Traffic Estimation with Short-Term Fluctuating Component

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Introduction

++Traffic volume

→ Increasing (See upper pic.)

++Traffic shape

→ Bursty and fluctuating (See bottom pic.)

→Focus on *short-term fluctuating component* during measured interval.

Problems:

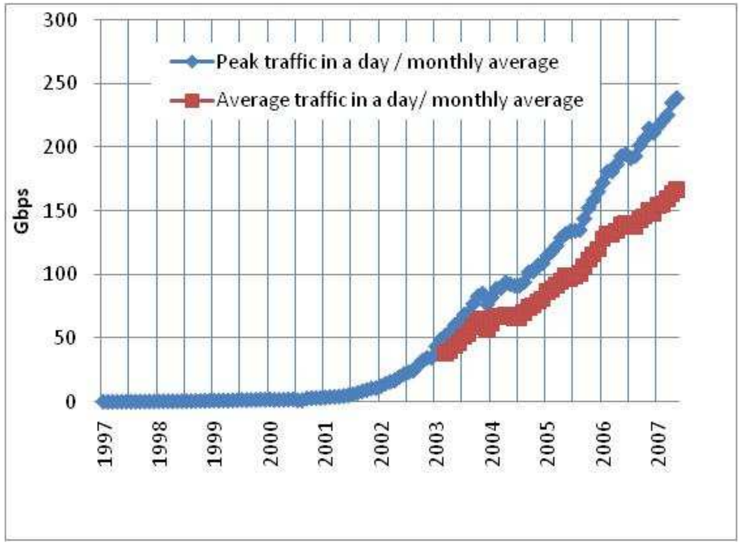
** Difficult to measure traffic in a short interval.

** Creates load on measurement instruments.

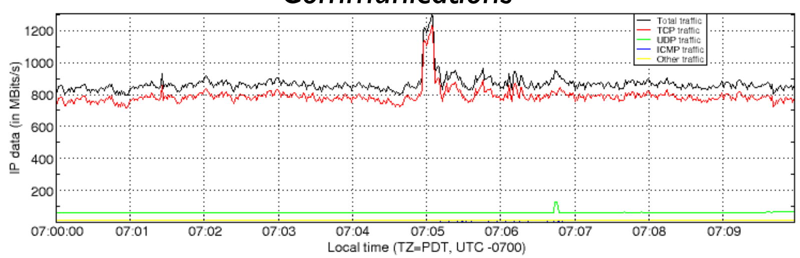
Modeling for estimation considering short-term fluctuating component.

- Network Management
  - Reduction in network management load.
- Network Design
  - Reduce cost of network.

