

# Distributed Local Data Structure for Parallel Computation

- Distributed local data structure for domain-to-domain communications has been introduced, which is appropriate for such applications with sparse coefficient matrices (e.g. FDM, FEM, FVM etc.).
  - SPMD
  - Local Numbering: Internal pts to External pts
  - Generalized communication table
- Everything is easy, if proper data structure is defined:
  - Values at boundary pts are copied into sending buffers
  - Send/Recv
  - Values at external pts are updated through receiving buffers

# Initial Mesh

t2

<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>	<u>25</u>
<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>	<u>20</u>
<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>	<u>15</u>
<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

演習

# 3領域に分割

#PE2

<u>21</u>	<u>22</u>	<u>23</u>	<u>24</u>
<u>16</u>	<u>17</u>	<u>18</u>	<u>19</u>
<u>11</u>	<u>12</u>	<u>13</u>	<u>14</u>
<u>6</u>	<u>7</u>	<u>8</u>	

#PE1

<u>23</u>	<u>24</u>	<u>25</u>
<u>18</u>	<u>19</u>	<u>20</u>
<u>13</u>	<u>14</u>	<u>15</u>
<u>8</u>	<u>9</u>	<u>10</u>
	<u>4</u>	<u>5</u>

#PE0

<u>11</u>	<u>12</u>	<u>13</u>		
<u>6</u>	<u>7</u>	<u>8</u>	<u>9</u>	<u>10</u>
<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>

# Three Domains

t2

#PE2

<b>7</b> <u>21</u>	<b>8</b> <u>22</u>	<b>9</b> <u>23</u>	<b>15</b> <u>24</u>
<b>4</b> <u>16</u>	<b>5</b> <u>17</u>	<b>6</b> <u>18</u>	<b>14</b> <u>19</u>
<b>1</b> <u>11</u>	<b>2</b> <u>12</u>	<b>3</b> <u>13</u>	<b>13</b> <u>14</u>
<b>10</b> <u>6</u>	<b>11</b> <u>7</u>	<b>12</b> <u>8</u>	

#PE1

<b>14</b> <u>23</u>	<b>7</b> <u>24</u>	<b>8</b> <u>25</u>
<b>13</b> <u>18</u>	<b>5</b> <u>19</u>	<b>6</b> <u>20</u>
<b>12</b> <u>13</u>	<b>3</b> <u>14</u>	<b>4</b> <u>15</u>
<b>11</b> <u>8</u>	<b>1</b> <u>9</u>	<b>2</b> <u>10</u>
	<b>9</b> <u>4</u>	<b>10</b> <u>5</u>

#PE0

<b>11</b> <u>11</u>	<b>12</b> <u>12</u>	<b>13</b> <u>13</u>		
<b>6</b> <u>6</u>	<b>7</b> <u>7</u>	<b>8</b> <u>8</u>	<b>9</b> <u>9</u>	<b>10</b> <u>10</u>
<b>1</b> <u>1</u>	<b>2</b> <u>2</u>	<b>3</b> <u>3</u>	<b>4</b> <u>4</u>	<b>5</b> <u>5</u>

# PE#0: sqm.0: fill O's

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
  2
#NEIBPE
  1  2
#NODE
  ○  ○
#IMPORTindex
  ○  ○
#IMPORTitems
  ○...
#EXPORTindex
  ○  ○
#EXPORTitems
  ○...

```



# PE#1: sqm.1: fill O's

#PE2

<b>7</b> 21	<b>8</b> 22	<b>9</b> 23	<b>15</b> 24
<b>4</b> 16	<b>5</b> 17	<b>6</b> 18	<b>14</b> 19
<b>1</b> 11	<b>2</b> 12	<b>3</b> 13	<b>13</b> 14
<b>10</b> 6	<b>11</b> 7	<b>12</b> 8	

#PE1

<b>14</b> 23	<b>7</b> 24	<b>8</b> 25
<b>13</b> 18	<b>5</b> 19	<b>6</b> 20
<b>12</b> 13	<b>3</b> 14	<b>4</b> 15
<b>11</b> 8	<b>1</b> 9	<b>2</b> 10
	<b>9</b> 4	<b>10</b> 5

#PE0

<b>11</b> 11	<b>12</b> 12	<b>13</b> 13		
<b>6</b> 6	<b>7</b> 7	<b>8</b> 8	<b>9</b> 9	<b>10</b> 10
<b>1</b> 1	<b>2</b> 2	<b>3</b> 3	<b>4</b> 4	<b>5</b> 5

