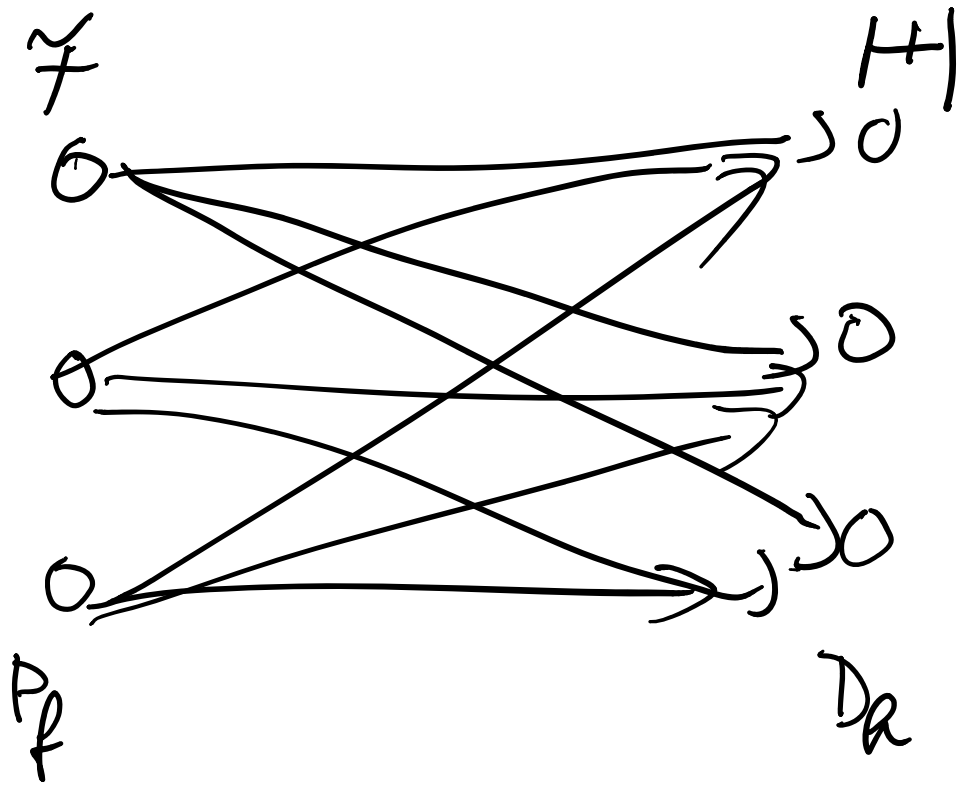


$$\sum_{f \in \mathcal{F}} p_f = \sum_{h \in \mathcal{H}} D_h$$

Ground Route

Datas :

All the costs(variables and fixed costs).

Pf : production of factory f wich belings to F={f1… fn}

Dh : demands of hubs h belonging to H={h1…hm}

Objective : Minimize costs of transportation of the electric plugs from Factories to hubs.

Variables :

Xod : number of pallets sent from o to d.

Tod : number of trucks sent from o to d.

Ground Route

Objective function :

Min sum (o in F) sum (d in H) [Xod.CTPod + Tod.CTod]

Constraints :