Ref. Aggregation of traffic volume in domestic IX

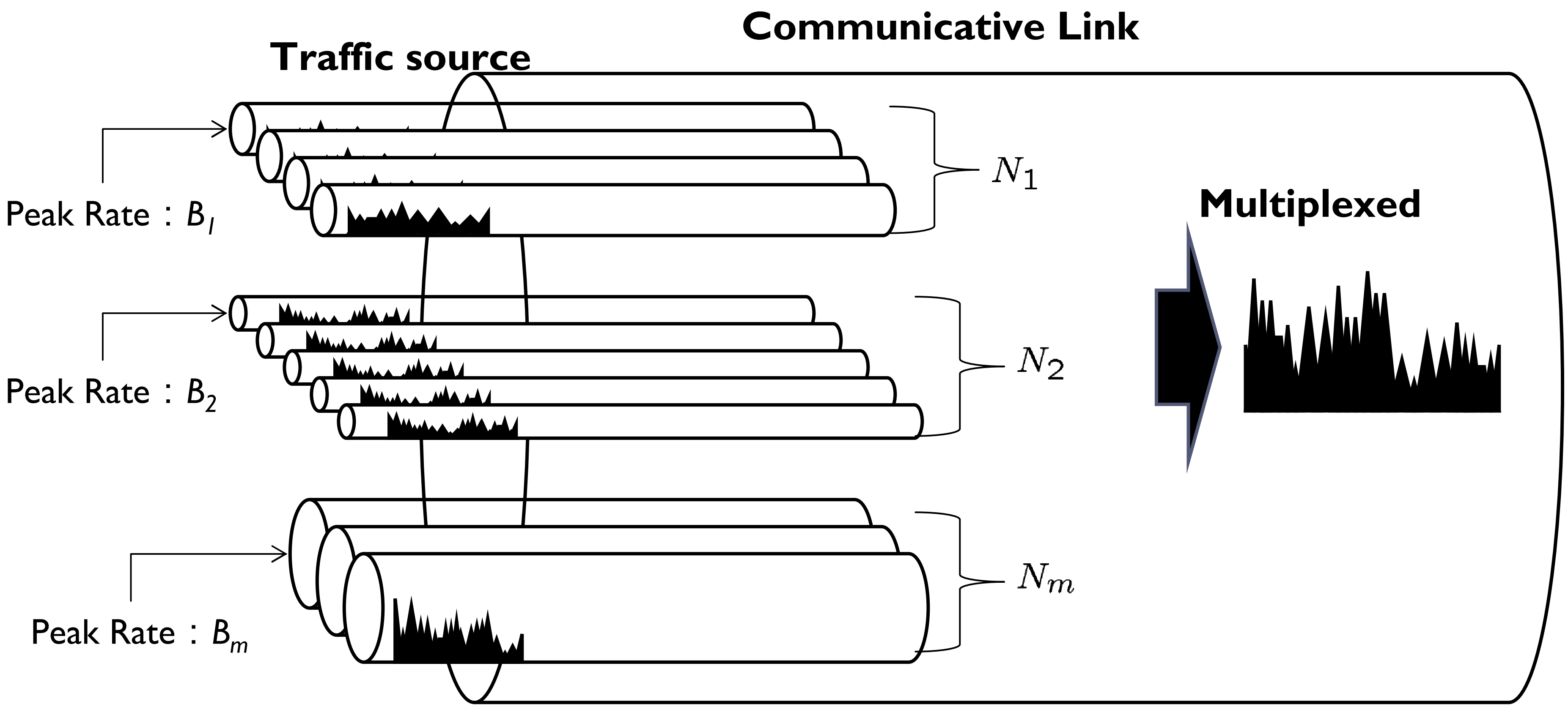


Reference : *Ministry of Internal Affairs and Communications*



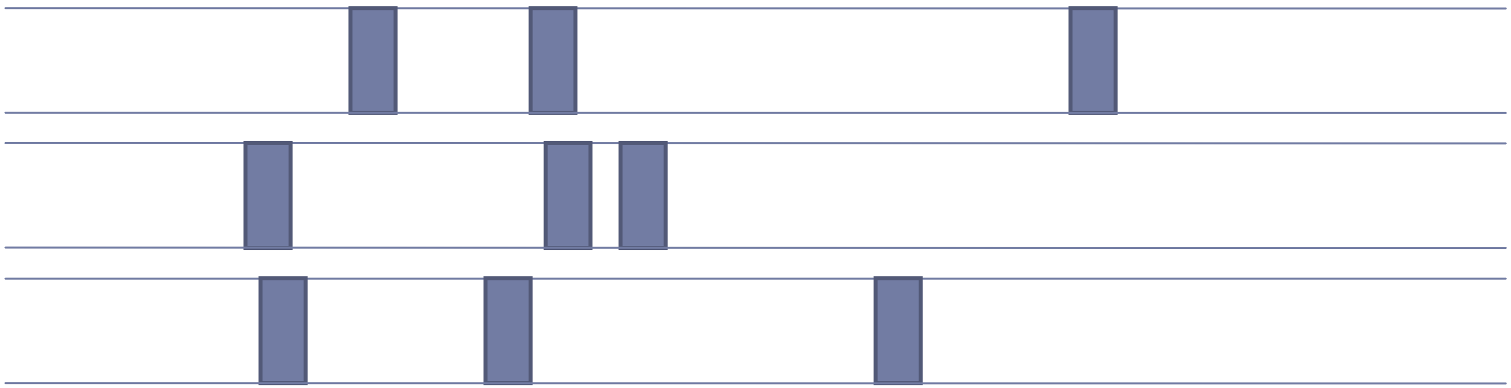
Reference : NLANR

Assumed Condition (Network)



