

CT 1502

Planning and Design of Communication Networks Store- and-Forward Networks

Chapter 4

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Outlines

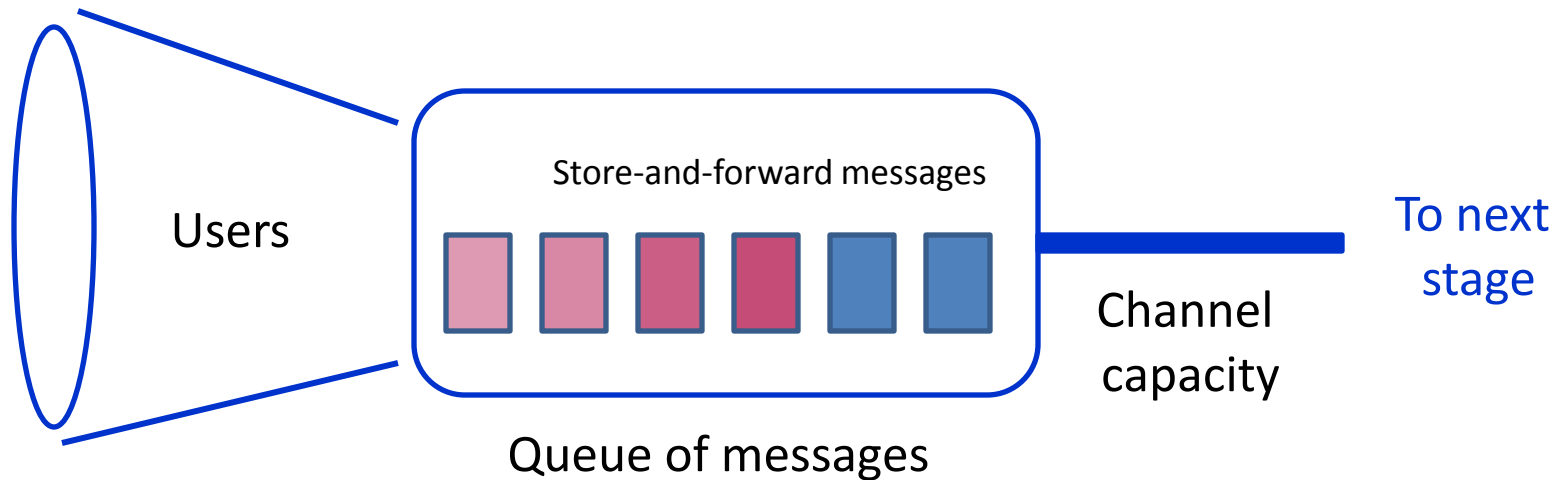
- **Store-and-Forward Principles and Benefits**
- **Store-and-Forward Networks Architecture**
- **High-Speed Networks**
- **Performance of Store-and-Forward Networks**
- **Applications**

