FORMULAZIONE COMPLETA

VARIABILI: X^i_{pq} → NODE i USED FOR VNF q ON SFC p

B → BANDWIDTH D → DELAY

R^w → NODE RESOURCE w

MINIMIZE:

$$\text{COST} = \sum_{i}\sum_{p}\sum_{q}\sum_{w} X^i_{pq} \cdot R^w_{pq} \cdot C^w_i + \quad \#\ \text{NODES}$$
$$q \neq q_{last},\ q \neq q_{init}$$

$$+ \sum_{i}\sum_{j}\sum_{p}\sum_{q} X^i_{pq} \cdot X^j_{pq+1} B_p \cdot C_{ij} \quad \#\ \text{LINKS}$$
$$i \neq j \qquad q \neq q_{last}$$

$$+ \sum_{p}\sum_{q} C_{pq} \quad (?) \qquad \#\ \text{EMBEDDING COST}$$

CONSTRAINTS

1) $\forall i \quad \sum_{p}\sum_{q}\sum_{w} X^i_{pq} R^w_{pq} \leq \text{MAX}(R^w_i)$ # NODE CAP
$q \neq q_{last}, q \neq q_{init}$

2) $\forall i,j \mid i \neq j \quad \sum_{p}\sum_{q} X^i_{pq} X^j_{pq+1} B_p \leq \text{MAX}(B_{ij})$ # LINK BW
$q \neq q_{last}$

3) $\forall p \quad \sum_{i}\sum_{j}\sum_{q} X^i_{pq} X^j_{pq+1} \cdot D_{ij} \leq D_p$ # LINK DELAY
$i \neq j \qquad q \neq q_{last}$

4) $\forall p,q \quad \sum_{i} X^i_{pq} = 1$ # ONE NODE FOR EVERY FUNCTION

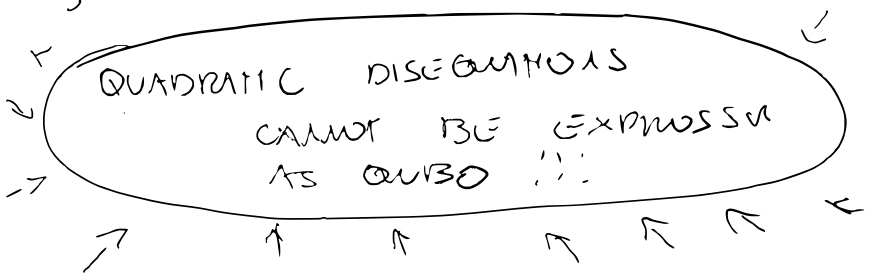
5) $\forall p \quad \sum_{q}\sum_{i}\sum_{j} X^i_{pq} X^j_{pq+1} = \text{LEN}(p) - 1$ ALL LINKS OF CHAIN ARE PROCESSED
$i \neq j$

6) $\forall_{p,q}$ $\sum_{i} \sum_{j \neq i} x'_{pq} x'_{p(q+1)} = 1$

NOTES

1) $B_{ij} = 0$ IF ij NOT CONNECTED

2) $D_{ij} \to \infty$ IF ij NOT CONNECTED



FORMULAZIONE INCOMPLETA (LINK BASED)

VARIABILI: y_{pq}^{ij} → LINK ij IS USED FOR GOING FROM VNF q TO $q+1$

B_i → BANDWIDTH D_i → DELAY

R_i^w → NODE RESOURCE w

MINIMIZE:

$$\text{COST} = \sum_{i}\sum_{j\neq i}\sum_{p}\sum_{q\neq \text{lastVNF}}\sum_{w} y_{pq}^{ij} \cdot R_{pq}^{w} \cdot C_j^w + \quad \text{\# NODES}$$

(C_j^w → CONSUMO PER NODO DI UN DATO TIPO)

$$+ \sum_{i}\sum_{j\neq i}\sum_{p}\sum_{q\neq \text{lastVNF}} y_{pq}^{ij} \cdot B_p C_{ij} \quad \text{\# LINKS}$$

$$+ \sum_{p}\sum_{q} C_{pq} \quad (?) \quad \text{\# EMBEDDING COST}$$

CONSTRAINTS

1) $\forall_{i,w}\ \sum_{j\neq i}\sum_{p}\sum_{q\neq \text{lastVNF}} y_{pq}^{ij} R_{pq}^{w} \leq \text{MAX}(R_i^w)$ \# NODE RES

2) $\forall_{i,j \mid i\neq j}\ \sum_{p}\sum_{q\neq \text{lastVNF}} y_{pq}^{ij} B_p \leq \text{MAX}(B_{ij})$ \# LINK BW