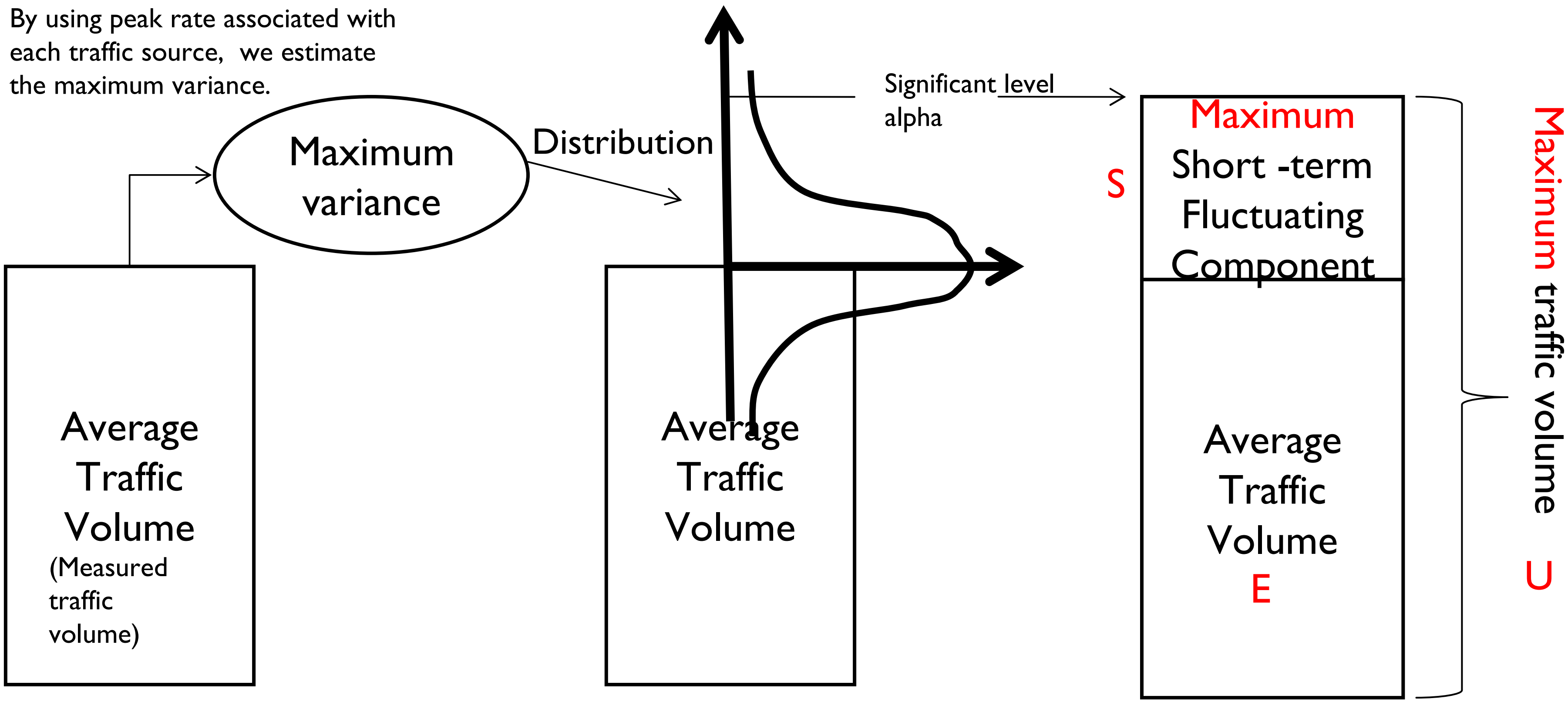
Assumed Conditions (Traffic)

- Short-term fluctuating traffic not measured.
- Average traffic volume and peak rates of each traffic source are given.
- Average traffic volume does not change in short time interval.
- Traffic from many sources is multiplexed in network.
- Each traffic source does not interfere.
- On/Off traffic.