Store-and-Forward Principles and Benefits

Store-and-Forward Principles and Benefits

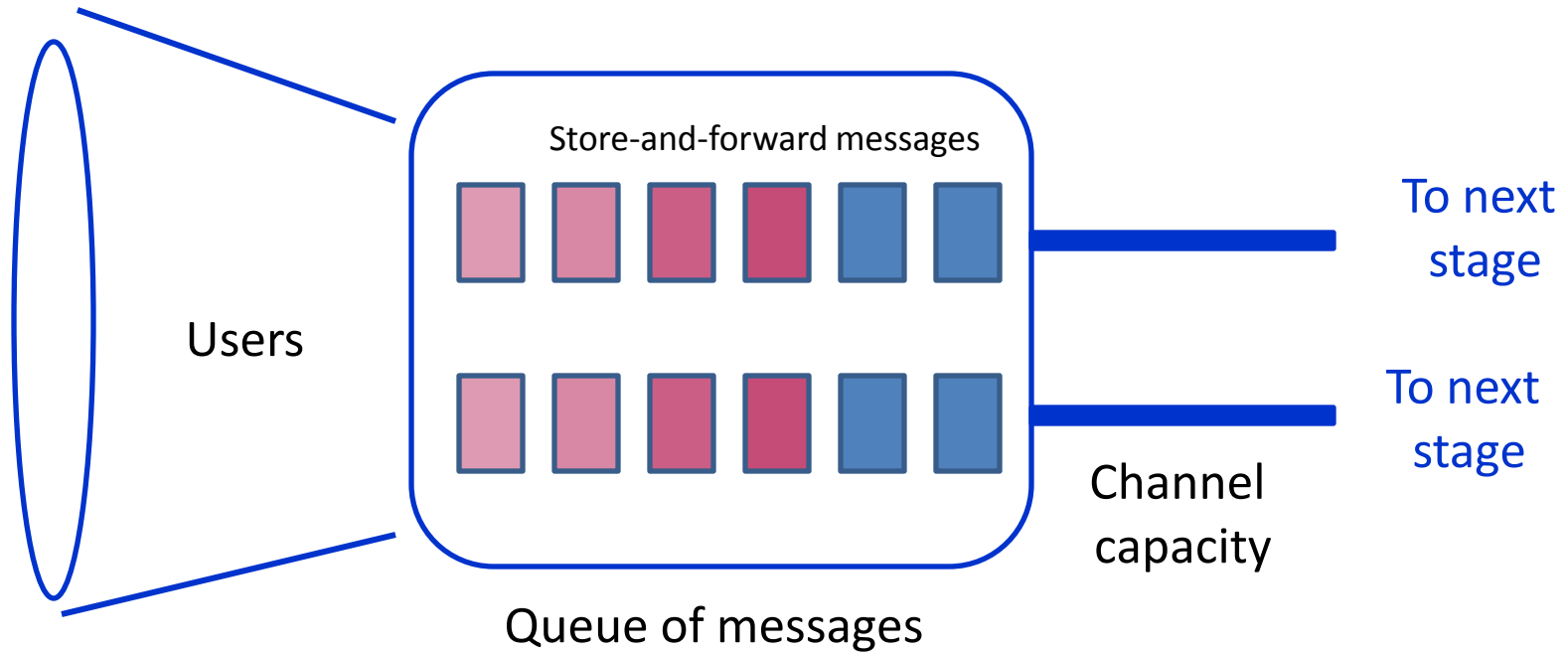
- Relays on “Dynamic Sharing”, but not the same in circuit switching
- Allow user to use the channel as long as he has message to send
- When user done, he should be eliminated (يستبعد)

Store-and-Forward switching



Store-and-Forward switching

Store-and-Forward switching

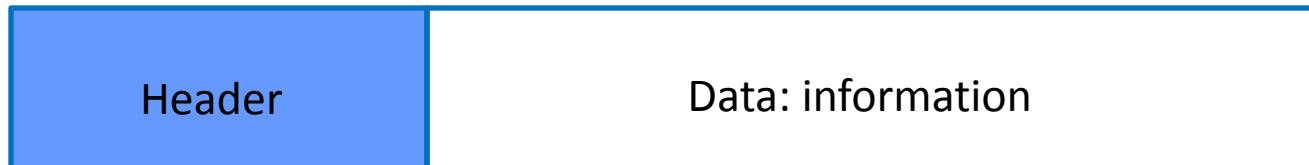


Store-and-Forward switching

Store-and-Forward Implementation

1. Message Arrival:

- Data: information
- Header: transmitter address, receiver address, network control



Message components

Store-and-Forward Implementation

2. **Processing(المعالجة)**: direct the message which path to take, witch channel to sent the message through, since the switch may has more then one channel.
3. **Storage(التخزين)**: after processing, the switch stores the message in “waiting queue”(طابور انتظار) linked to the shared channel.
4. **Waiting(الانتظار)**: the message waits until sending previous messages in queue

Store-and-Forward Implementation

5. **Transmission(الارسال):** when message be the first message in the queue, the message will be sent through shared channel.
6. **Propagation(الانتشار):** when the switch broadcast the message, the message “propagate”(تنتشر/ترسل) on wires or wireless channels from the node to another

Store-and-Forward Implementation Techniques

- Three factors define which technique to use:
 - Message: how long the message? Is the length dynamic or fixed? Does it contain the whole information or part of?
 - Network: security, network protocols
 - Channel: how fast the channel transmit the message

Store-and-Forward Implementation Techniques

1. Message Switching:

- Transmit the message as one whole unit
- Low speed channel

2. Packet Switching:

- Message divided (تقسم) into fixed length “packets” (رزم)
- Sent each packet using store-and-forward technique

