Reducing total call-blocking rates by flow admission control based on equality of heterogeneous traffic

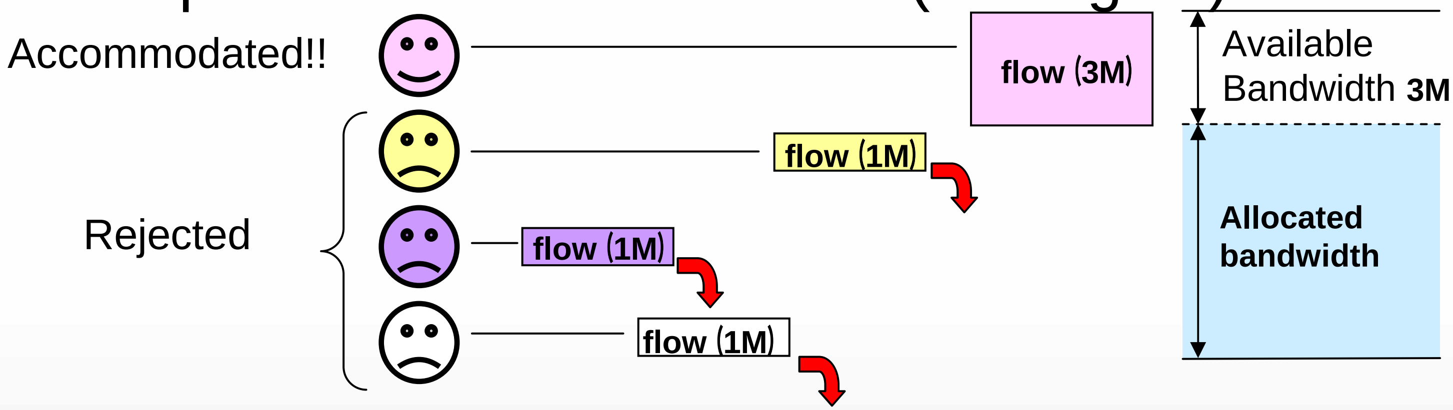
Tokyo Institute of Technology

Sumiko SHIRATA, Katunori YAMAOKA

東京工業大学
酒井・山岡研究室
TOKYO INSTITUTE OF TECHNOLOGY
SAKAI YAMAOKA LABORATORY

Background(1/2)

- The spread of multimedia stream applications
  - Increase in flows of various bandwidth (heterogeneous traffic)
  - Occupies most networks
    - To maintain high-quality service → CAC
- CAC (Call Admission Control)
  - To improve resource utilization (main goal)

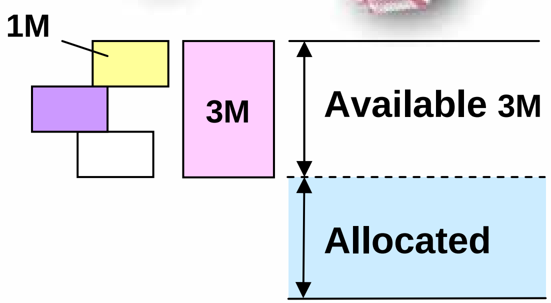


  - **What do you think about users' satisfaction?**

Users' satisfaction: the level of individual satisfaction depend on the success of CACs in accommodating flows

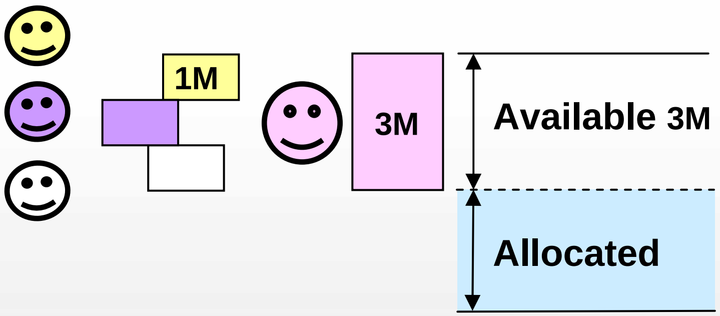
Background(2/2)