```
#NEIBPEtot
    2
#NEIBPE
    0    2
#NODE
    ○    ○
#IMPORTindex
    ○    ○
#IMPORTitems
    ○...
#EXPORTindex
    ○    ○
#EXPORTitems
    ○...
```

# PE#2: sqm.2: fill O's

#PE2

<b>7</b> 21	<b>8</b> 22	<b>9</b> 23	<b>15</b> 24
<b>4</b> 16	<b>5</b> 17	<b>6</b> 18	<b>14</b> 19
<b>1</b> 11	<b>2</b> 12	<b>3</b> 13	<b>13</b> 14
<b>10</b> 6	<b>11</b> 7	<b>12</b> 8	

#PE1

<b>14</b> 23	<b>7</b> 24	<b>8</b> 25
<b>13</b> 18	<b>5</b> 19	<b>6</b> 20
<b>12</b> 13	<b>3</b> 14	<b>4</b> 15
<b>11</b> 8	<b>1</b> 9	<b>2</b> 10
	<b>9</b> 4	<b>10</b> 5

#PE0

<b>11</b> 11	<b>12</b> 12	<b>13</b> 13		
<b>6</b> 6	<b>7</b> 7	<b>8</b> 8	<b>9</b> 9	<b>10</b> 10
<b>1</b> 1	<b>2</b> 2	<b>3</b> 3	<b>4</b> 4	<b>5</b> 5

```
#NEIBPEtot
    2
#NEIBPE
    1    0
#NODE
    ○    ○
#IMPORTindex
    ○    ○
#IMPORTitems
    ○...
#EXPORTindex
    ○    ○
#EXPORTitems
    ○...
```

t2

#PE2

<b>7</b> <u>21</u>	<b>8</b> <u>22</u>	<b>9</b> <u>23</u>	<b>15</b> <u>24</u>
<b>4</b> <u>16</u>	<b>5</b> <u>17</u>	<b>6</b> <u>18</u>	<b>14</b> <u>19</u>
<b>1</b> <u>11</u>	<b>2</b> <u>12</u>	<b>3</b> <u>13</u>	<b>13</b> <u>14</u>
<b>10</b> <u>6</u>	<b>11</b> <u>7</u>	<b>12</b> <u>8</u>	

#PE1

<b>14</b> <u>23</u>	<b>7</b> <u>24</u>	<b>8</b> <u>25</u>
<b>13</b> <u>18</u>	<b>5</b> <u>19</u>	<b>6</b> <u>20</u>
<b>12</b> <u>13</u>	<b>3</b> <u>14</u>	<b>4</b> <u>15</u>
<b>11</b> <u>8</u>	<b>1</b> <u>9</u>	<b>2</b> <u>10</u>
	<b>9</b> <u>4</u>	<b>10</b> <u>5</u>

#PE0

<b>11</b> <u>11</u>	<b>12</b> <u>12</u>	<b>13</b> <u>13</u>			
<b>6</b> <u>6</u>	<b>7</b> <u>7</u>	<b>8</b> <u>8</u>	<b>9</b> <u>9</u>	<b>10</b> <u>10</u>	
<b>1</b> <u>1</u>	<b>2</b> <u>2</u>	<b>3</b> <u>3</u>	<b>4</b> <u>4</u>	<b>5</b> <u>5</u>	



# Procedures

- Number of Internal/External Points
- Where do External Pts come from ?
  - **IMPORTindex, IMPORTitems**
  - Sequence of NEIBPE
- Then check destinations of Boundary Pts.
  - **EXPORTindex, EXPORTitems**
  - Sequence of NEIBPE

# Answer

