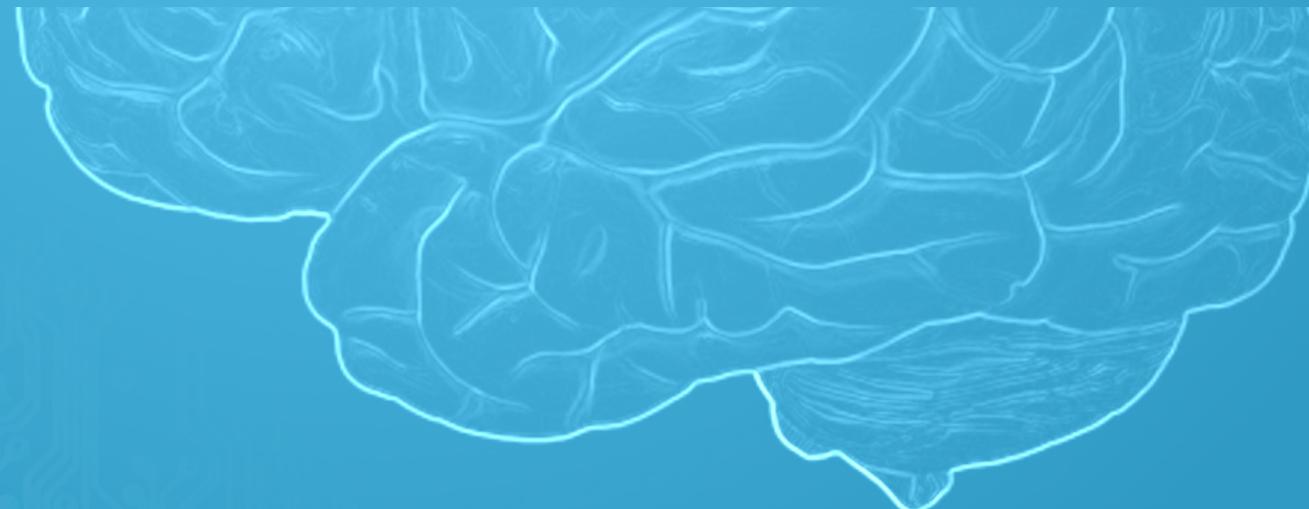
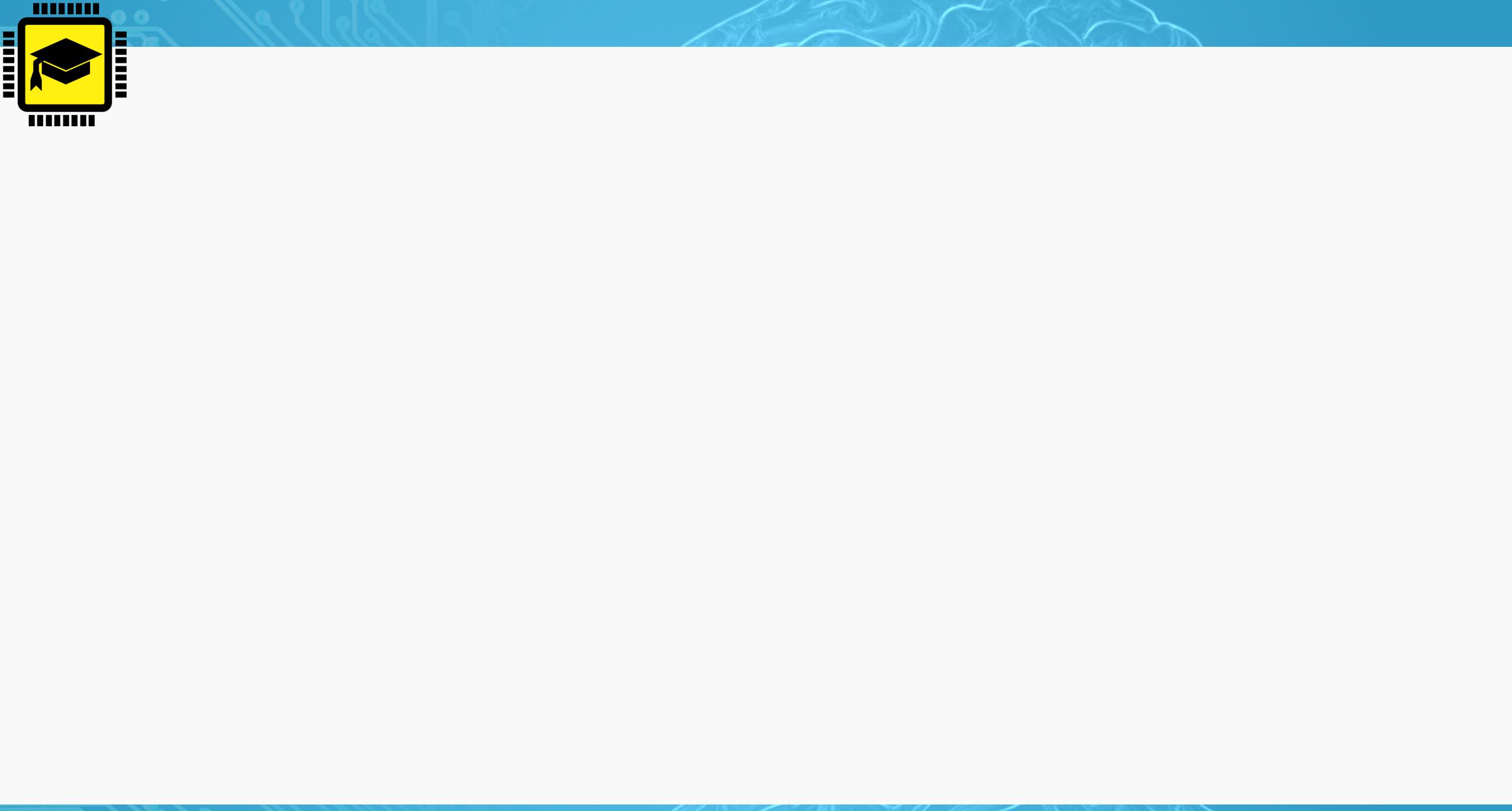


Sisteme Tolerante la Defecte Sisteme Distribuite

Dr. Ing. Cristian Chilipirea – cristian.chilipirea@gmail.ro







Când discutăm de sisteme distribuite?



Când discutăm de sisteme distribuite?

- P2P
- Server-Client
- Clustere
- Cloud
- Sisteme de calcul intensiv (supercomputer)
- Rețele ad-hoc (ex. rețele formate **doar** din senzori WiFi sau telefoane mobile)



Când discutăm de sisteme distribuite?

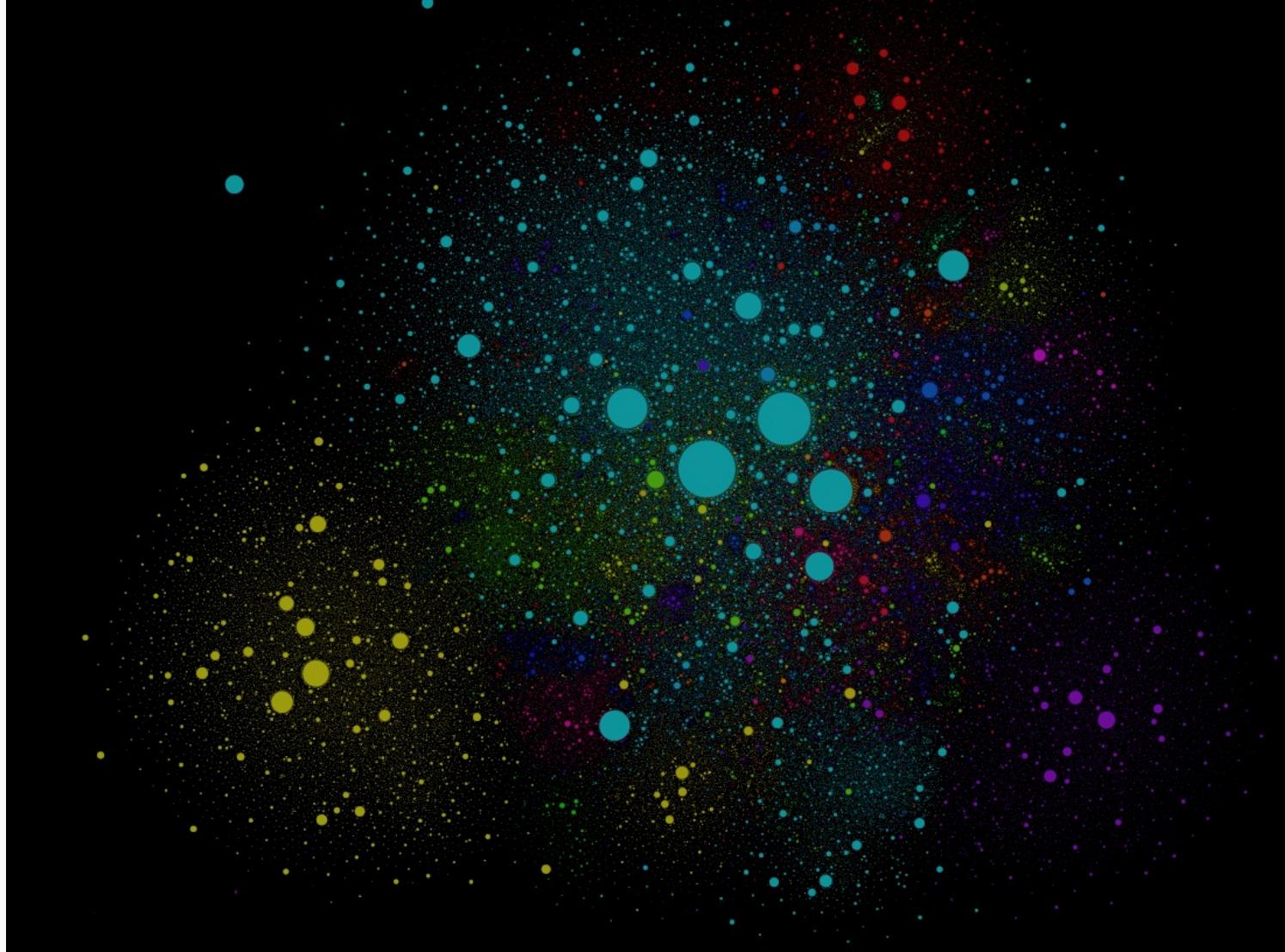
Oricând avem mai mult de un sistem



Care este cel mai mare sistem distribuit?

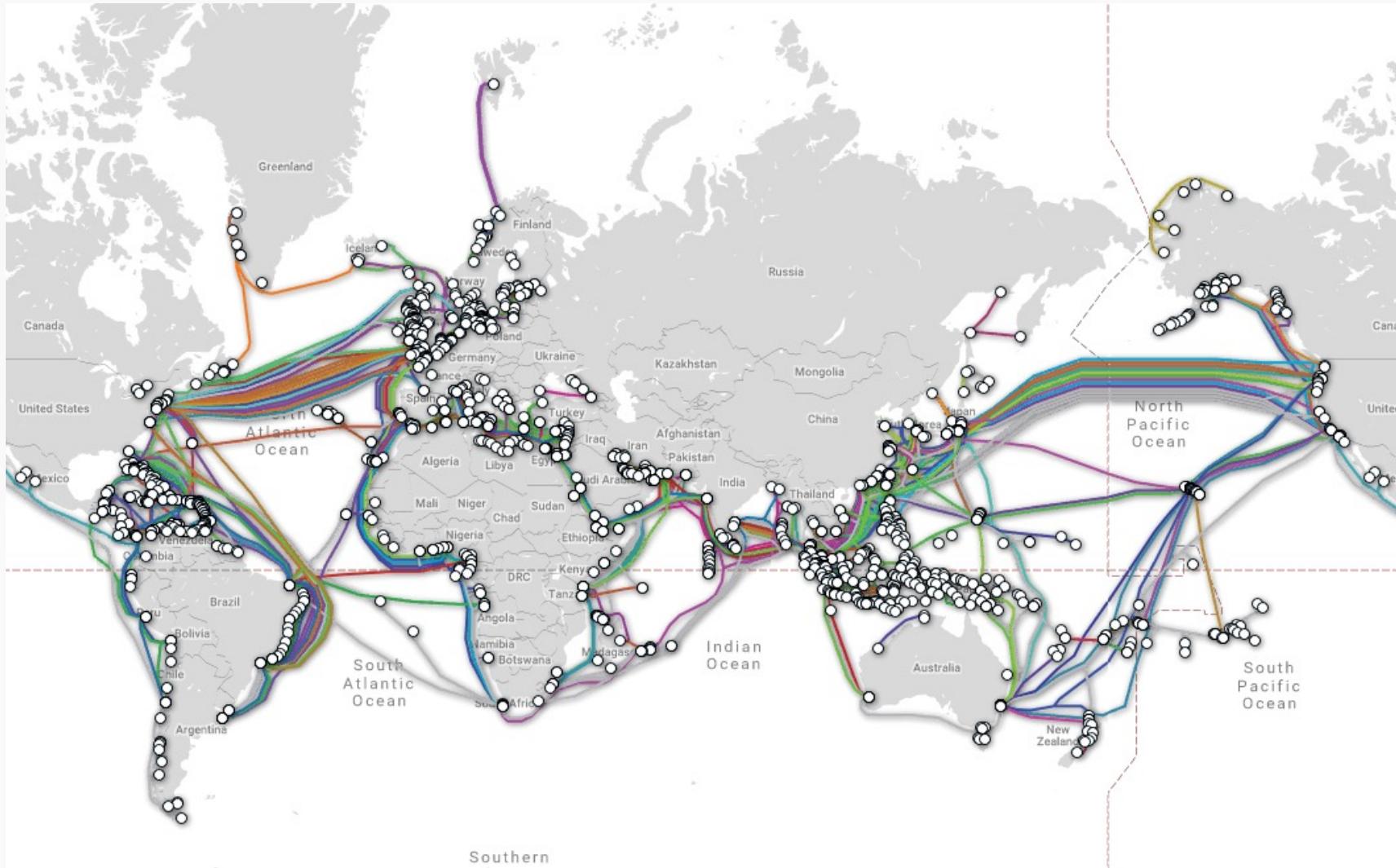


Care este cel mai mare sistem distribuit?



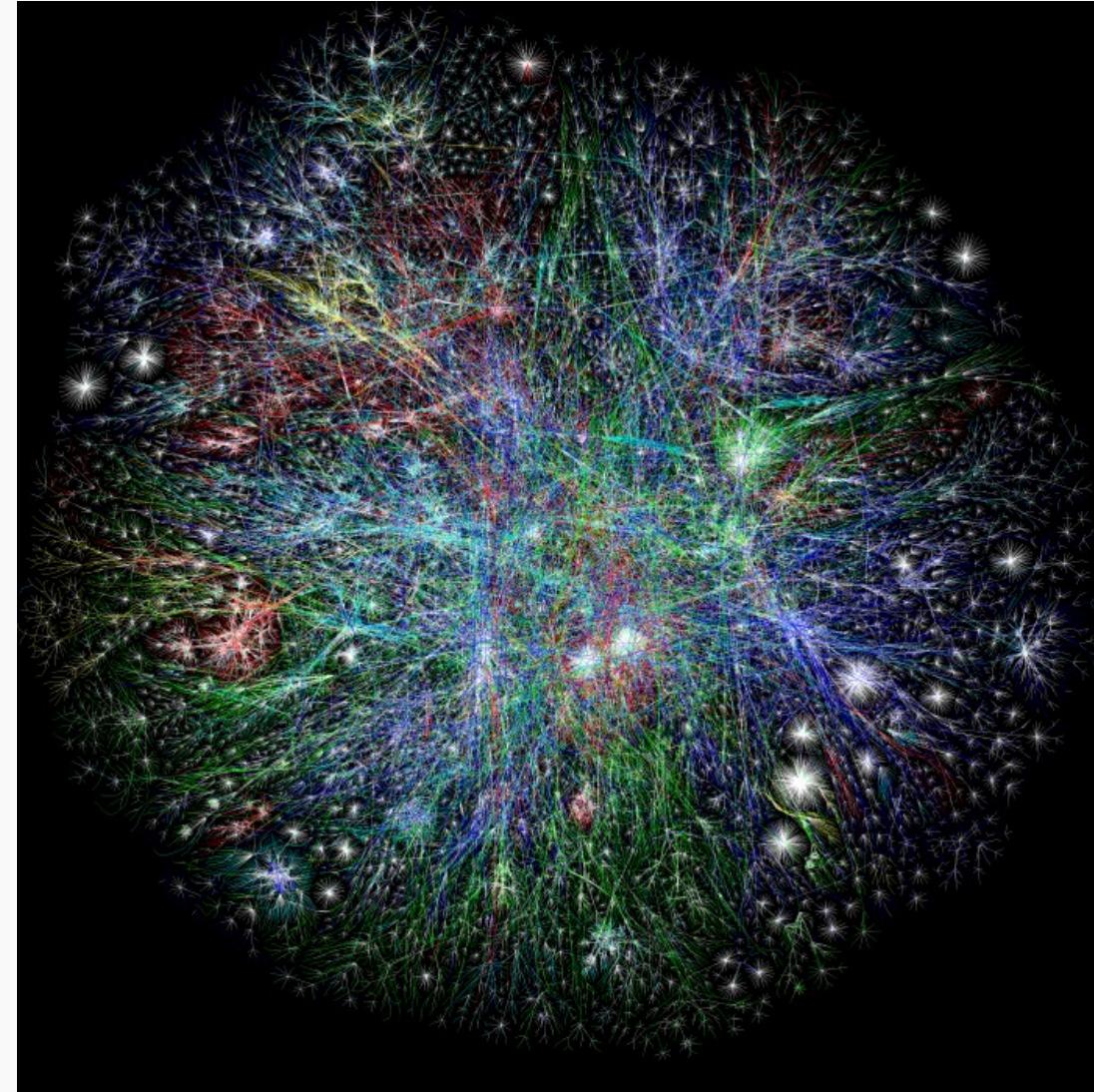


Care este cel mai mare sistem distribuit?





Care este cel mai mare sistem distribuit?





Care este cel mai mare sistem distribuit?





Care este cel mai mare sistem distribuit?





Care este cel mai mare sistem distribuit?

The INTERNET



Distributed Systems – The INTERNET

DISTRIBUTED WEB-BASED SYSTEMS

The World Wide Web (WWW) can be viewed as a huge distributed system consisting of millions of clients and servers for accessing linked documents. Servers maintain collections of documents, while clients provide users an interface for presenting and accessing those documents.

Web started as a project at CERN, the European Particle Physics Laboratory in Geneva, to let its large and geographically dispersed group





Cine a construit Internetul?



Cine a construit Internetul? - Vint Cerf

A Protocol for Packet Network Intercommunication

VINTON G. CERF AND ROBERT E. KAHN,
MEMBER, IEEE

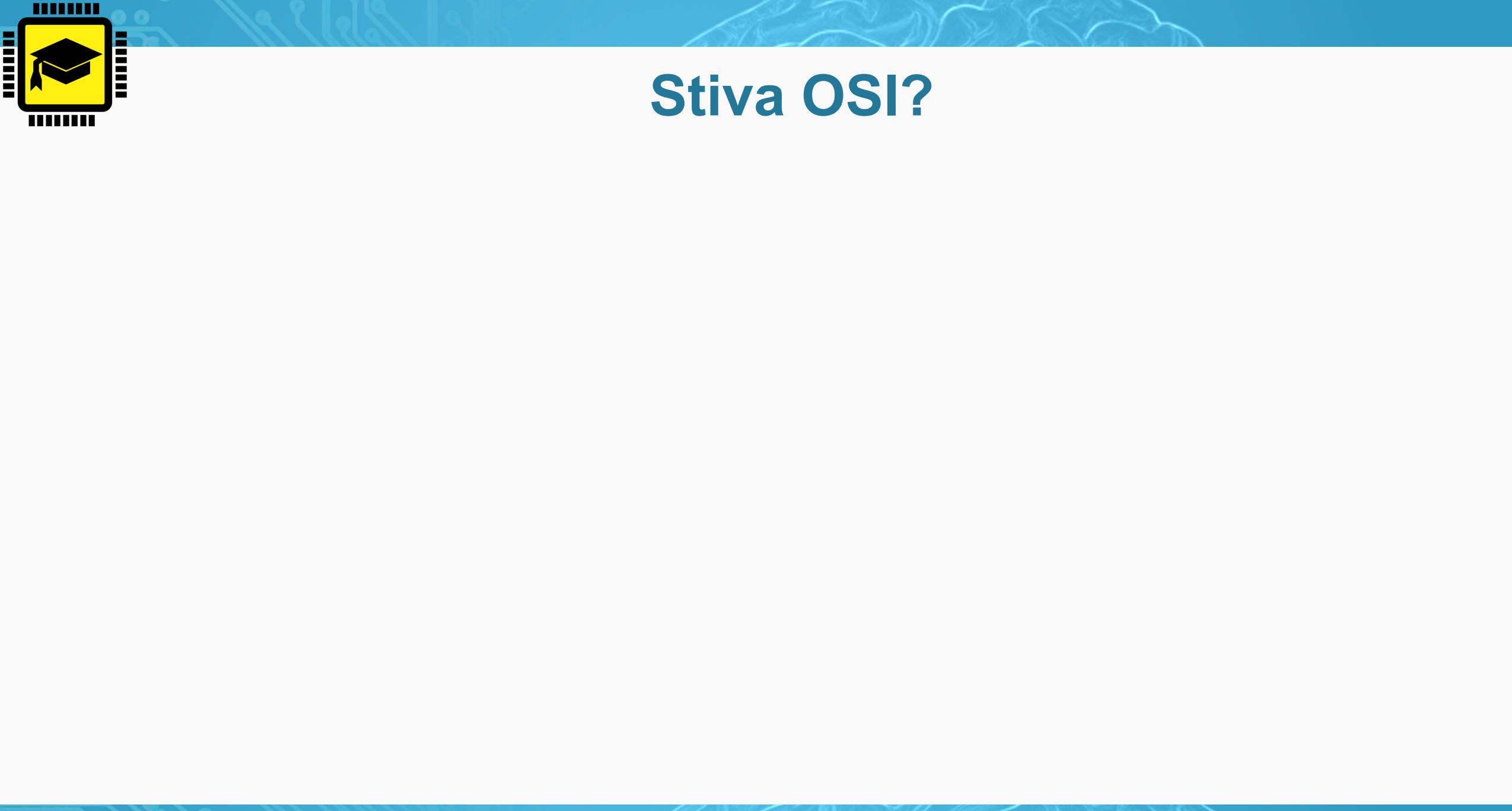
Abstract — A protocol that supports the sharing of resources that exist in different packet switching networks is presented. The protocol provides for variation in individual network packet sizes, transmission failures, sequencing, flow control, end-to-end error checking, and the creation and destruction of logical process-to-process connections. Some implementation issues are considered, and problems such as internetwork routing, accounting, and timeouts are exposed.

