MIDTERM REVIEW
Wednesday, Oct 25, 2017
Regular class

MIDTERM EXAM
Open book and notes
Saturday, Oct 28, 2017
8:00 am - 12:00 pm
Room LW-836

Assignment 8. Due 10/30/17 (extra credit).

17. Draw a network representation of the maintenance planning model for 3 power units p_1 , p_2 and p_3 with

demanded power	$w_1 = 5$, $w_2 = 3$, $w_3 = 3$,
fall in the operating power	$h_1 = 3$, $h_2 = 2$, $h_3 = 2$,
required duration	$x_1^{max} = 3$, $x_2^{max} = x_3^{max} = 2$.

The planning period $T_{max} = 4$ days with the power reserve

$f(1) = 4$, $f(2) = 5$, $f(3) = 7$, $f(4) = 2$.

Explain your network.

Maintenance Planning as ABG: Artificial Agents

(For more details see Chapter 7 of the book on LG)

Assume that a power-producing company is going to set up a maintenance plan for the power-producing equipment for a given planning period T_{max}, e.g., a month or a year. There exists an array of *m* demands for maintenance work of power units. The problem is to satisfy these demands. To do that we must include the maintenance work for all the demanded units into the plan, i.e., to schedule maintenance. A maintenance work of a power unit causes turning off of this unit, and, consequently, a loss of generating power in the system. Thus, it is impossible to meet all the demands because of problem constraints, which is basically the power reserve, i.e., the amount of power to be lost without turning off customers. This amount varies daily.

Each demand requests maintenance work for one power unit (*j*-th unit) and contains three attributes:

w_j,	**is a demanded power of the unit (power production capacity);**
h_j,	**is a loss in the operating power of the energy-producing system because of maintenance of this unit (resources requirements); and**
x_j^{max}	**is a required duration of maintenance.**

For simplicity, we neglect the rest of the demand's attributes. For the same reason we specify the only type of constraints - function *f(i)* of power reserve for the power-producing system, where *i* is the number of a day of the planning period. On the *i*-th day of the planning period the total loss in the operating power, because of the maintenance of some power units, cannot be greater than the value *f(i)*. The values of all the parameters are positive integer numbers.

The optimum criterion of the plan is the maximum total demanded power of the units being maintained.

Maintenance Planning Model

2 power units p_1 and p_2 with

demanded power

operating power loss

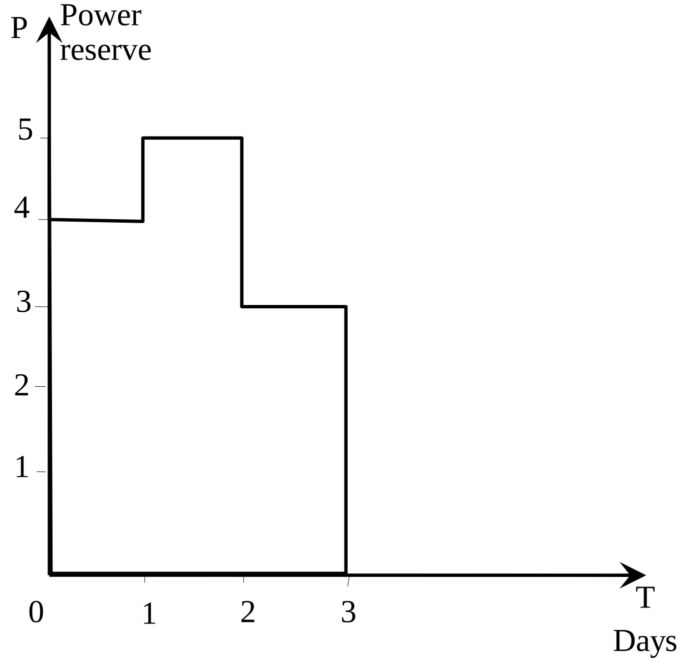
required duration

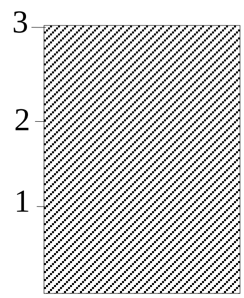
p_1	p_2
$w_1 = 5$	$w_2 = 2$
$h_1 = 3$	$h_2 = 2$
$x_1^{max} = 2$	$x_2^{max} = 2$