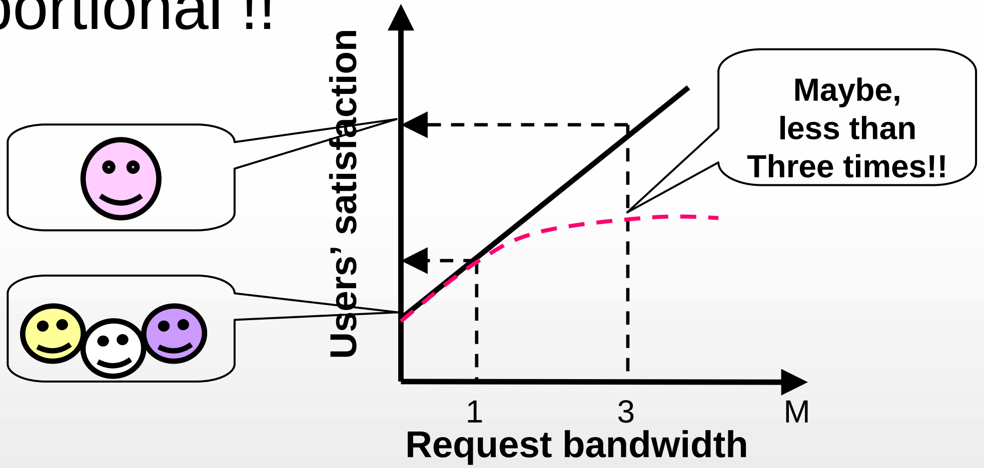
- To improve **resource utilization**
  - “three flows of 1M”=“a flow of 3M”



- To improve **total users’ satisfaction**
  - “three flows of 1M”≠“a flow of 3M”
    - have to give “request bandwidth” – “users’ satisfaction” relation properly

→ is NOT always proportional !!

