

# **Model: Oblivious routing**

: Tags	112-2 Oblivious Routing
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© Präsentation	https://docs.google.com/presentation/d/1RmGI7sELMFbk2IOxzNBs6EziNTCBfE1dtSw2Sp2Es1o/edit#slic
🔆 Status	Es kann geändert werden

# Der Thikung von dem Lehrer

 $\textbf{Input}: \textbf{Given a Demand Matrix } DM_1$ 

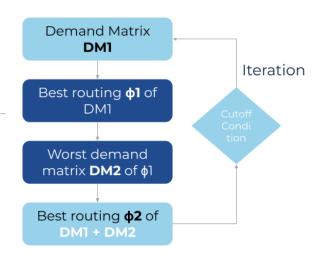
 $\textbf{Output}: \textbf{Routing } \phi \text{ (Fraction of demand entering vertex)}$ 

- 1. Find the best routing  $\phi_1$  of  $DM_1$
- 2. Find the worst demand matrix  $DM_2$  of the routing  $\phi_1$
- 3. Find the best routing  $\phi_2$  of  $DM_1+DM_2$
- 4. Iteration until it meet the cutoff condition

# ှိုင်္ဂိ Approach

Input: A demand Matrix Output: Routing (Fraction of demand entering vertex)

**Best routing**: Minimize maximum link ultialization **Worst demand matrix**: Maximum maximum link ultialization



# Pseudo code

Algorithm 1: main algorithm

Input: Demand matrix DM

**Output:** Routing  $\phi_{best}$  (Fraction of demand)

- 1 Initialization :  $DM_{worst} = \emptyset$ ;
- ${f 2}$  while not meet the cutoff condition  ${f do}$
- 3  $DM = DM + DM_{worst};$
- 4 Find the best routing  $\phi$  of DM; // The First model
- $\phi_{best} = \phi;$
- Find the worst demand matrix  $DM_{worst}$  of  $\phi_{best}$  // The second model
- 7 end
- 8 return  $\phi_{best}$

# Finden Sie größe Routing $\phi$

Finding the link weight and traffic splitting ratio to minimize the maximum link ultilization



## **Indicate**

DM Demand matrix

e=(u,v)∈E Edges form vertex u to vertex v

dst Demand form s to t

fst(u) Fraction of demand entering vertex u

ce Link capacity

Given demand matrix DM, find the fraction of

demands that minimizing

the maximum link

ultilization.

## **Variable**

α The maximum link ultilization of the

demand matrix DM

 $\phi_{st}(e)$  Routing fraction for edge e=(u, v)

#### Indicate

DM	Demand matrix
$e=(u,v)\in E$	Edges
$d_{st}$	Demand from $s$ to $t$
$f_{st}(u)$	Fraction of demand entering vertex $\boldsymbol{u}$
$c_e$	Link capacity

#### Variable

lpha The maximum link ultilization of the demand matrix DM

 $\phi_{st}(e)$  Routing fraction for edge e=(u,v)

## **Objective function**

Minimize the maximum link ultilization lpha

 $\min \alpha$ 

#### **Constraints**

$$0 \leq \alpha \leq 1 \text{ (Decision variable constraint)}$$

$$0 \leq \phi_{st}(e) \leq 1 \text{ ,} \forall e \in E \text{ (Decision variable constraint)}$$

$$\sum_{(s,t)} \frac{d_{st}f_{st}(u)\phi_{st}(e)}{c(e)} \leq \alpha \text{ (Link capacity constraint)}$$

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ ,} \forall (s,t) \in D \text{(Flow conservation)} \\ 0 & \text{others} \end{cases}$$

Model: Demand matrix has no constrainted

 $\min \alpha$  (Minimize maximum link ultilization)

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ ,} \forall (s,t) \in D, \forall u \in V \\ 0 & \text{others} \end{cases}$$

$$\sum_{(s,t)} \frac{d_{st}f_{st}(u)\phi_{st}(e)}{c(e)} \leq \alpha$$

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(Link capacity constraint)
$$0 \leq \phi_{st}(e) \leq 1 \text{ ,} \forall e \in E$$
(Decision variable constraint)
$$0 \leq \alpha \leq 1$$
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 $\min \alpha$  (Minimize maximum link ultilization)

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(Decision variable constraint)
$$0 \leq \alpha \leq 1$$
(Decision variable constraint)

# Find the worst demand matrix of routing $\phi$

Find the demand matrix maximizing the maximum link ultilization with given routing  $\phi$ 



# The second model

## **Indicate**

$\phi_{st}(e)$	Given routing fraction for edge e=(u, v)	
e=(u,v)∈E	Edges form vertex u to vertex v	
<b>d</b> st	Demand form s to t	Given routing (Fracttion of demand) φ, find the
fst(u)	Fraction of demand entering vertex u	demand matrix maximizing
Ce	Link capacity	maximum link ultilization with routing φ.