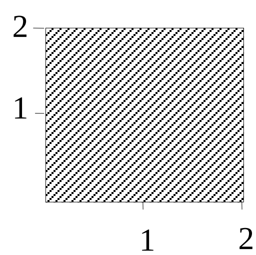
The planning period $T_{max} = 3$ days with the power reserve

$f(1) = 4$, $f(2) = 5$, $f(3) = 3$

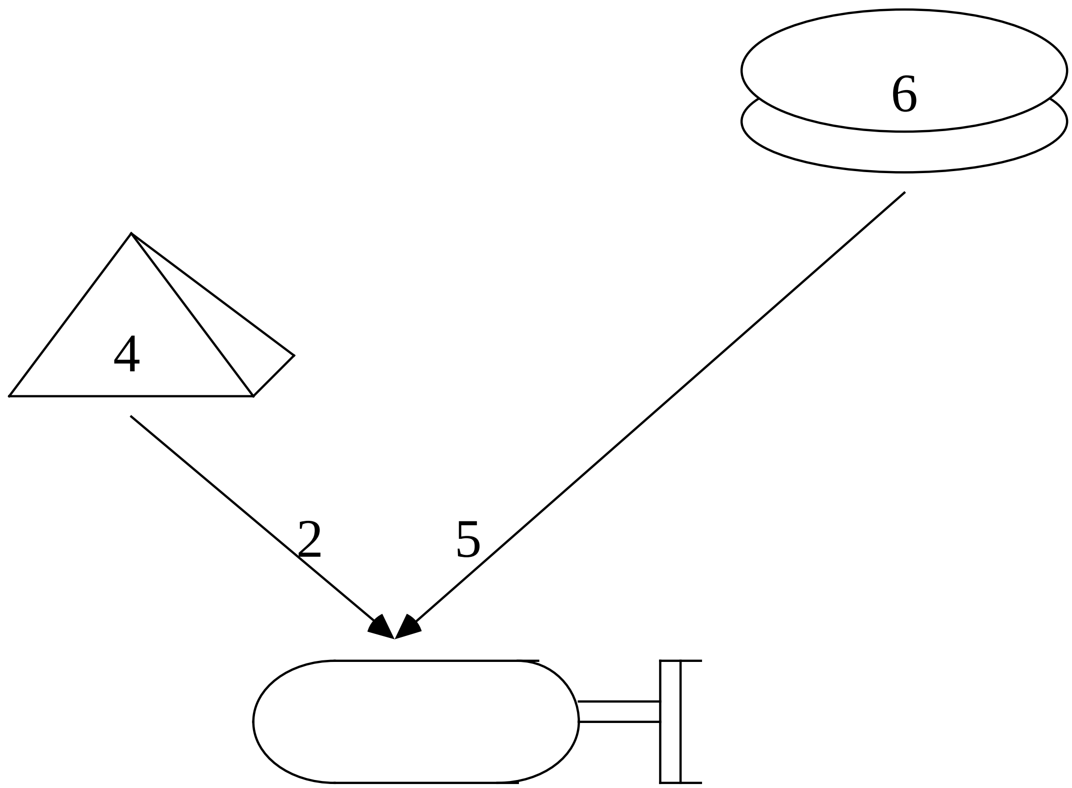
Conventional Representation



