}=\{\Omega_{7-1}, \Omega_{10-1}, \Omega_{13-1}\}$	$M_{130}=3p_7+7p_8+p_{10}+9p_{12}+p_{13}+p_{18}+p_{19}+9p_{20}+2p_{21}+p_{22}+p_{25}$