"PERFORMANCE RELIABILITY OF FLOW NETWORKS"

Presentation on December 2,2005

in

2005 Asia-Pacific Conference on Risk Management and Safety

at

Kowloon Shangri-La 64 Mody Road Kowloon

Hong Kong

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FLOW NETWORK

Flow : *Commodity to be transmitted from starting point to target point.*

Network: *System used for the transmission of flow*

Some flow networks

Flow Networks	Flow
• Transportation network	• Vehicles
• Communication network	• Data, message, packets

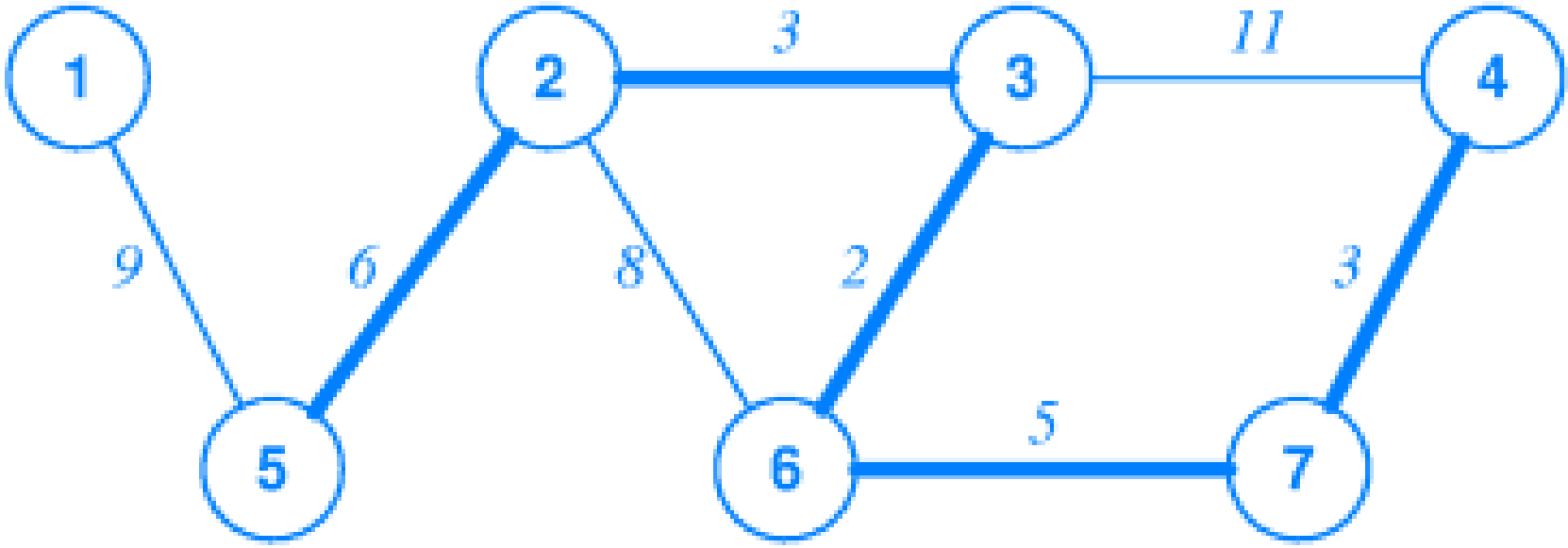
- Others:

  Oil supply network,

  Gas supply network,

  Power supply network

Model of the flow network system, G(N,E)



Components of the network:

Node: Service centre, routers, exchange

Edge: Physical link between nodes

All the nodes and edges work together to provide connectivity and communication/transportation

Network service

Sets of network capabilities that can be configured and managed within the network

Or

Sets of requirements from the network that are expected by the users, applications.