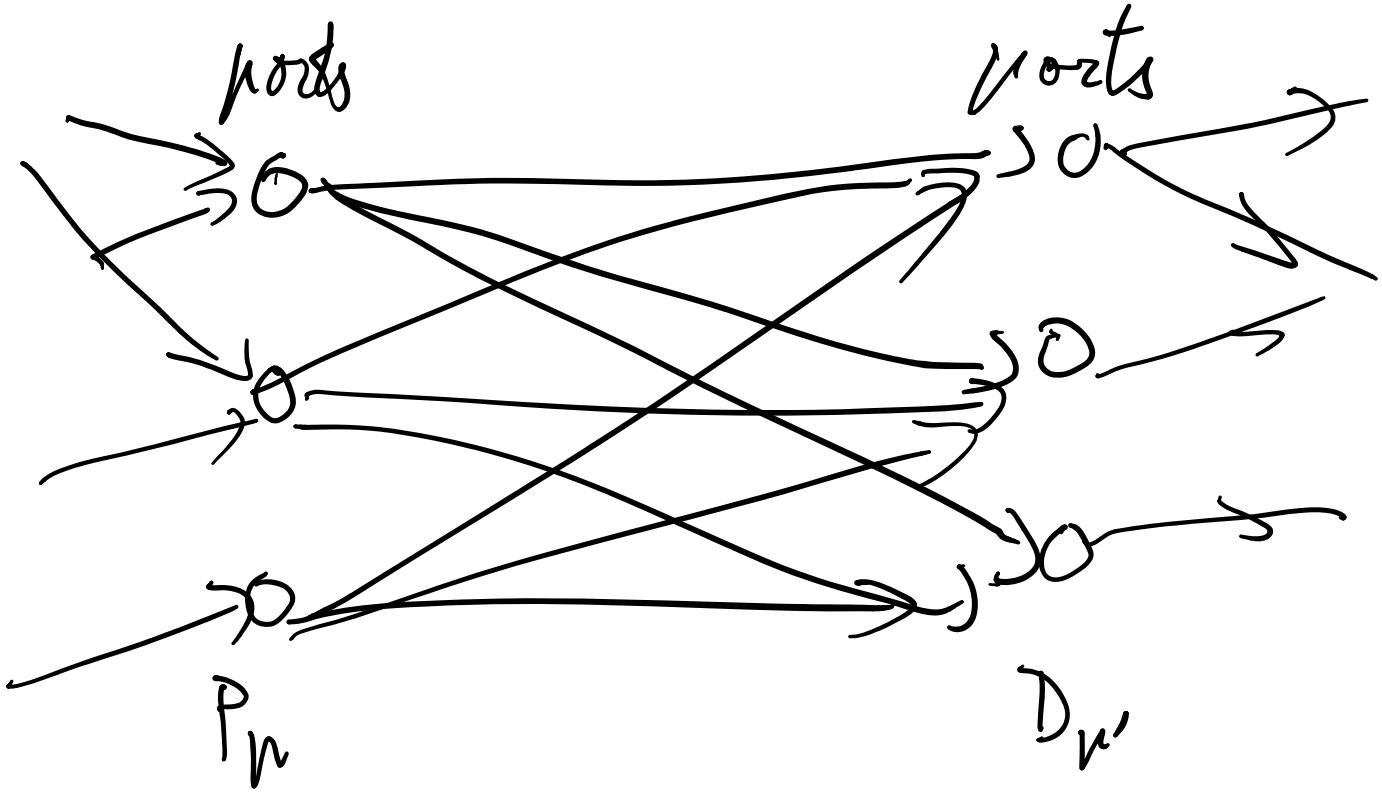
Xod <= N9.Tod ; For all o in F and d in H (Capacity constraint)

Flow constraints :

0 - Sum (o in F) Xod = -Dd (for all d in H)

Sum (d in H) Xod - 0 = Po (for all o in F)

Xod, Tod belongs to N



$$\sum_{n \in \text{ports}} P_n = \sum_{n' \in \text{ports}} D_{n'}$$

Maritime Route

Data :

Assumption : Sum (o in P) Po = Sum (d in P) Dd

Costs for maritime route. Po : production at the departure ports.

Dd : Demand at the arrival ports.

P is a set of ports. o are departure ports, d are destination ports.

Variables :

XIod : nb of individual pallets sent by boats from o (o in P) to d (d in P) P = {p1…pj} related to CBPod

Z11od : Nb of containers N11 sent from o to d related to CBN11od

X11od : Nb of pallets transfered into N11 containers

Z22od : nb of containers N22 sent from o to d related to CBN22od

X22od : Nb of pallets transfered into N22 containers.

Yod : binary, 1 if a pallet or more is sent from o to d, else 0. related to CBFCod

Xod : nb of pallet sent from o to d. related to CBPCod

Maritime Route

Objective function :

Min sum (o in P) sum (d in P) [XIod.CBPod + Z11od.CBN11od + Z22.CBN22od + Yod.CBFCod + Xod.CBPCod]

Constraints :

Sum (d in P) Xod -0 = Po for all o in P (Departure ports)

0 - Sum (o in P) Xod = - Dd for all d in P (Arrival ports)