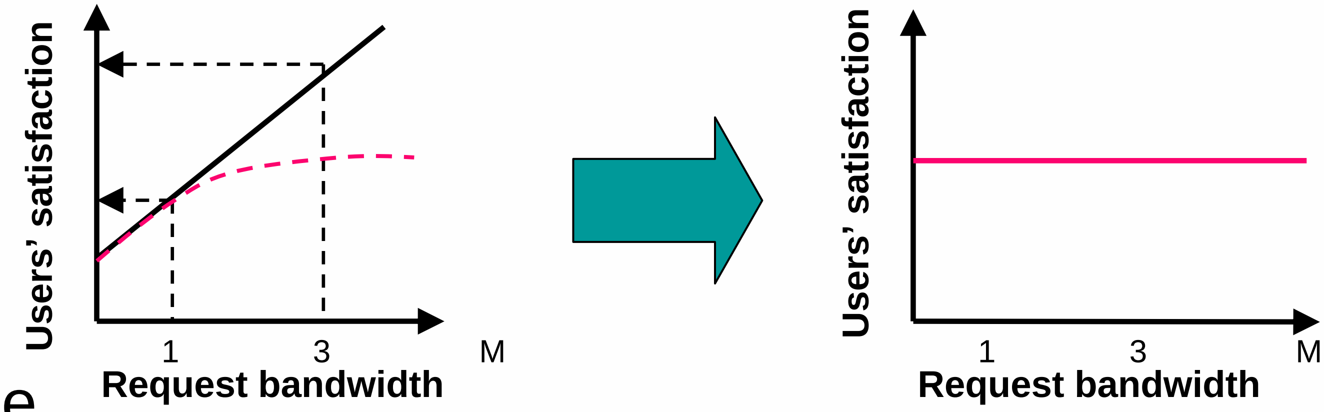




Purpose of study

To improve total users' satisfaction

- Constant users' satisfaction (assumption)
  = Various bandwidths are fair



Purpose

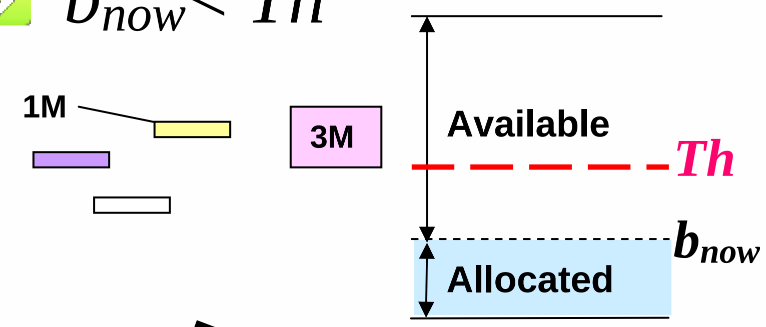
- Maximize the total number of accommodated flows in a network.

- Minimize the total number of blocked flows (total call-blocking rate) in a network.

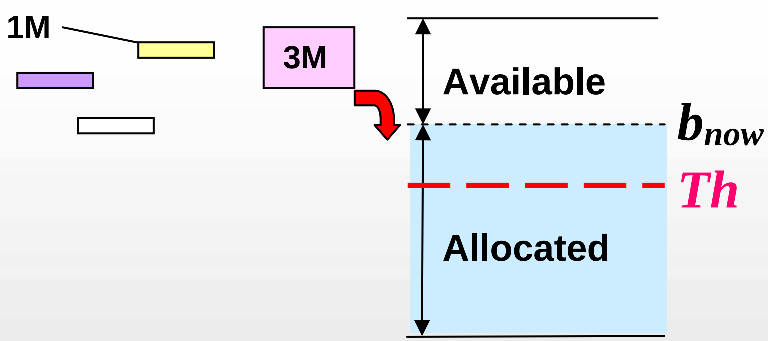
Proposed CAC

- Concept of new CAC
  - Reject broadband flows for narrowband flows more than *Th*

- $b_{now} < Th$



- $b_{now} \geqq Th$



b_{now} : total accommodating bandwidth at the time

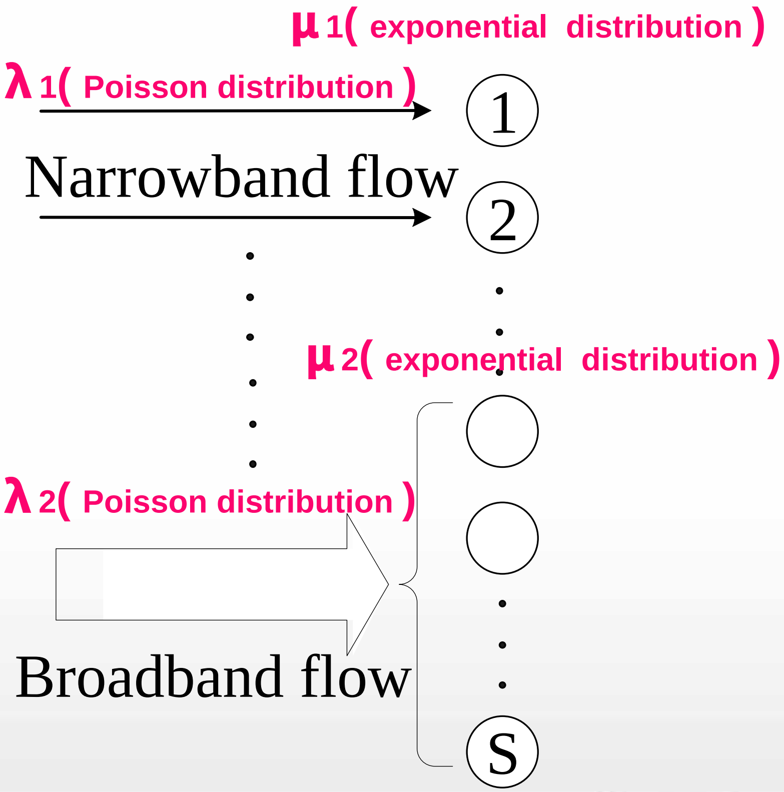
Th : threshold that decides whether the accommodated broadband bandwidth