Store-and-Forward Implementation Techniques

3. Frame Relay(ترحيل الأطر):

- Message divided into fixed length “frames”(أُطر)
- Using different protocols that using in packet switching

4. Cell Relay(ترحيل الخلايا):

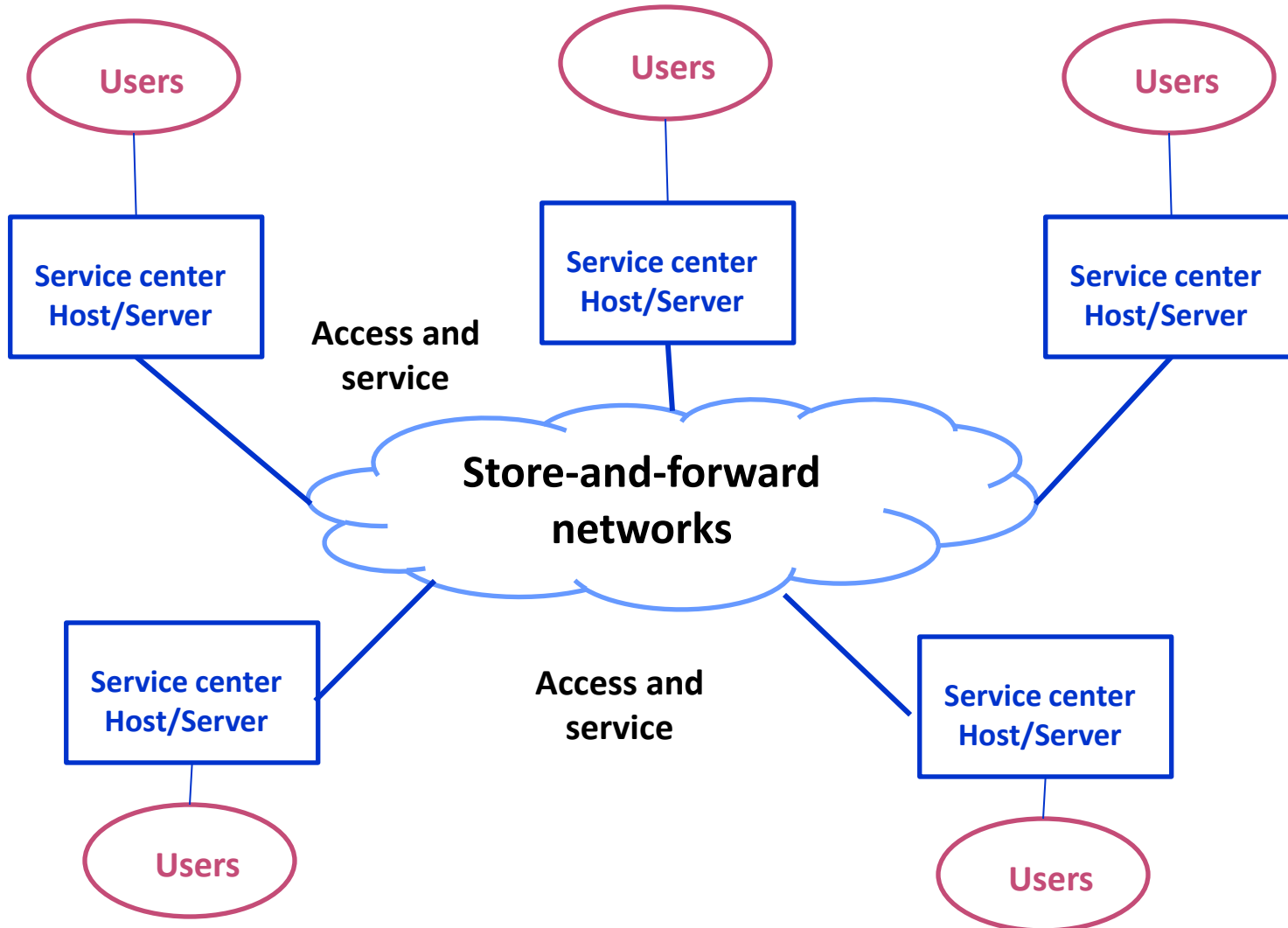
- Used to transmit multimedia data
- High speed channels such as fiber optic wires
- Fixed length
- Different protocols