Network services as levels of performance

Levels of performance are described by *performance characteristics*:

capacity

delay

reliability

Systems and Network Services: Systems

"A network system is the set of components that work together to support or provide connectivity, communications, and network services to users of the system"

Motivation

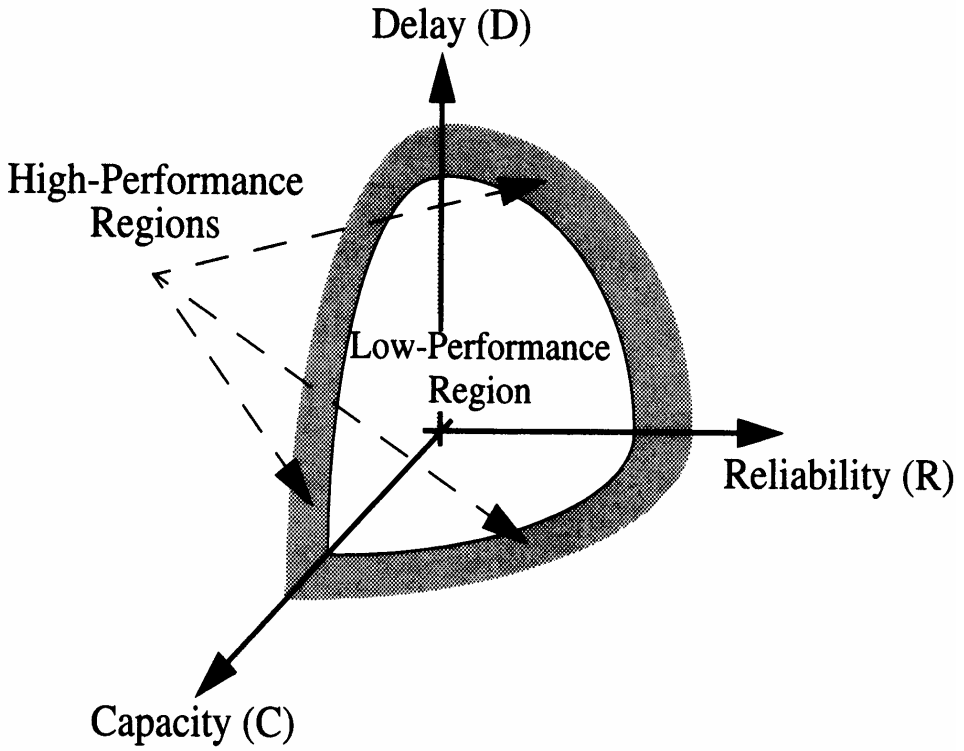
J.D.Mc Cabe in

"Network Analysis, Architecture and De . "

Stressed on the Performance Requirements:

1.Reliability,
2.Capacity and
3. Delay

are related with each other



Capacity

Capacity

- *"It is a measure of the system's ability to transfer information"*
- **This term is often used interchangeably with bandwidth, throughput**

- Bandwidth is sometime described as theoretical capacity what is not strictly correct

- Throughput is the realizable capacity of the system or its components or elements

  - **SONET OC-3c circuit is designed to achieve data rate 155.52 Mb/s = 3x51.84 Mb/s (i.e. 3xOC-1 circuits)**
  - **Practically achievable throughput is ~80-128 Mb/s**

Delay

- Delay
  - *"It is a measure of the time which is taken for the transmission of the single unit of information (bit, byte, cell, frame, packet) across the system"*
  - Often used are propagation, transmission, queuing, and processing delays
  - End-to-end and round-trip delays are useful measurements

  Delay represents microscopic view of network behavior

- *Latency can be defined as an overall delay caused by the application processing and task completion times*
  - ***Latency represents macroscopic view of network behaviour***

Reliability

- **Reliability:**

"Reliability is a measure of the system's ability to provide deterministic and accurate information about delivery of the flow:

that flow has been transmitted *successfully* from sending end to the receiving end."

Need of Overall Index

Integrating the three performance characteristics:

Reliability, Capacity and Delay

Overall index is important from the perspective of:

Designer & User

Traditional Approach:

Network Design engineer

responsible for planning and designing

- -topology
- -capacity assignment
- -minimum delay and minimum congestion

Reliability engineers provide tools to help designers make good design choices and sound design trade offs.

- Reliability engineers do not design products.
- Reliability engineer and design engineer may not have good understanding to design a reliable and well performed product.
- The reliability engineer needs to establish mutual trust with the designer if we wants to be effective at implementing change and improving product reliability.