INTRODUCTION

IN THE LAST few years considerable effort has been expended on the design and implementation of packet switching networks [1]-[7],[14],[17]. A principle reason for developing such networks has been to facilitate the sharing of computer resources. A packet communication network includes a transportation mechanism for delivering data between computers or between computers and terminals. To make the data meaningful, computer and terminals

of one or more *packet switches* which connect communication media through the *switches*. Within each *host* there exist *processes* which communicate with other processes in their own order. A *process* is defined as a program designed for specific purposes [13]. These programs represent the ultimate source and destination of data in a network. Typically, within a host there exists a protocol for establishing connections between any source and destination processes. There is also a convention for communicating between processes in two distinct environments. Processes in two distinct environments may use different protocols. The ensemble of packet switches connecting hosts through various media is called the *packet switch network*.



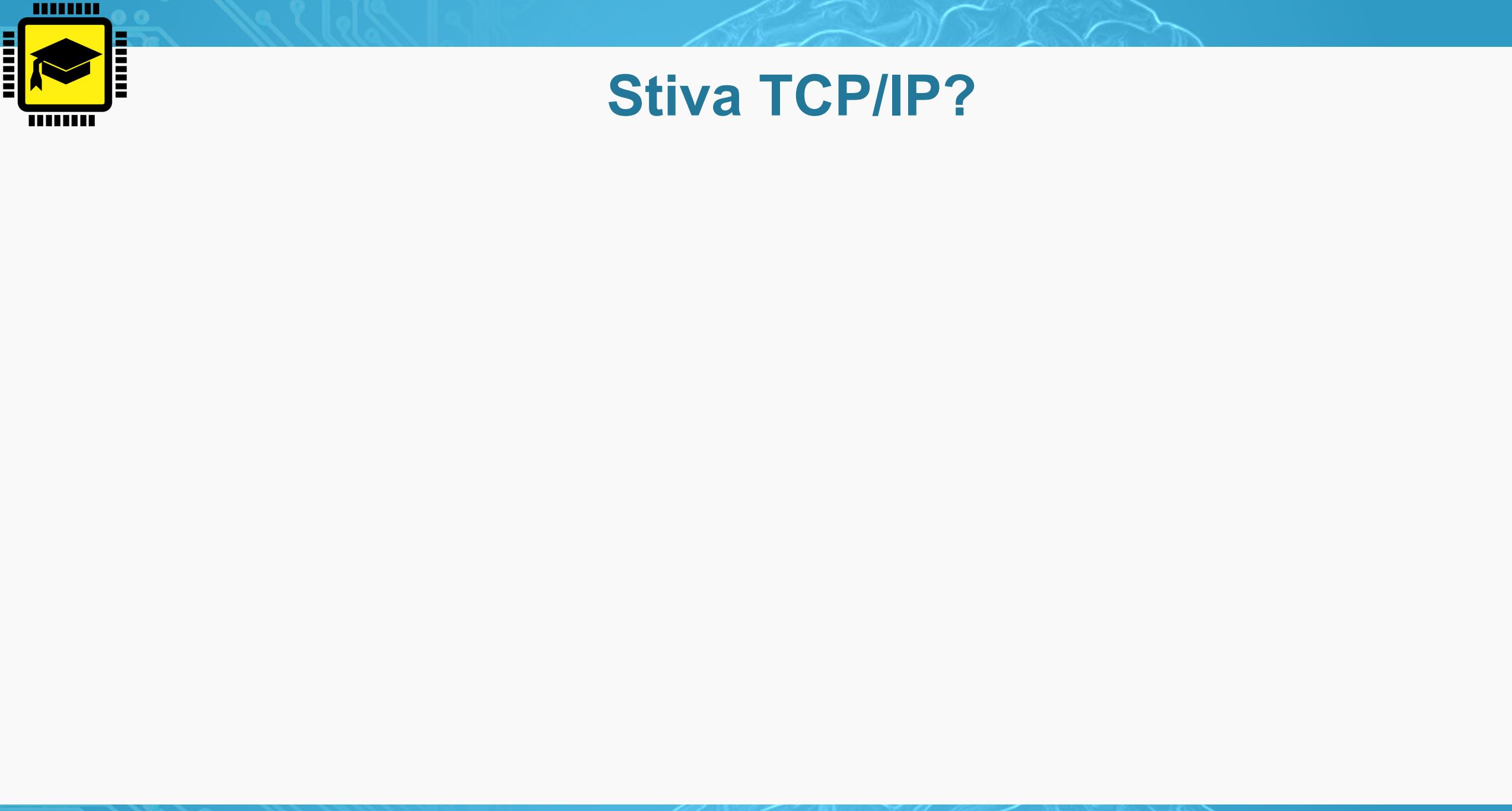


Stiva OSI?



Stiva OSI?

OSI Model				
Layer		Protocol data unit (PDU)	Function ^[3]	
Host layers	7	Application	Data	High-level APIs, including resource sharing, remote file access
	6	Presentation		Translation of data between a networking service and an application; including character encoding, data compression and encryption/decryption
	5	Session		Managing communication sessions, i.e. continuous exchange of information in the form of multiple back-and-forth transmissions between two nodes
	4	Transport	Segment, Datagram	Reliable transmission of data segments between points on a network, including segmentation, acknowledgement and multiplexing
Media layers	3	Network	Packet	Structuring and managing a multi-node network, including addressing, routing and traffic control
	2	Data link	Frame	Reliable transmission of data frames between two nodes connected by a physical layer
	1	Physical	Symbol	Transmission and reception of raw bit streams over a physical medium





Stiva TCP/IP?

OSI	TCP/IP
Application	
Presentation	
Session	Data
Transport	TCP
Network	IP
Data link	Ethernet
Physical	Cupru



Granții stiva TCP/IP?

OSI	TCP/IP	Garanții
Application		
Presentation		
Session	Data (HTTP)	
Transport	TCP	
Network	IP	
Data link	Ethernet	
Physical	Cupru	Mesajul e transmis



Granții stiva TCP/IP?

OSI	TCP/IP	Garanții
Application		
Presentation		
Session	Data (HTTP)	
Transport	TCP	
Network	IP	
Data link	Ethernet	Best efort ca mesajul să ajungă unde trebuie în rețea
Physical	Cupru	Mesajul e transmis



Granții stiva TCP/IP?

OSI	TCP/IP	Garanții
Application		
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Session	Data (HTTP)	
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Network	IP	Best efort ca mesajul să ajungă unde trebuie în Internet
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Physical	Cupru	Mesajul e transmis



Granții stiva TCP/IP?

OSI	TCP/IP	Garanții
Application		
Presentation		
Session	Data (HTTP)	
Transport	TCP	Mesajul ajunge
Network	IP	Best efort ca mesajul să ajungă unde trebuie în Internet
Data link	Ethernet	Best efort ca mesajul să ajungă unde trebuie în rețea
Physical	Cupru	Mesajul e transmis

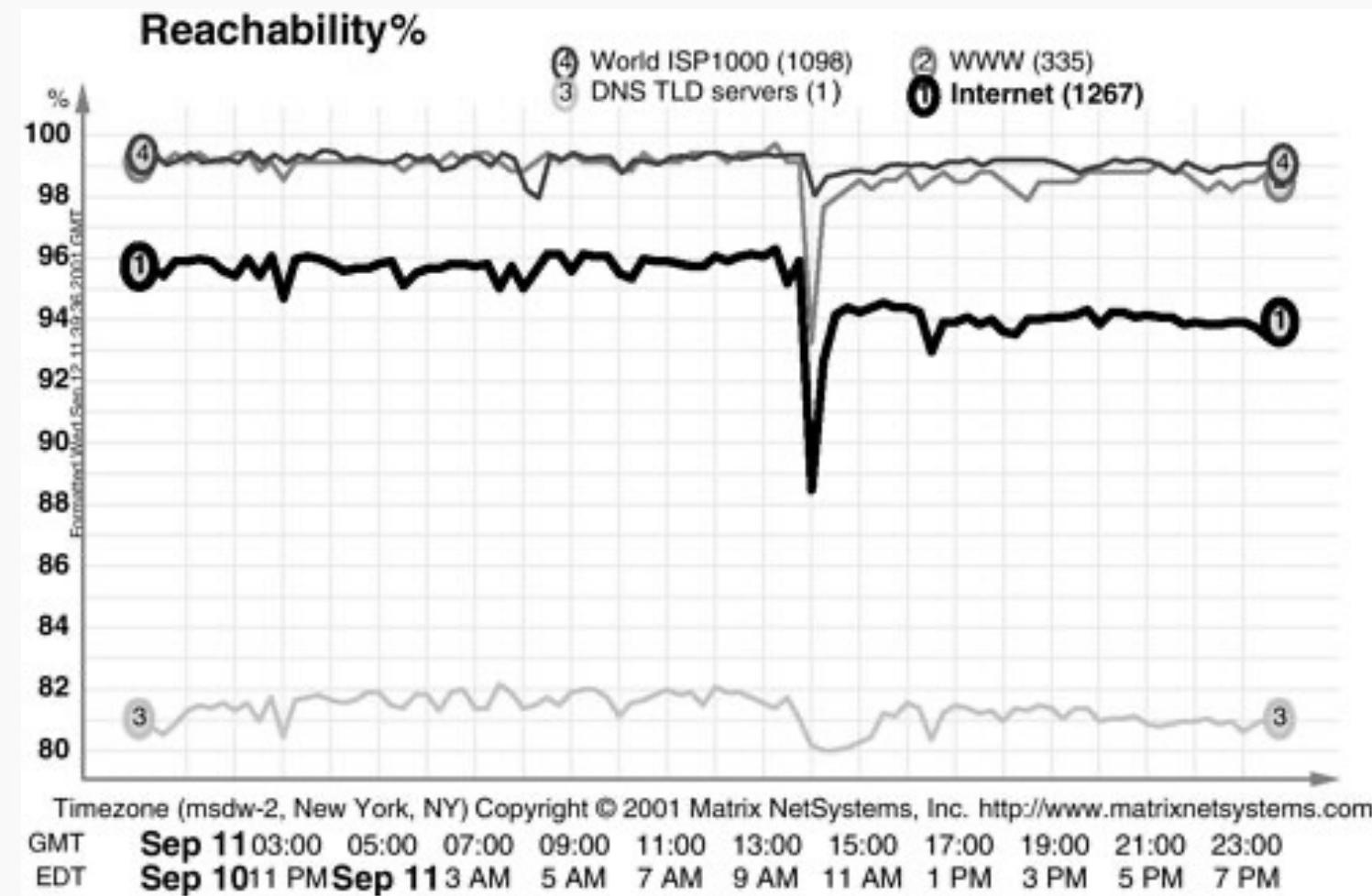


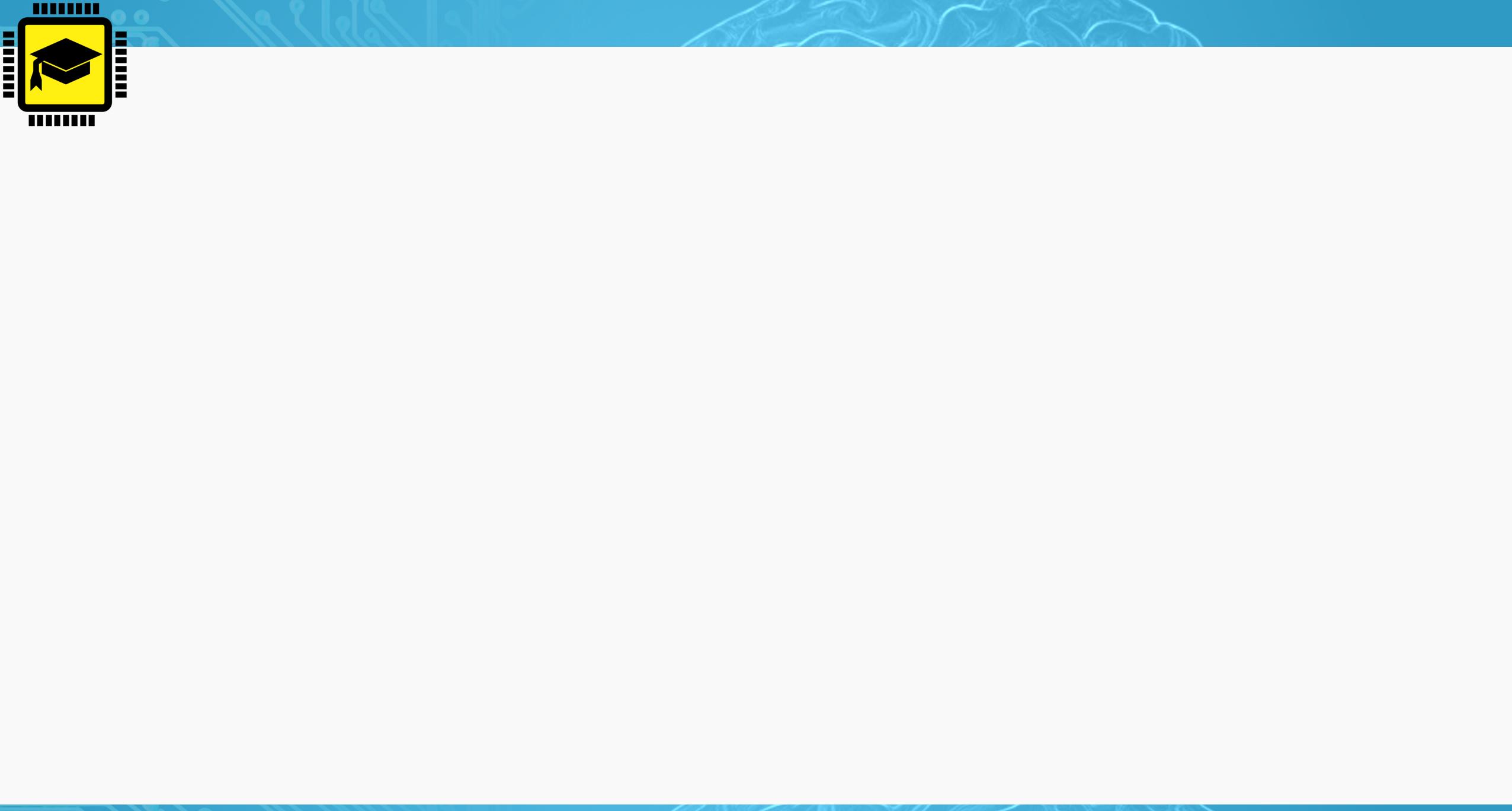
Granții stiva TCP/IP?

OSI	TCP/IP	Garanții
Application		
Presentation		
Session	Data (HTTP)	Mesajul va fi înțeles de server/browser
Transport	TCP	Mesajul ajunge
Network	IP	Best efort ca mesajul să ajungă unde trebuie în Internet
Data link	Ethernet	Best efort ca mesajul să ajungă unde trebuie în rețea
Physical	Cupru	Mesajul e transmis



Deci cât de bun e internetul ca sistem distribuit?







Cine a inventat Ethernet?



Cine a inventat Ethernet? - Robert Metcalfe

Computer
Systems

G. Bell, S. Fuller and
D. Siewiorek, Editors

Ethernet: Distributed Packet Switching for Local Computer Networks

Robert M. Metcalfe and David R. Boggs
Xerox Palo Alto Research Center

Ethernet is a branching broadcast communication system for carrying digital data packets among locally distributed computing stations. The packet transport mechanism provided by Ethernet has been used to build systems which can be viewed as either local computer networks or loosely coupled multiprocessors. An Ethernet's shared communication facility, its Ether, is a pas-

1. Background

One can characterize distributed computing as a spectrum of activities varying in their degree of decentralization, with one extreme being remote computer networking and the other extreme being multiprocessing. Remote computer networking is the loose interconnection of previously isolated, widely separated, and rather large computing systems. Multiprocessing is the construction of previously monolithic and serial computing systems from increasingly numerous and smaller pieces computing in parallel. Near the middle of this spectrum is local networking, the interconnection of computers to gain the resource sharing of computer networking and the parallelism of multiprocessing.

The separation between computers and the associated bit rate of their communication can be used to divide the distributed computing spectrum into broad activities. The product of separation and bit rate, now about 1 gigabit-meter per second (1 Gbmps), is an indication of the limit of current communication technology and can be expected to increase with time:

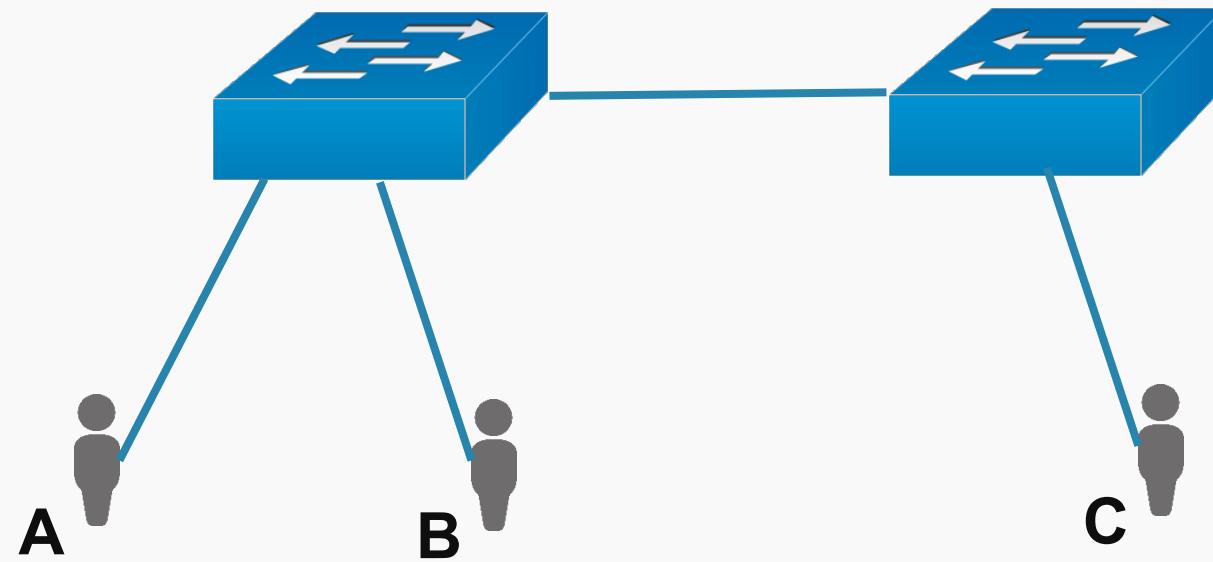
Activity	Separation	Bit rate
Remote networks	> 10 km	< .1 Mbps
Local networks	10-.1 km	.1-10 Mbps
Multiprocessors	< .1 km	> 10 Mbps