```
/home/z30088/class_eps/answer/t2
```

# Where do Ext Pts come from ? : PE#0

#PE2

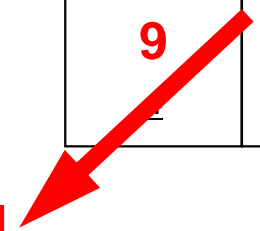
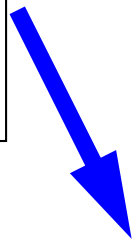
<b>7</b> <u>21</u>	<b>8</b> <u>22</u>	<b>9</b> <u>23</u>	<b>15</b> <u>24</u>
<b>4</b> <u>16</u>	<b>5</b> <u>17</u>	<b>6</b> <u>18</u>	<b>14</b> <u>19</u>
<b>1</b> <u>11</u>	<b>2</b> <u>12</u>	<b>3</b> <u>13</u>	<b>13</b> <u>14</u>
<b>10</b> <u>6</u>	<b>11</b> <u>7</u>	<b>12</b> <u>8</u>	

#PE1

<b>14</b> <u>23</u>	<b>7</b> <u>24</u>	<b>8</b> <u>25</u>
<b>13</b> <u>18</u>	<b>5</b> <u>19</u>	<b>6</b> <u>20</u>
<b>12</b> <u>13</u>	<b>3</b> <u>14</u>	<b>4</b> <u>15</u>
<b>11</b> <u>8</u>	<b>1</b> <u>9</u>	<b>2</b> <u>10</u>
	<b>9</b> <u>4</u>	<b>10</b> <u>5</u>

#PE0

<b>11</b> <u>11</u>	<b>12</b> <u>12</u>	<b>13</b> <u>13</u>		
<b>6</b> <u>6</u>	<b>7</b> <u>7</u>	<b>8</b> <u>8</u>	<b>9</b> <u>9</u>	<b>10</b> <u>10</u>
<b>1</b> <u>1</u>	<b>2</b> <u>2</u>	<b>3</b> <u>3</u>	<b>4</b> <u>4</u>	<b>5</b> <u>5</u>



# PE#0: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
2
#NEIBPE
1 2
#NODE
13 8
#IMPORTindex
2 5
#IMPORTitems
9
10
11
12
13
#EXPORTindex
3 6
#EXPORTitems
4
5
8
6
7
8
    
```

# Where do Ext Pts come from ? : PE#1

#PE2

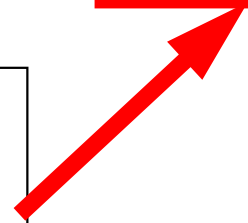
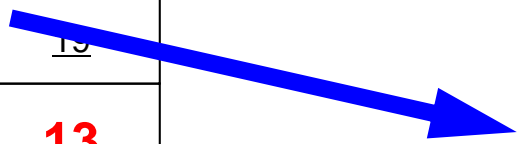
<b>7</b> <u>21</u>	<b>8</b> <u>22</u>	<b>9</b> <u>23</u>	<b>15</b> <u>24</u>
<b>4</b> <u>16</u>	<b>5</b> <u>17</u>	<b>6</b> <u>18</u>	<b>14</b> <u>19</u>
<b>1</b> <u>11</u>	<b>2</b> <u>12</u>	<b>3</b> <u>13</u>	<b>13</b> <u>14</u>
<b>10</b> <u>6</u>	<b>11</b> <u>7</u>	<b>12</b> <u>8</u>	

#PE1

<b>14</b> <u>23</u>	<b>7</b> <u>24</u>	<b>8</b> <u>25</u>
<b>13</b> <u>18</u>	<b>5</b> <u>19</u>	<b>6</b> <u>20</u>
<b>12</b> <u>13</u>	<b>3</b> <u>14</u>	<b>4</b> <u>15</u>
<b>11</b> <u>8</u>	<b>1</b> <u>9</u>	<b>2</b> <u>10</u>
	<b>9</b> <u>4</u>	<b>10</b> <u>5</u>