Should configured ***Th*** appropriately to maximize the total number of accommodated flows.

a theoretical analysis

Model

- $M_1M_2/M_1M_2/S/S$ (loss system)
  - Only narrowband and broadband (Arrival flows)
  - Narrowband flow (be normalized)
    - Occupies one server
  - Broadband flow
    - Occupies b_2 servers



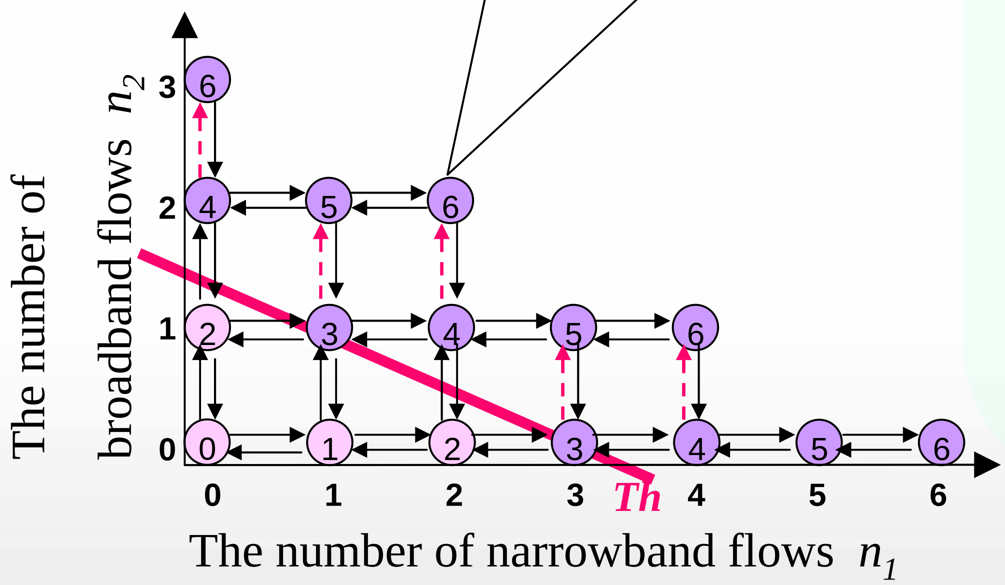
State transition diagram

State transition diagram

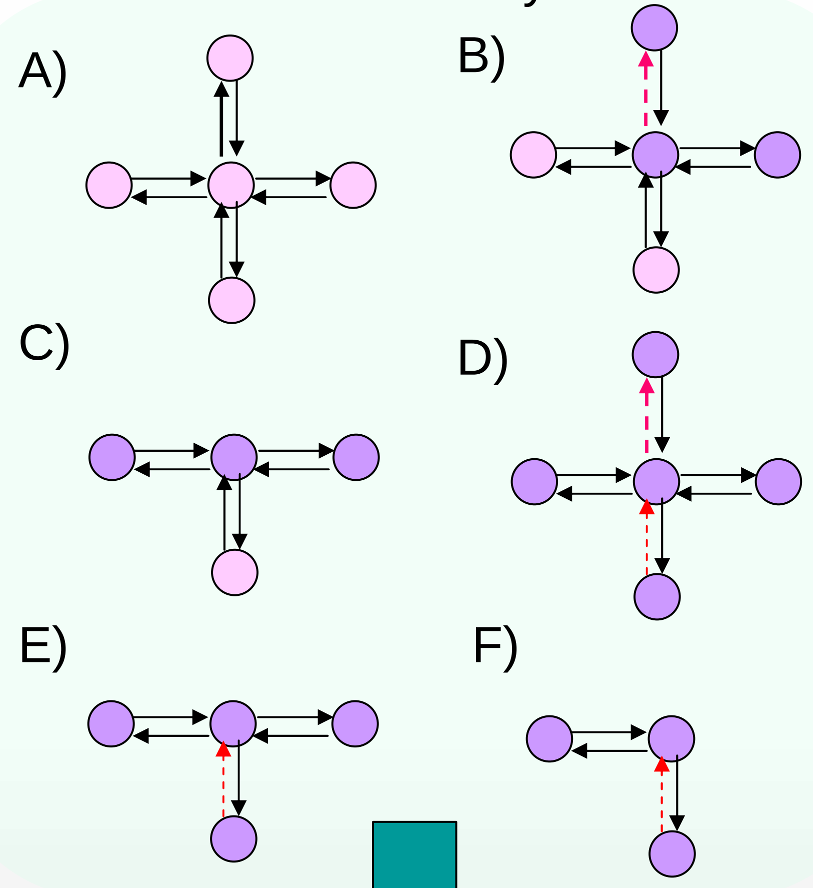
Ex) $B=6, b_1=1, b_2=2, Th=3$

state probability

$P(n_1, n_2)$



Each State is divided by b_{now}



State equations

State equations

A) $(\lambda_1 + \lambda_2 + n_1\mu_1 + n_2\mu_2)P(n_1, n_2)$

$= \lambda_1 P(n_1 - 1, n_2) + \lambda_2 P(n_1, n_2 - 1) + \mu_1(n_1 + 1)P(n_1 + 1, n_2) + \mu_2(n_2 + 1)P(n_1, n_2 + 1)$

B) $(\lambda_1 + n_1\mu_1 + n_2\mu_2)P(n_1, n_2)$

$= \lambda_1 P(n_1 - 1, n_2) + \lambda_2 P(n_1, n_2 - 1) + \mu_1(n_1 + 1)P(n_1 + 1, n_2) + \mu_2(n_2 + 1)P(n_1, n_2 + 1)$