Xod <= M.Yod for all o in P and d in P

X11od <= N11.Z11od for all o in P and d in P

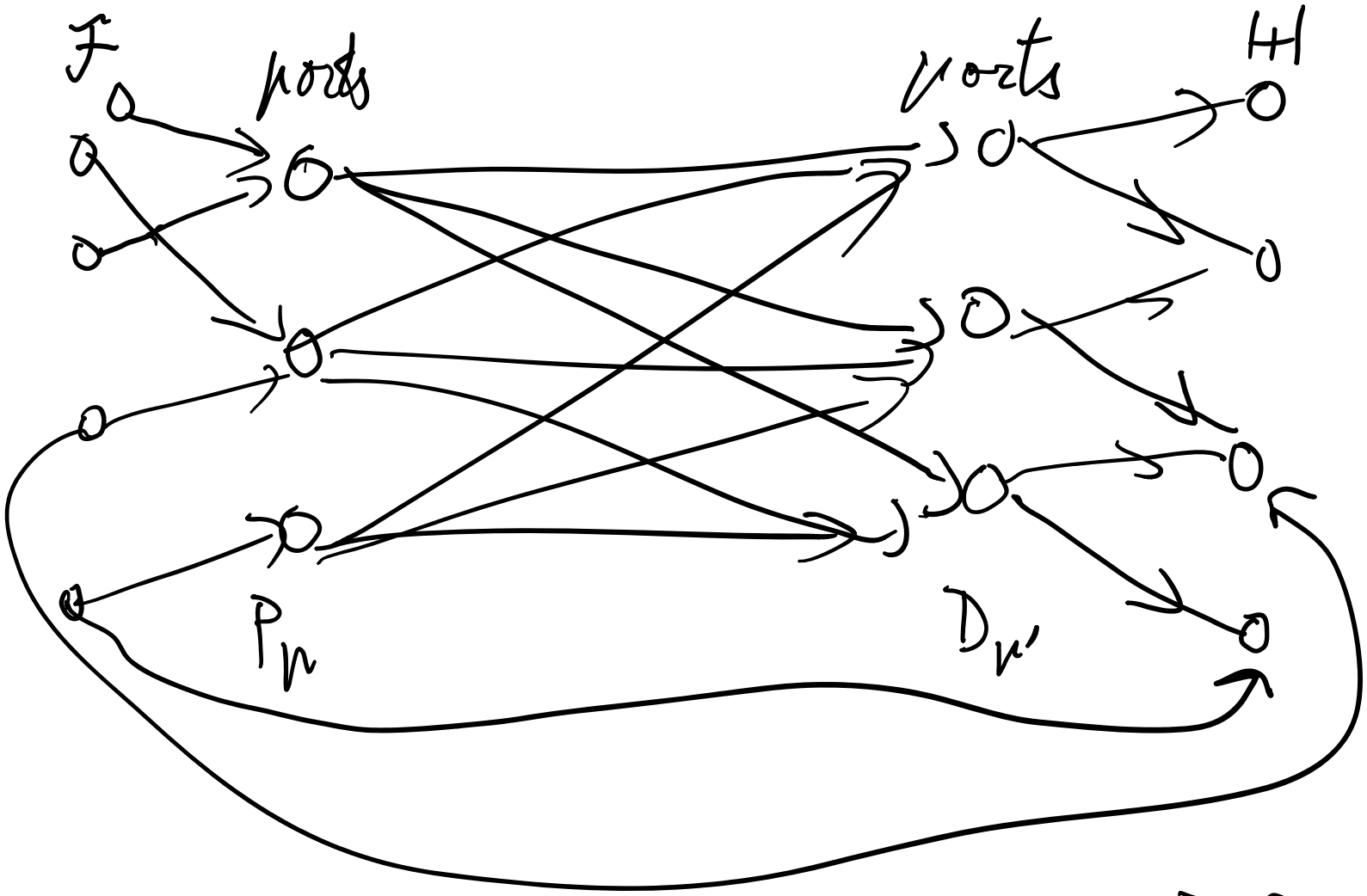
X22od <= N22.Z22od for all o in P and d in P

XIod + X11od + X22od = Xod for all o in P and d in P *(the total number of pallets sent in N11 containers or N22 containers or individualy from o to d equals Sum of all the pallets sent by boat from o to d) => Conservation constraint.*

Domain definition :

XIod, X11od, X22od, Xod, Z11od, Z22od belongs to N+ (positive integers)

Yod belongs to {0;1} (binary)


F
ports
ports
H
P_μ
$D_{\mu'}$
$\sum_{f \in \mathcal{F}} P_f$
=
$\sum_{h \in H} D_h$

Merging the maritime and ground route

Constraints :

Xod <= N9.Tod ; For all o in FUP and d in HUP\-(od in P.P) *(Capacity constraint, applies only to transfer from factories to ports or hubs, or from ports to hubs)*

Sum (d in PUH) Xod -0 = Po for all o in F

0 - Sum (o in PUF) Xod = - Dd for all d in H

Sum (o in P+)Xod – Sum (d in P-) Xdo = 0 for all o in P *(what goes inside the ports goes out).*

Constraints for maritime Route :

Xod <= M.Yod for all o in P and d in P

X11od <= N11.Z11od for all o in P and d in P

X22od <= N22.Z22od for all o in P and d in P

XIod + X11od + X22od = Xod for all o in P and d in P *(the total number of pallets sent in N11 containers or N22 containers or individualy from o to d equals Sum of all the pallets sent by boat from o to d) => Conservation constraint.*

Merging the maritime and ground route

Objective Function :

Min (sum (o in FUP) sum (d in HUP) [Xod.CTPod + Tod.CTod]) + (sum (o in P) sum (d in P) [XIod.CBPod + Z11od.CBN11od + Z22.CBN22od + Yod.CBFCod + Xod.CBPCod])

Ground route

Maritime Route