Store-and-Forward Networks Architecture

General structure

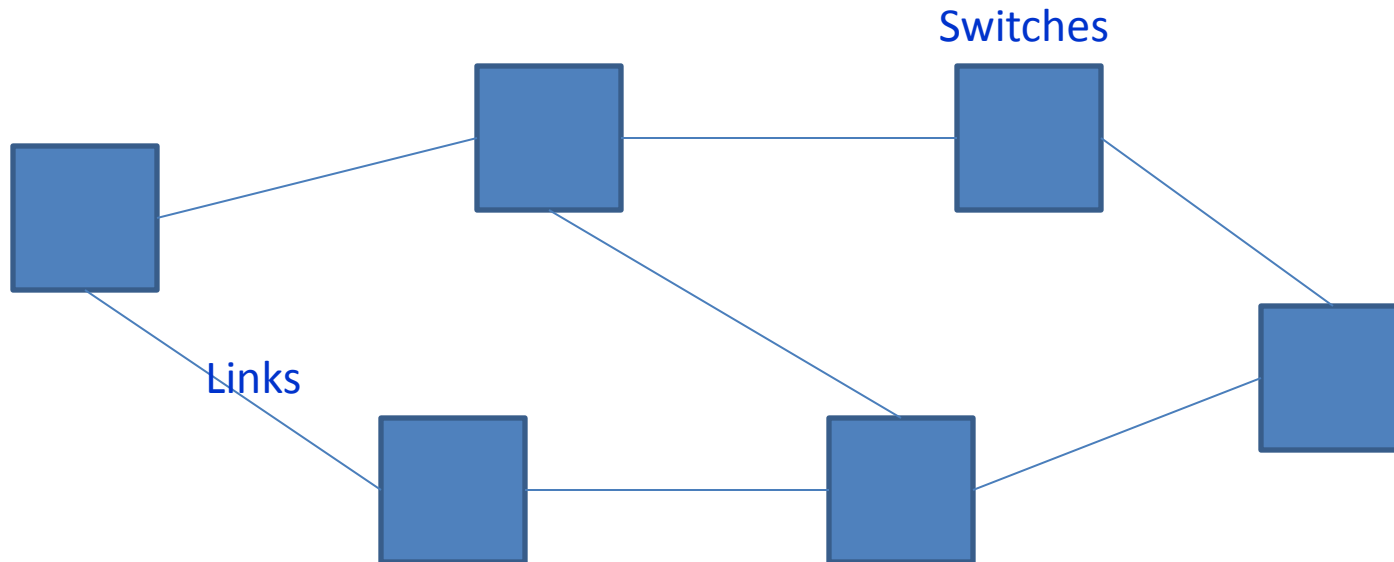
- **Store-and-forward networks** provide connectivity between “network service centers” that connect users and provide information from network
- **Networks divided into two sections:**
 - Communication Network
 - Access and Services Sub-Network

General structure



General structure

- **Communication Network(backbone network)** (شبكة العمود الفقري):
 - Store-and Forward Nodes
 - Wired or wireless links



General structure

- **Access and Services Sub-Network**
 - Groves of users connected to Servers/Hosts that linked to store-and-forward nodes in the network

Network Protocols

- **Protocol:** define how two parties communicate
- Since communication is performed between “machines”, protocols have to be “complicated” (معقدة) for smart and effective network
- Complicated protocols were divided into “layers” (طبقات) to fit in the network structure

Network Protocols

- **OSI: Open System Interconnection** created by ISO(International Standards Organization) is the base of many networks protocols



Users					
Source	Access & Service Sub-Network				Destination
Application	A-- protocol --A				Application
Presentation	P-- protocol --P				Presentation
Session	S-- protocol --S				Session
Transportation	T--protocol --T				Transportation
Network	Comm. Sub-Network (backbone)				Network
	N--protocol --N	Network	N--protocol --N		
Data Link	D--protocol --D	Data Link	D--protocol --D		Data Link
Physical	Y--protocol --Y	Physical	Y--protocol --Y		Physical
Communication Medium (Channels)					
Network protocol according to ISO-OSI					