1.1 Remote Computer Networking



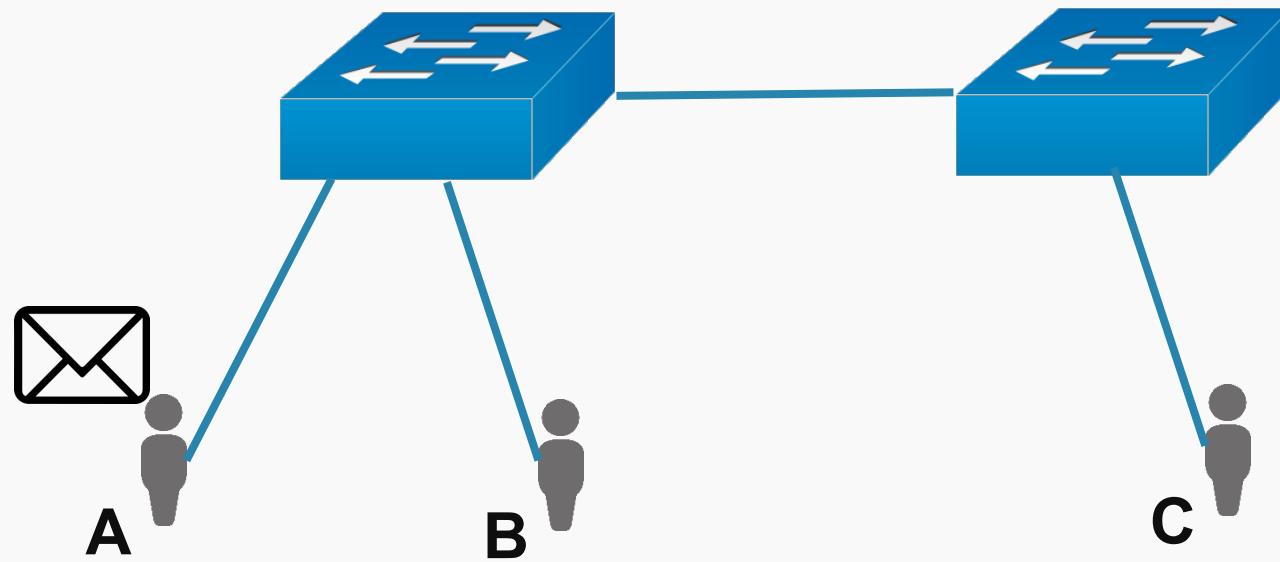


Ethernet – CAM table



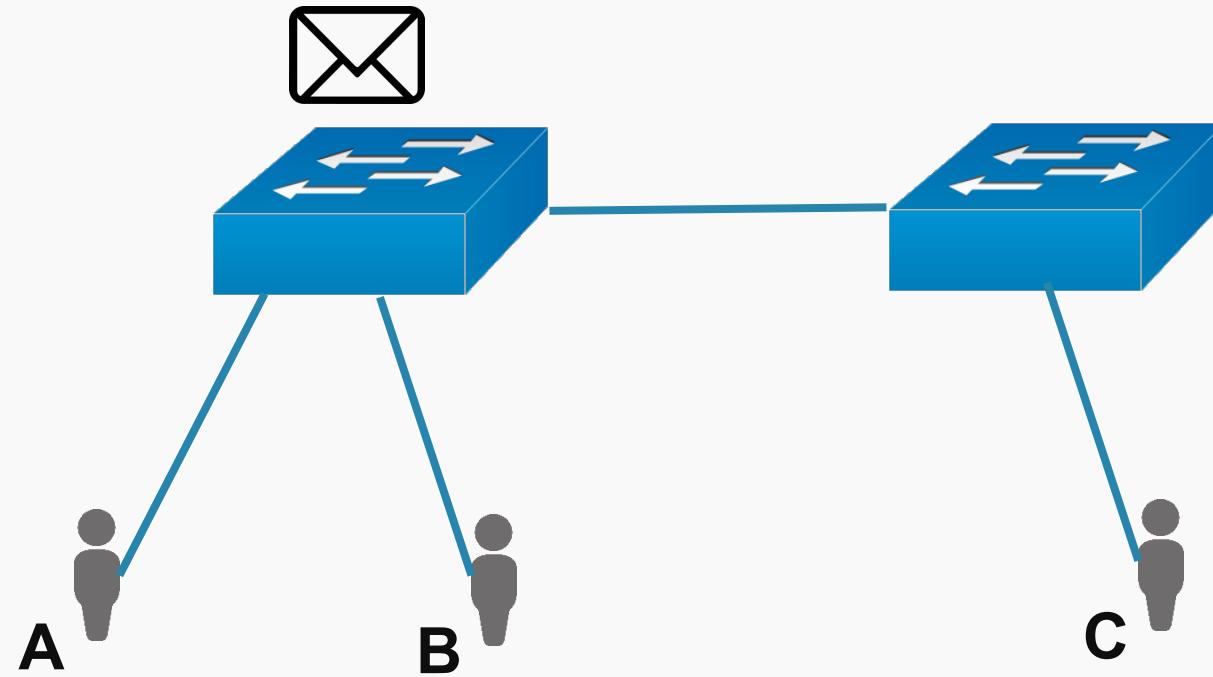


Ethernet – CAM table



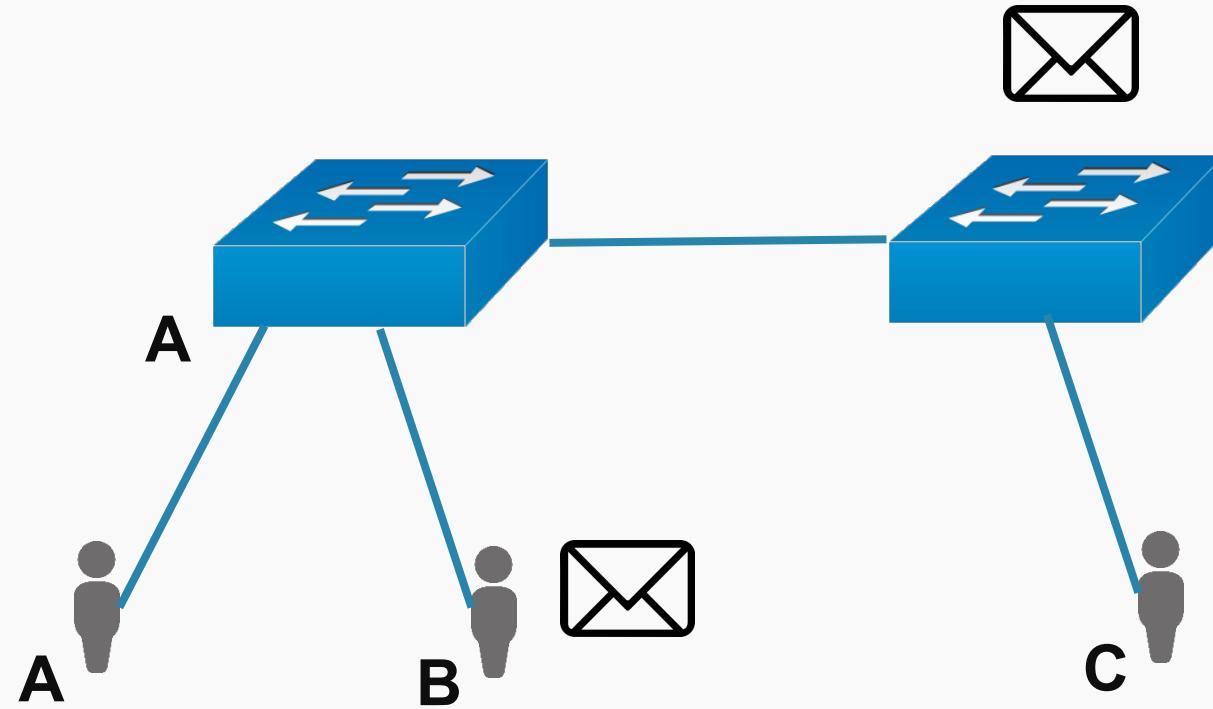


Ethernet – CAM table



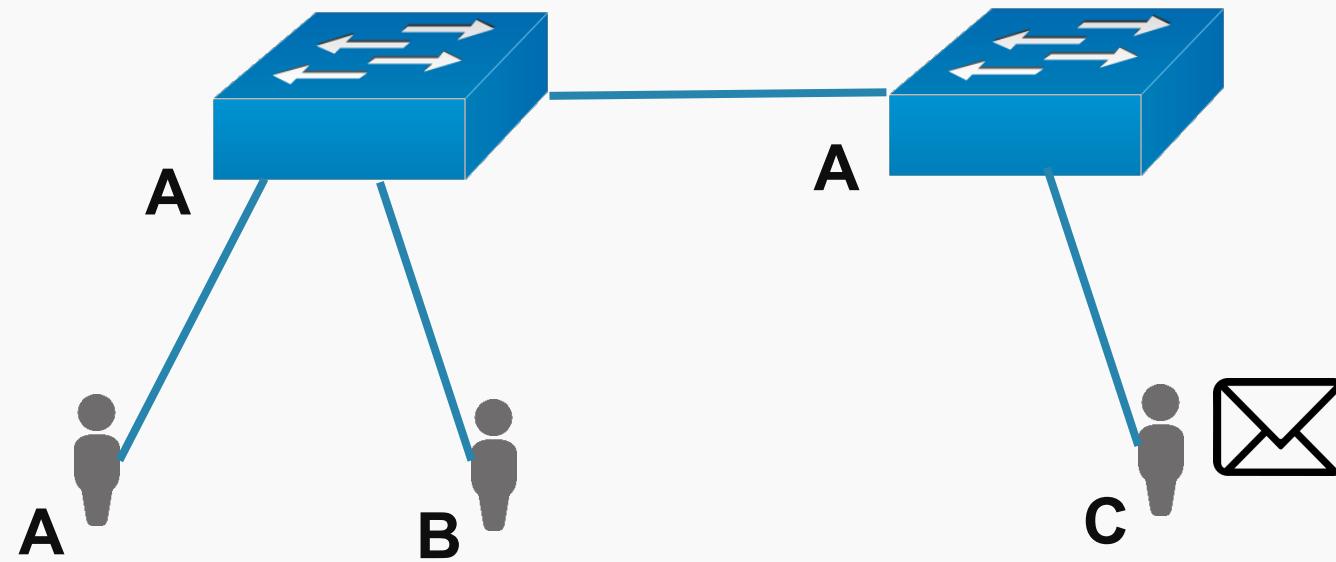


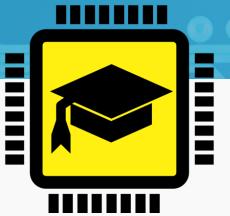
Ethernet – CAM table



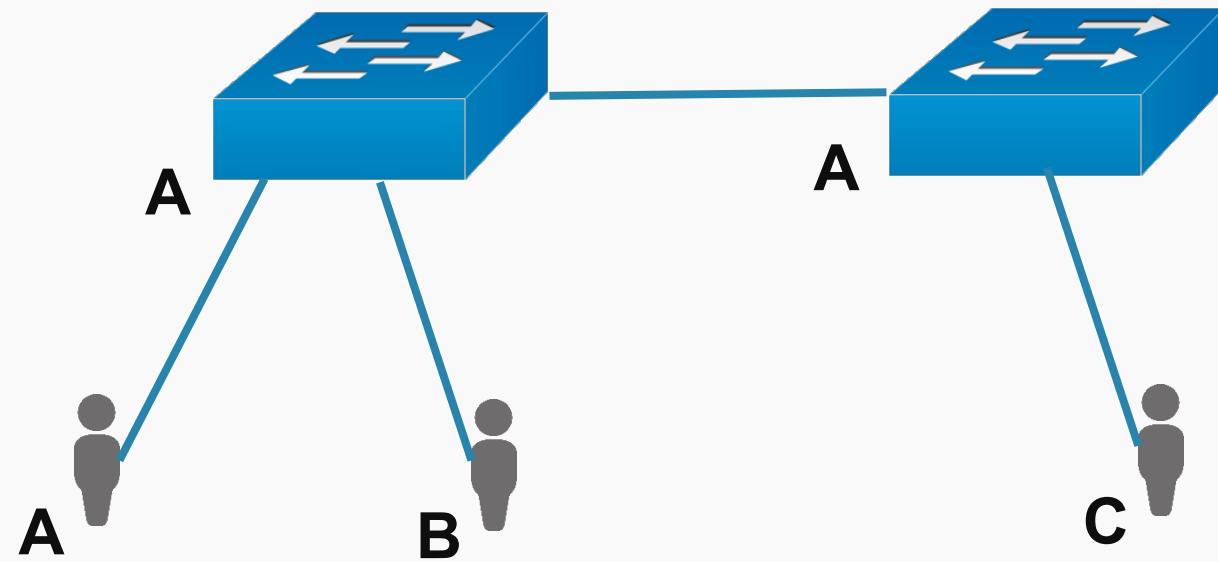


Ethernet – CAM table



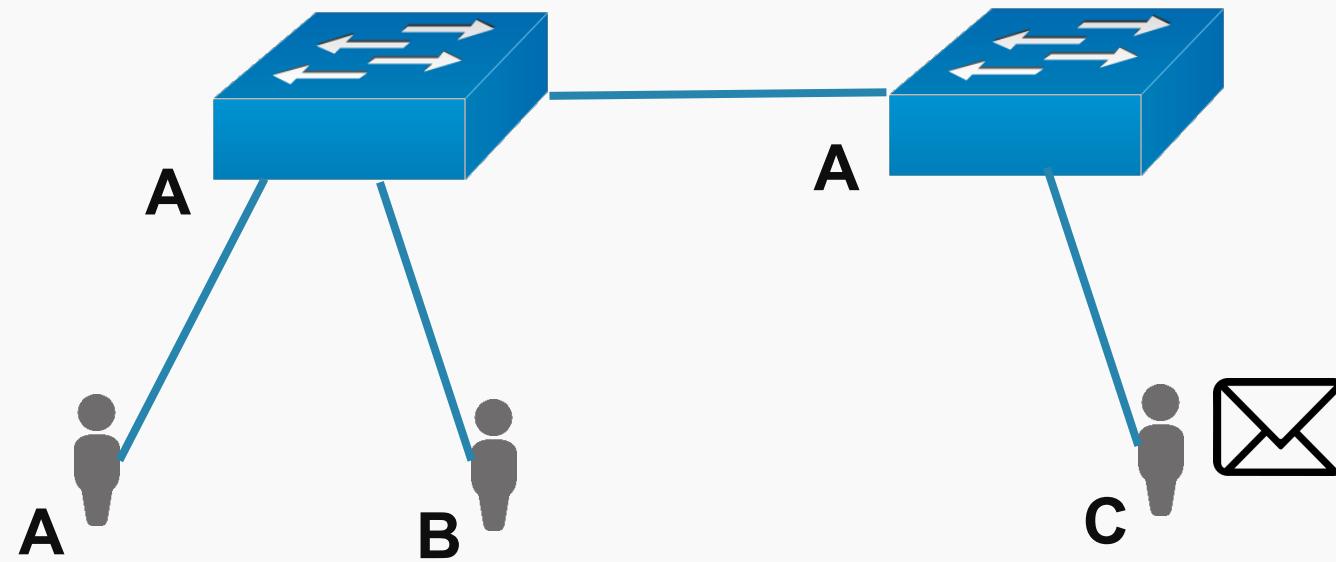


Ethernet – CAM table



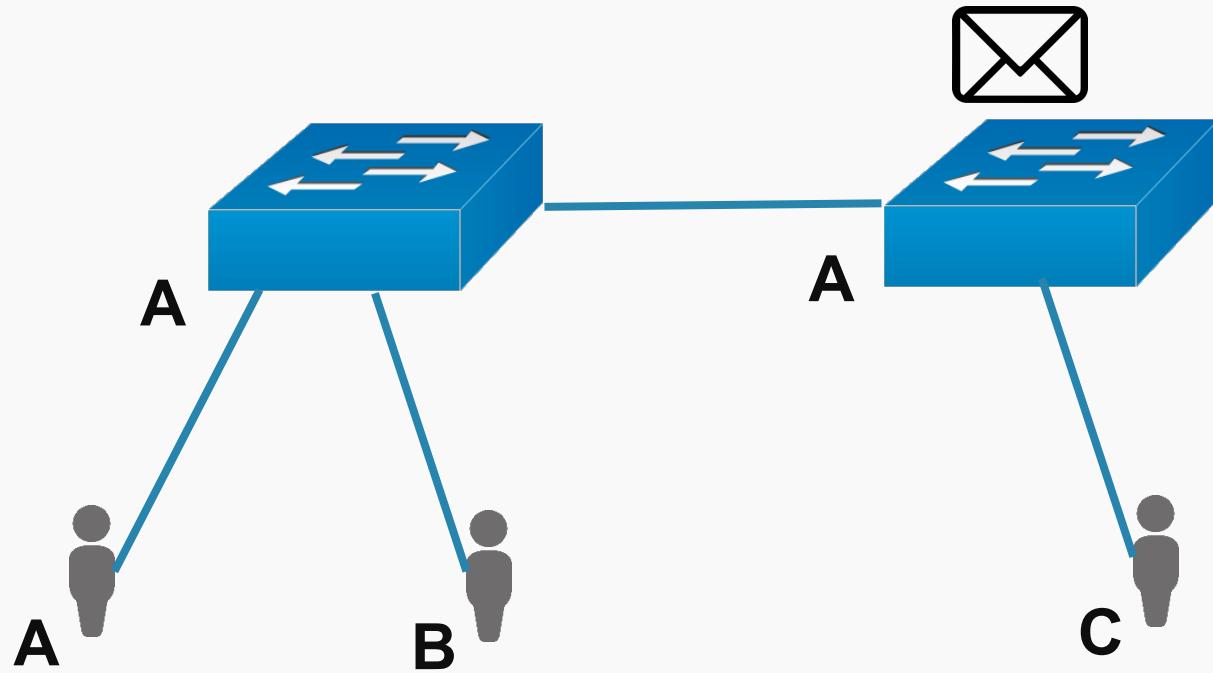


Ethernet – CAM table



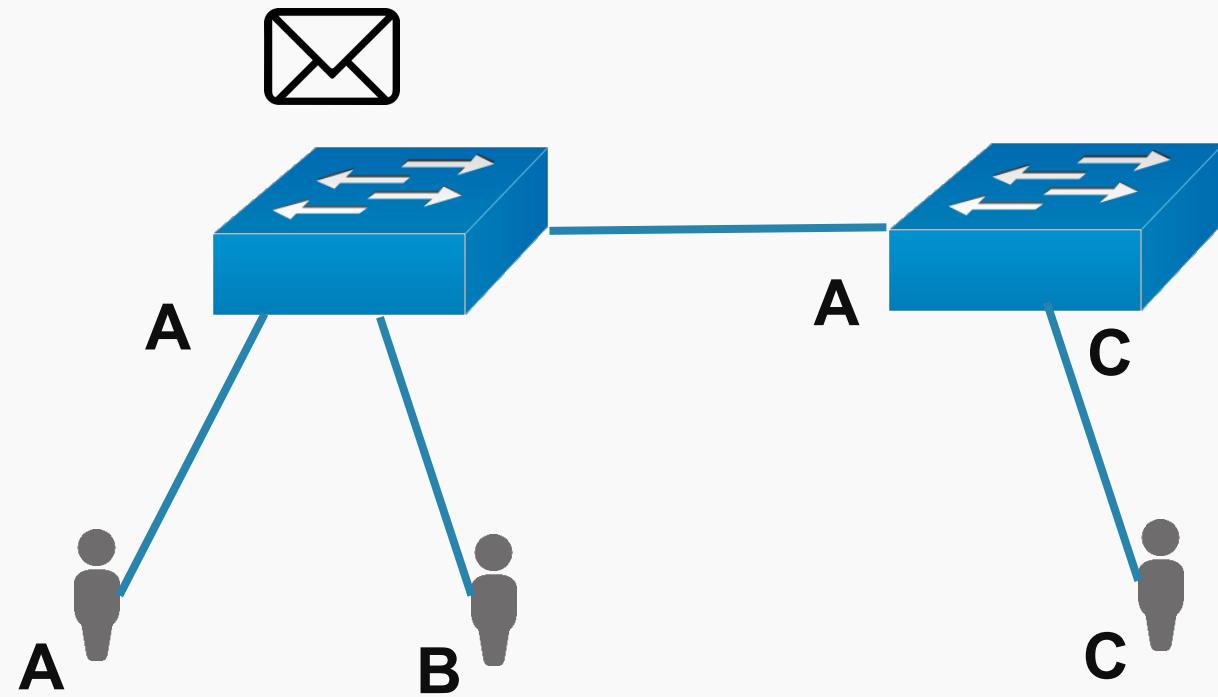


Ethernet – CAM table



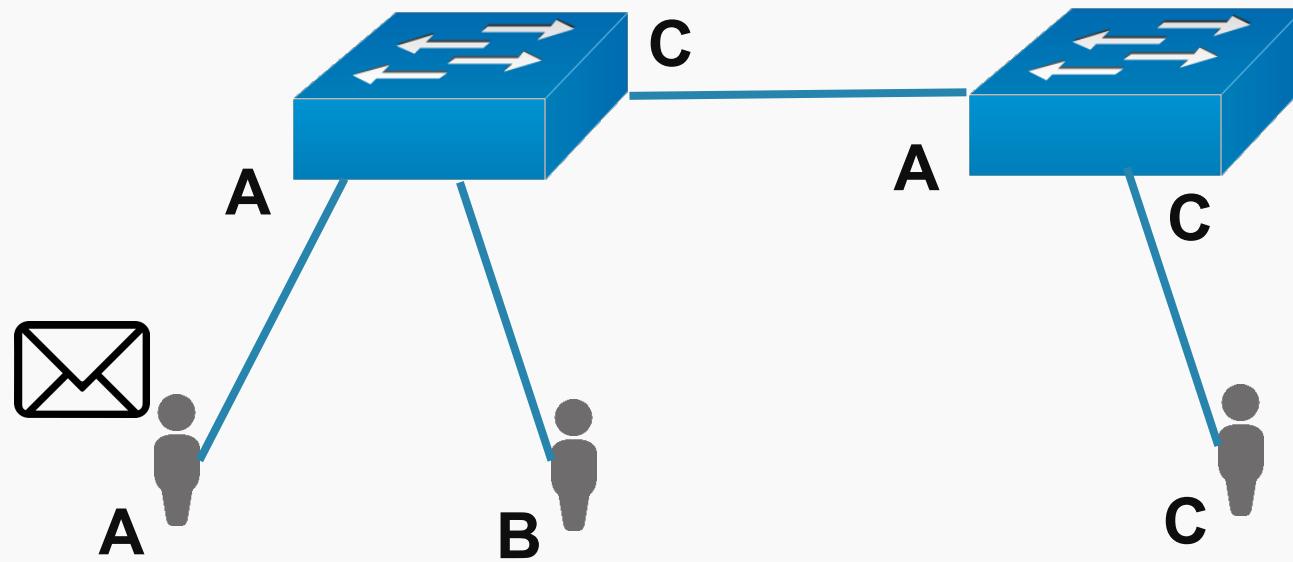


Ethernet – CAM table



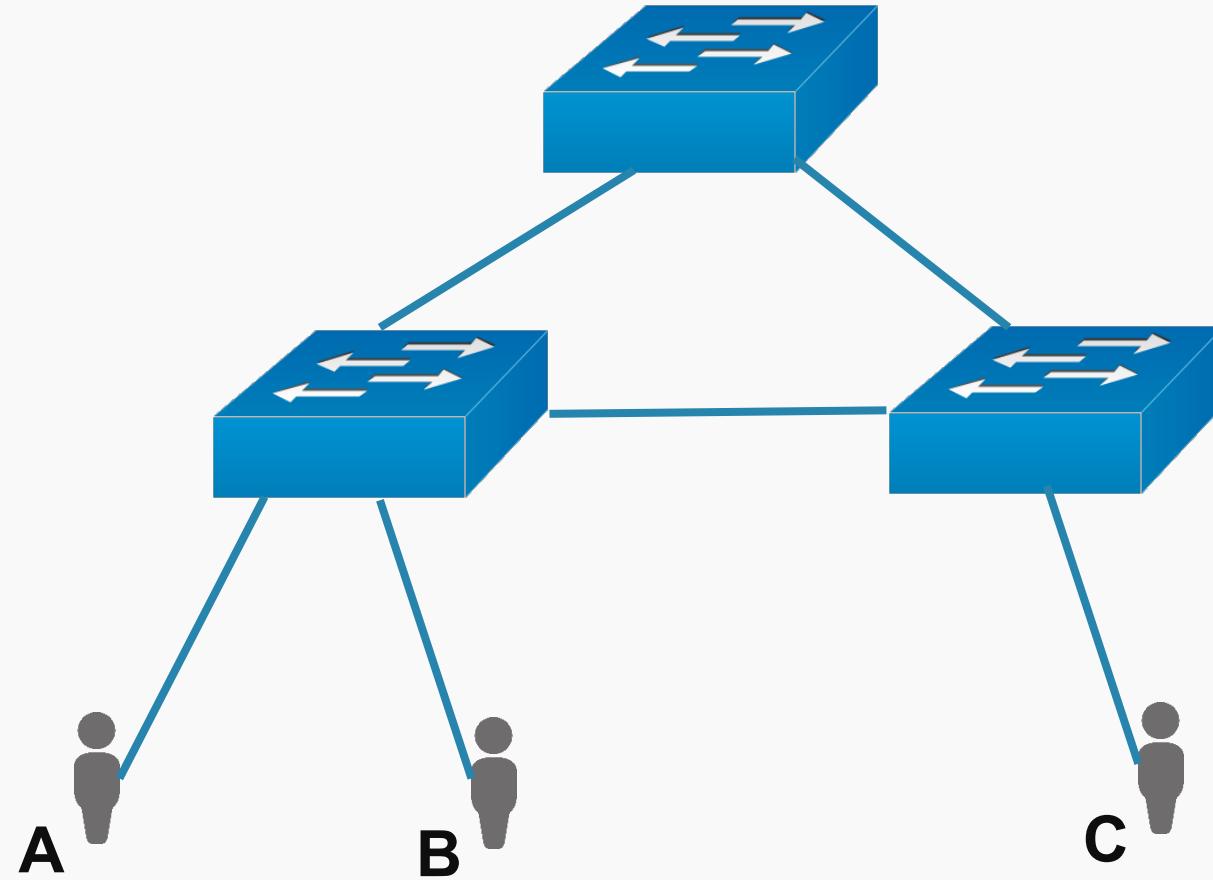


Ethernet – CAM table



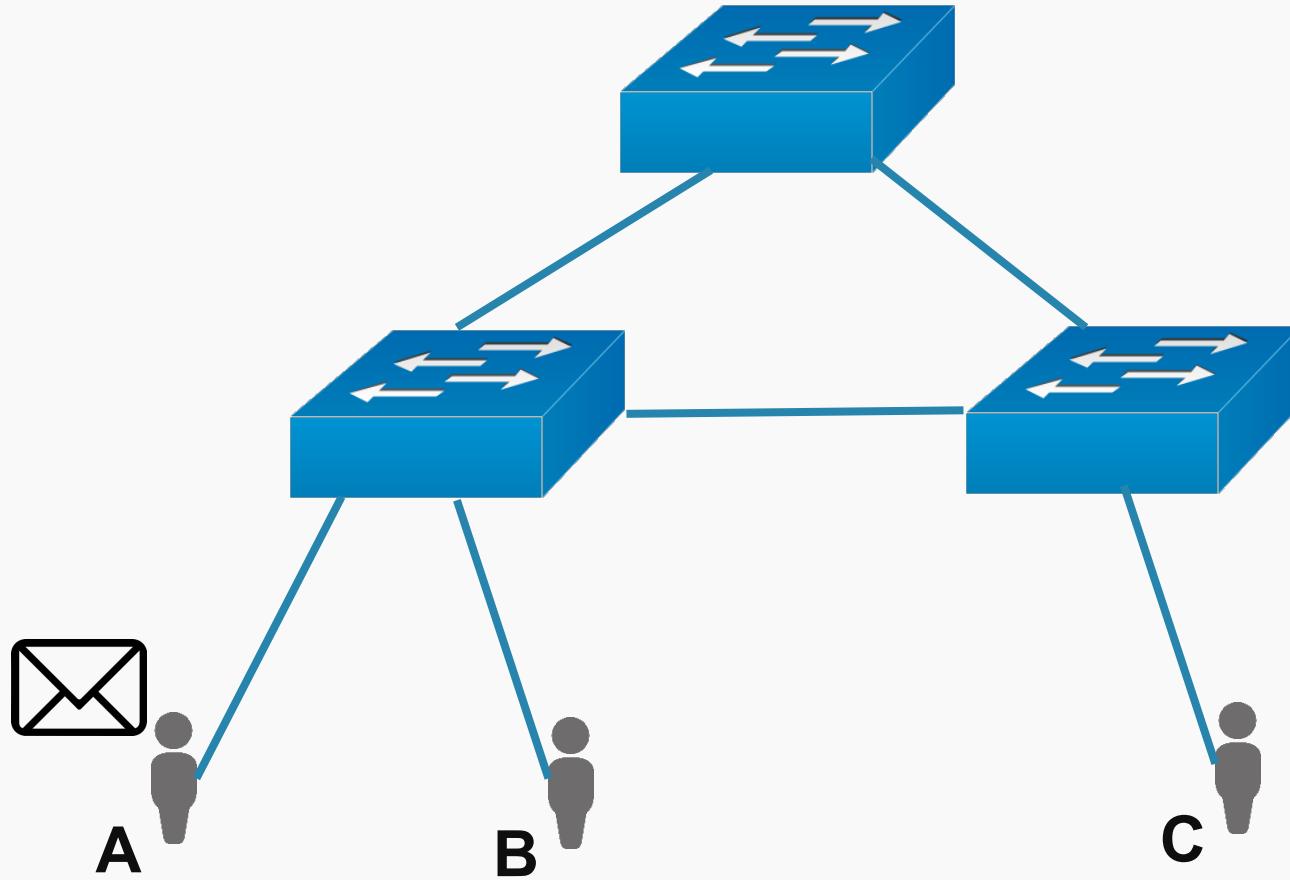


Ethernet – CAM table – Probleme cu cicluri