#PE0

<b>11</b> <u>11</u>	<b>12</b> <u>12</u>	<b>13</b> <u>13</u>		
<b>6</b> <u>6</u>	<b>7</b> <u>7</u>	<b>8</b> <u>8</u>	<b>9</b> <u>9</u>	<b>10</b> <u>10</u>
<b>1</b> <u>1</u>	<b>2</b> <u>2</u>	<b>3</b> <u>3</u>	<b>4</b> <u>4</u>	<b>5</b> <u>5</u>



# PE#1: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
2
#NEIBPE
0 2
#NODE
14 8
#IMPORTindex
3 6
#IMPORTitems
9
10
11
12
13
14
#EXPORTindex
2 5
#EXPORTitems
1
2
3
5
7
    
```

# Where do Ext Pts come from ? : PE#2

#PE2

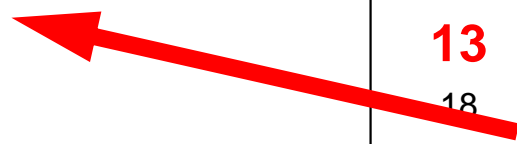
<b>7</b> <u>21</u>	<b>8</b> <u>22</u>	<b>9</b> <u>23</u>	<b>15</b> <u>24</u>
<b>4</b> <u>16</u>	<b>5</b> <u>17</u>	<b>6</b> <u>18</u>	<b>14</b> <u>19</u>
<b>1</b> <u>11</u>	<b>2</b> <u>12</u>	<b>3</b> <u>13</u>	<b>13</b> <u>14</u>
<b>10</b> <u>6</u>	<b>11</b> <u>7</u>	<b>12</b> <u>8</u>	

#PE1

<b>14</b> <u>23</u>	<b>7</b> <u>24</u>	<b>8</b> <u>25</u>
<b>13</b> <u>18</u>	<b>5</b> <u>19</u>	<b>6</b> <u>20</u>
<b>12</b> <u>13</u>	<b>3</b> <u>14</u>	<b>4</b> <u>15</u>
<b>11</b> <u>8</u>	<b>1</b> <u>9</u>	<b>2</b> <u>10</u>
	<b>9</b> <u>4</u>	<b>10</b> <u>5</u>

#PE0

<b>11</b> <u>11</u>	<b>12</b> <u>12</u>	<b>13</b> <u>13</u>		
<b>6</b> <u>6</u>	<b>7</b> <u>7</u>	<b>8</b> <u>8</u>	<b>9</b> <u>9</u>	<b>10</b> <u>10</u>
<b>1</b> <u>1</u>	<b>2</b> <u>2</u>	<b>3</b> <u>3</u>	<b>4</b> <u>4</u>	<b>5</b> <u>5</u>



# PE#2: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

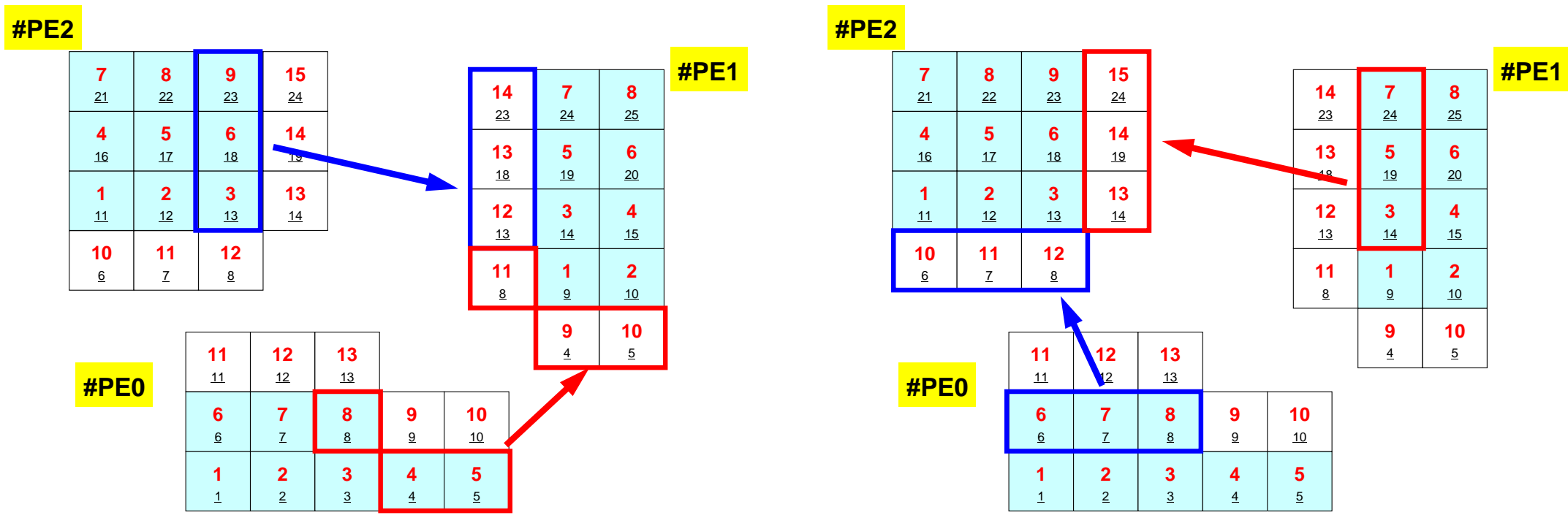
```