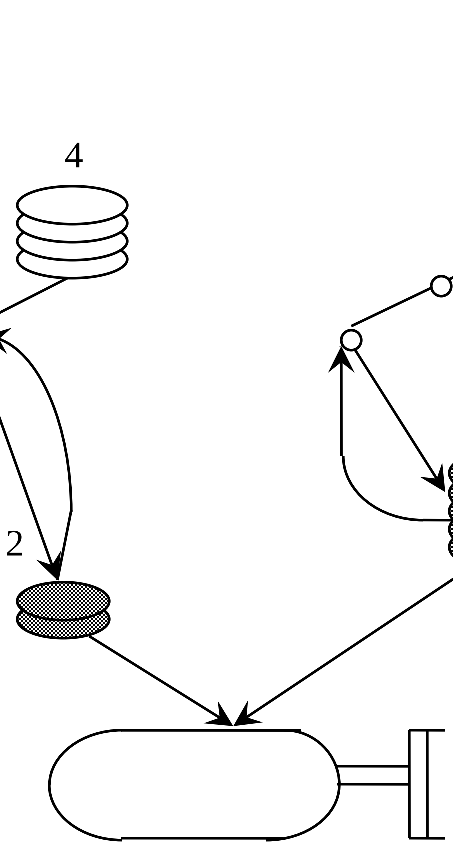




Resources Requirements for Maintenance Work



Resources Requirements as Opposing Agent



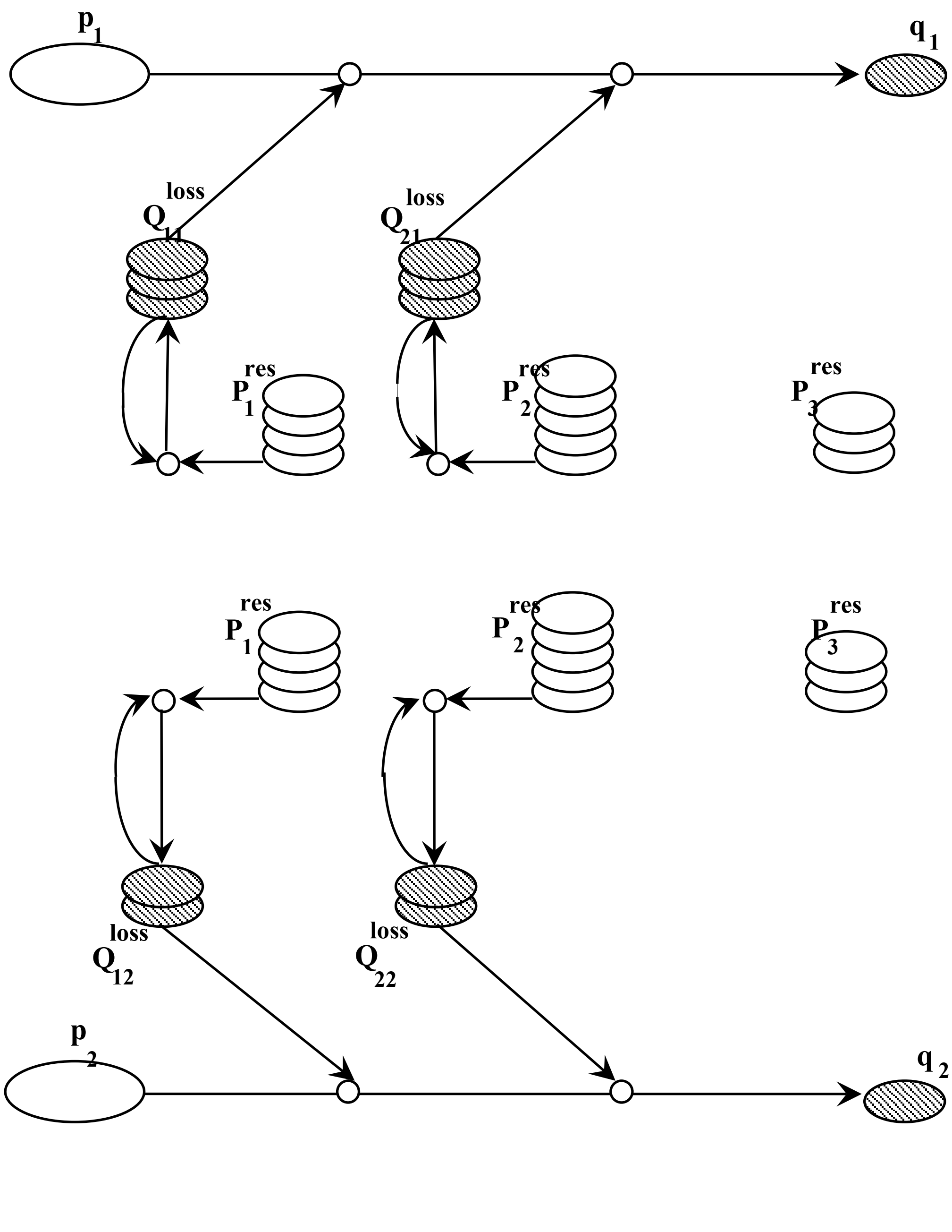
Network Representation (draft)