Traditional Method: Shortcomings in calculating the reliability of flow network:

Successfully transmission of flow from source to destination

if there exist at least one path from source to destination (not realistic assumption)

After S.H. Lee

Capacity was considered with redefining the reliability of flow as the measure of the transmission of required amount of flow.

(insufficient)

Performance Reliability

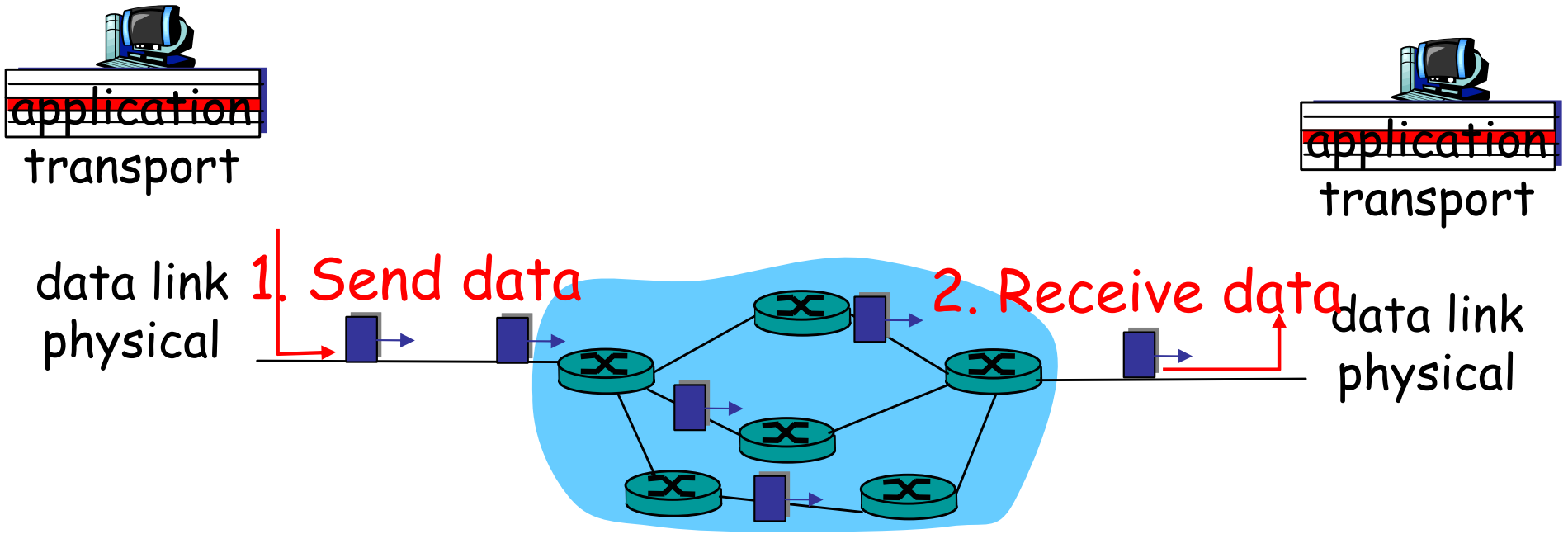
New Measure expresses the ability of network

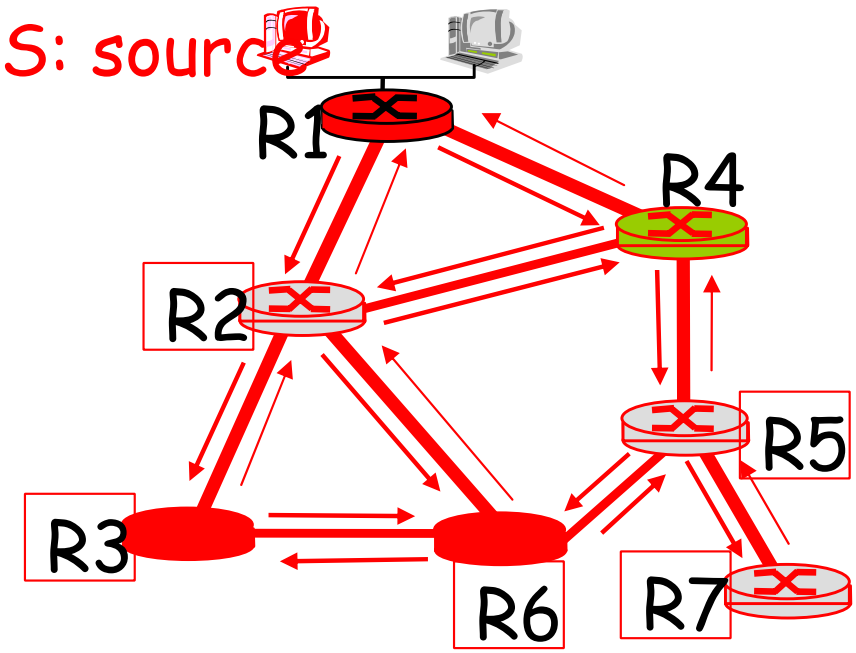
Ability of network: performance +reliability