#NEIBPEtot
2
#NEIBPE
1 0
#NODE
15 9
#IMPORTindex
3 6
#IMPORTitems
13
14
15
10
11
12
#EXPORTindex
3 6
#EXPORTitems
3
6
9
1
2
3

```



# Where do Boundary Pts go to ? : PE#0



# PE#0: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

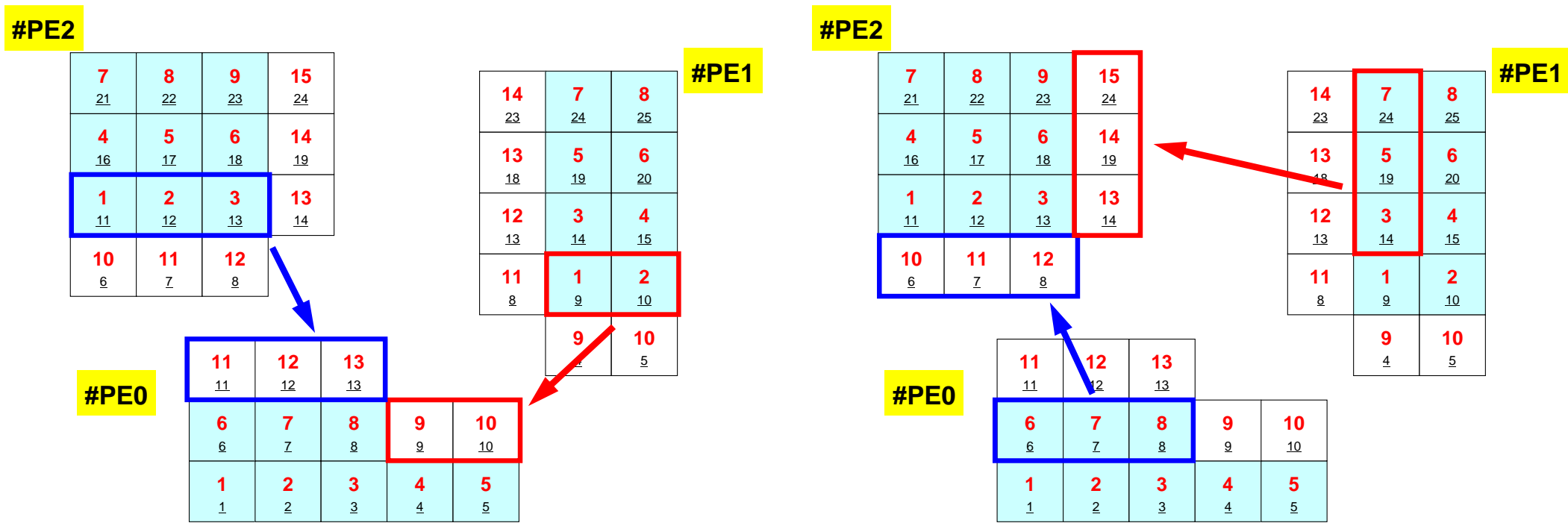
#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
2
#NEIBPE
1 2
#NODE
13 8
#IMPORTindex
2 5
#IMPORTitems
9
10
11
12
13
#EXPORTindex
3 6
#EXPORTitems
4
5
8
6
7
8
    
```