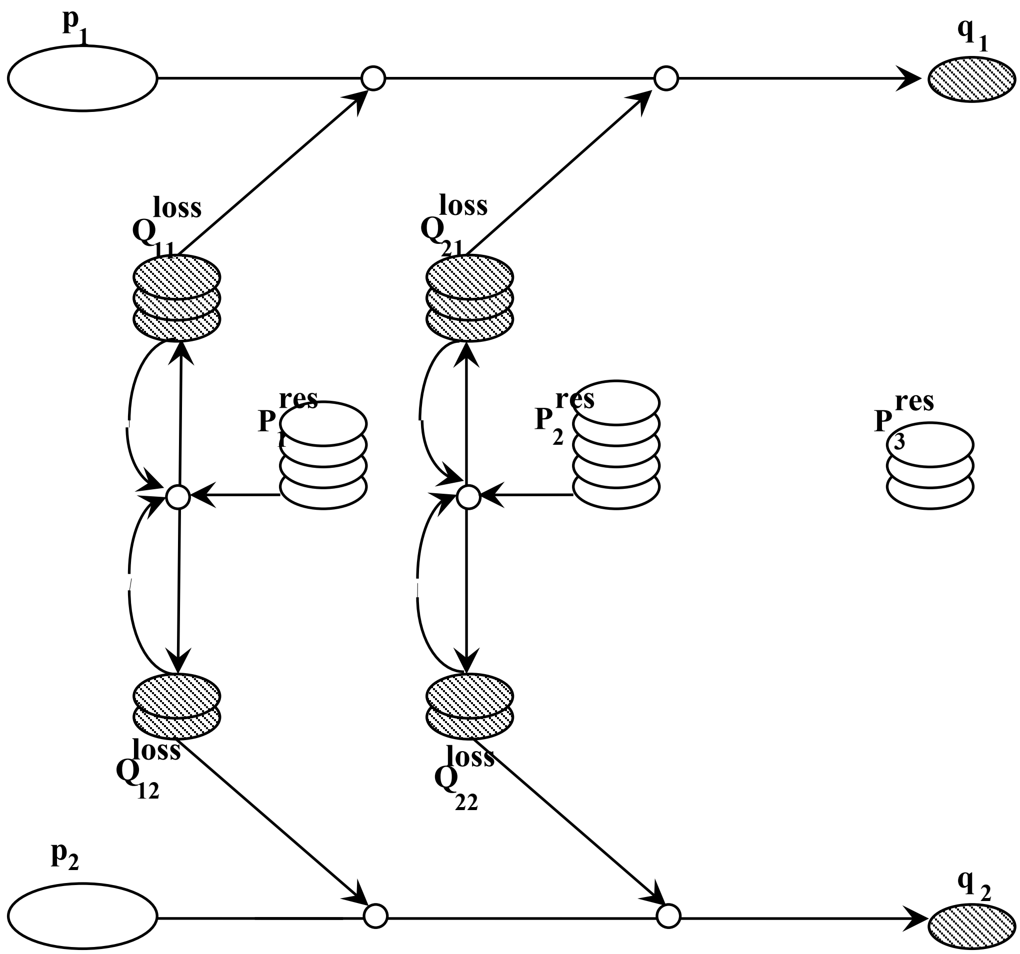
2 power units p_1 and p_2 with

demanded power	$w_1 = 5$,	$w_2 = 2$
oper. power loss	$h_1 = 3$,	$h_2 = 2$
required duration	$x_1^{max} = x_2^{max} = 2$	