Network Protocols

- ◎ **Physical layer:** responsible of connecting to communication medium
- ◎ **Data-Link Layer:** provides accurate (صحيح / خالي من الأخطاء) connection between two points
- ◎ **Network Layer:** provides connection through network store-and-forward switching between sources and destination
- ◎ **Transport Layer:** provide connection between transmitter service center and receiver service center “Host-to-Host”

Network Protocols

- **Session Layer:** meet the user requirements using the previous layers, provide connection, manage connection and ending connection
- **Presentation Layer:** “represent” the information including: coding, compression(ضغطها), encryption(تشفيرها) and translation(الترجمة بين الرموز)
- **Application Layer:** enable user to access the network, select service, direct messages and deal with the incoming and outgoing messages

High-Speed Networks

High-Speed Networks

- **How is High-Speed network different?**
 - **Network Channels**
 - **Transmission Speed**
 - **High-Speed Networks Protocols**

Network channels

القنوات "التماثلية" Analog "المعيارية الدولية"			
عرض النطاق الترددي		القناة	
4 kHz		القناة الصوتية Voice Grade	
12 x 4 = 48 kHz		المجموعة Group	
5 x 48 = 240 kHz		المجموعة العليا Super Group	
5 x 240 = 1.2 MHz		المجموعة الرئيسية Master Group	
القنوات "الرقمية" Digital "المعيارية الدولية والأمريكية"			
الأمريكية		الدولية	
64 kbps	الأساس: PCM	64 kbps	الأساس: PCM
1.5 Mbps	T-1	2 Mbps	E-1
6.3 Mbps	T-2	8.45 Mbps	E-2
45 Mbps	T-3	34 Mbps	E-3
قنوات الألياف البصرية المعيارية الدولية والأمريكية (السريعة)			
الأمريكية SONET		الدولية SDH	
52 Mbps	OC-1	155 Mbps	STM-1
155 Mbps	OC-3		
622 Mbps	OC-12	622 Mbps	STM-4

Example of: Standard Network Channels

SDH: Synchronous Digital Hierarchy

Transmission Speed

زمن إرسال رسالة طولها "١٠٢٤ بتة 1024 bits"		
زمن الإرسال = طول الرسالة \ سعة القناة	القناة	
	السعة	اسم القناة
64 (ms)	64 kbps	PCM
2.7 (ms)	1.5 Mbps	T-1
91 (μs)	45 Mbps	T-3
26 (μs)	155 Mbps	OC-3 : STM-1

Duration of sending one message through deferent channels

High-Speed Networks Protocols

- High-speed networks aim to transmit multimedia signals rapidly and efficiency using store-and-forward switching and **cell relay technique**
- Example:
 - Asynchronous Transfer Mode(ATM)

Asynchronous transfer mode

- Fixed length packet (53bytes)
- Data link layer
- Using fiber optic (less noise)
- No security procedure(except for user authentication), so less complications

ATM: Asynchronous Transfer Mode	ISO-OSI
higher level protocols	Application
	Presentation
	Session
	Transportation
Adaptation (المواءمة)	Network
ATM	Data Link
Physical Layer	

Performance of Store-and-Forward Networks

Performance of Store-and-Forward Networks

1. Use Demands:

- Request rate (how many message in one time unit) **R [messages / time unit]**
- Message size: **M [bits / message]**
- Traffic: **F [(bit per second: bps) = $R \cdot M$]**

Performance of Store-and-Forward Networks

2. Network Capacity(C):

- Bit per second(bps)

3. Performance Measures:

- No rejected traffic
- Instead: Time delay
- Time delay can increase to **infinity**

Performance Measure

1. Processing Time:

- Very small**
- Cant be controlled by traffic or network capacity**
- Dose not depend on request rate**

