

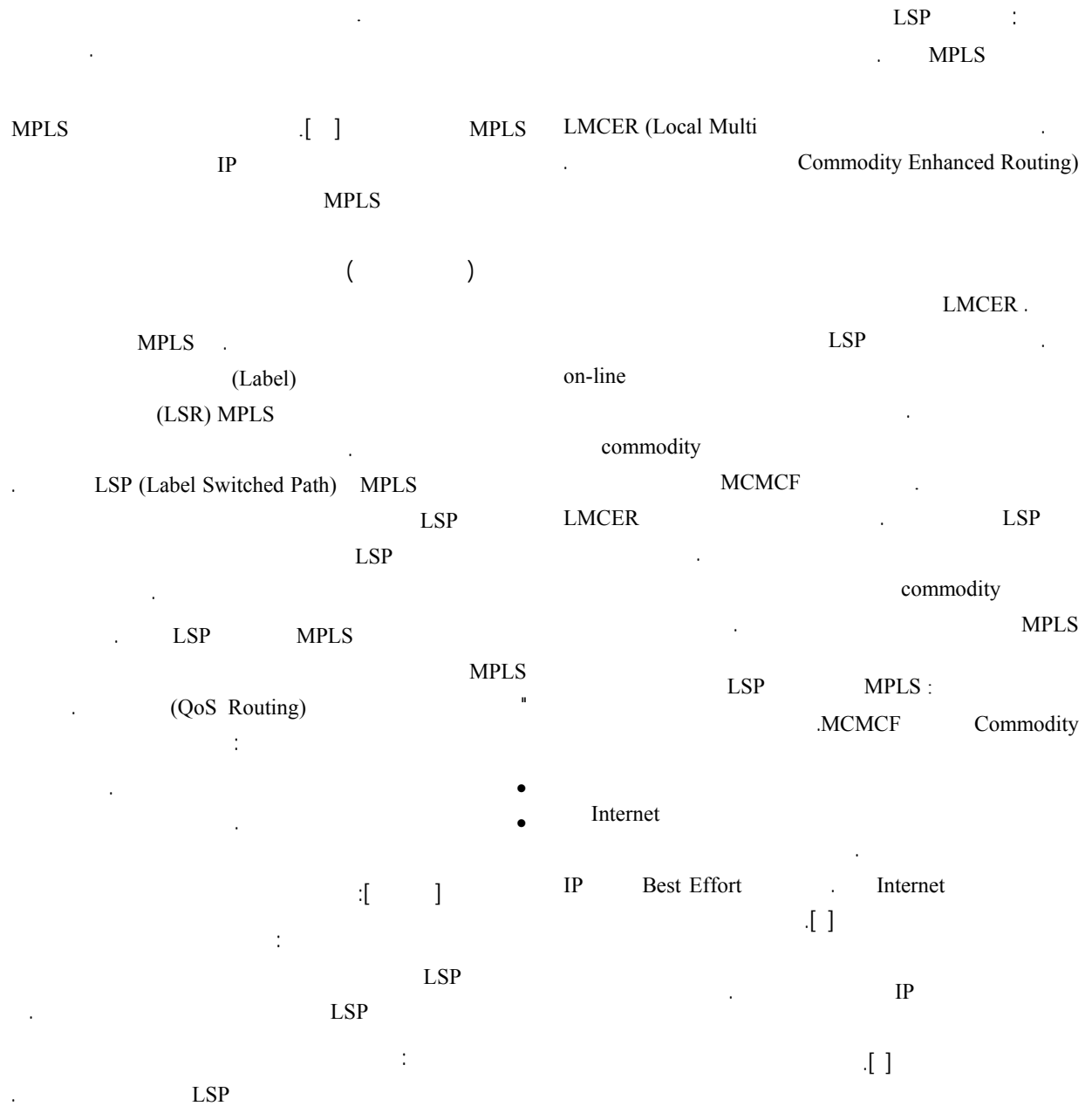
commodity

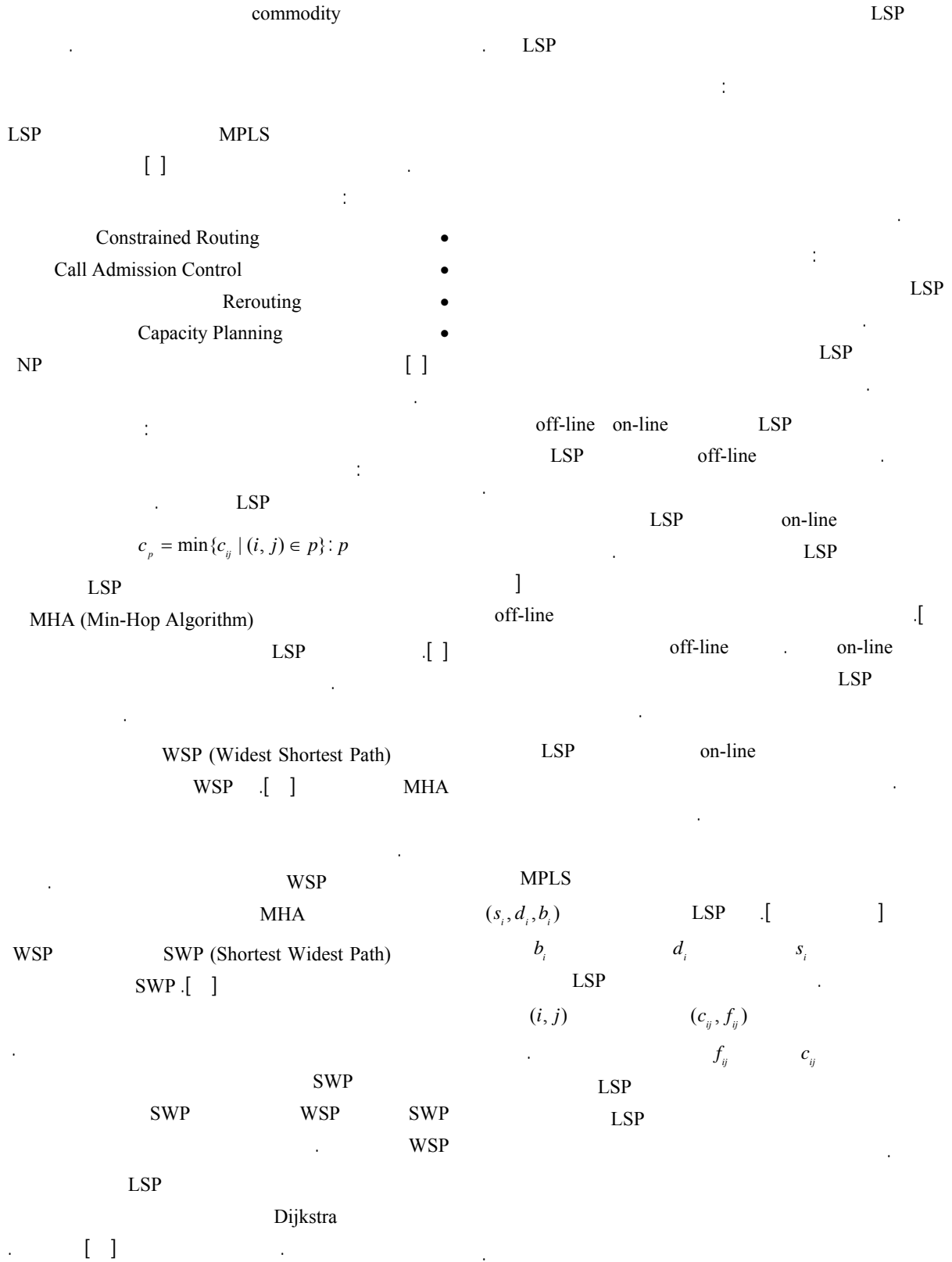
LSP

MPLS

bbakhshi@aut.ac.ir

khorsand@cic.aut.ac.ir





on-line []

off-line PBR :

LSP $w_{ij} = e^{\frac{c_{ij}}{c_{ij}-f_{ij}}} \quad ()$

$w_{ij} = \frac{c_{ij}}{c_{ij}-f_{ij}} \quad ()$

$w_{ij} = \frac{1}{c_{ij}-f_{ij}} \quad ()$

[]

LSP

LSP

MIRA (Minimum Interference Routing Algorithm) []

LSP

LSP

LSP

MIRA

A

LSP

LSP

LSP

LSP

(s_i, d_i, b_i) LSP

[] on-line

IP ()

$\max \sum_{(S_i, D_j) \in A} \text{maxflow}(S_i, D_j) \quad ()$

Multi Class Erlang Formula

S

$\text{maxflow}(S, D)$

Maximum Multi Commodity Flow

D

MIRA VFD

A

LMCER

LSP

VFD [] VFD (Virtual Flow Deviation)

LMCER

MIRA

LSP

V

(V, E)

LSP

VFD

LSP

E

LSP

(i, j)

$j \ i$

V

(s_i, d_i, b_i)

LSP

(j, i)

LSP

LSP

$:C$

LSP

$:F$

[] Flow Deviation

(i, j)

k

PBR on-line

[] (Profile Based Routing)