C) $(\lambda_1 + n_1\mu_1 + n_2\mu_2)P(n_1, n_2)$

$= \lambda_1 P(n_1 - 1, n_2) + \mu_1(n_1 + 1)P(n_1 + 1, n_2) + \mu_2(n_2 + 1)P(n_1, n_2 + 1)$

D) $(\lambda_1 + n_1\mu_1 + n_2\mu_2)P(n_1, n_2)$

$= \lambda_1 P(n_1 - 1, n_2) + \lambda_2 P(n_1, n_2 - 1) + \mu_1(n_1 + 1)P(n_1 + 1, n_2)$

E) $(\lambda_1 + n_1\mu_1 + n_2\mu_2)P(n_1, n_2) = \lambda_1 P(n_1 - 1, n_2) + \mu_1(n_1 + 1)P(n_1 + 1, n_2)$

F) $(n_1\mu_1 + n_2\mu_2)P(n_1, n_2) = \lambda_1 P(n_1 - 1, n_2)$

Solve state probability $P(n_1, n_2)$

Result

- ***After setting up $P(n_1, n_2)$***
  - ***Narrowband call-blocking rate*** : $$r_1 = \sum_{n2=0}^{N2'} p(B - b_2 n_2, n_2)$$
  - ***Broadband call-blocking rate*** : $$r_2 = \sum_{n2=0}^{N2'} \sum_{n1=Max[0, Th-b_2 n_2]}^{B-b_2 n_2} p(n_2, n_2)$$
  - ***Total call-blocking rates :*** $$r_{total} = \frac{\rho_1 r_1 + \rho_2 r_2}{\rho_1 + \rho_2}$$