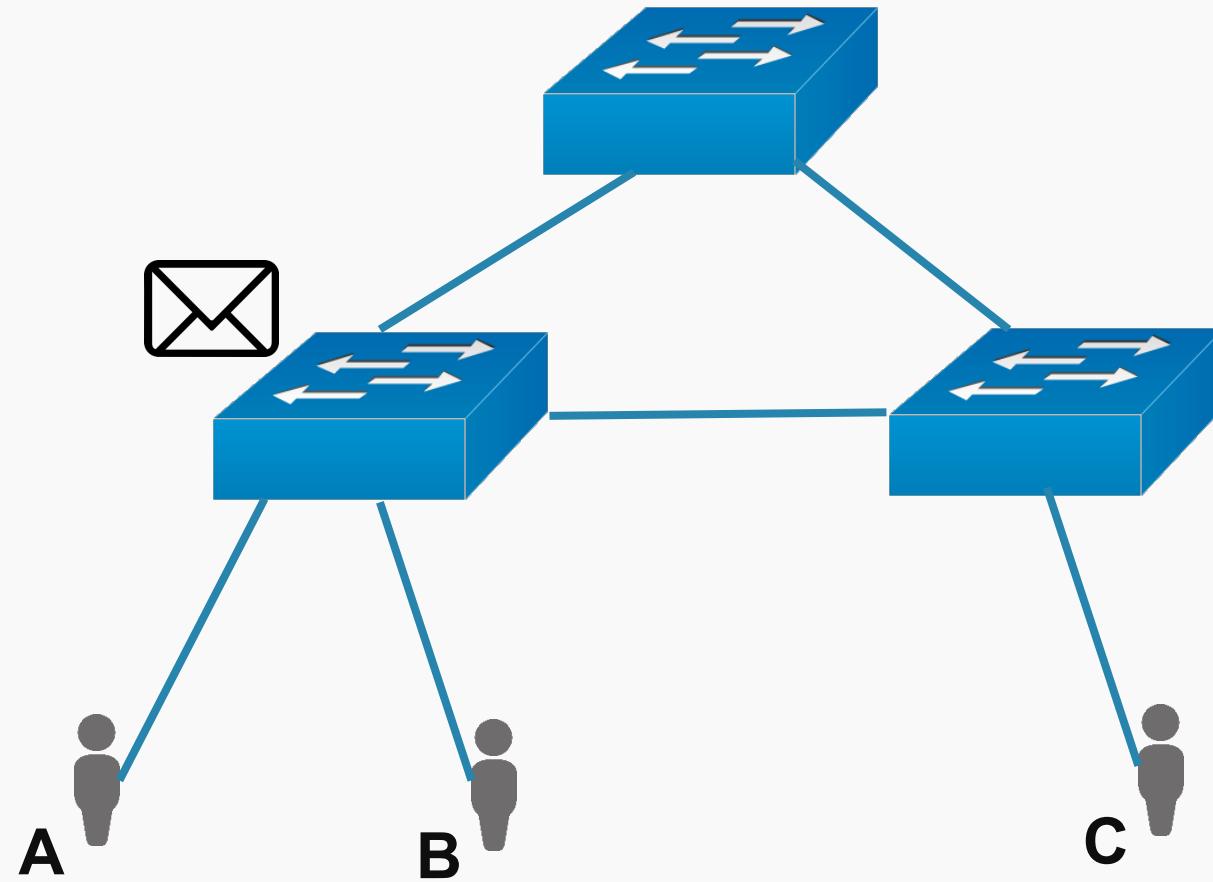


Ethernet – CAM table – Probleme cu cicluri



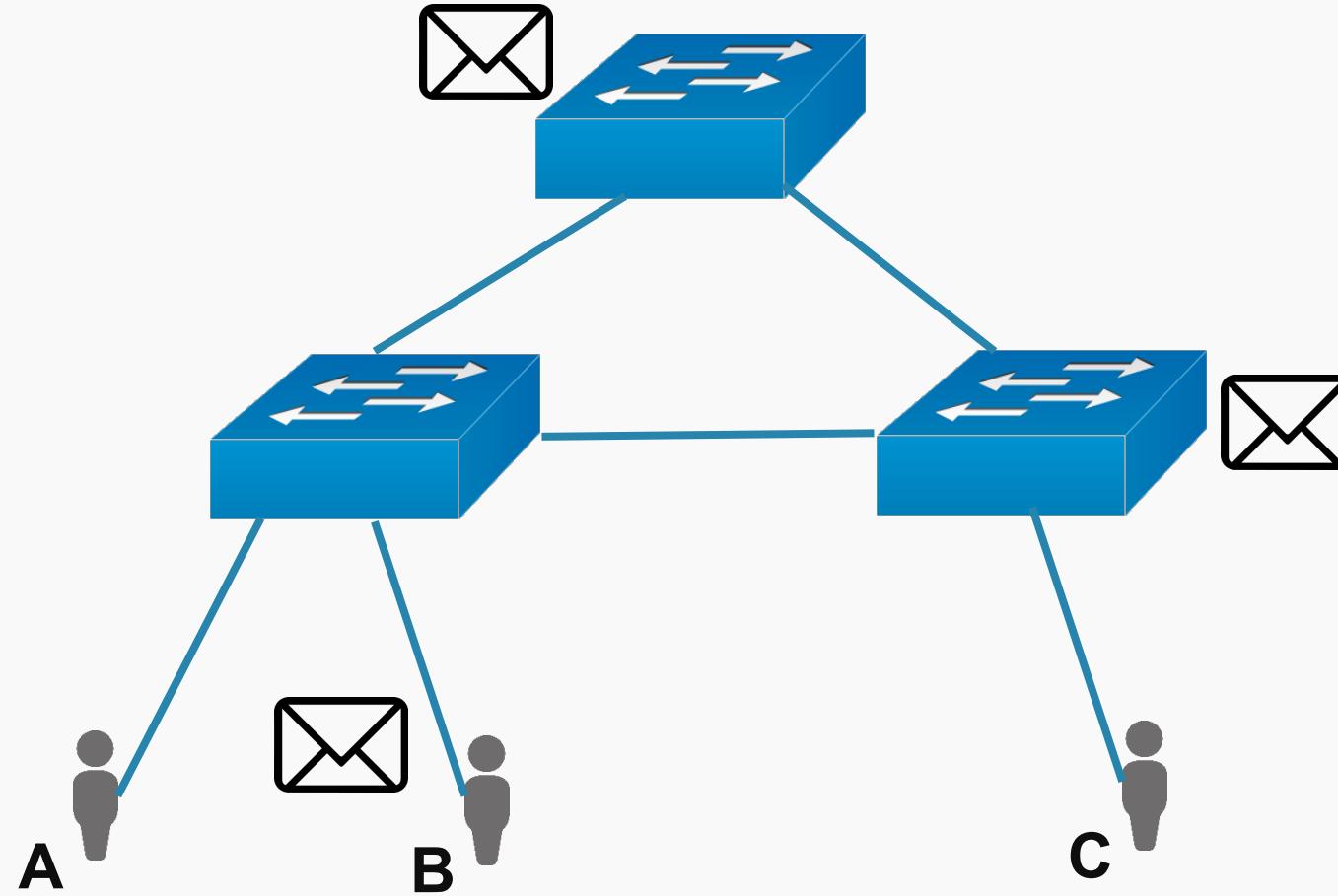


Ethernet – CAM table – Probleme cu cicluri



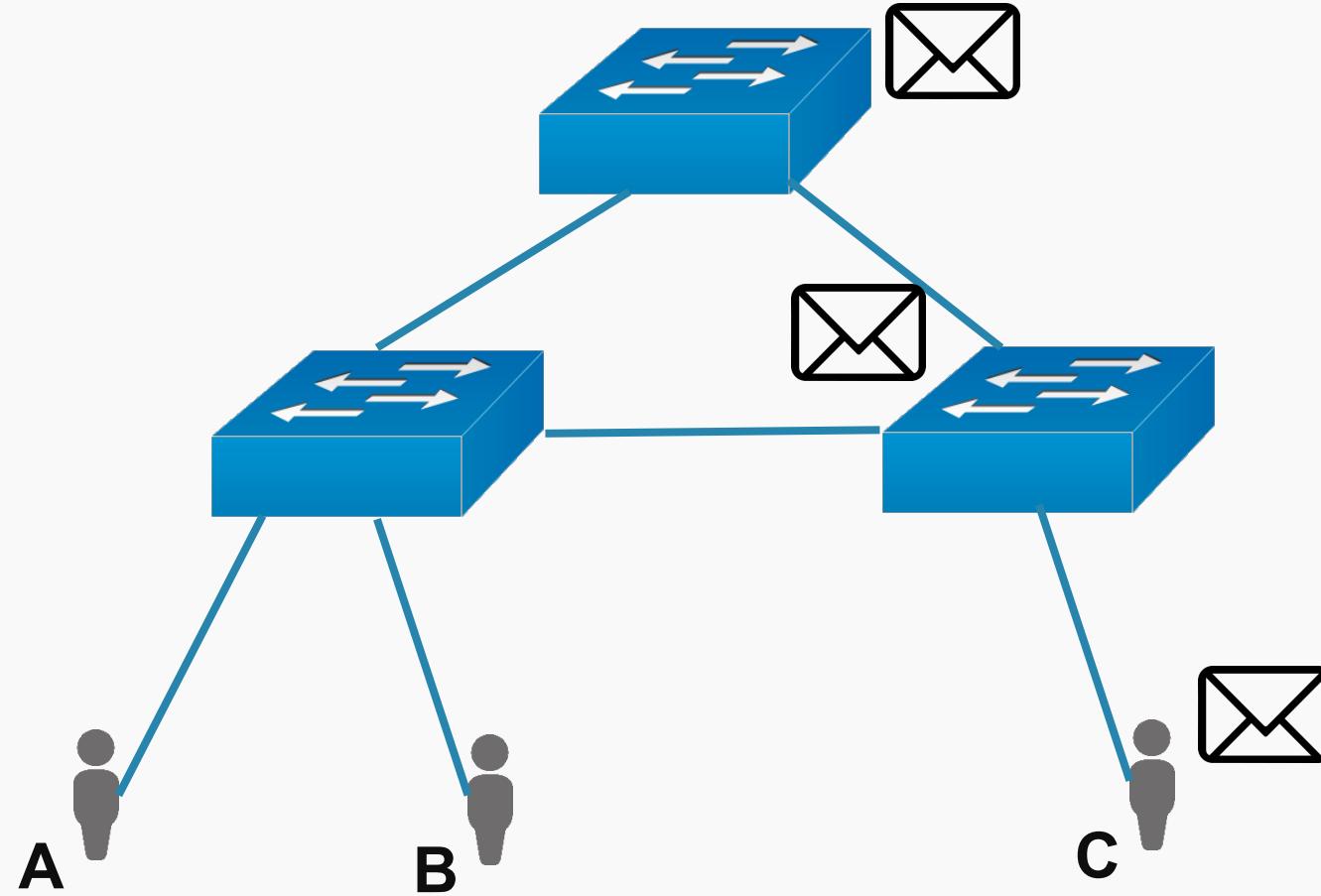


Ethernet – CAM table – Probleme cu cicluri



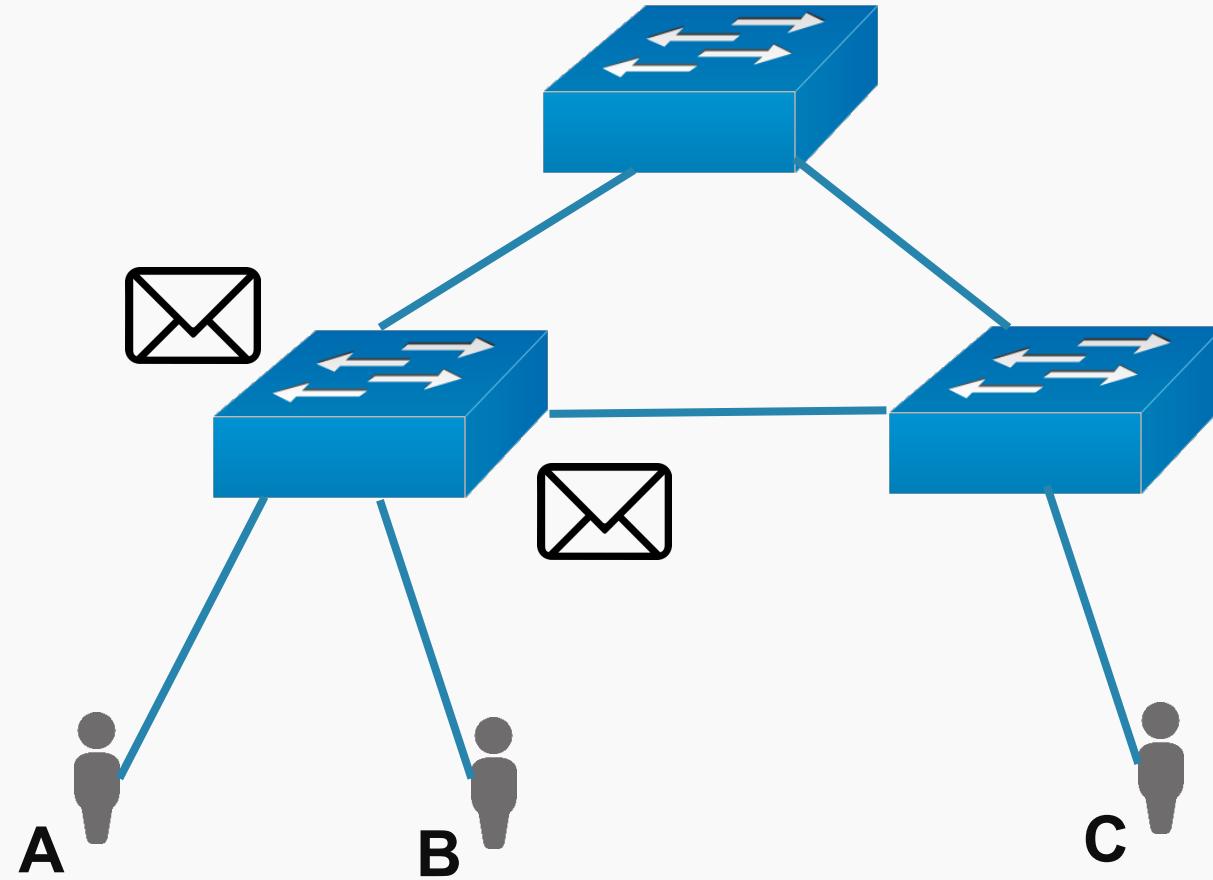


Ethernet – CAM table – Probleme cu cicluri



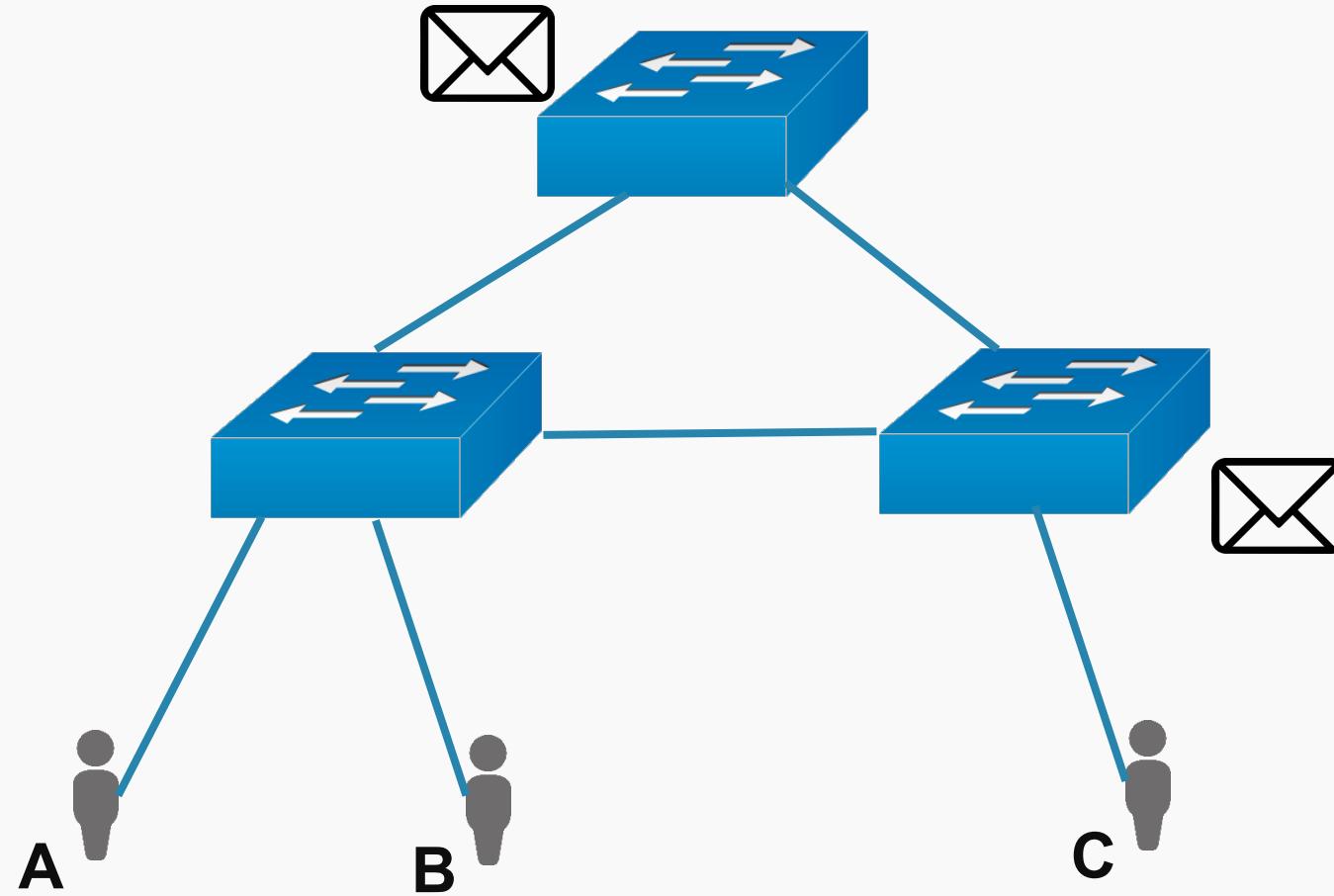


Ethernet – CAM table – Probleme cu cicluri



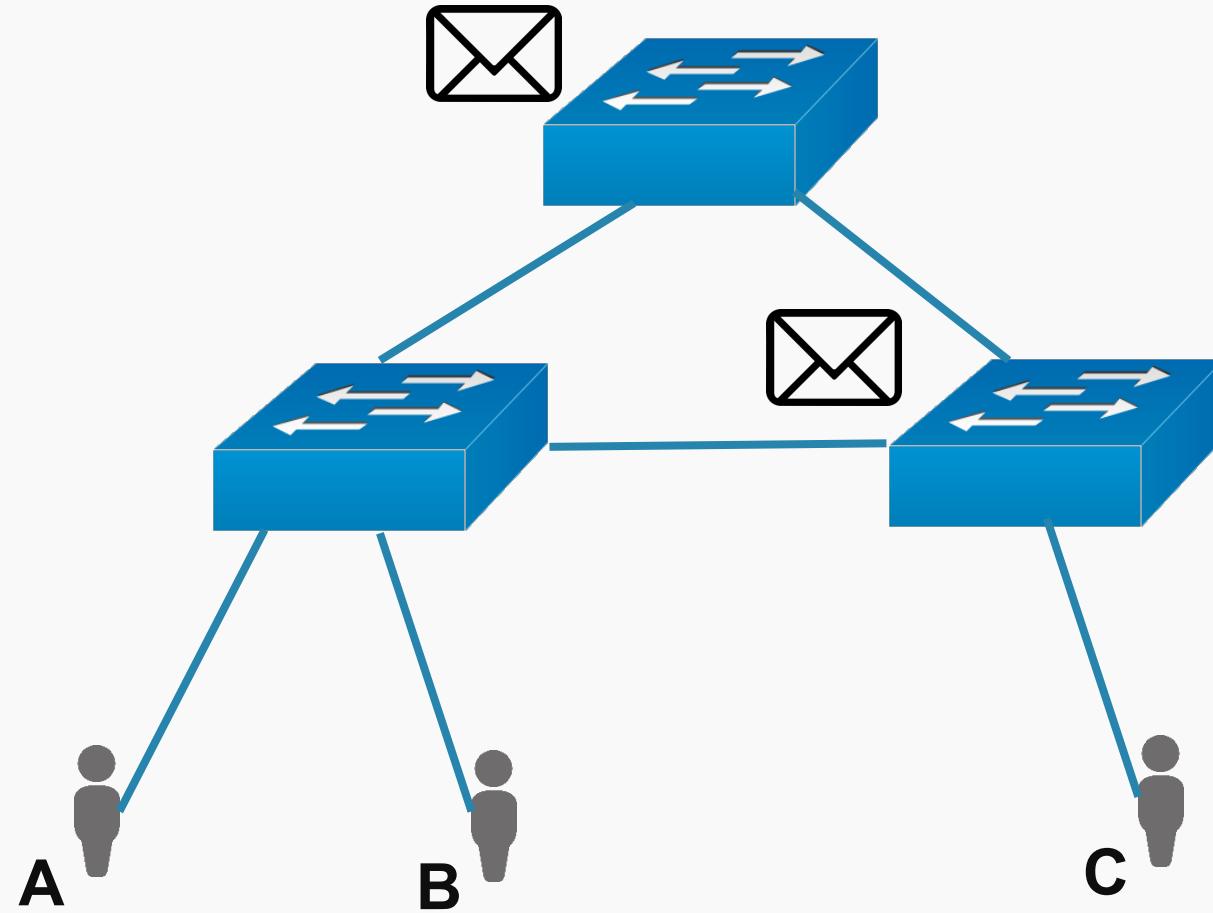


Ethernet – CAM table – Probleme cu cicluri



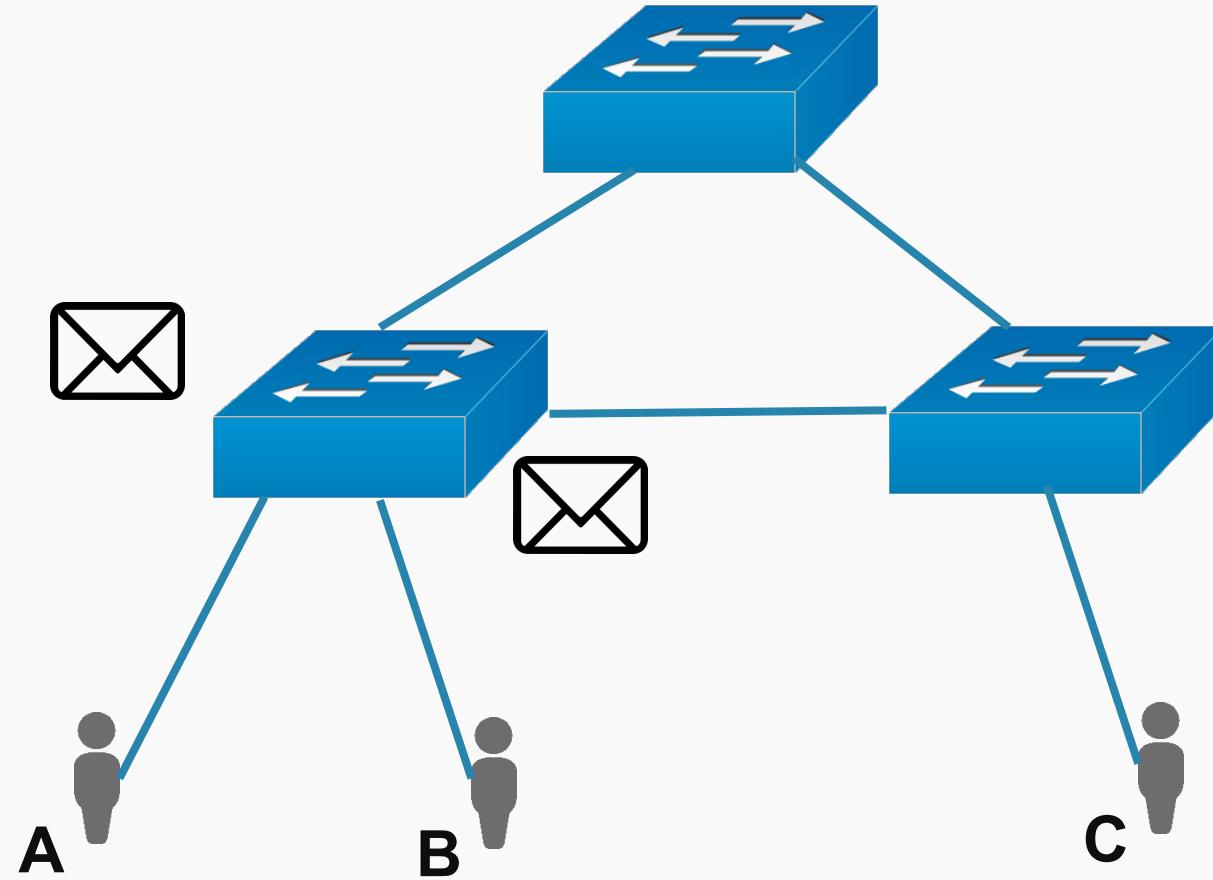


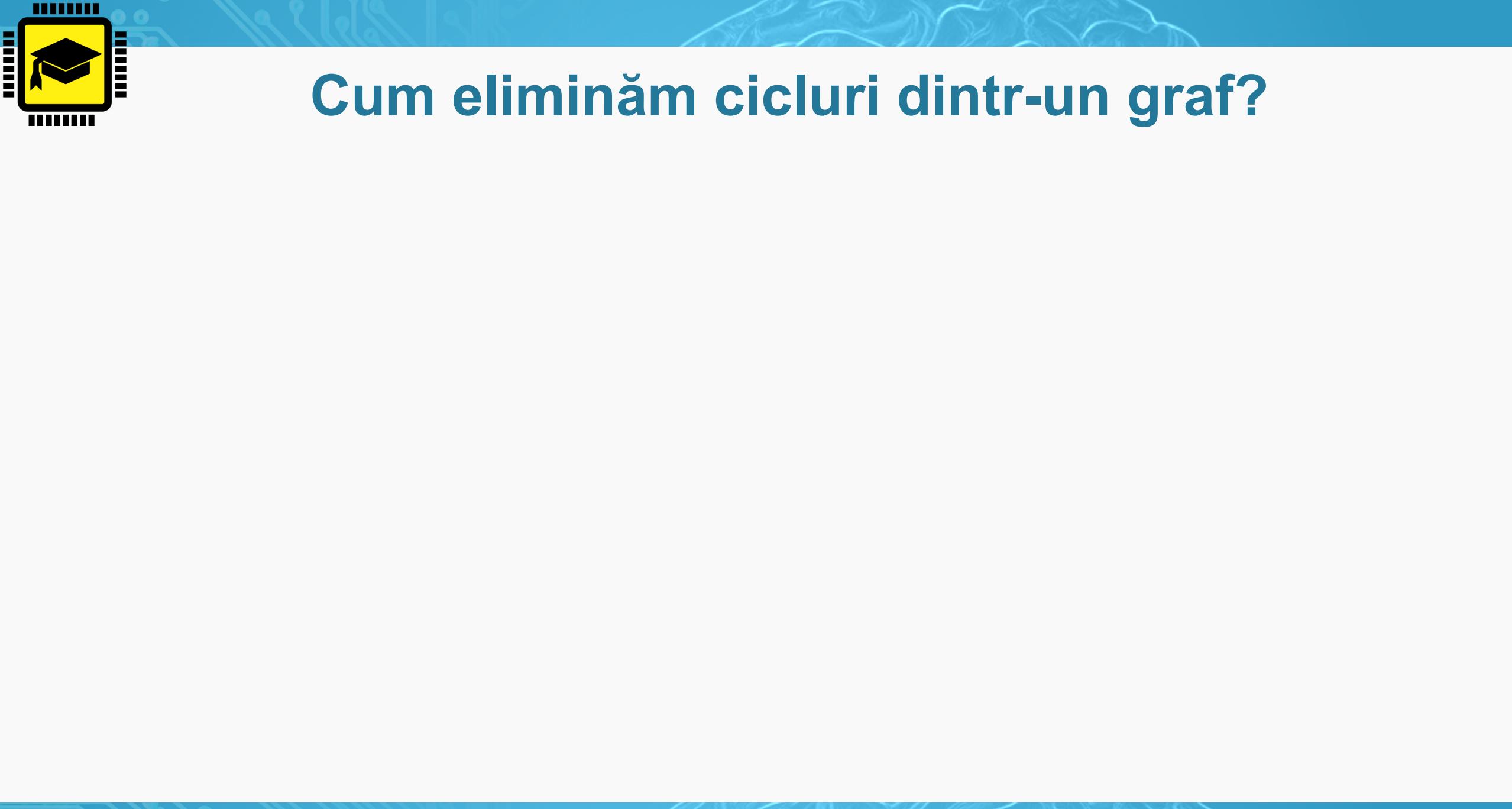
Ethernet – CAM table – Probleme cu cicluri





Ethernet – CAM table – Probleme cu cicluri





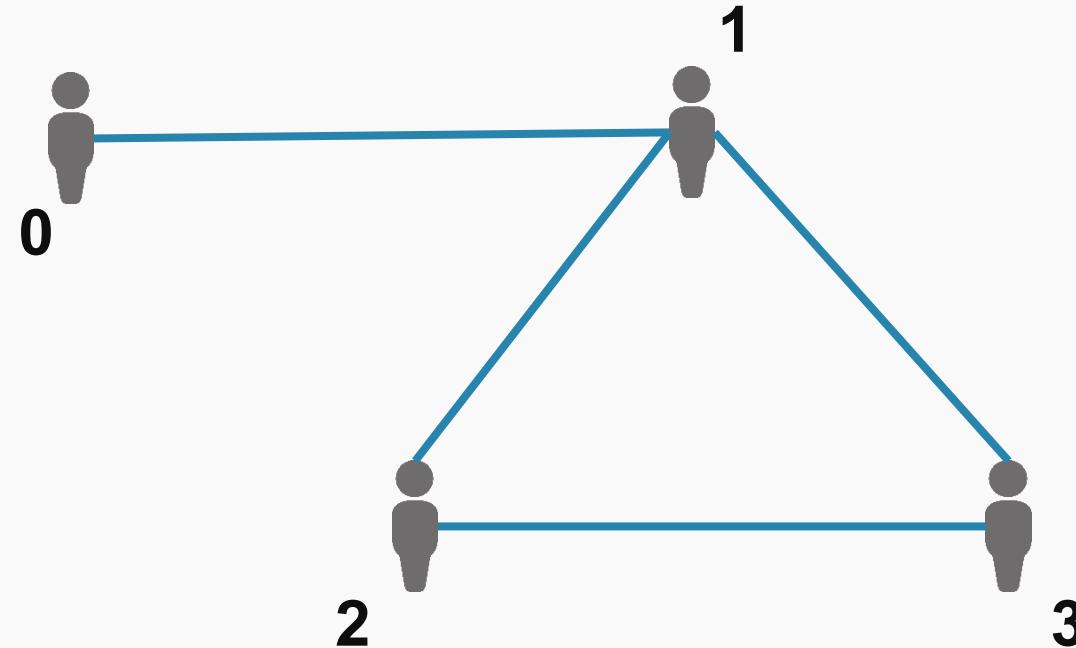


Cum eliminăm cicluri dintr-un graf?

Spanning Tree Protocol