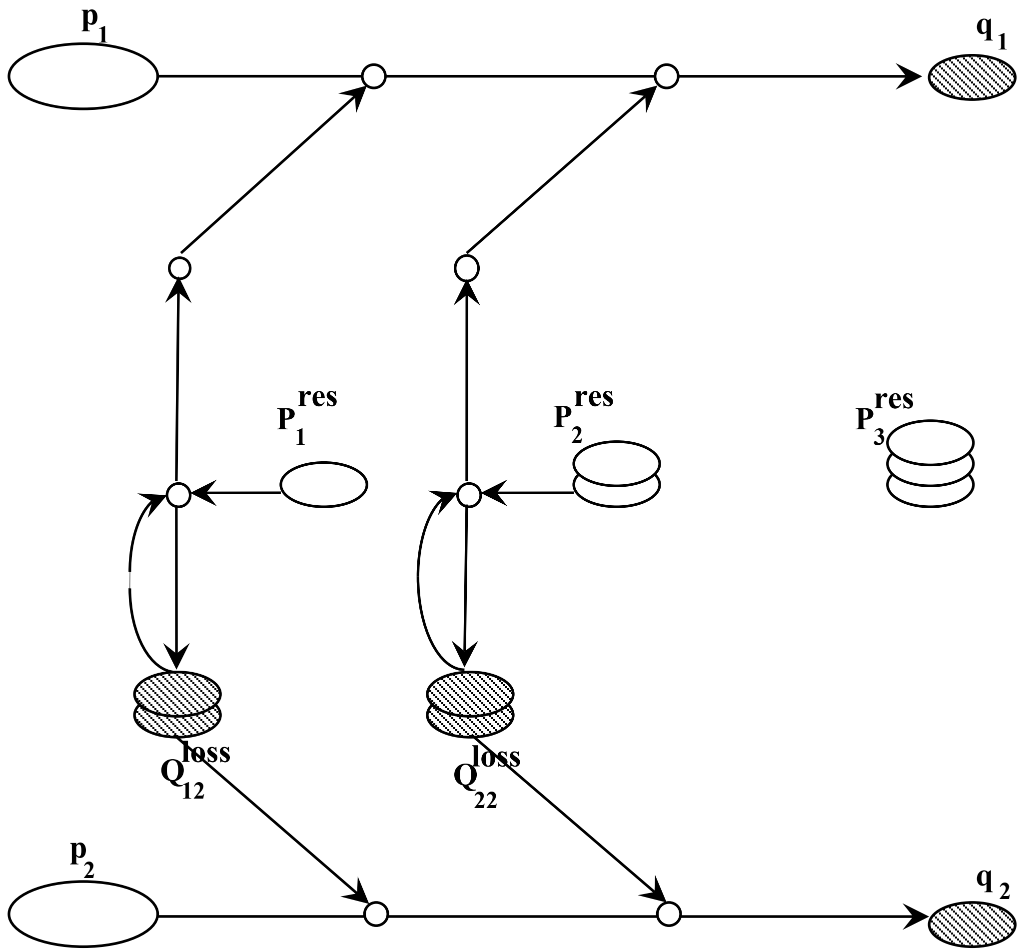
The planning period $T_{max} = 3$ days with the power reserve