$:x_{ij,k} \in \{0,1\}$

PBR

$\min z = f(C, F)$

()

off-line PBR

MCMCF (Minimum Cost Multi Commodity Flow)

LSP

$$f_{ij} = \sum_k x_{ij,k} b_k \leq c_{ij}, \quad \forall (i, j) \in E \quad ()$$

min-mean

$$\sum_{(s_k, j) \in E} x_{s_k, j, k} = 1, \quad \forall k \quad ()$$

$$\sum_{(i, d_k) \in E} x_{i, d_k, k} = 1, \quad \forall k \quad ()$$

Minimum

$$\sum_{(i, j) \in E} x_{ij, k} - \sum_{(j, i) \in E} x_{ji, k} = 0, \quad \forall k, \forall i \in V \quad ()$$

Cost Multi Commodity Flow Problem

تابع $f(C, F)$
()

commodity (i, j)

j i commodity

() ()

commodity

$x_{ij, k}$

LSP

LSP

commodity

commodity

flow

()

conservation

$$f(C, F) = \sum_{\forall (i, j) \in E} -\ln\left(m - \frac{f_{ij}}{c_{ij}}\right) \quad ()$$

[]

NP

Constrained Routing

m

$$\ln\left(m - \left(\frac{f_{ij}}{c_{ij}}\right)\right) \leq 0 \quad m \leq 1 \quad \left(\frac{f_{ij}}{c_{ij}}\right) \leq m$$

$$m \quad \frac{f_{ij}}{c_{ij}}$$

LSP

MCMCF

(utilization)

m

LSP

PBR

commodity

commodity

commodity

LSP

LMCER

()

LSP

(V, E)

LSP

Dijkstra

()

LSP

Check-

Condition

min-max

ALGORITHM: LMCER
INPUT: Network (V, E, C, F) , LSP (s, d, b)
OUTPUT: Route of the LSP

1 $(V', E') \leftarrow \text{Feasible-Network}(V, E, b)$
 $\leftarrow \text{Shortest-Path}(V', E', C, F, s, d, b)$

if (Check-Condition) **then**

2 $A \leftarrow \text{Create-Commodities}(V, E, C, F)$
 $(V', E', C', F') \leftarrow \text{Remove-Commodities}(A)$
 $B \leftarrow \text{MCMCF}(V', E', C', F', A)$
for \forall commodity $i \in A$ **do**
 $(V'', E'', C'') \leftarrow \text{Create-Virtual-Network}(B)$
Sort-LSPs-in-Commodity
for \forall LSP $l \in i$ **do**
SWP-Reroute (V'', E'', C'', l)
end for
end for
end if

LMCER (V, E, C, F, s, d, b)

ALGORITHM: Create-Commodities
INPUT: Network (V, E, C, F)
OUTPUT: Set of Commodities

for each LSP l in Network **do**
for each (i, j) in LSP's Route **do**
if Is-Critical (i, j) **then**
Add-to-Commodity (i, j, l)
if (there is commodity started in node k and finished in i) **then**
Remove-from-Commodity (i, j, l)
Add-to-Commodity (k, j, l)
end if
end for
end for

Create-Commodities (V, E, C, F)

LSP
LSP

commodity
LSP
SWP
LSP
MCMCF
SWP

LSP
LSP
commodity
Create-Commodities
LSP
 (i, j)
LSP
 j
 i commodity
LSP
commodity
min-mean min-max
commodity
commodity LSP
commodity
commodity
Remove-Commodities
 (V, E, C, F')

MCMCF
) PPRN

<http://www-eio.upc.es/~jcastro/pprn.html>
PPRN MCMCF
PPRN

$m - (f_y / c_y)$
PPRN
commodity MCMCF
commodity
 (V', E', C')
commodity
PPRN
LSP

commodity LSP
commodity MCMCF
LSP
LSP

() : PBR
 commodity LSP MCMCF"

() LSP
) LSP MCMCF

(SWP-Reroute
 SWP
 LSP LSP
 MCMCF (i, j) (j, k)
 commodity
 (k, l) (l, m) (m, i) (i, n)
 (m, i) (l, m) (k, l) (j, k) (i, j) LSP

LMCER
 SWP-Reroute (i, n)
 LMCER LSP MCMCF
 ()

LMCER LMCER
 WSP SWP
 SP
 (LMCER) ()

() []
 LMCER ()