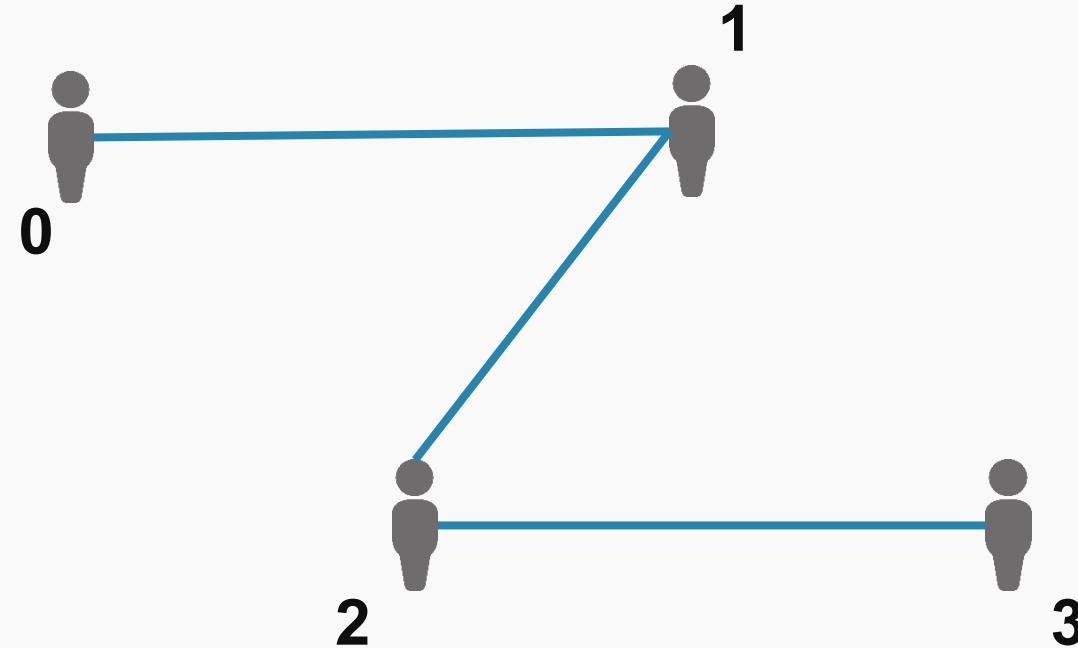


Distributed Spanning Tree



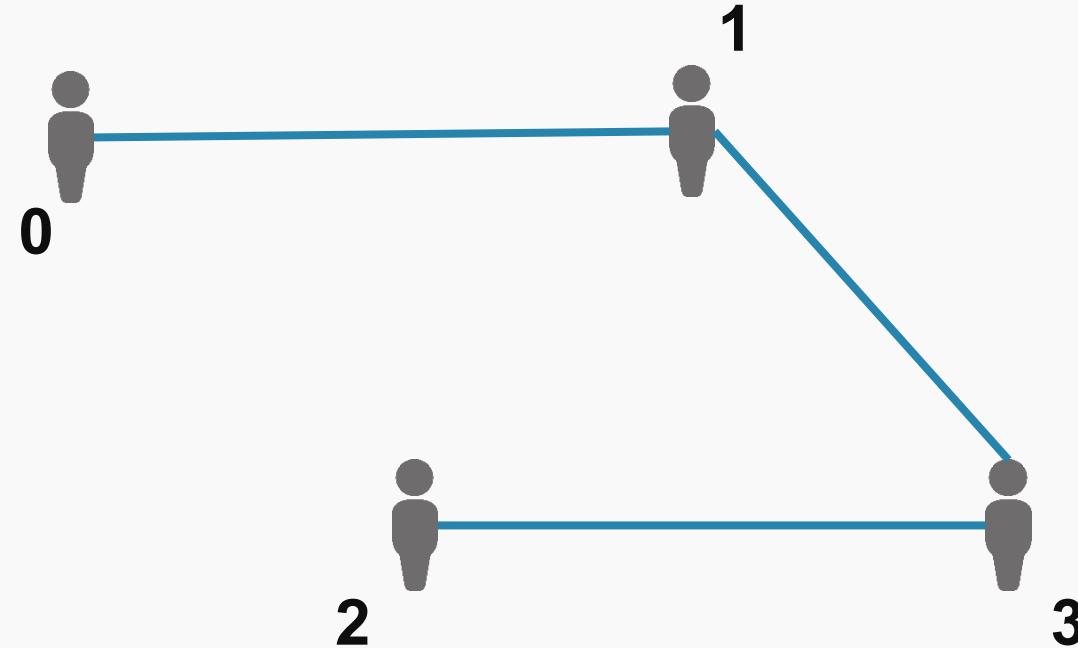


Distributed Spanning Tree – soluția



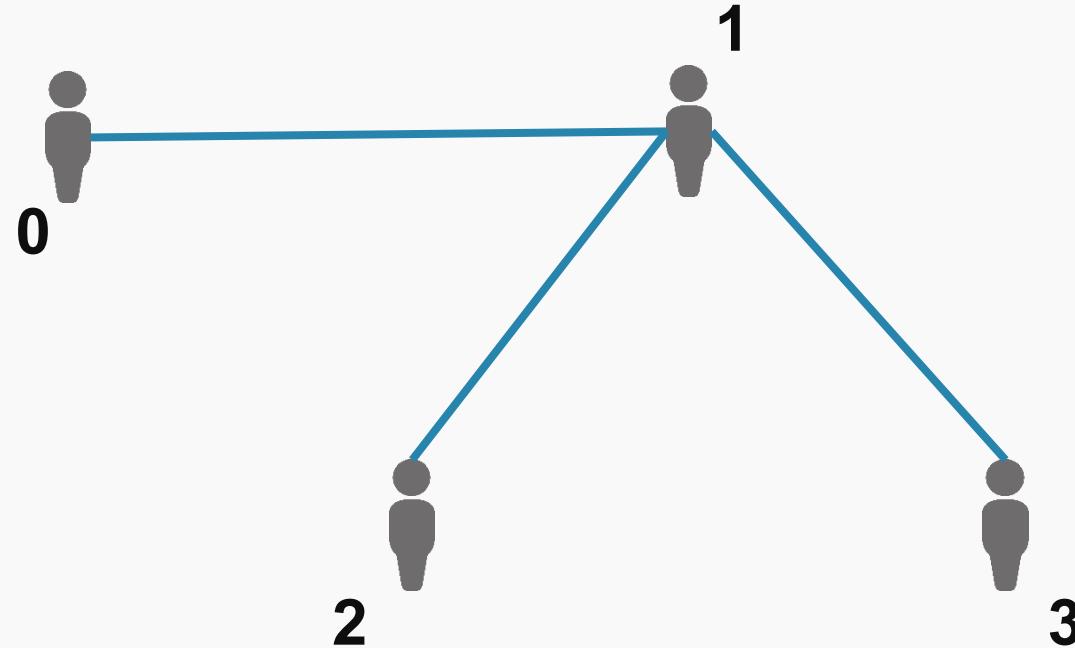


Distributed Spanning Tree - soluția





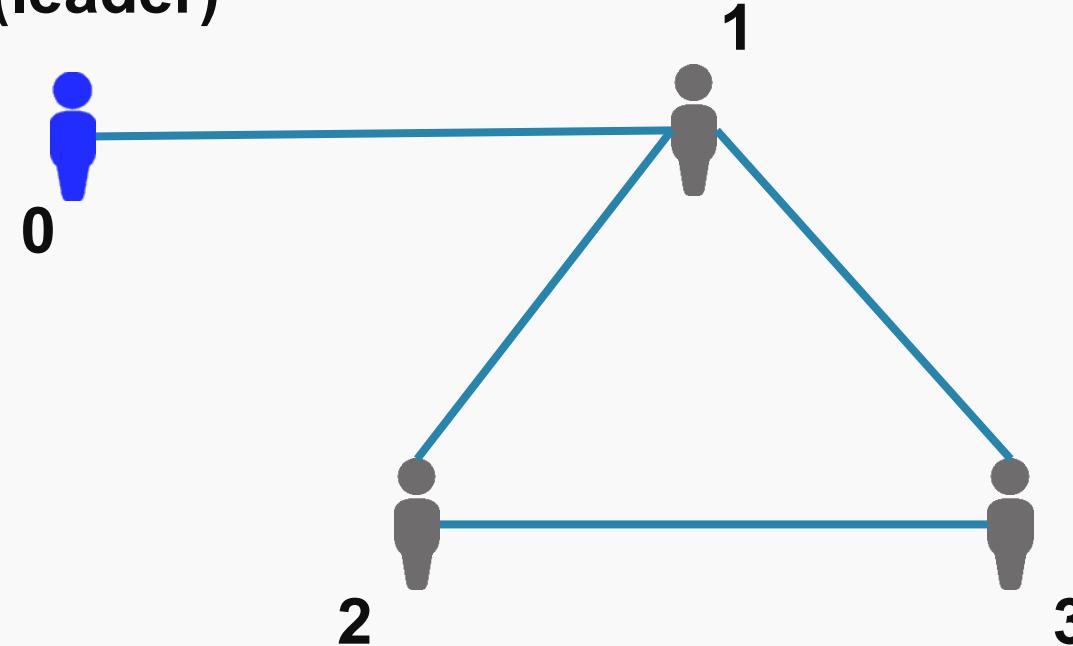
Distributed Spanning Tree - soluția





Distributed Spanning Tree – Initiator

Initiator (leader)





Distributed Spanning Tree

Initiator (leader)



- Send Probe to all neighbors
- Receive response from all neighbors
- Compute the entire graph

- Send graph to everyone



Distributed Spanning Tree

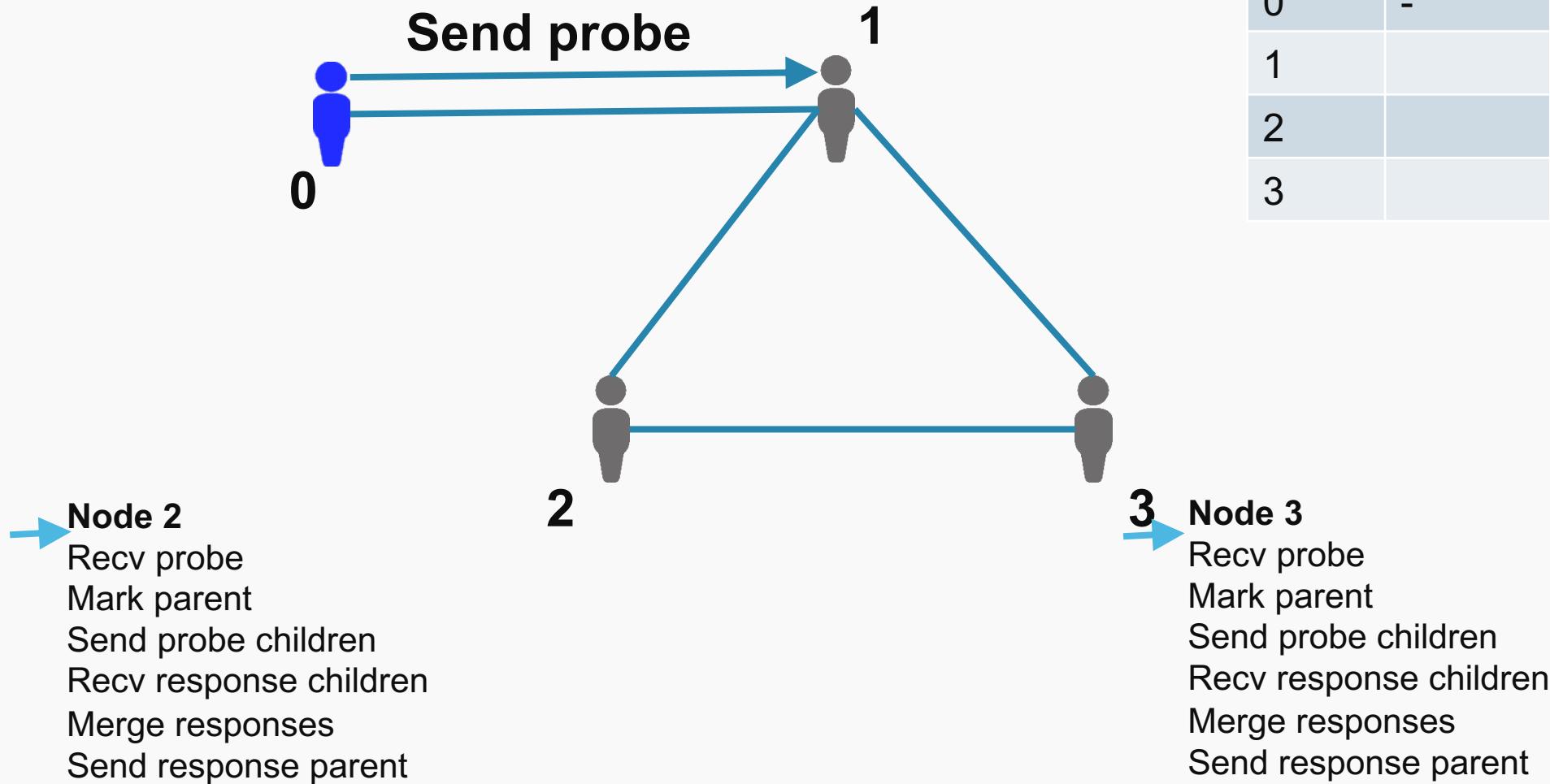
Everyone else



- Receive probe from someone
- That someone is marked as parent
- Forward probe to all neighbors except parent
- Receive response from all neighbors
- Merge responses
- Send response to parent