Performance: Ability to transfer the given flow (data) within time.

Performance Reliability: Ability that network would transfer the given data being failure

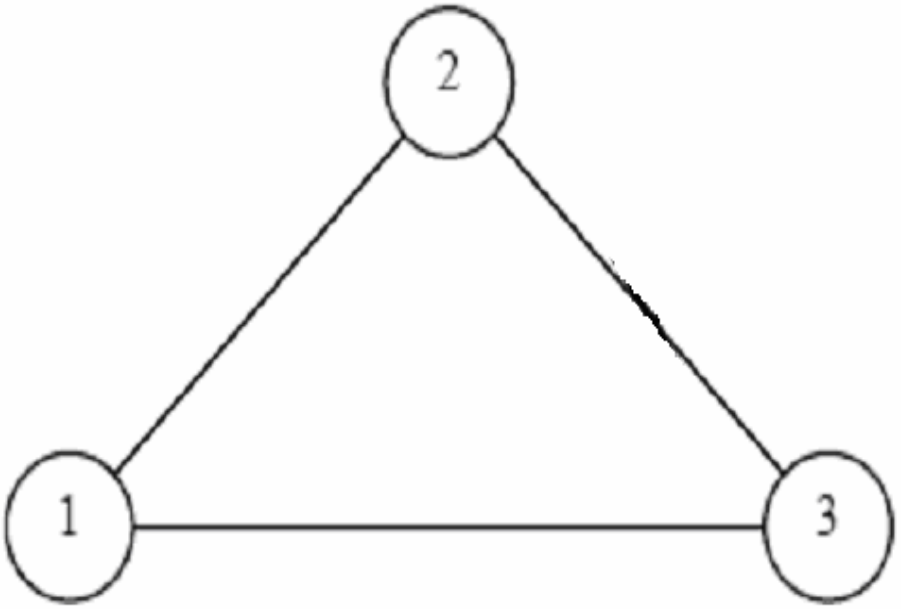
Datagram networks: Internet's model



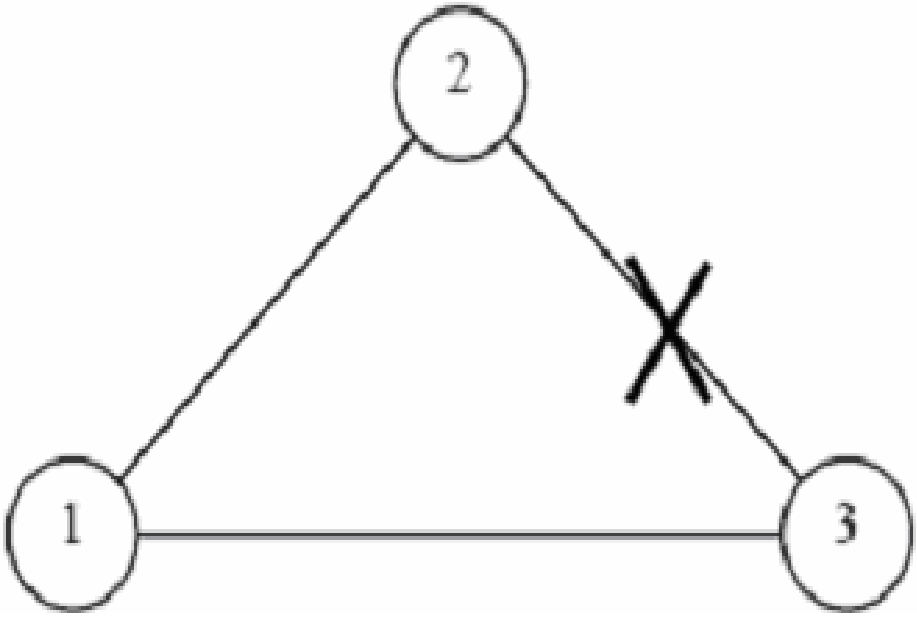

S: source
R1
R4
R2
R5
R3
R6
R7

Transfer of data from source node-1 to destination node-3

All 3 links working



Link(2,3) fails



Network Performance Reliability (NPR)

Network Performance Reliability (NPR) is defined as:

$$NPR(\sigma, \hat{c}_i, p_i) = \left\langle \sum_{i=1}^{i=N} \exp\left(-\frac{\tau_i}{\hat{T}}\right).P_i \right\rangle$$

N, number of connected states

P_i reliability of connected state

$\hat{T}$ maximum allowable time during which data-flow should reach at the destination node

τ_i Actual time required by data in transmitting data

States of the network

If 'N' are the number of links of the network.

There will be total states of the network 2^N

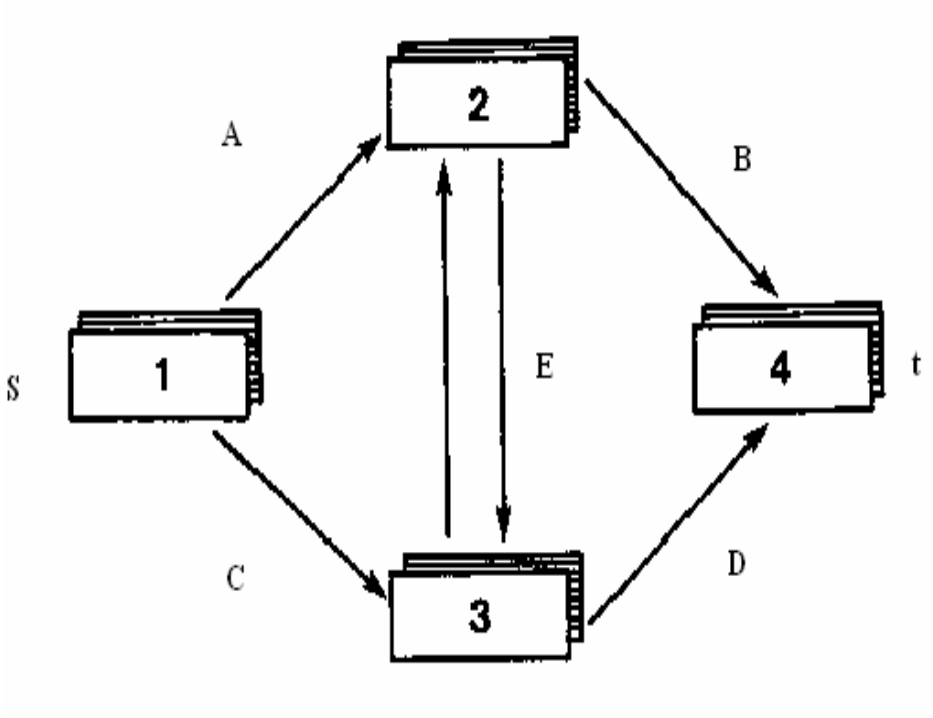
e.g. in picture given

32 states

Total States=

(Connected + Unconnected)