By multiplexing many traffic sources, the distribution of the traffic volume becomes (multi) binomial distribution.

Maximum traffic volume



Modeling

Evaluated Function P_h : Traffic rate

$$V = f(\boldsymbol{P}) = f(P_1, \ldots, P_m) = \sum_{h=1}^{m} B_h^2 N_h P_h (1 - P_h).$$

Maximize

Constraints

$$E = g(P_1, \ldots, P_m) = \sum_{h=1}^{m} B_h N_h P_h, \quad (1)$$

Summation of traffic volume of each traffic source becomes average traffic volume E of multiplexed traffic

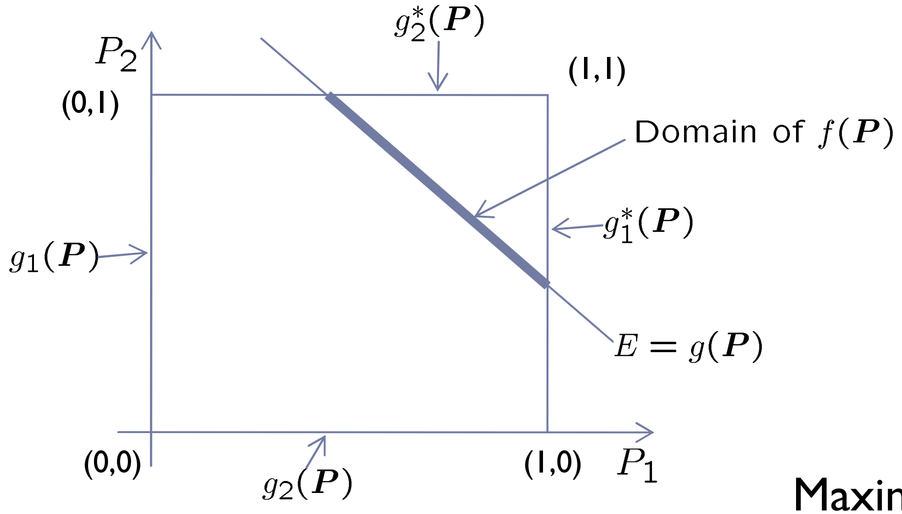
$$g_h(P_1, \ldots, P_m) = -P_h \leq 0, \quad (2)$$