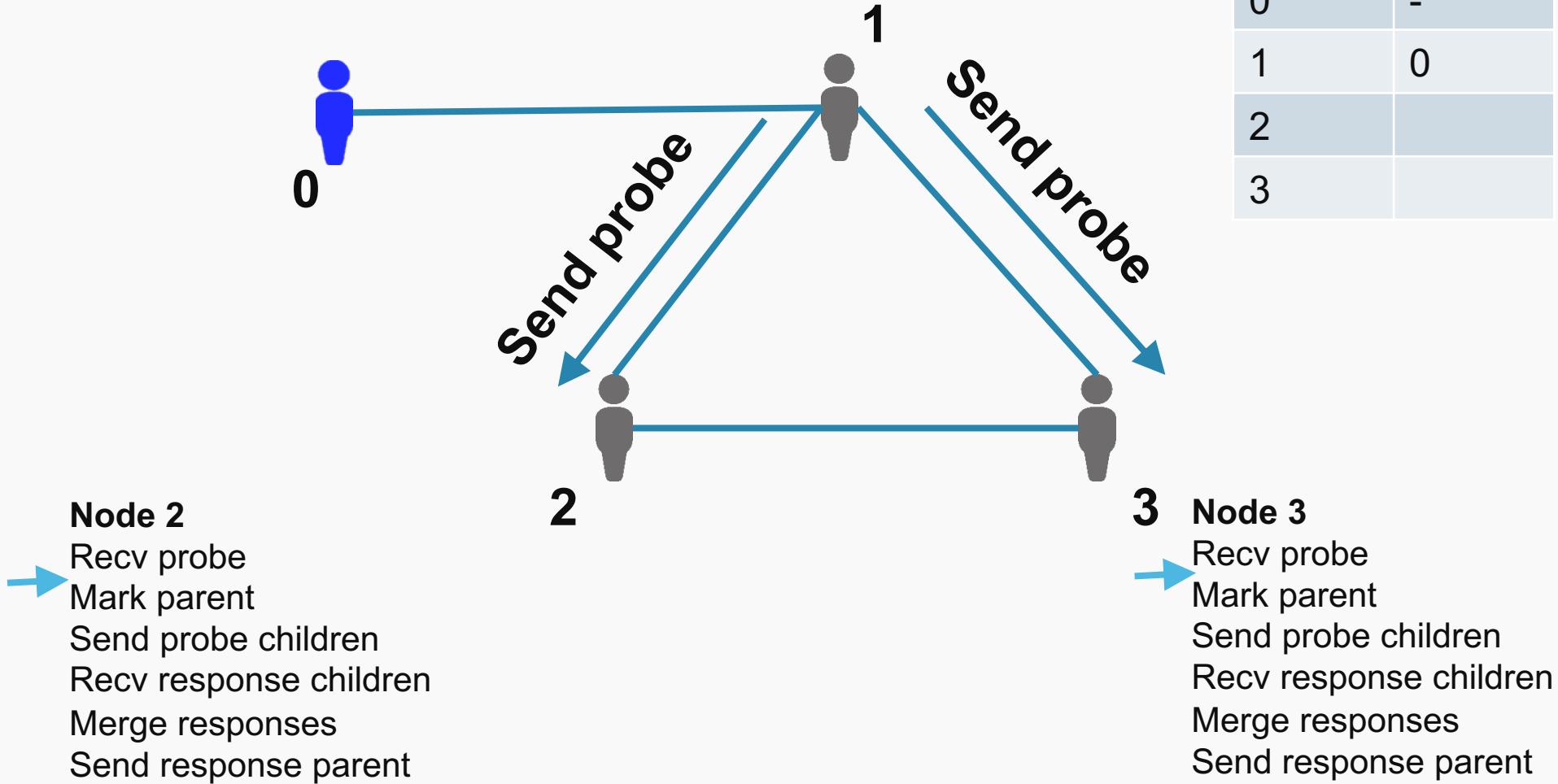


Distributed Spanning Tree



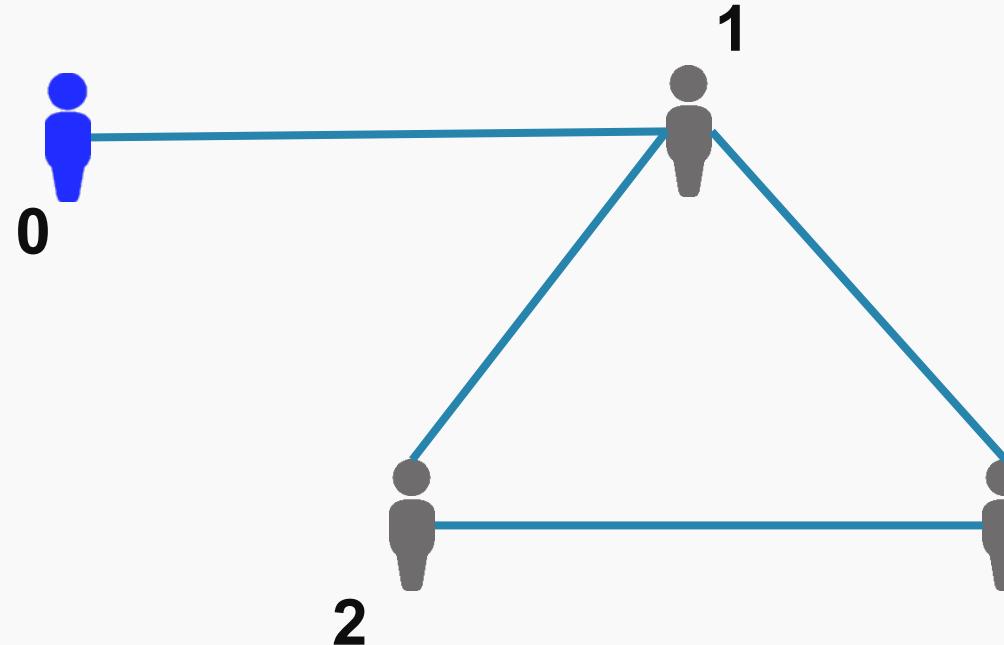


Distributed Spanning Tree





Distributed Spanning Tree



Node	Parent
0	-
1	0
2	1
3	1

Node 2

Recv probe
Mark parent
Send probe children
Recv response children
Merge responses
Send response parent



Node 3

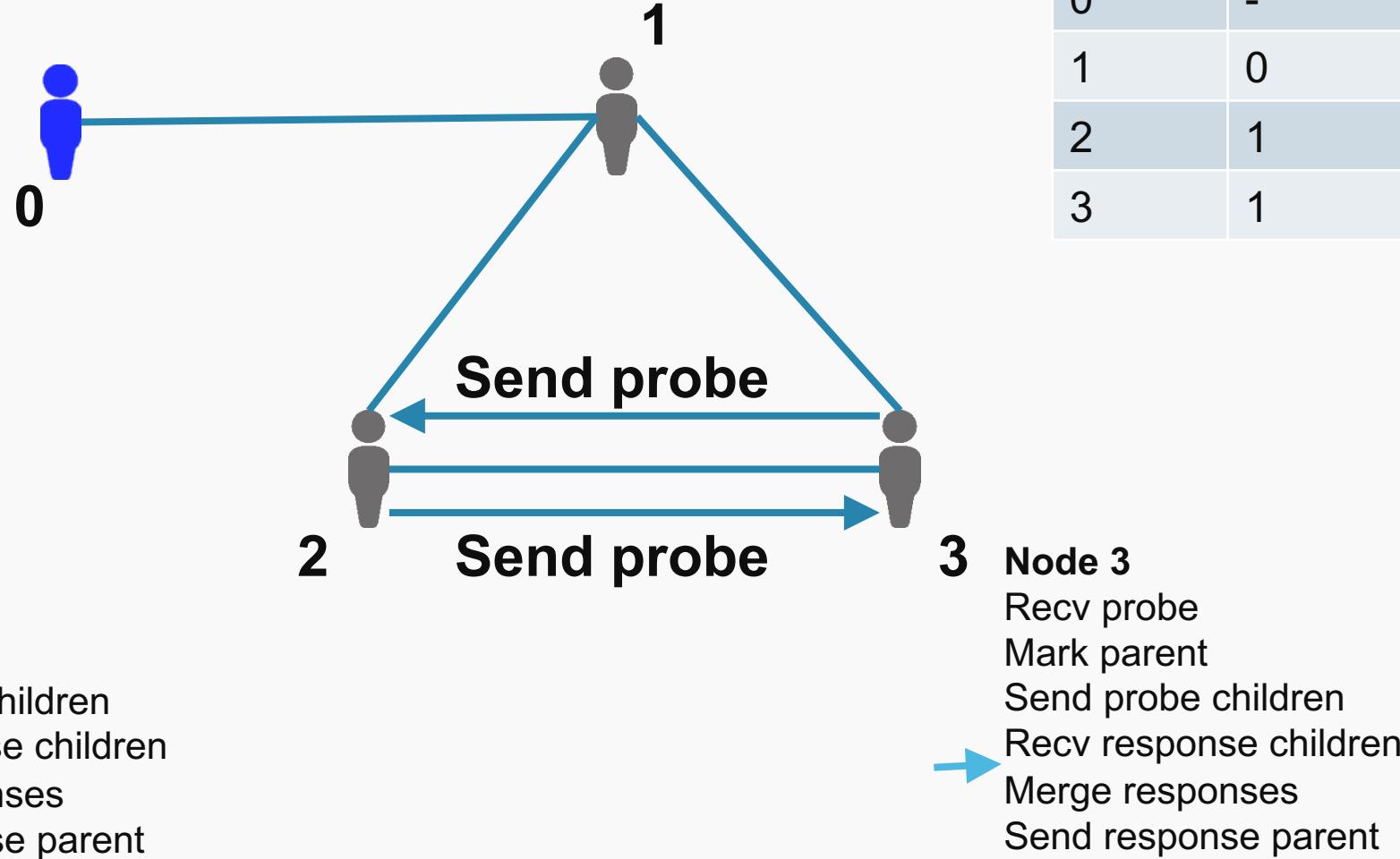
Recv probe
Mark parent
Send probe children
Recv response children
Merge responses
Send response parent





Distributed Spanning Tree – Initiator

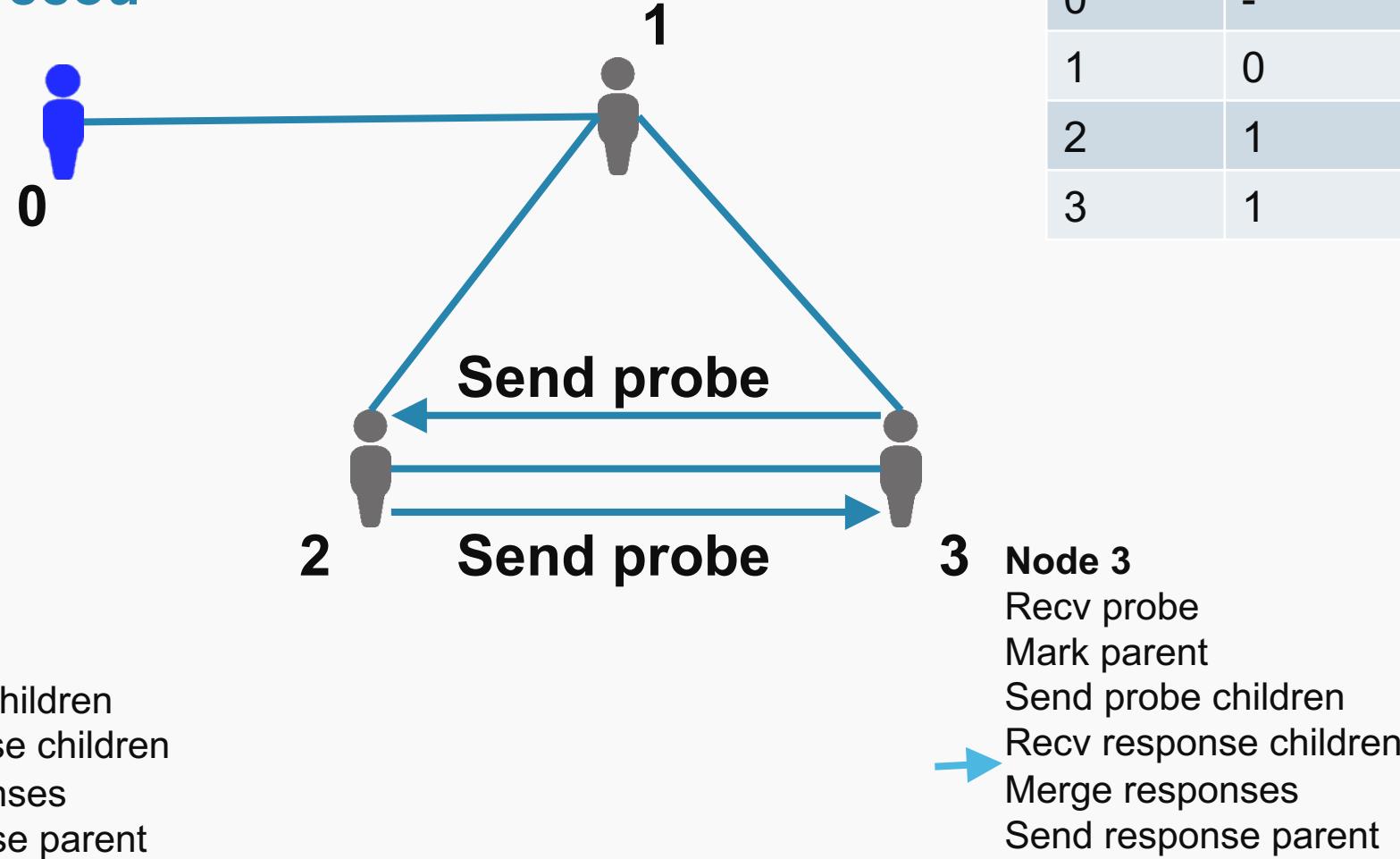
2 și 3 tratează probele unul altuia ca răspunsuri





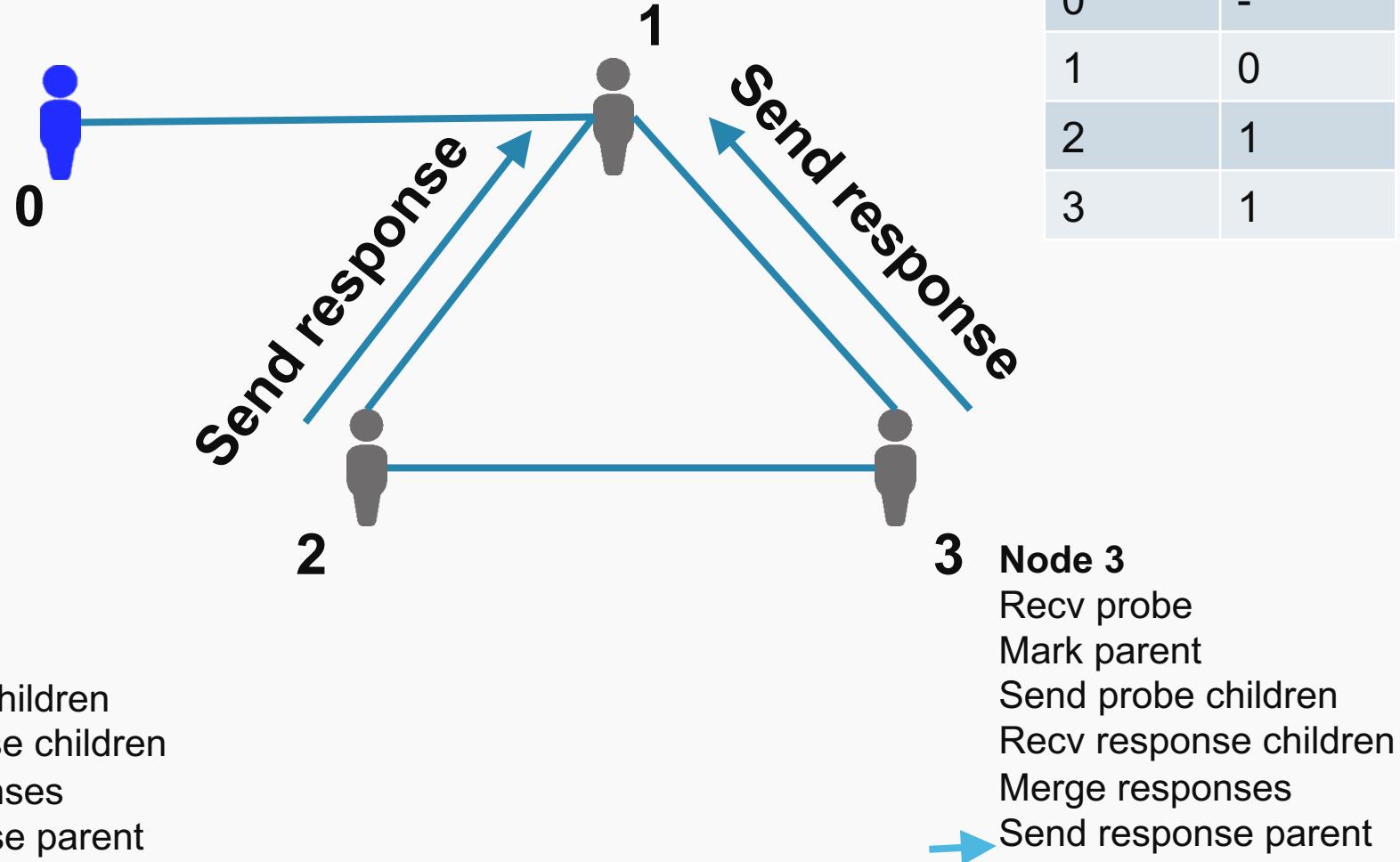
Distributed Spanning Tree – Initiator

Funcționează doar dacă proba are același format ca ecou



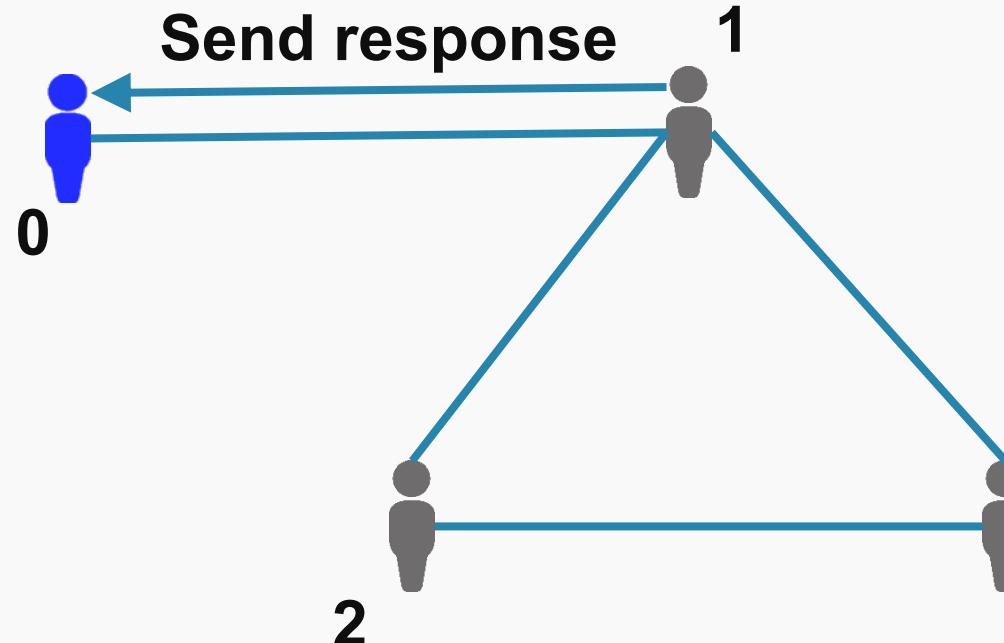


Distributed Spanning Tree





Distributed Spanning Tree



Node 2
Recv probe
Mark parent
Send probe children
Recv response children
Merge responses
Send response parent

Node 3
Recv probe
Mark parent
Send probe children
Recv response children
Merge responses
Send response parent

Node	Parent
0	-
1	0
2	1
3	1



Distributed Spanning Tree

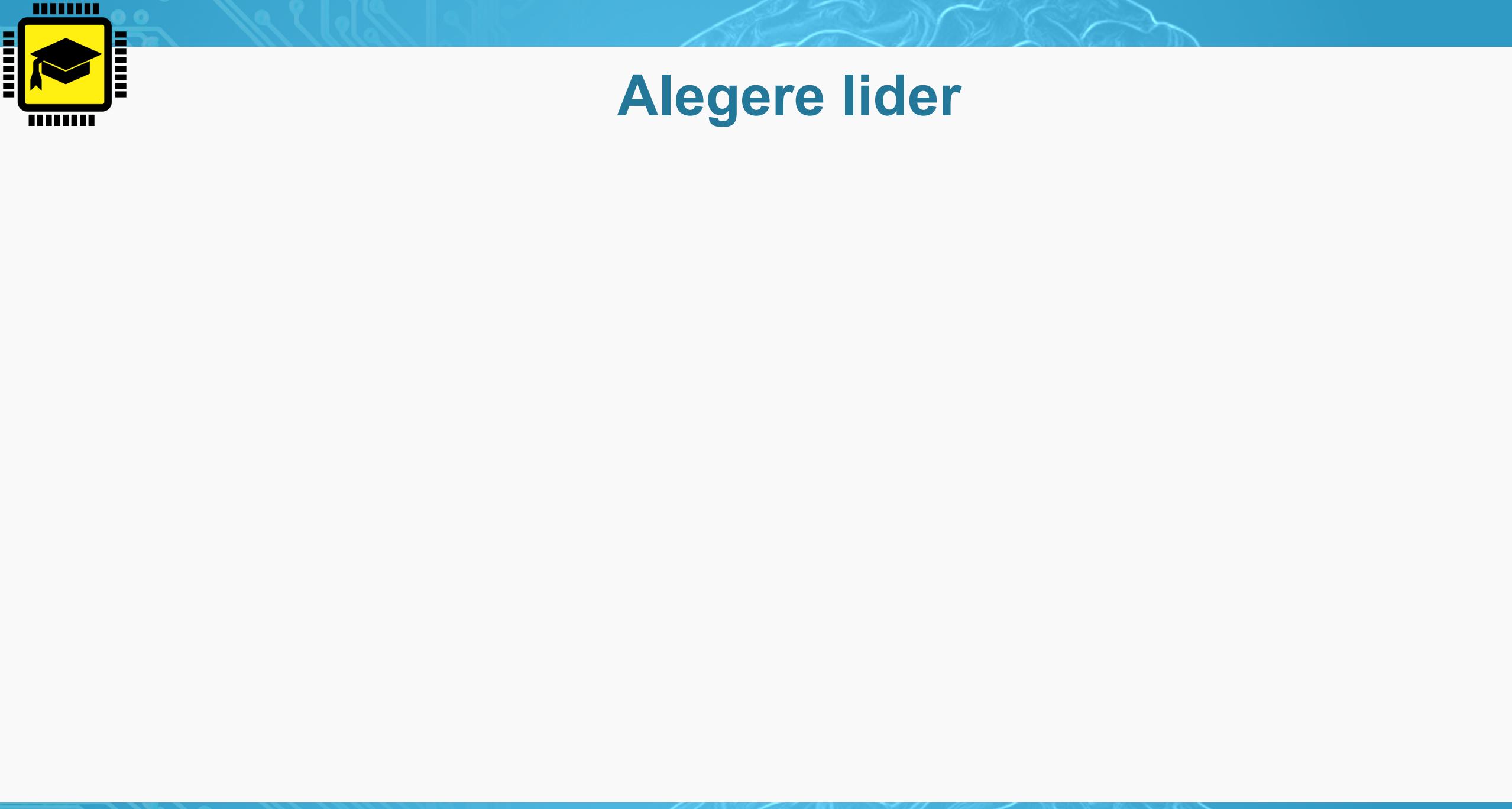
Comunicație full sincronă



Distributed Spanning Tree



Cum alegem inițiatorul?