5-links Network



Each connected state is characterized by

- Capacity
- Reliability
- Delay

Calculation of Capacity, delay and reliability of the state

Capacity {max-flow min-cut theorem}

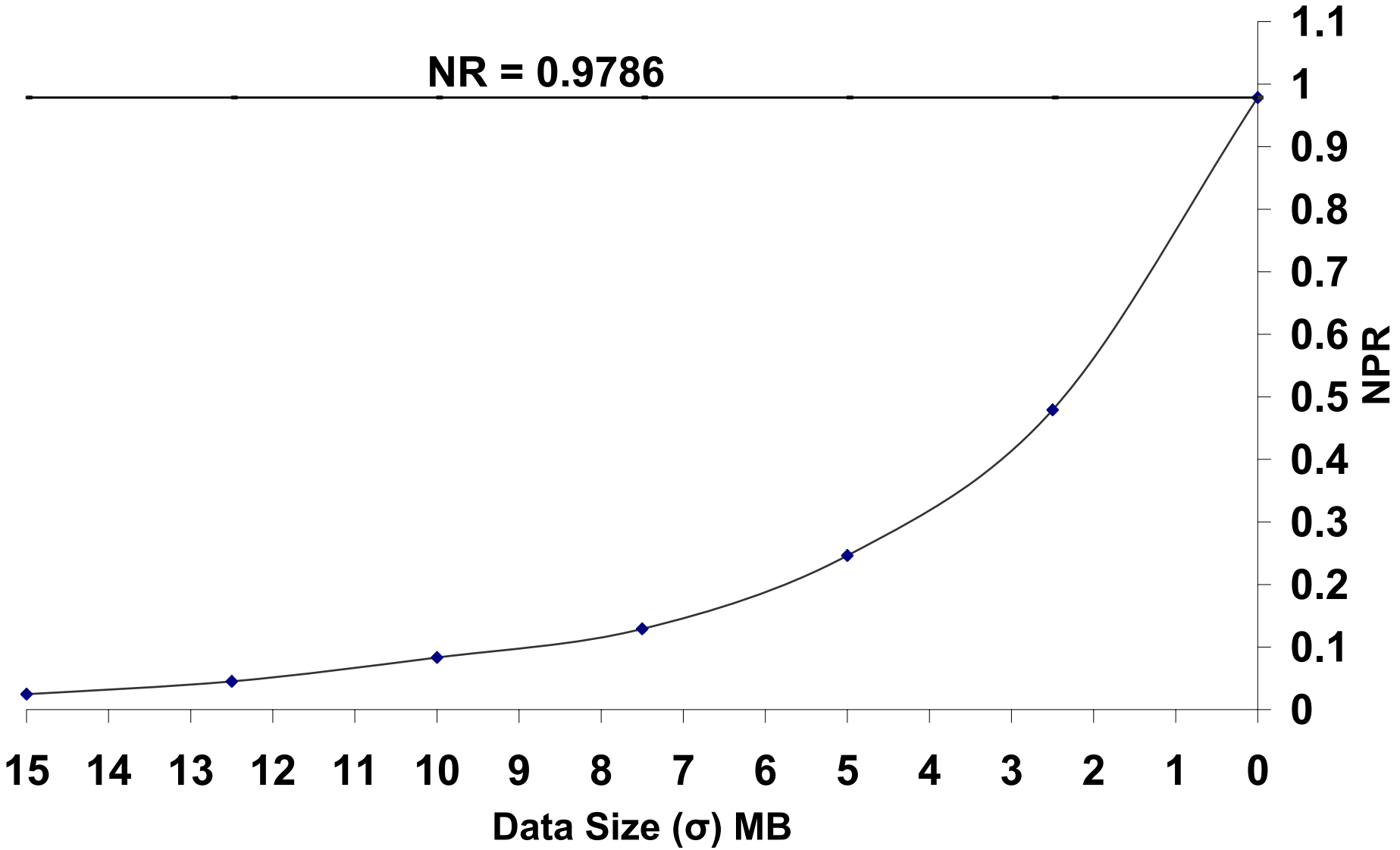
Delay {Amount of flow/ capacity of state}