$$g_h^*(P_1, \ldots, P_m) = P_h - 1 \leq 0. \quad (3)$$

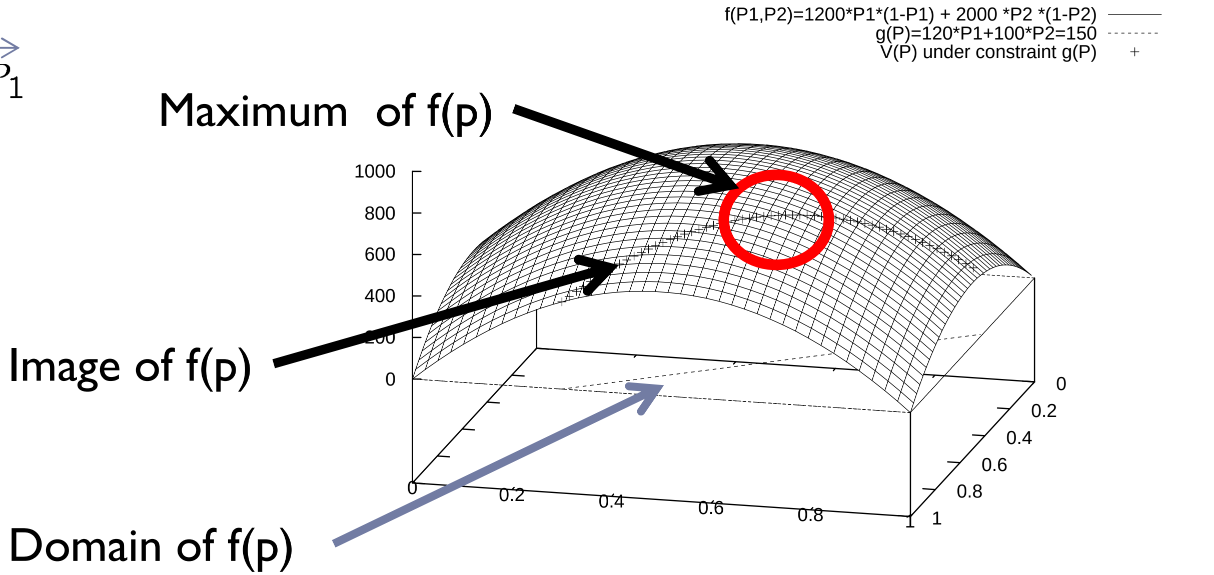
Boundary conditions

Domain and maximum value

Domain of the function $f(\boldsymbol{P})$



Maximum value of the function $f(\boldsymbol{P})$



Solutions

Lagrangean function

$$L(\boldsymbol{P}, \lambda, \boldsymbol{\mu}) = -f(\boldsymbol{P}) + \lambda g(\boldsymbol{P}) + \sum_{h=1}^{m} \mu_h g_h(\boldsymbol{P}) + \sum_{h=1}^{m} \mu_h^* g_h^*(\boldsymbol{P}).$$

Maximum value of function

$$V = \frac{1}{4} \sum_{h \in A_3} B_h^2 N_h - \frac{T^2}{4 \sum_{h \in A_3} N_h},$$

where $$T = 2 \sum_{h \in A_2} B_h N_h + \sum_{h \in A_3} B_h N_h - 2E$$

Traffic rate values that give maximum value

$$\begin{aligned} P_j &= 0 & j \in A_1, \\ P_j &= 1 & j \in A_2, \\ P_j &= \frac{1}{2} - \frac{T}{2B_j \sum_{h \in A_3} N_h} & j \in A_3. \end{aligned}$$