Alegere lider

Scopul este transformarea automată a unui sistem distribuit, decentralizat, într-un sistem cu topologie client-server;

Mai mult, dacă serverul moare, poate fi ales un nou "lider".



Alegere lider Le Lann

DISTRIBUTED SYSTEMS—TOWARDS A FORMAL APPROACH

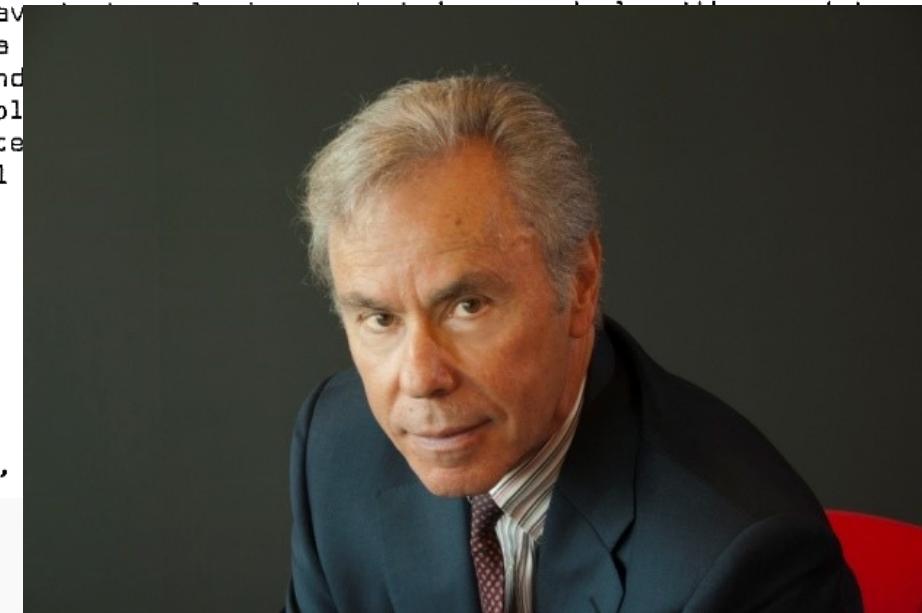
GÉRARD LE LANN

IRISA—Université de Rennes—BP 25 A
35 031 Rennes Cedex, France

Packet-switching computer communication networks are examples of distributed systems. With the large scale emergence of mini and micro-computers, it is now possible to design special or general purpose distributed systems. However, as new problems have been identified, the need for a formal approach has been devised to operate such distributed systems in a reliable manner. In this paper, the basic characteristics of distributed systems are analysed and fundamental problems are discussed. It is shown that distributed systems are not just simple extensions of existing systems. The main difference lies in the techniques used in some planned or existing systems. The main problem in distributed systems is the lack of a common environment. This problem is illustrated by the study of a mutual exclusion problem in a distributed environment.

1. INTRODUCTION

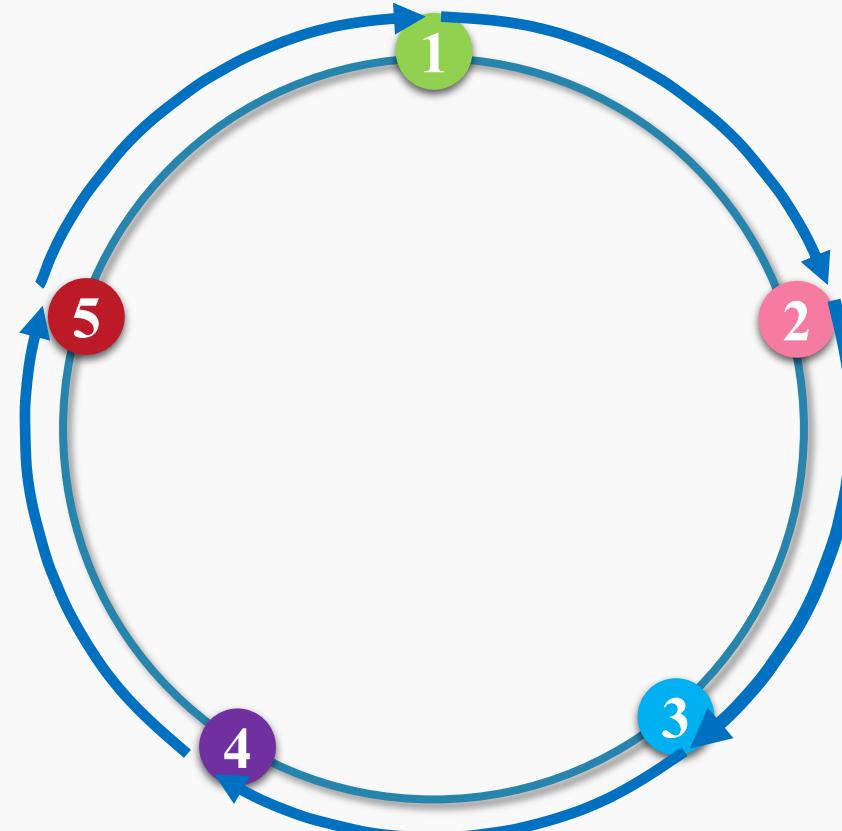
Computer communication networks using packet-switching technology provide for the interconnection of data-processing equipments of any kind. Such systems, sometimes also referred to as computer networks,



C-
S-
is
ato



Algoritmul Le Lann



Fiecare transmite ID-ul său în dreapta

Până își primește ID-ul său
Primește ID din stânga
Trimite ID primit în dreapta

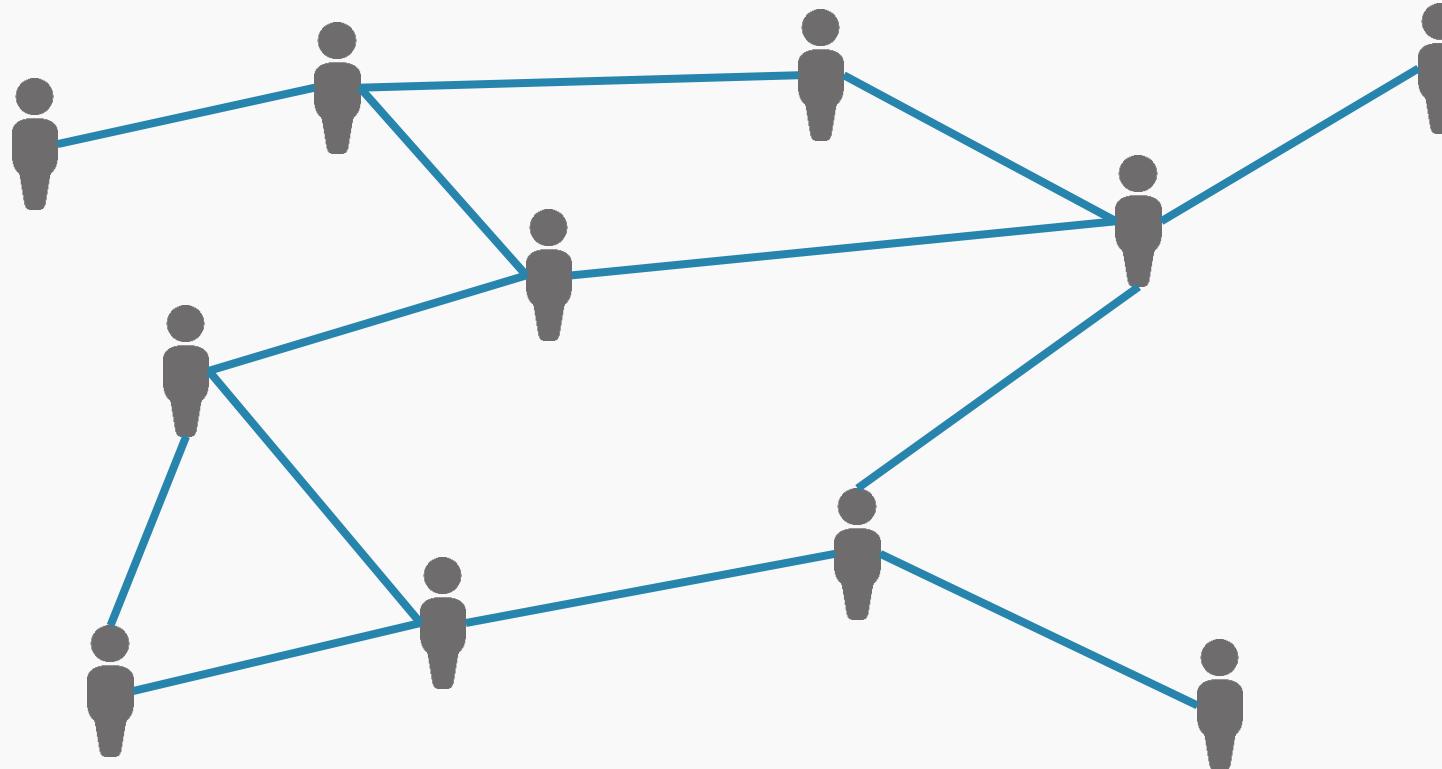
Cel mai mare/mic/etc. este ales lider



De ce mai discutăm despre topologii inel?

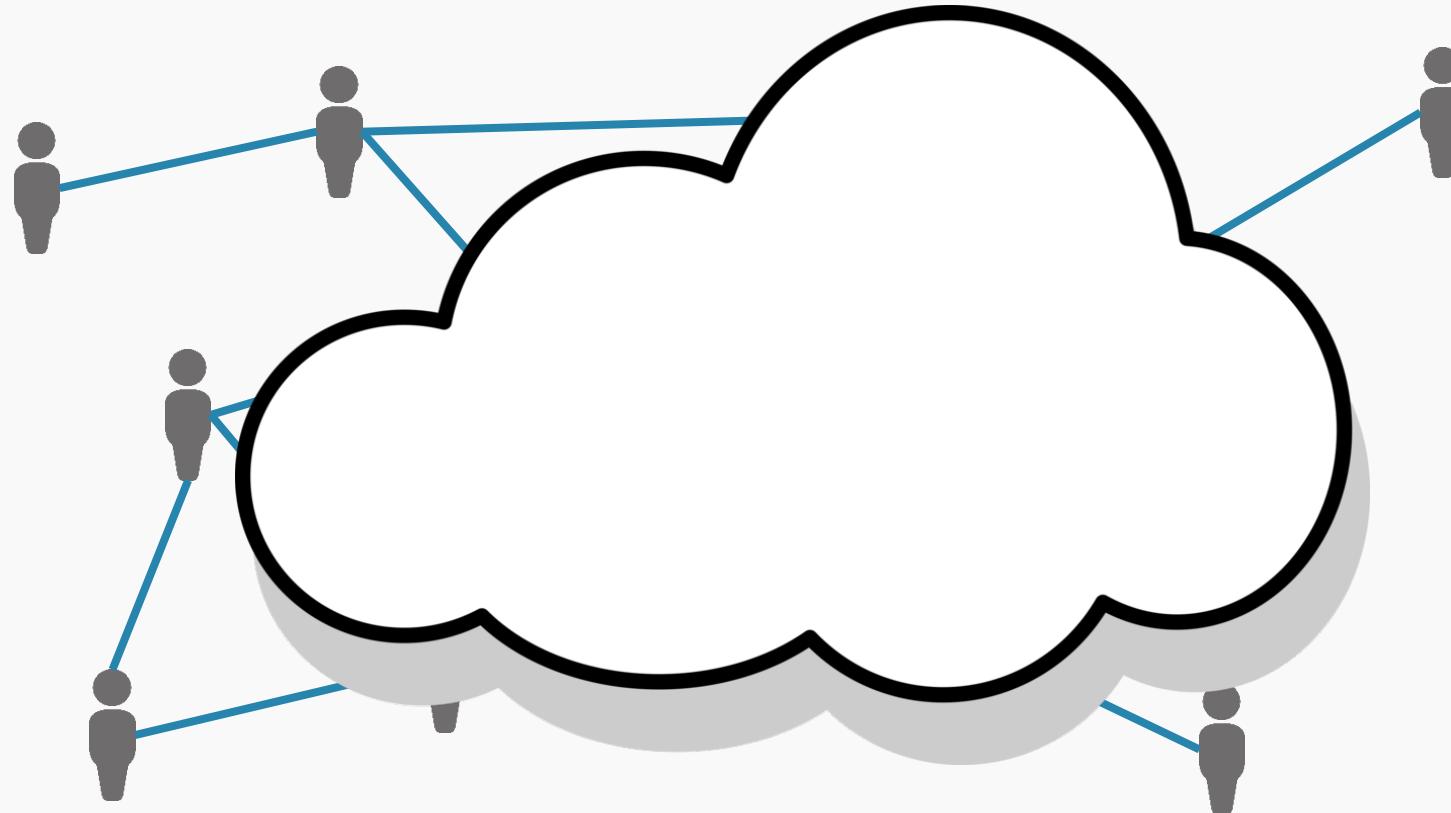


Una e topologia fizică



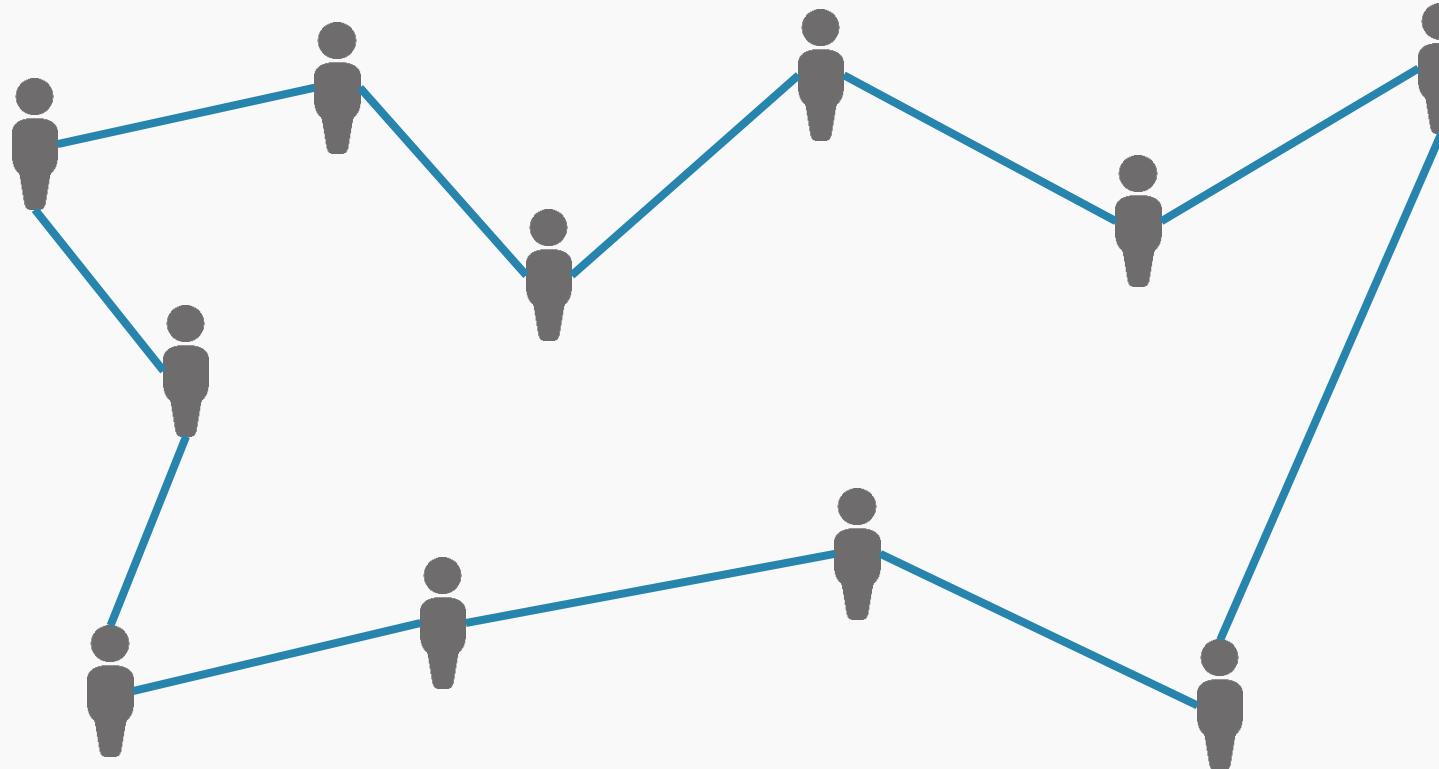


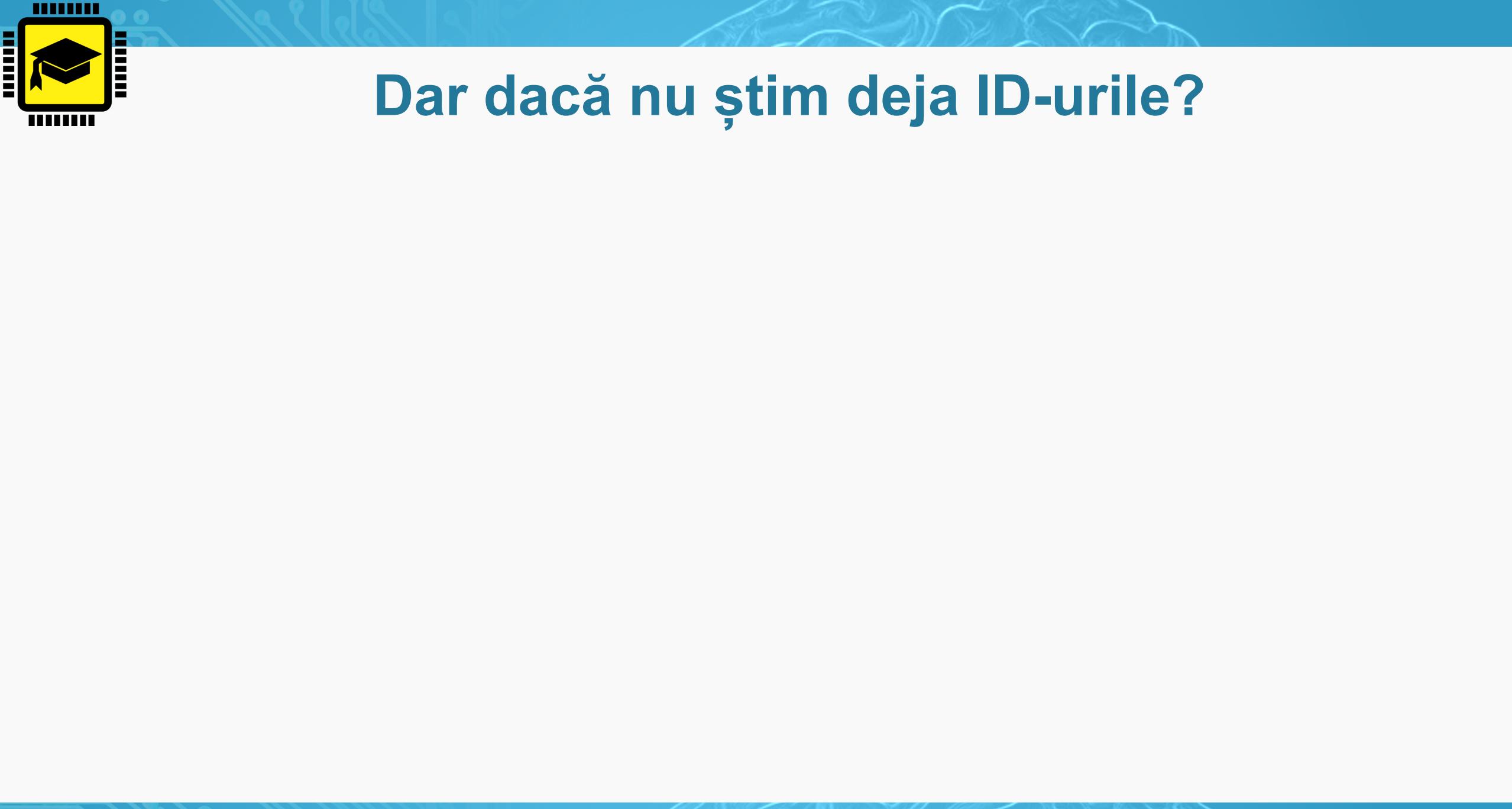
Una e topologia fizică





Alta e topologia software





Dar dacă nu știm deja ID-urile?