Performance Measure

A. Waiting (Queuing) Time:

- Effected by traffic and network capacity
- Queuing Theory :
- for random size M:

$$q = \frac{(R.M) / C}{(C/M) - R}$$

- For fixed size M (cell relay):

$$q(\text{fixed}) = (1/2).q$$

Performance Measure

B. Transmission Time: service duration

$$s = M/c$$

C. Propagation:

$$g = L/v$$

- L: distance between sender and receiver
- V: propagation speed

Performance Measure

D. Time delay :

$$d = q + s = \frac{1}{\frac{C}{M} - R}$$

E. Level of use:

$$u = \frac{R.M}{C} = \frac{F}{C}$$

Performance Measure

F. Relationship between **Delay** and **Level of use**:

$$\mathbf{D} = \frac{\mathbf{1}}{\mathbf{1} - \mathbf{u}}$$

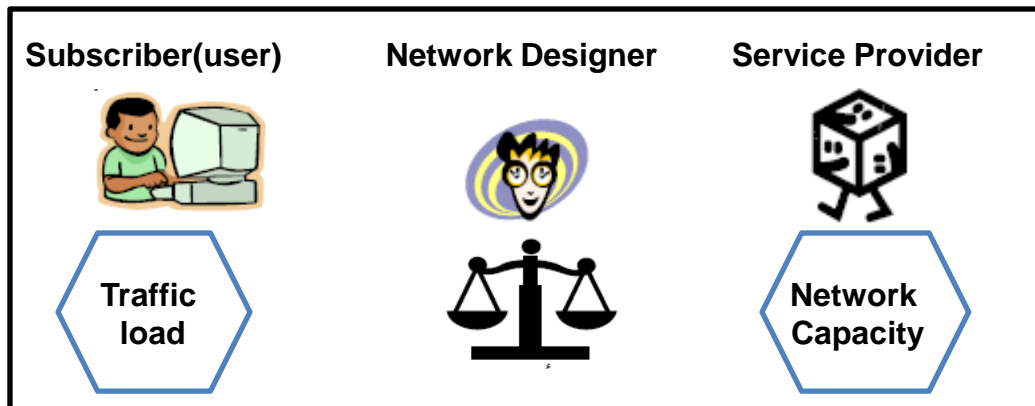
Only if: $U < 1$

$F < C$

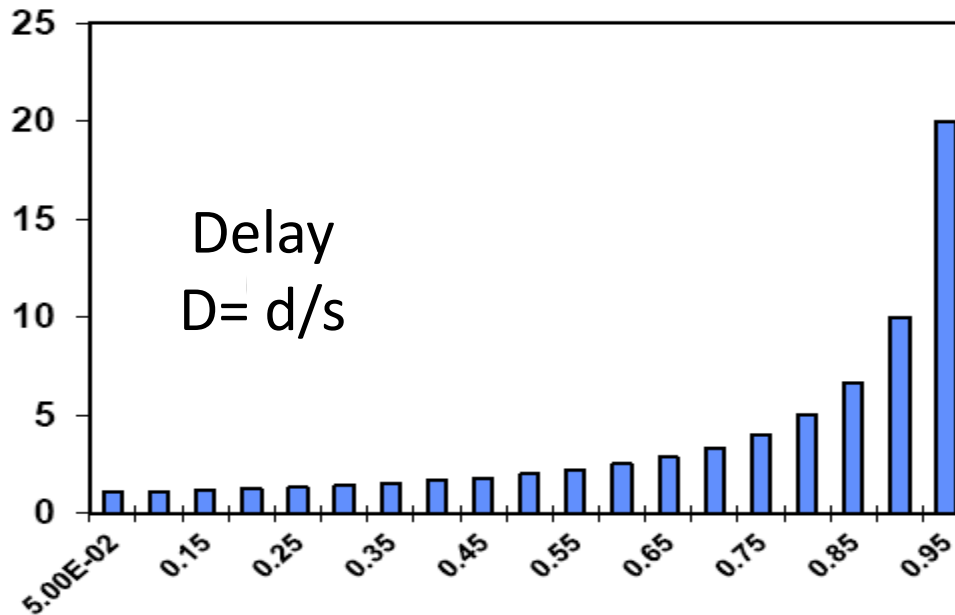
Performance Evaluation

$$D = \frac{1}{1 - u}$$

- Declare the balance between the **service provider(maximize level of use)** and the **user(minimize the delay)**



Applications



Level of
use
(U)

Recommendations:

- Level of use must be under 0.5 ($F=1/2 C$)
- Level of use must not be over 0.75 ($F=3/4 C$)

Answer:

$$D1 = 1/(1-0.5) = 2 \text{ s}$$

$$D2 = 1/(1-0.75) = 4 \text{ s}$$