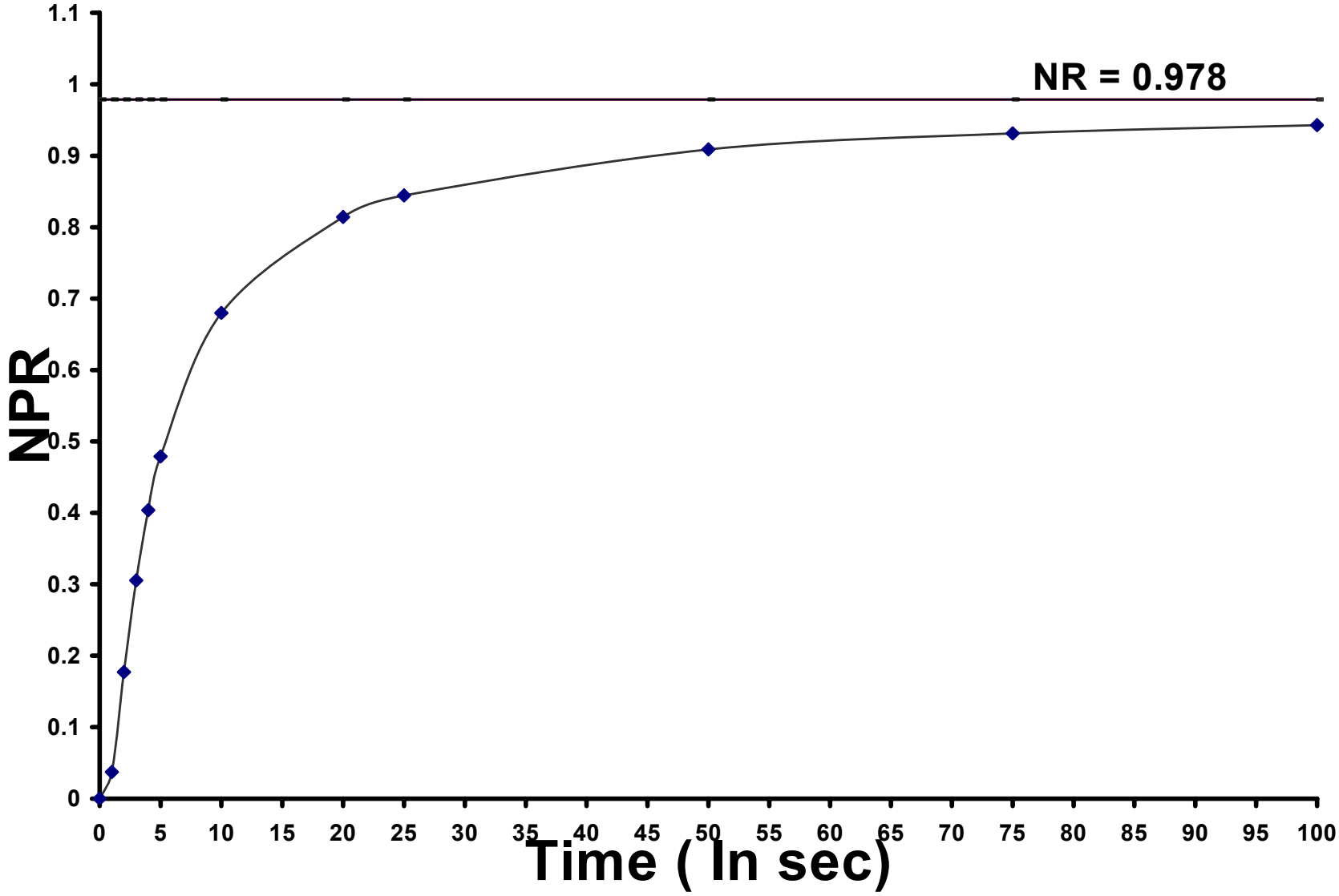
Reliability{ $P_i = \prod_{j=\alpha, k=\beta} p_j . q_k$ }

For Data size= 2.5 MB,NPR=0.479, NR=0.9786

Link *i*	Reliability of Link *i*	Capacity of Link-i (in Mbps)
A	0.9	10
B	0.9	3
C	0.9	4
D	0.9	4
E	0.9	5

NPR Vs Data Size σ




NPR Vs. Time
NR = 0.978
NPR
Time (In sec)
1.1
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100