Traffic intensity : $\rho 1 = \lambda 1 / \mu 1$
$\rho 2 = \lambda 2 / \mu 2$

Solve the minimum total call-blocking rate in full search of ***Th***

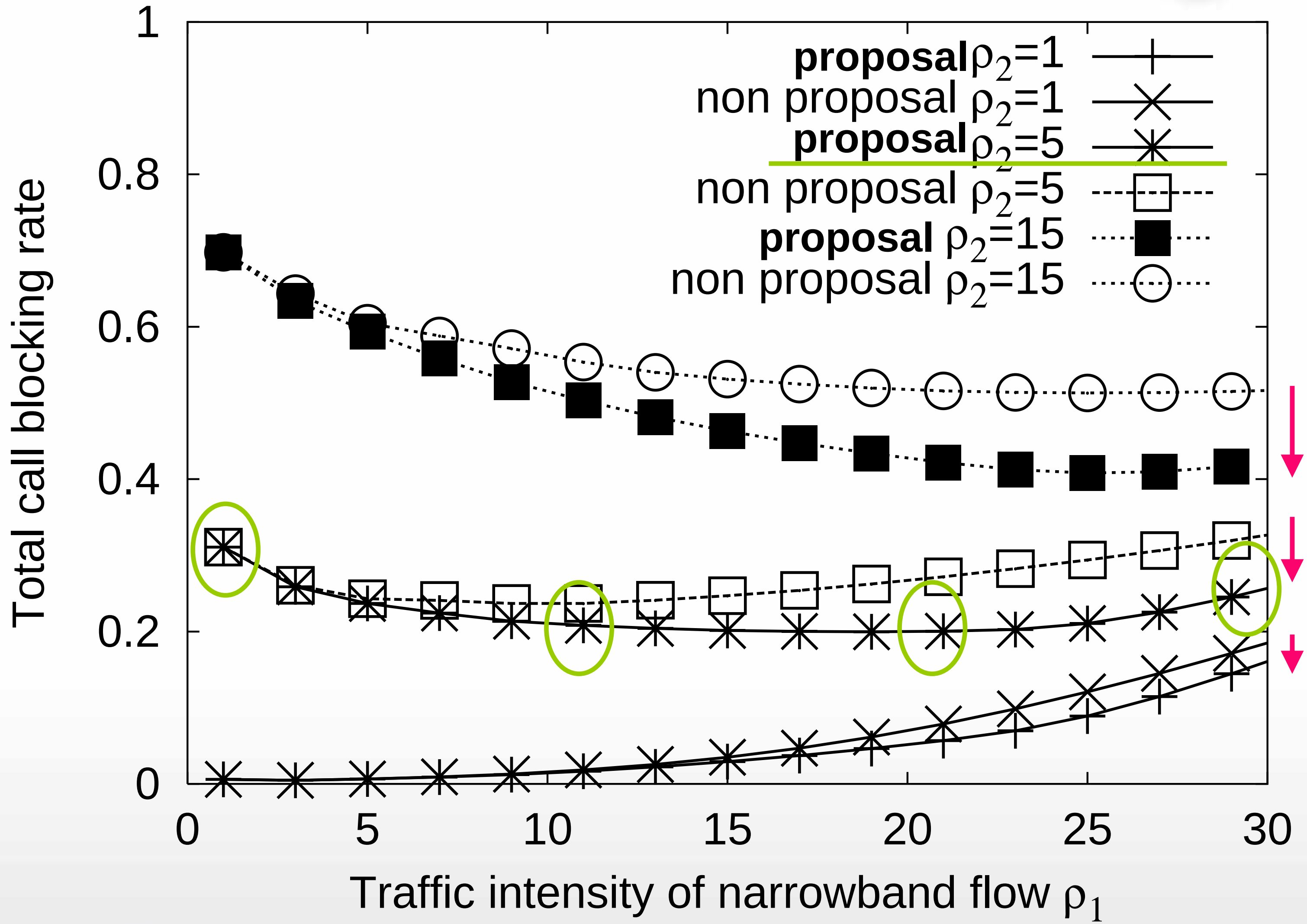
→ **optimal total call-blocking rate !**