3) $\forall_p\ \sum_{i}\sum_{j\neq i}\sum_{q\neq \text{lastVNF}} y_{pq}^{ij} D_{ij} \leq D_p$ \# LINK DELAY

4) $\forall_{p,q\neq \text{lastVNF}}\ \sum_{i}\sum_{j\neq i} y_{pq}^{ij} = 1$ \# ONE NODE FOR EVERY FUNCTION

5) $\forall_p\ \sum_{q\neq \text{lastVNF}}\sum_{i}\sum_{j\neq i} y_{pq}^{ij} = \text{LEN}(p) - 1$ ALL LINKS OF CHAIN ARE DIFFERENT

6) $\forall p,q$ $\sum_i \sum_j y_{pq}^{ij} = 1$ ONLY ONE LINK BETWEEN TWO VERTICES
$q \neq q_{ST}$ $i \neq j$

NOTES

- CONDIZIONE 5) NON FORZA UNA DELLA STESSA CLIQUE AD ESSERE COMPLETA !!

↳ DIFFICILE AGGIUNGERE COME CONSTRAINT CHE SIA QUADRATICO

LINK FORMULATION (NEW)

VARIABLES

L_{pq}^{ij} → LINK $i \to j$ IS USED FOR VNF CONNECTION $q \to q+1$ OF CHAIN p

q_0 → FAKE FUNCTION ASSIGNED TO ENTRY NODE

q_L → FAKE FUNCTION ASSIGNED TO EXIT NODE

↳ $L_{pq_L}^{ij}$ DOES NOT NOT

B → BANDWIDTH

R^w → NODE RESOURCE w

D → DELAY

C^w → UNIT COST OF RESOURCE w

$T(i) \mid i \in NODES \to \{ SERVER, ENTRY, EXIT \}$

MINIMIZE:

$$COST = \sum_{\substack{i \\ i \neq j}} \sum_{j} \sum_{p} \sum_{\substack{q \\ T(i)=SERV. \\ T(j)=SERV.}} \sum_{\substack{w \\ q \neq q_0 \\ q=q_L}} L_{pq}^{ij} \cdot R_{pq}^{w} \cdot C_{j}^{w} \quad \# \text{ NODE COST}$$

$$+ \sum_{\substack{i \\ i \neq j}} \sum_{j} \sum_{p} \sum_{\substack{q \\ q \neq q_L}} L_{pq}^{ij} \cdot B_p C_{ij} \quad \# \text{ LINK COST}$$

$$+ \sum_{p} \varepsilon_q C_{pq} \to \text{DOES NOT MATTER FOR QUBO} \quad \# \text{ EMBEDDING COST}$$

CONSTRAINTS

1) $\forall_{i,w} \sum_{j} \sum_{p} \sum_{q} L^{ij}_{pq} R^{w}_{pq} \leq MAX(R^{w}_{i})$ # NODE RES

$T(i)$ = serv. $T(j)$ = serv. $i \neq j$ $q \neq q_0$ $q \neq q_L$

2) $\forall_{i,j \mid i \neq j} \sum_{p} \sum_{q} L^{ij}_{pq} B_p \leq MAX(B_{ij})$ # LINK BANDWIDTH

$q \neq q_L$

3) $\forall_p \sum_{i} \sum_{j} \sum_{q} L^{ij}_{pq} D_{ij} \leq D_p$ # LINK DELAY

$i \neq j$ $q \neq q_L$

4) $\forall_{p,q} \sum_{i} \sum_{j} L^{ij}_{pq} = 1$ # EXACTLY ONE LINK FOR EVERY $q \to q+1$

$q \neq q_L$

5) $\forall_p \sum_{q} \sum_{i} \sum_{j} L^{ij}_{pq} = LEN(p) - 1$ # LENGTH OF CHAIN IS FIXED

$q = q_L$ $i \neq j$

6) $\forall_{j,p,q} \sum_{i} L^{ij}_{pq} - \sum_{k} L^{jk}_{pq+1} = 0$ # CONTINUITY AND ORDER OF VNF LINKS.

$T(j) = serv.$ $q \neq q_L$

COMMONS

A) IF BOTH $i \neq j$ CONSTRAINTS MAYBE YOU CAN PUT CONSECUTIVE VNF_n ON SAME NODE

B) L_{pq}^{ij} WITHOUT $type(i) = ONLY$ ($type(j) = EXIT$) AND $q \neq q_0$ ($q \neq q_{L-1}$) DOES NOT EXIST