Challenges in computing NPR

How to find a large no of state,
reliability, capacity and delay of each

when there is a large no. of links in the network

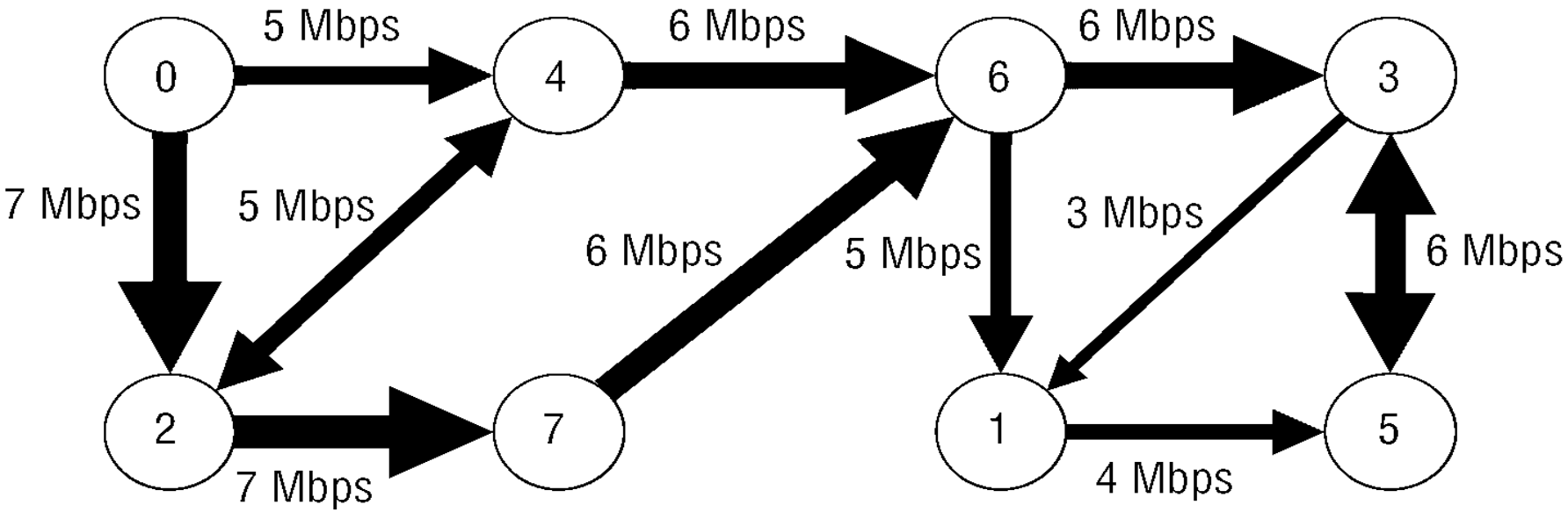
Two solutions:

1. Develop an efficient algorithm that gives only the connected states.

2. Sampling of the states on the basis of their requirements.

Performance Reliability-2:Terminal Performance Reliability (TPR)

TPR: Measure the Ability of network that containing the best path from source to destination



Method of finding TPR

1. **Weight of link(u,v)**

$$w(u,v) = -\ln PR(u,v)$$

$$= -\ln r(u,v).e^{-(\sigma/c(u,v)+d(u,v))}$$

2. **Apply *Dijkstra's algorithm* for finding path with maximum PR(P).**

1. **Choose the PR(P) in step 2 as TPR**

Algorithm for Finding NPR

Step 0 Inputs:

σ , size of data-flow to be transmitted through network,

equivalent capacity of link-i of the network,

p_i, reliability of link-i of the network.

, maximum time allowed during which data should reach at destination

,… are the minimal paths of the network

Step 1 Find set S of success states $S_1, S_2 \ldots\ldots S_N$ corresponding to minimal paths,…using method of[20]

Define S = $(S_1, S_2 \ldots\ldots S_i \ldots\ldots S_N)$

Initialize-

i = 0; NPR=0

Step 2 Let i = i+1

Find;

Capacity of state S_i(using method given in 3.1),

Reliability P_i of state S_i,

, transmission time of data-flow through state S_i of network,

calculate-

,

Step 3 If i = n then Go to 2,

Otherwise,

NPR=NPR

Conclusion

- Integration of reliability while design
- Single index
- Performance with reliability
- Performance Reliability: NPR,TPR as grade-of-the-service
- Network topology architecture on the basis both performance and reliability.
- Protocol development

THANK YOU!