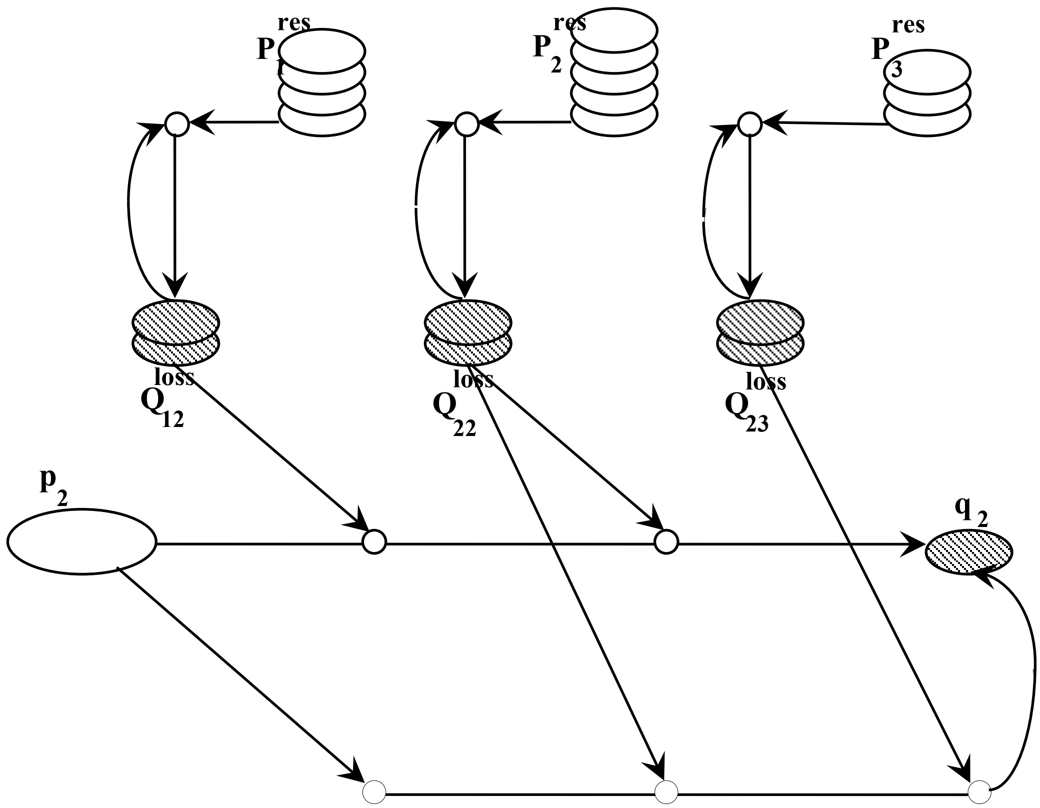
$f(1) = 4$, $f(2) = 5$, $f(3) = 3$



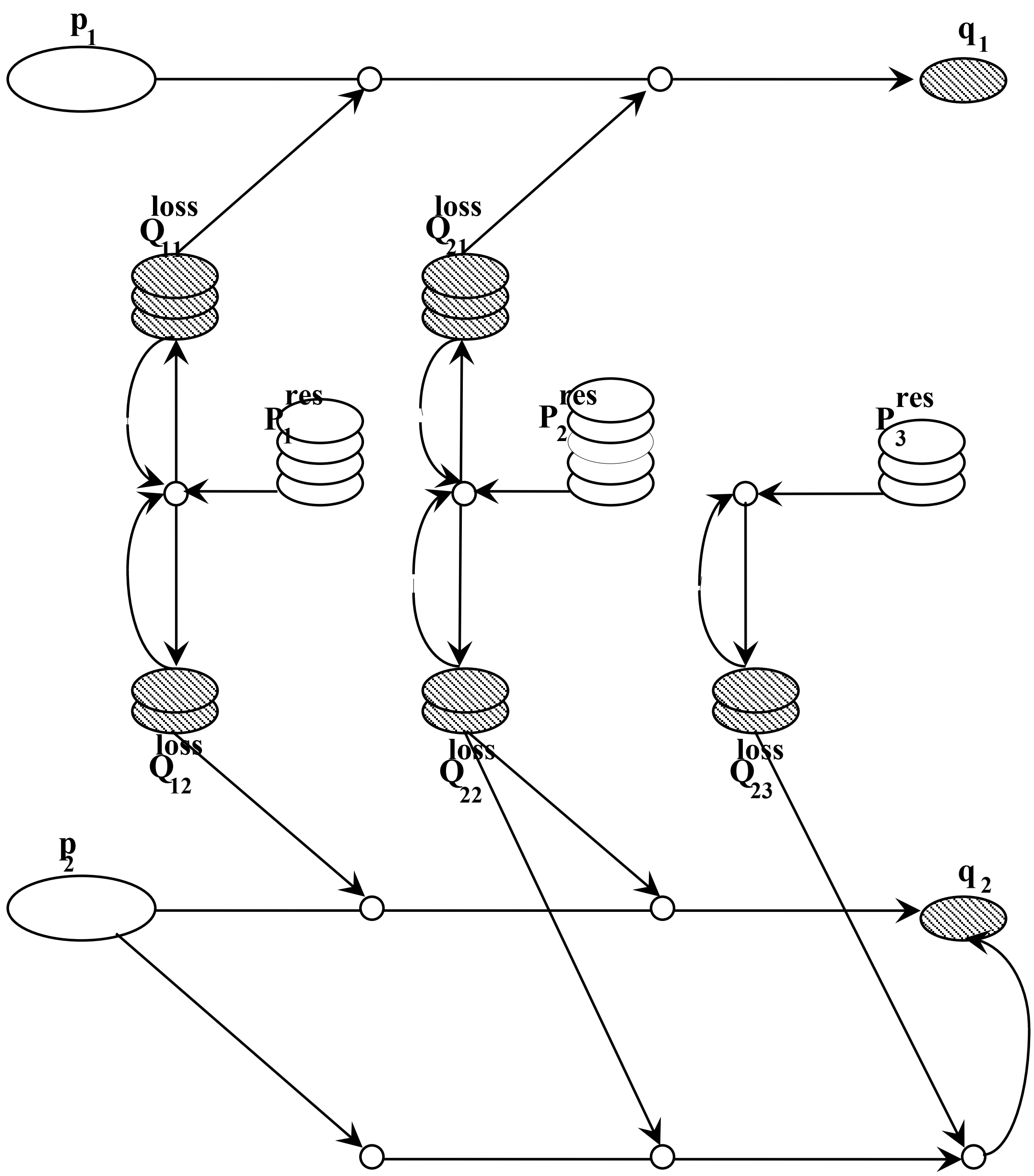


p1
q1
Q11 loss
Q21 loss
P1 res
P2 res
P3 res
Q12 loss
Q22 loss
p2
q2


p_1
q_1
P_1^{res}
P_2^{res}
P_3^{res}
Q_{12}^{loss}