# Where do Boundary Pts go to ? : PE#1



# PE#1: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

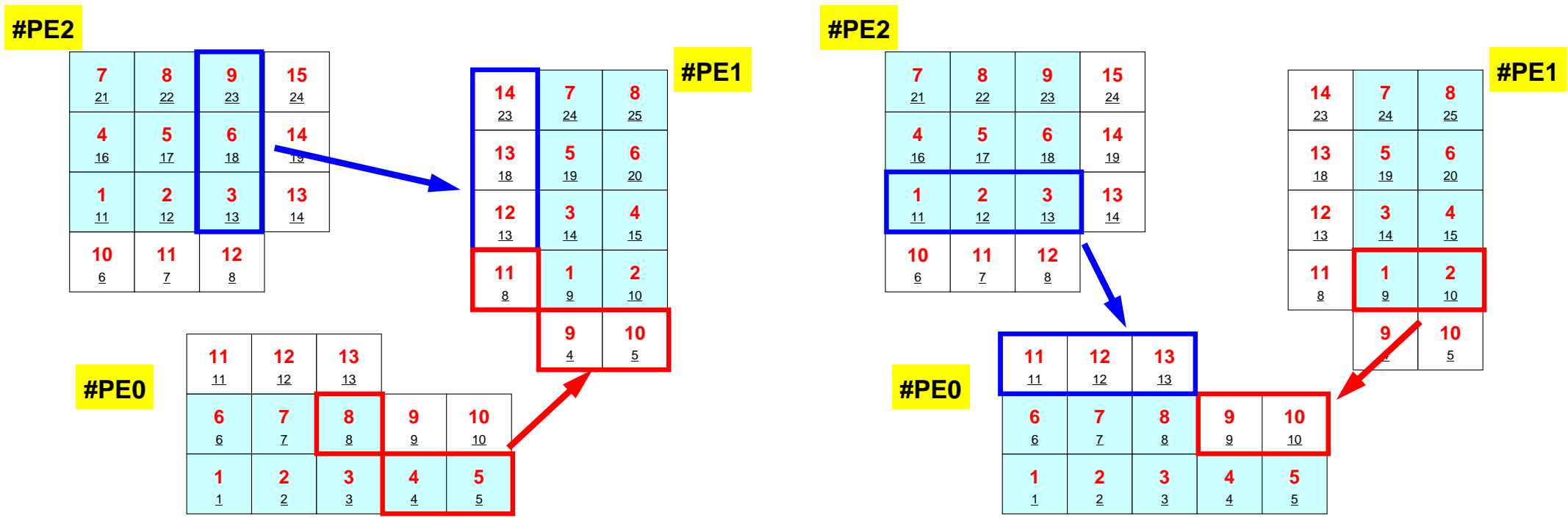
#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
2
#NEIBPE
0 2
#NODE
14 8
#IMPORTindex
3 6
#IMPORTitems
9
10
11
12
13
14
#EXPORTindex
2 5
#EXPORTitems
1
2
3
5
7
    
```

# Where do Boundary Pts go to ? : PE#2



# PE#2: Distributed Local Data

#PE2

7 21	8 22	9 23	15 24
4 16	5 17	6 18	14 19
1 11	2 12	3 13	13 14
10 6	11 7	12 8	

#PE1

14 23	7 24	8 25
13 18	5 19	6 20
12 13	3 14	4 15
11 8	1 9	2 10
	9 4	10 5

#PE0

11 11	12 12	13 13		
6 6	7 7	8 8	9 9	10 10
1 1	2 2	3 3	4 4	5 5

```

#NEIBPEtot
2
#NEIBPE
1 0
#NODE
15 9
#IMPORTindex
3 6
#IMPORTitems
13
14
15
10
11
12
#EXPORTindex
3 6
#EXPORTitems
3
6
9
1
2
3
    
```