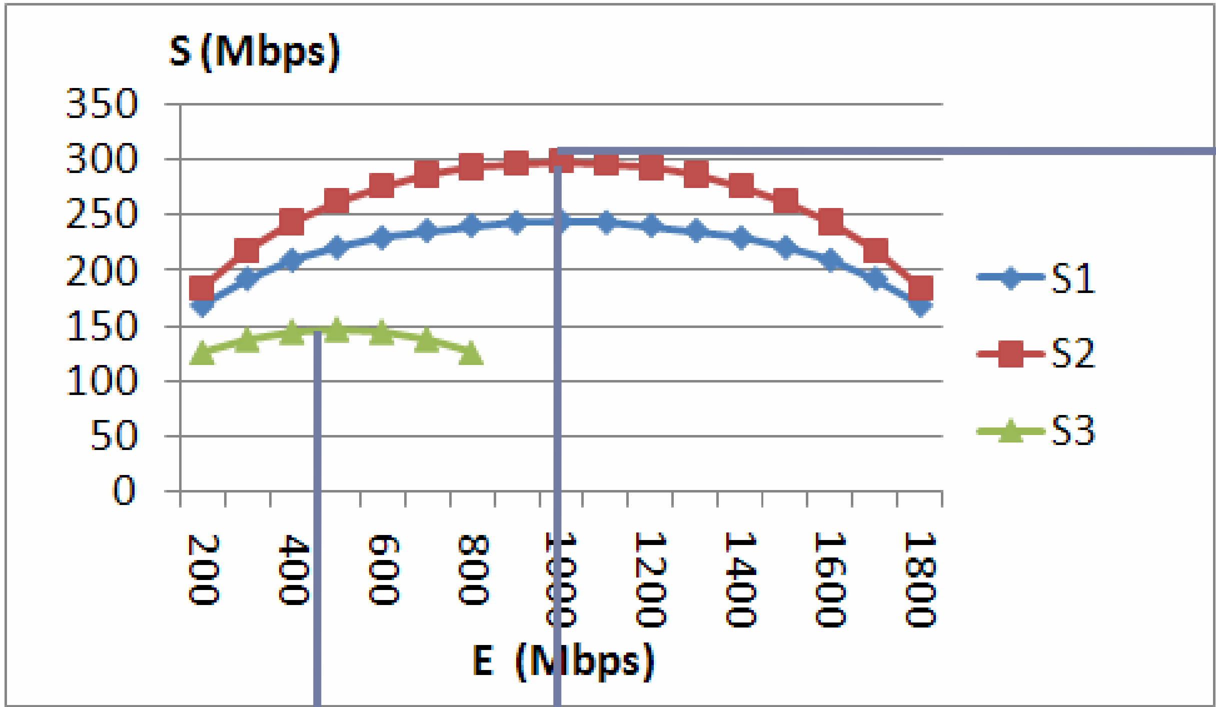
Experiments: Three peak rates

Peak rates B_i	S1	S2	S3
5Mbps	120	20	120
10Mbps	60	10	20
20Mbps	40	90	10
Sum of Peak rates	2000Mbps	2000Mbps	1000Mbps

Same value.

Ratio of high peak rate is big.

Estimation maximum short-term fluctuating component



$$\frac{1}{4}\sum_{h=1}^{m} B_h^2 N_h.$$

Trivial upper bound

(All peak rates are 1/2)

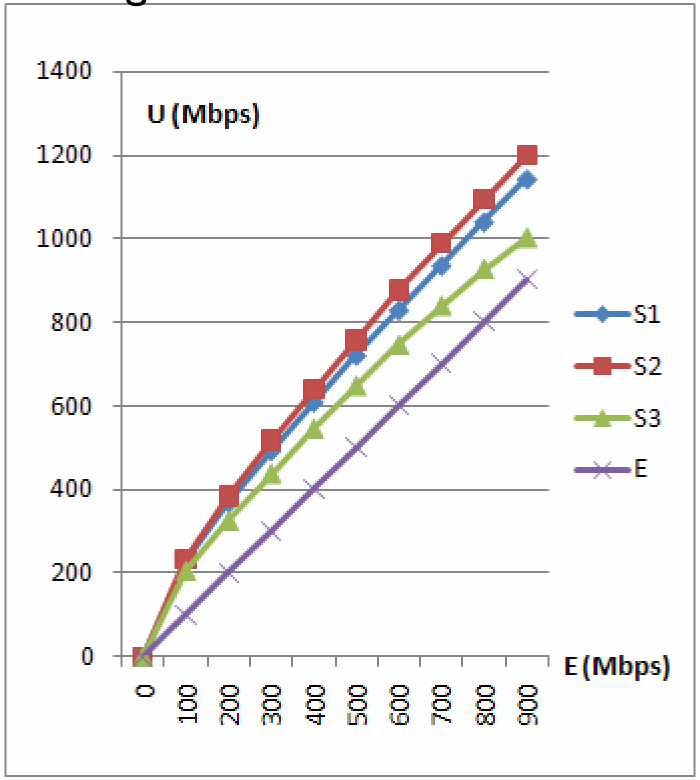
$$E = \frac{1}{2}\sum_{h=1}^{m} B_h N_h.$$

$$E = \frac{1}{2}\sum_{h=1}^{m} B_h N_h.$$

Short-term fluctuating component takes trivial upper bound when average traffic volume is half of sum of peak rates.