Q_{22}^{loss}
p_2
q_2

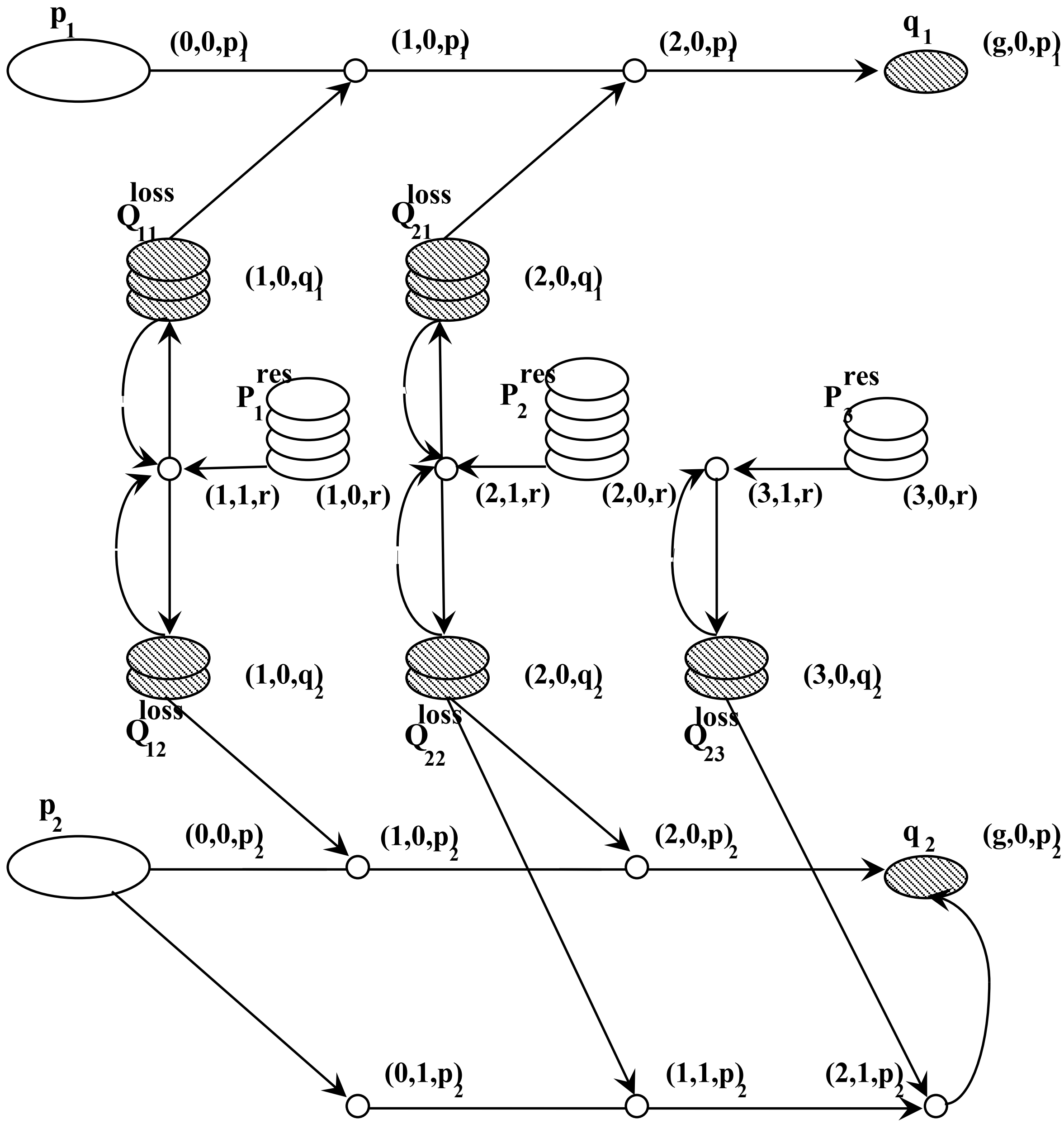


P_1^{res}
P_2^{res}
P_3^{res}
Q_{12}^{loss}
Q_{22}^{loss}
Q_{23}^{loss}
p_2
q_2



p
1
q
1
loss
Q
11
loss
Q
21
res
P
1
res
P
2
res
P
3
loss
Q
12
loss
Q
22
loss
Q
23
p
2
q 2