LSP bps bps

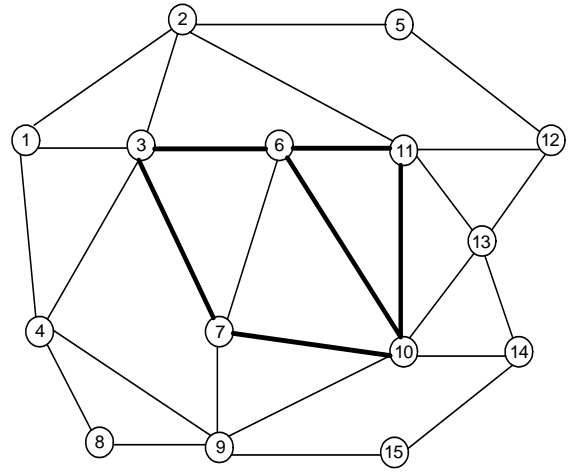
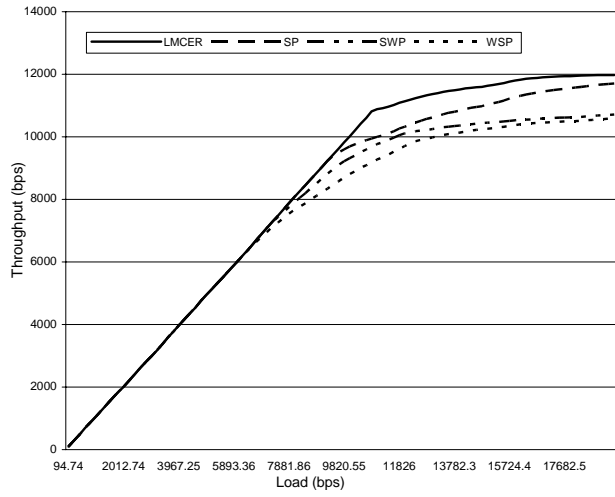
LMCER LSP
 VFD MIRA ()

[] LSP
 MIRA VFD bps
 LMCER LSP LSP

LMCER LMCER
 commodity ()

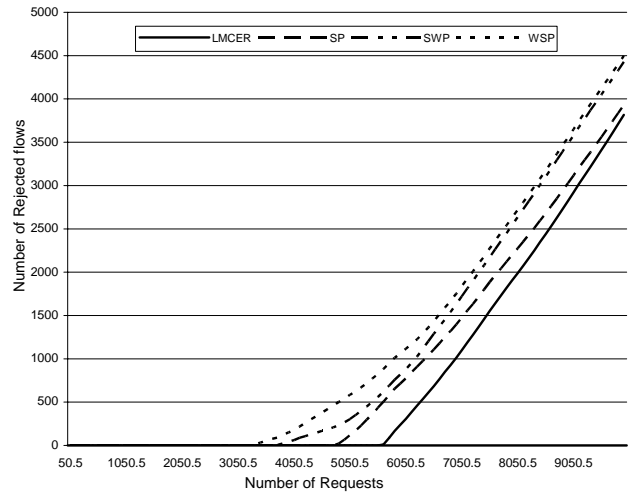
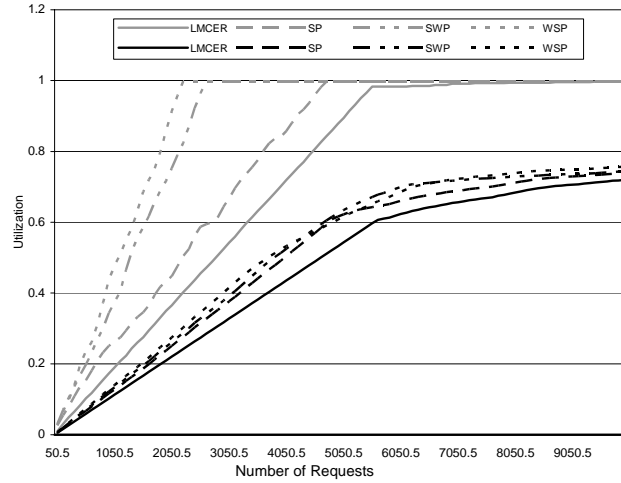
LMCER WSP LMCER
 commodity)

commodity (on-line



(.)

(.)



()

LSP (.)

MCMCF
 commodity
 LSP
 LMCER
 LSP
 MCMCF
 LSP

MPLS
 on-line
 LMCER
 commodity
 MIRA
 LMCER
 VFD
 LMCER
 MPLS

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MPLS LSP

on-line

commodity

commodity

MCMCF

LMCER

LSP

LSP

LMCER

LSP

LMCER

SWP WSP

LMCER

LMCER

SP

LSP

commodity

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on-line

LMCER)

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LMCER

MCMCF