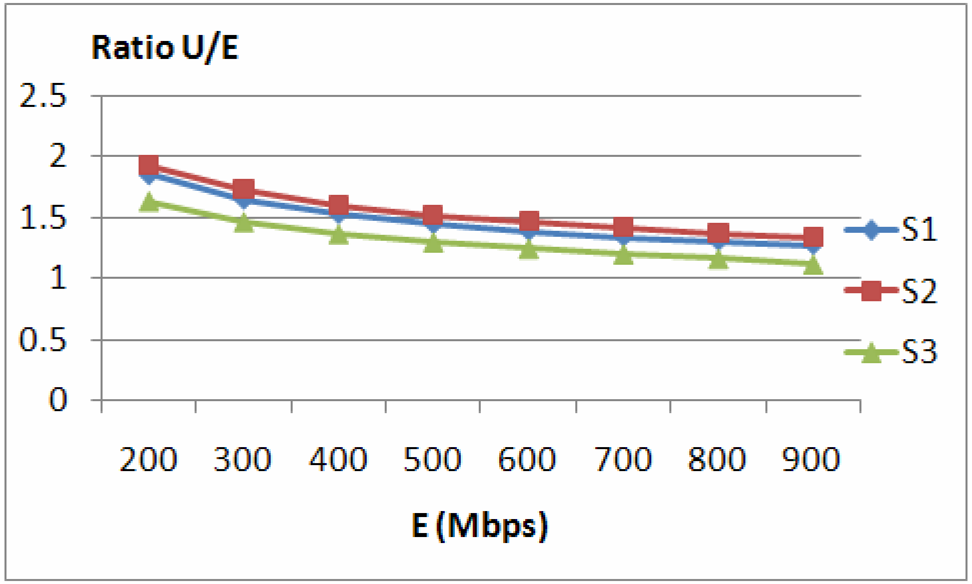
Relevance between maximum traffic volume and short-term fluctuating component

Relevance between maximum traffic volume and average traffic volume



Axis： Average traffic volume

Ratio of maximum traffic volume over average traffic volume.



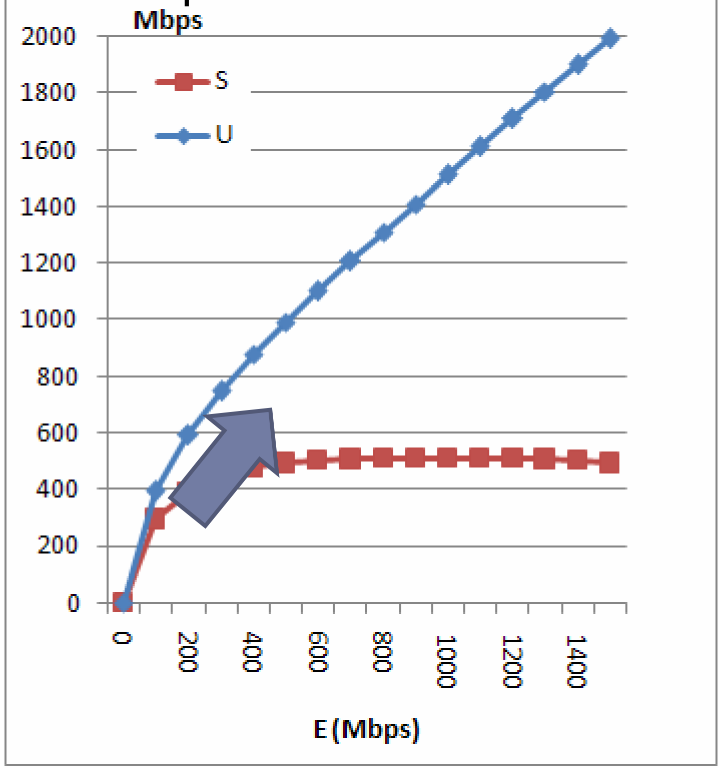
⇒In this experiment, for maximum traffic volume, we need 1.5 to 2 times the traffic volume as that of average traffic E.