A Network of Trajectories for Maintenance Planning



Class of Problems

An **ABG** is the following eight-tuple

$$< X, P, R_p, \{ON\}, v, S_i, S_t, TR>$$

$X = \{x_i\}$ is a finite set of ***points***;

$P = \{p_i\}$ is a finite set of ***elements***; $P= P_1 \cup P_2$, $P_1 \cap P_2=\emptyset$;

$R_p(x, y)$ is a family of binary relations of ***reachability*** in X
($x \in X$, $y \in X$, $p \in P$); y is ***reachable*** from x for p;

ON(p) = x is a partial function of ***placement*** of elements P into X;

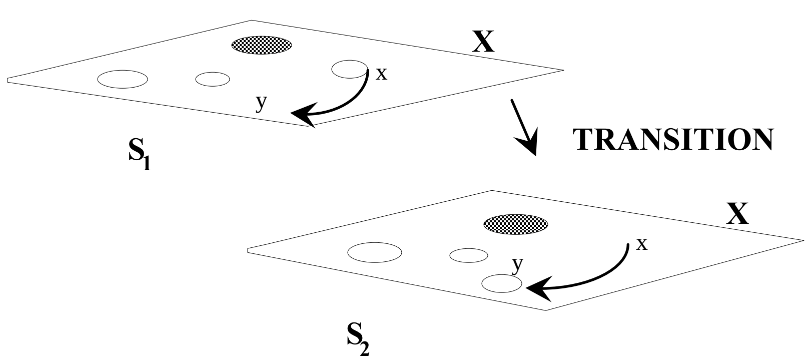
v > 0 is a real function, **v**(p_i) are the ***values*** of elements;

S_i is a set of ***initial*** states of the system,
a certain set of formulas $\{ON(p_i)=x_i\}$;

S_t is a set ***target*** states of the system (as S_i);

TR is a set of operators **TRANSITION(p, x, y)** for transition of the system from one state to another described as follows

precondition: $(ON(p) = x) \wedge R_p(x, y)$
delete: $ON(p) = x$, $ON(q) = y$
add: $ON(p) = y$



Formal representation of the ABG for the maintenance problem is as follows:

$$\mathbf{X = (Y \cup \{g\}) \times Y \times (P_{dem} \cup Q_{dem} \cup \{r\})},$$
where $\mathbf{Y = \{0, 1, ..., T_{max}\}}$,

P_{dem} is the set of power units included in the demands, $|P_{dem}|$ is the number of demands. A duplicate set Q_{dem} of the elements q_j is introduced, and one-to-one correspondence $q_j \leftrightarrow p_j$ is established between elements of $\mathbf{Q_{dem}}$ and $\mathbf{P_{dem}}$

$\mathbf{P = P_1 \cup P_2, P_1}$ and $\mathbf{P_2}$ are not intersected and

$$\mathbf{P_1 = P_{dem} \cup P_{reserve}}, \quad \mathbf{P_2 = Q_{dem} \cup Q_{loss}},$$

$$\mathbf{P_{reserve}} = \bigcup_{i=1}^{T_{max}} \mathbf{P_i^{res}}, \quad \mathbf{Q_{loss}} = \bigcup_{i=1}^{T_{max}} \bigcup_{j=1}^{|Q_{dem}|} \mathbf{Q_{ij}^{loss}}$$

To determine the number of elements $|P_{reserve}|$ and $|Q_{loss}|$ we have to define $\mathbf{v_0}$. It is the quantum of power loss, the common factor of all values $f(i)$ of power reserve and all values h_j of power loss (for all demanded units); for example, $\mathbf{v_0}$=1 Megawatt. We can now determine $|P_{reserve}|$ and $|Q_{loss}|$, having given $|P_i^{res}|$ and $|Q_{ij}^{loss}|$. Thus,

$$|\mathbf{P_i^{res}}| = f(i)/\mathbf{v_0} \quad \textbf{and} \quad |\mathbf{Q_{ij}^{loss}}| = h_j/\mathbf{v_0}.$$