Weekly Report (2009-01-17)

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As our problem model is a *Binary Mixed Integer Linear Programming* problem, I read more books and papers on this part. I also read some content about *Primal Dual Decomposition Method* which may help to find a solution to our problem.

In the analysis we find the previous model, the variables in which are presented in matrix form, is not convenient for processing and even brings in non-linear elements (constraint 2 and 4). Also the constraints for tree construction is redundant since they can also be characterized by link schedule (S). So we convert the problem into the following

$$
\begin{aligned}
minimize \quad & (\sum_t y_t)^a (\sum_{i,j,t} P_{ijt})^b \\
s.t. \quad & \sum_{j,t} s_{ijt} = 1,\ \forall i \in [1, n-1] \\
& \sum_{j,t} s_{njt} = 0 \\
& \sum_{j} s_{ijt} \le 1 - \frac{1}{n^2} \sum_{l \ge t, j} s_{jil},\ \forall i, t \in [1, n] \\
& \sum_{i,j} s_{ijt} \le n^2 y_t,\ \forall t \in [1, n] \\
& 0 \le P_{ijt} \le P_{max} s_{ijt} \quad \forall t, i, j \in [1, n] \\
& G_{ij} P_{ijt} - \beta \sum_{u \ne i} \sum_{w \ne j} G_{uj} P_{uwt} - \beta \sum_{u > i} G_{uj} P_{ujt} - \beta N_0 \ge \Phi(s_{ijt} - 1) \quad \forall t, i, j \in [1, n] \\
& s_{ijt}, y_t \in \{0, 1\},\ \forall i, j, t \in [1, n]
\end{aligned}
$$

Here, s_{ijt} marks whether node i will transmit to node j in time slot t. 1 stands for a transmission while 0 means there is not transmission. P_{ijt} represents the power assignment to node i if it transmits to node j in time slot t. Then we can interpret the constraints as: constraints 1 ensures that each non-sink node will only transmit exactly once in the time-span; constraint 2 means the sink node will not transmit; constraint 3 is to make sure that if one node has already transmitted it will never act as a receiver any more; constraint 4 is the implementation of indicator function, in which $y_t = 0$ if and only if there is no positive element in $s_{ijt} \forall i, j \in [1, n]$, mentioned in last report; constraints 5, 6, 7 are the same with previous definition.

If we change the objective function into $a \log \sum_t y_t + b \log \sum_{i,j,t} P_{ijt}$, we can see that the primal problem is the in the form as

$$
\begin{aligned}
minimize \quad & f_1(Y) + f_2(P) \\
s.t. \quad & f_3(s) = 0 \\
& f_4(s) \leq 0 \\
& f_5(s) \leq 0 \\
& f_6(P) \leq 0 \\
& f_7(P, S) \leq 0 \\
& f_8(P, S) \leq 0 \\
& s_{ijt}, y_t \in \{0, 1\}, \ \forall i, j, t \in [1, n]
\end{aligned}
$$

Here, f_1 and f_2 serve as the objective functions on Y and P; f_3 is for constraint 1 and 2; f_4 and f_5 are for constraint 3 and 4 respectively; f_6 and f_7 are for constraint 5; f_8 is for constraint 6.

We can see that the primal problem is not ready for *Primal decomposition*. Thus I am trying the *Dual decomposition* now.