Characteristic analysis

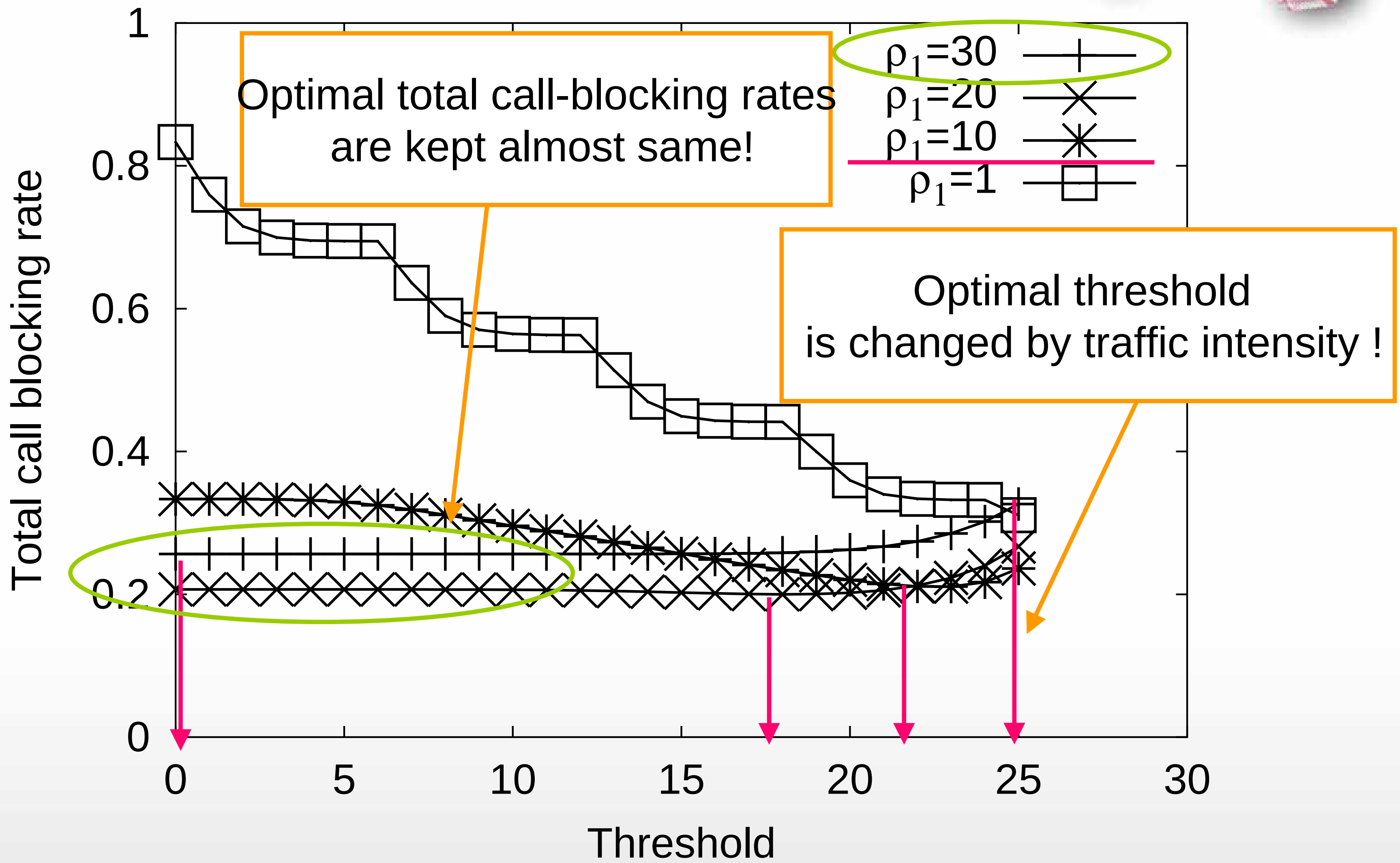
- Parameter
  - Full band B=30[Mbps]
  - Narrowband flows b_1=1[Mbps], Broadband flows b_2=6[Mbps]
  - Processing rate μ=1/45[flow/s]

- Characteristic analysis
  - (1)total call-blocking rates
  - (2)Relative total call-blocking rate and threshold

(1) total call-blocking rates



(2) total call-blocking rate and threshold（ρ_2=5）



Summary and future works

- Summary
  - Proposed CAC to improve total users' satisfaction
    - Minimize the total number of flows rejected (total call-blocking rate) in a network (Constant users' satisfaction).
- Future works
  - More applicative threshold method
    - Obtain a suboptimal solution of total call-blocking rates
  - Consideration relation request bandwidth and users' satisfaction
  - Expand heterogeneous traffic model