### **Variable**

The maximum link ultilization of the demand matrix DM DM The worstcase demand matrix of given routing  $\phi$ 

# Indicate

$\phi_{st}(e)$	Given routing
$e=(u,v)\in E$	Edges
$d_{st}$	Demand from $s$ to $t$
$f_{st}(u)$	Fraction of demand entering vertex ${\it u}$

Link capacity

#### Variable

DM The worstcase demand matrix of given routing  $\phi$  lpha The maximum link ultilization of the demand matrix  ${
m DM}$ 

# **Objective function**

Maximize the maximum link ultilization lpha

 $\max \alpha$ 

#### **Constraints**

#### Demand matrix is unconstrained

$$0 \leq lpha \leq 1 ext{ (Decision variable constraint)} \ \sum_{(s,t)} rac{d_{st}f_{st}(u)\phi_{st}(e)}{c(e)} \leq lpha ext{ (Link capacity constraint)} \ \sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = egin{cases} 1 & ext{if } u=s \ -1 & ext{if } u=t \ , \ orall (s,t) \in D ext{(Flow conservation)} \ 0 & ext{others} \end{cases}$$

#### Demand matrix must in a set D

$$0 \leq \alpha \leq 1 \text{ (Decision variable constraint)}$$
 
$$DM \in D(\text{Decision variable constraint})$$
 
$$\sum_{(s,t)} \frac{d_{st} f_{st}(u) \phi_{st}(e)}{c(e)} \leq \alpha \text{ (Link capacity constraint)}$$
 
$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u=s \\ -1 & \text{if } u=t \end{cases}, \ \forall (s,t) \in D(\text{Flow conservation})$$
 others

#### Model

#### Demand matrix is unconstrained

 $\max \alpha$  (Maximize maximum link ultilization)

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ ,} \forall (s,t) \in D, \forall u \in V \\ 0 & \text{others} \end{cases}$$

$$\sum_{(s,t)} \frac{d_{st} f_{st}(u) \phi_{st}(e)}{c(e)} \leq \alpha \qquad \qquad \text{(Link capacity constraint)}$$

$$0 \leq \alpha \leq 1 \qquad \qquad \text{(Decision variable constraint)}$$

 $\max \alpha$  (Maximize maximum link ultilization)

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ ,} \forall (s,t) \in D, \forall u \in V \\ 0 & \text{others} \end{cases}$$

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(Link capacity constraint)
$$0 \leq \alpha \leq 1$$
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#### Demand matrix must in a set D

 $\max \alpha$  (Maximize maximum link ultilization)

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ ,} \forall (s,t) \in D, \forall u \in V \\ 0 & \text{others} \end{cases}$$

$$\sum_{(s,t)} \frac{d_{st} f_{st}(u) \phi_{st}(e)}{c(e)} \leq \alpha$$
(Link capacity constraint)

 $\mathrm{DM} \in D$ 

(Decision variable constraint)

 $0 \le \alpha \le 1$ 

(Decision variable constraint)

 $\max \alpha$  (Maximize maximum link ultilization)

$$\sum_{e=(v,u)\in E} \phi_{st}(e) - f_{st}(u) = \begin{cases} 1 & \text{if } u = s \\ -1 & \text{if } u = t \text{ , } \forall (s,t) \in D, \forall u \in V \\ 0 & \text{others} \end{cases}$$
 (Flow conservation) 
$$\sum_{(s,t)} \frac{d_{st} f_{st}(u) \phi_{st}(e)}{c(e)} \leq \alpha$$
 (Link capacity constraint) 
$$DM \in D$$
 (Decision variable constraint) 
$$0 \leq \alpha \leq 1$$
 (Decision variable constraint)

# **Etwas Fragen**



# Some question

#### About model 1:

What happens if total traffic is over than the total capacity of the network?

### About model 2:

- 1. How to defined the constraints of the OD pairs with continuous interval constraints?
- 2. In practice, how to define the first demand matrix?
- 3. In model 2, there is high probability that several feasible solution.

#### Über Modell Eins

What happens if total traffic is over than the total capacity of the network?

#### Antwort

# Über Modell Zwei

1. How to defined the constraints of the OD pairs with continuous interval constraints?

#### **Antwort**

2. In practice, how to define the first demand matrix?

#### **Antwort**

3. In model 2, there is high probability that several feasible solution.

#### **Antwort**



# Some question

## **About cutoff condition:**

- 1. How to set the **cutoff condition**?
- 2. About the routing will **converge with interaction**, how can I prove it?

### Else:

How I change model for PD routing?

# Über die Abschaltbedingung

1. How to set the cutoff condition?

#### **Antwort**

2. About the routing will **converge with interaction**, how can I prove it?

#### **Antwort**

## **Andere**

How I change model for PD routing?

#### **Antwort**