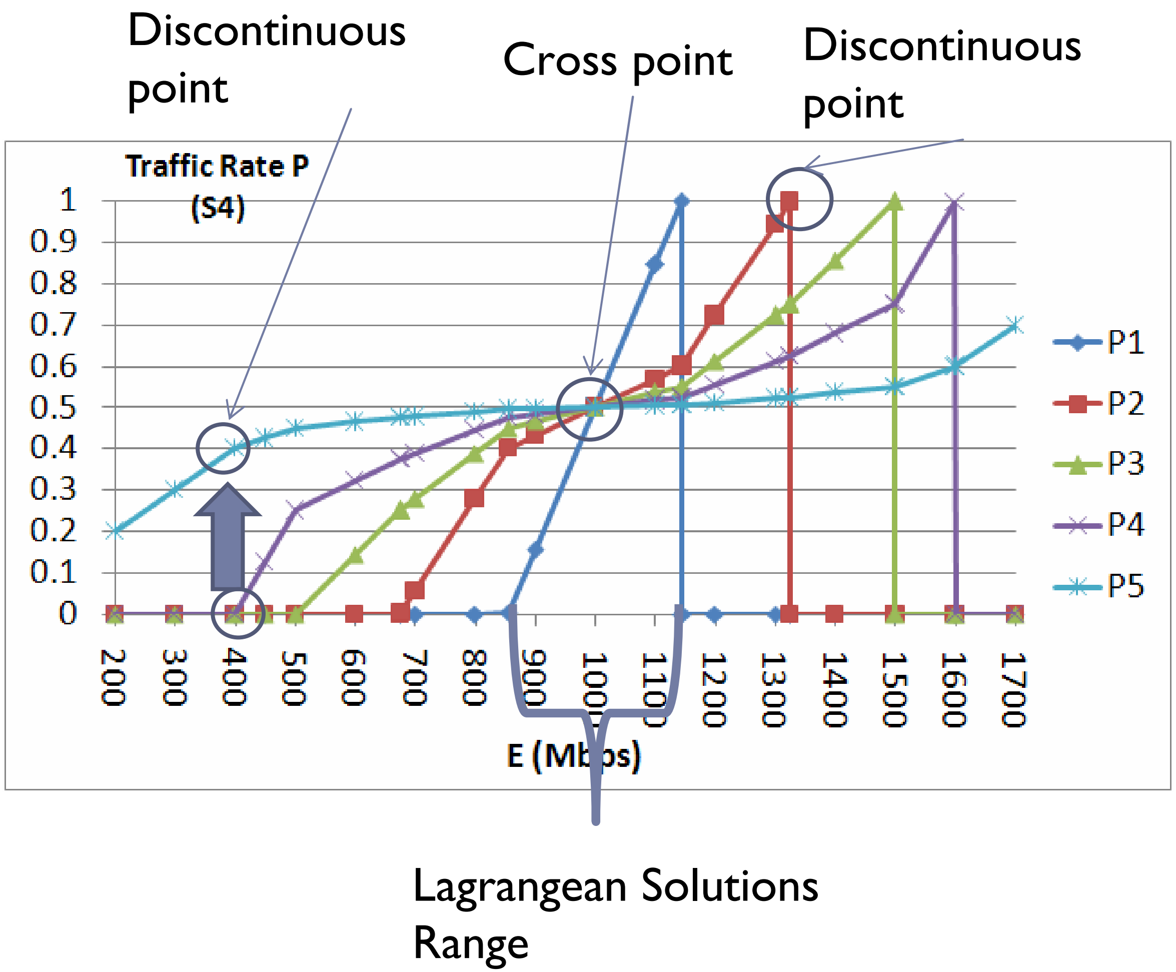
Experiments: Five peak rates

Peak Rates B_i	S4
1Mbps	200
5Mbps	20
10Mbps	50
20Mbps	10
100Mbps	10
Sum of peak rates	2000Mbps

Results 2

Relevance between maximum traffic volume and short-term fluctuating component





Summary

Technical Findings:

- Even if the sum of peak rates are same, the estimation of maximum traffic volume is different.
- If the traffic with high peak rates exists, the maximum traffic volume tends to be big since the variance is high.
- When all peak rates are 1/2, the maximum traffic volume takes the trivial upper bound. The neighborhood of the trivial upper bound takes a maximum upper bound when all traffic source lies between 0 and 1.
- The maximum solution point, namely, the peak rate that gives the maximum traffic volume, is given by the discontinuous function.