UUID sau GUID (Global Unique Identifier)

Network Working Group
Request for Comments: 4122
Category: Standards Track

P. Leach
Microsoft
M. Mealling
Refactored Networks, LLC
R. Salz
DataPower Technology, Inc.
July 2005

A Universally Unique IDentifier (UUID) URN Namespace

Status of This Memo

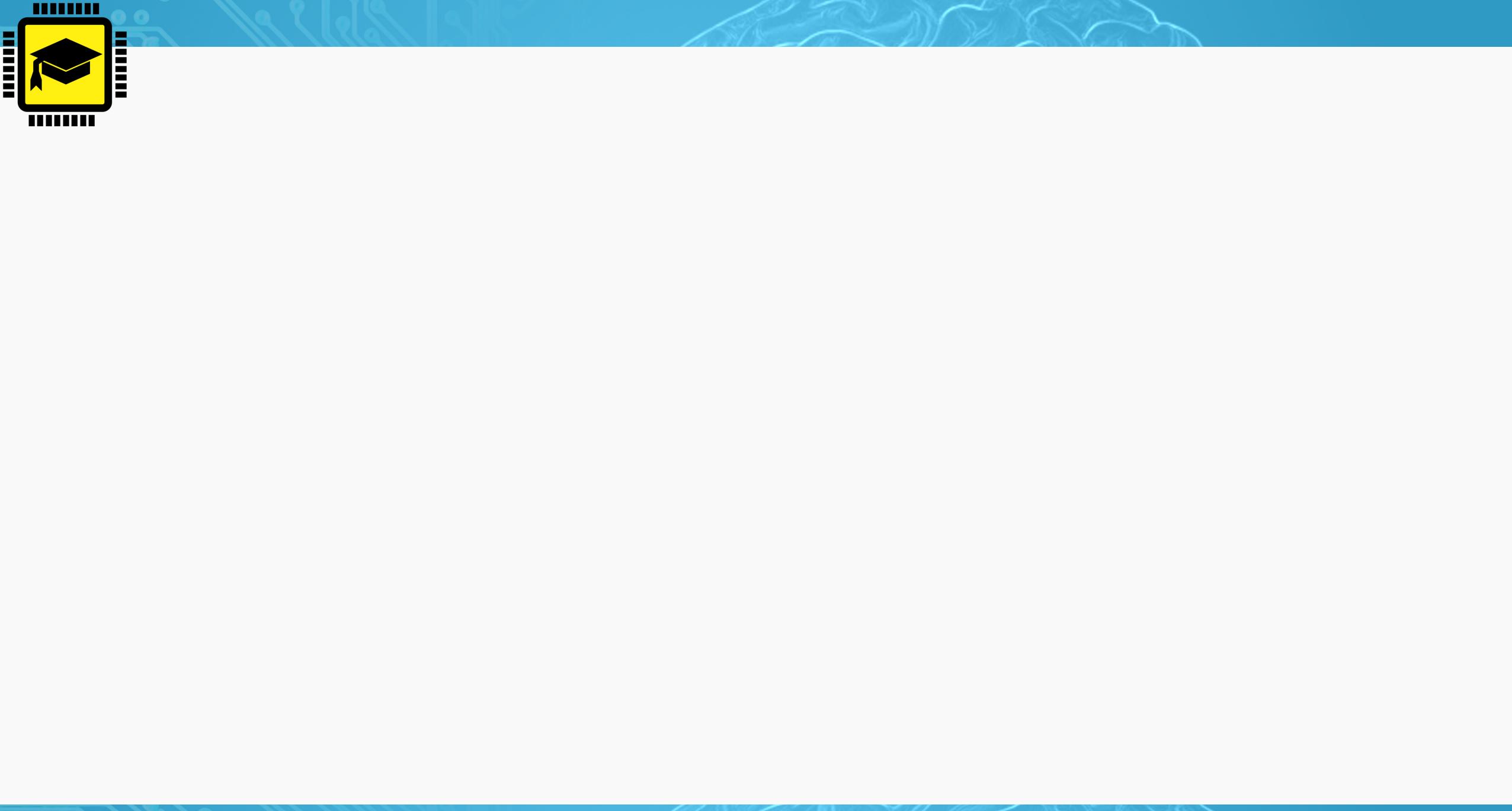
This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Copyright Notice

Copyright (C) The Internet Society (2005).

Abstract

This specification defines a Uniform Resource Name namespace for UUIDs (Universally Unique IDentifier), also known as GUIDs (Globally Unique IDentifier). A UUID is 128 bits long, and can guarantee uniqueness across space and time. UUIDs were originally used in the Apollo Network Computing System and later in the Open Software





Stabilirea Topologiei IP

În alte cuvinte: stabilirea rutelor și tabelelor de rutare.



Algoritmi de stabilire rute în IP?



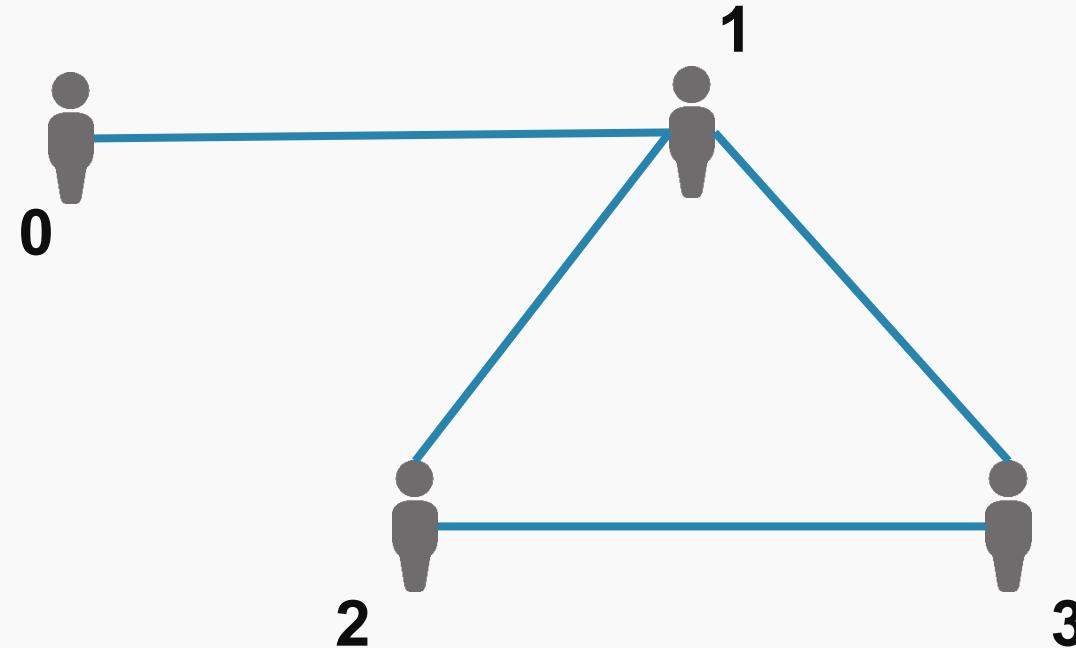
Algoritmi de stabilire rute în IP?

- BGP
- RIP
- IGRP
- EIGRP
- OSPF

-



Algoritm stabilire topologie





Algoritm stabilire topologie



Trimite topologie cunoscută tuturor vecinilor
Primește de la toți vecinii topologiile cunoscute de ei
Adaugă informații la topologia cunoscută.

Repetă la infinit!!



Algoritm stabilire topologie



Trimite topologie cunoscută tuturor vecinilor
Primește de la toți vecinii topologiile cunoscute de ei
Adaugă informații la topologia cunoscută.

Repetă la infinit!!

Atenție în forma actuală nu se pot șterge conexiuni.



Algoritm stabilire topologie

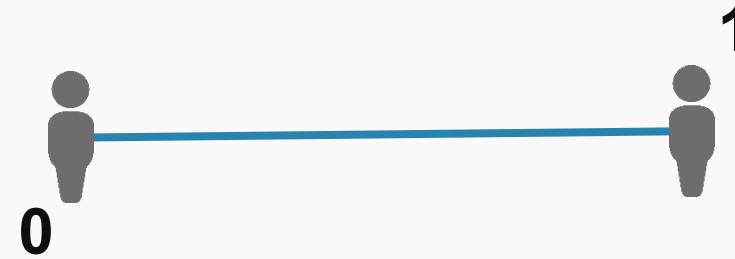


Trimite topologie cunoscută tuturor vecinilor
Primește de la toți vecinii topologiile cunoscute de ei
Adaugă informații la topologia cunoscută.

Dacă topologia s-a modificat, repetă.

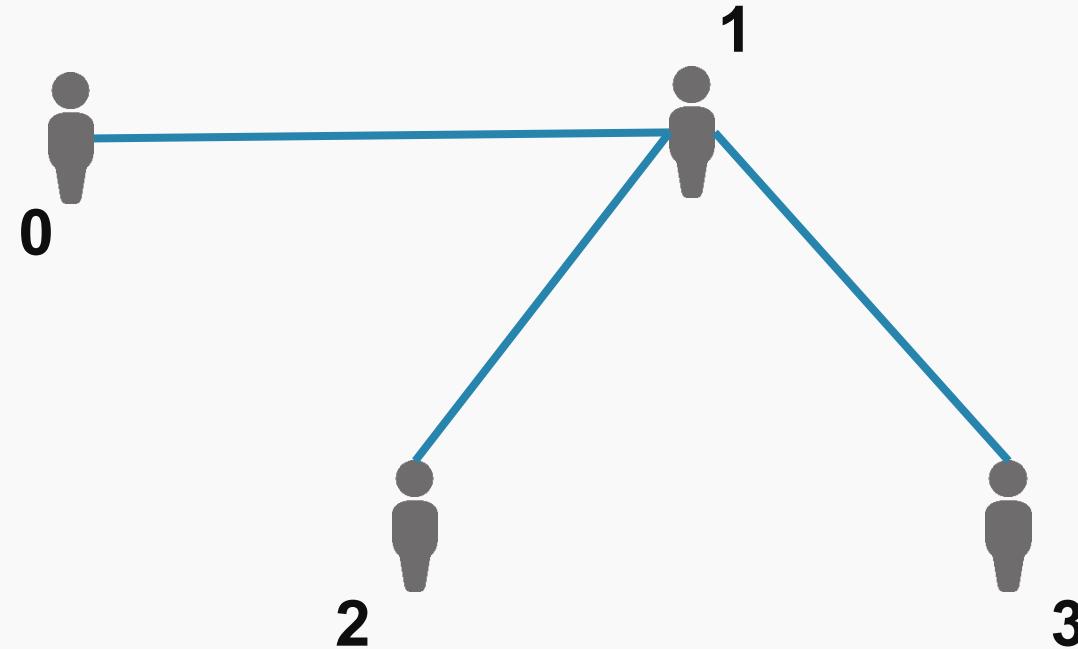


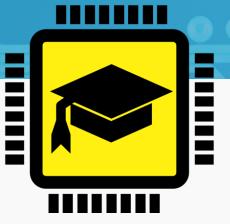
Topologii inițiale - 0



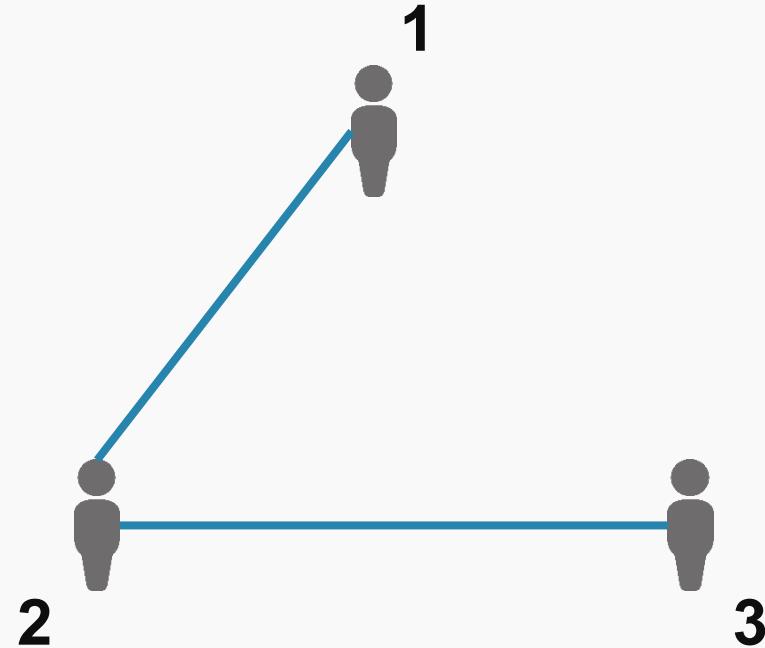


Topologii inițiale - 1



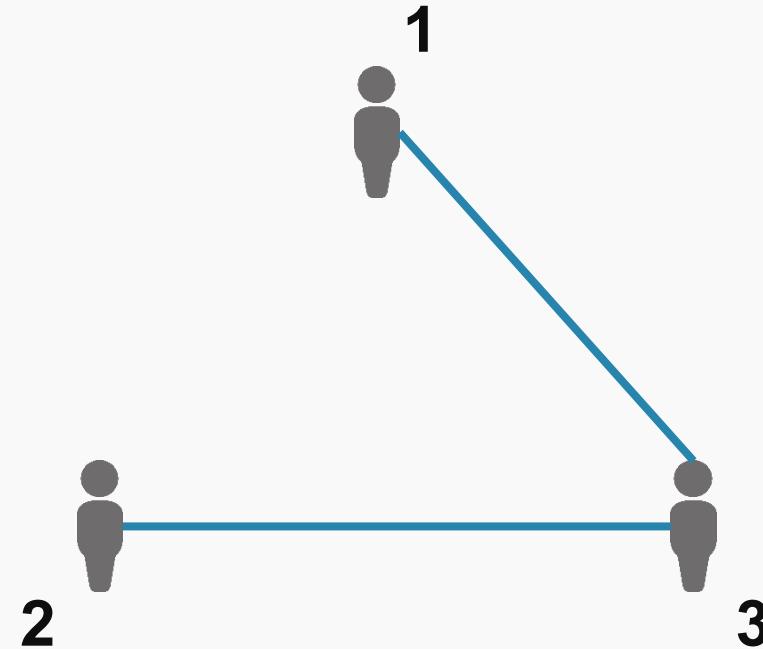


Topologii inițiale - 2





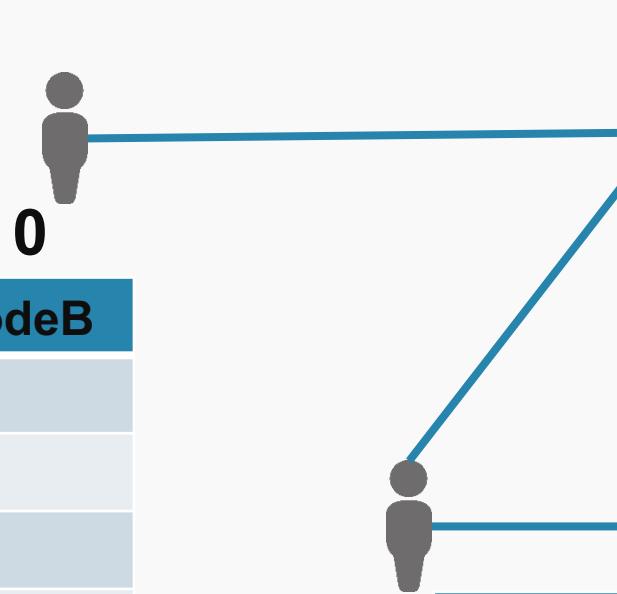
Topologii inițiale - 3





Algoritm stabilire topologie

NodeA	NodeB
0	1



NodeA	NodeB
1	0
1	2
1	3

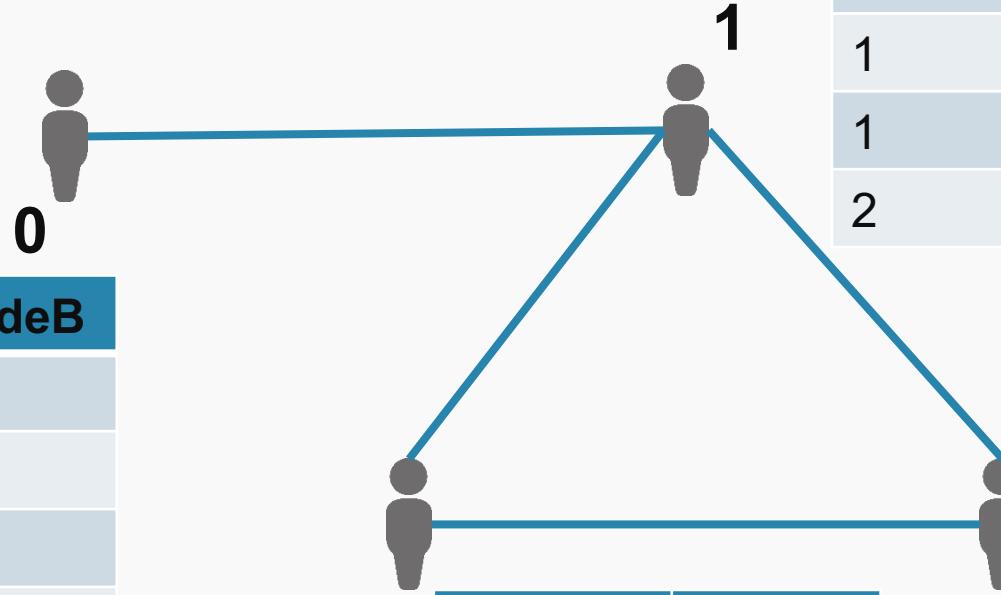
NodeA	NodeB
2	1
2	3

NodeA	NodeB
3	1
3	2



Algoritm stabilire topologie

NodeA	NodeB
0	1
1	2
1	3



NodeA	NodeB
1	0
1	2
1	3
2	3

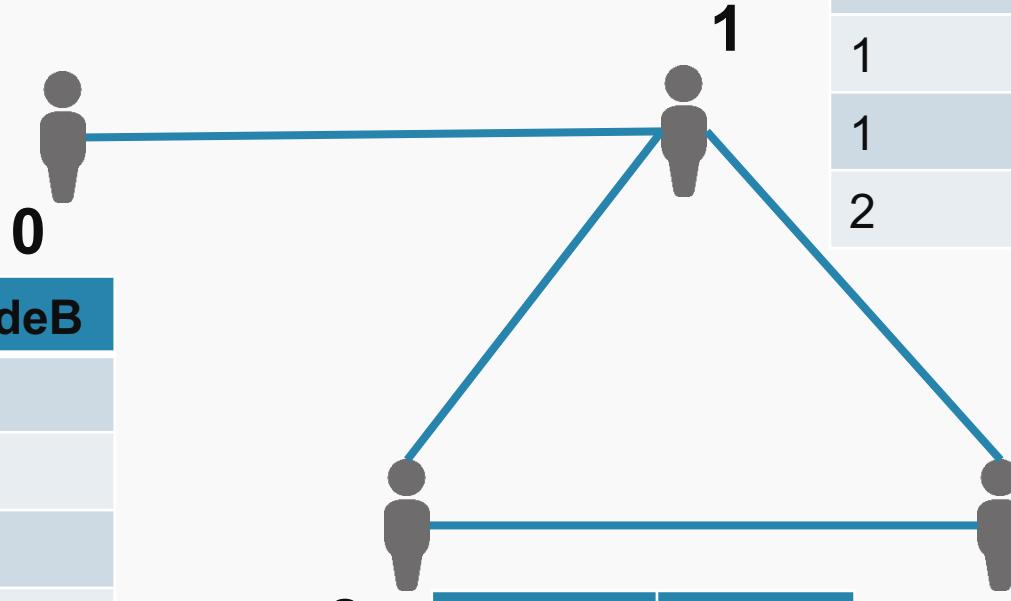
NodeA	NodeB
2	1
2	3
1	0
1	3

NodeA	NodeB
3	1
3	2
1	0
1	2



Algoritm stabilire topologie

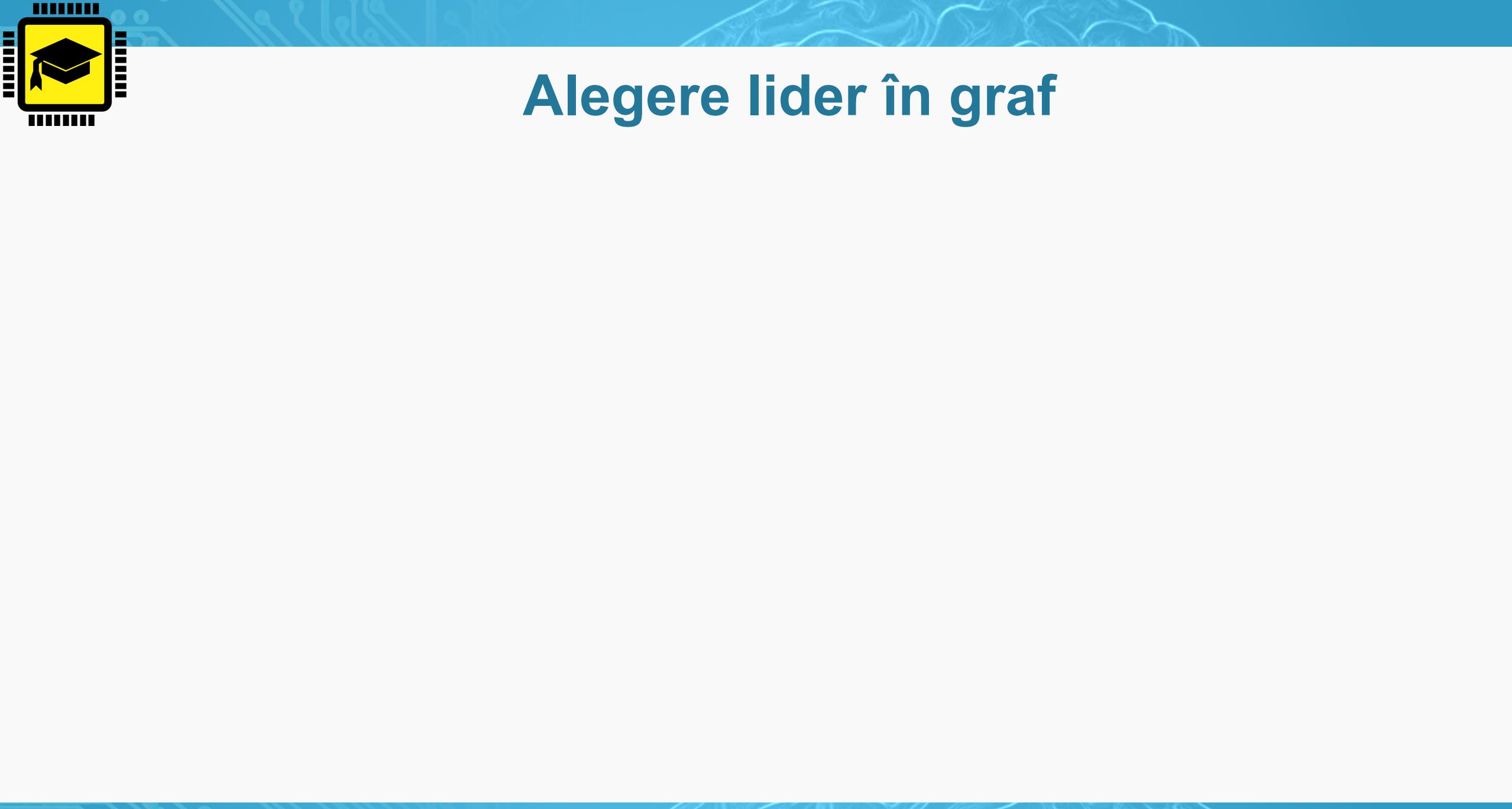
NodeA	NodeB
0	1
1	2
1	3
2	3



NodeA	NodeB
1	0
1	2
1	3
2	3

NodeA	NodeB
2	1
2	3
1	0
1	3

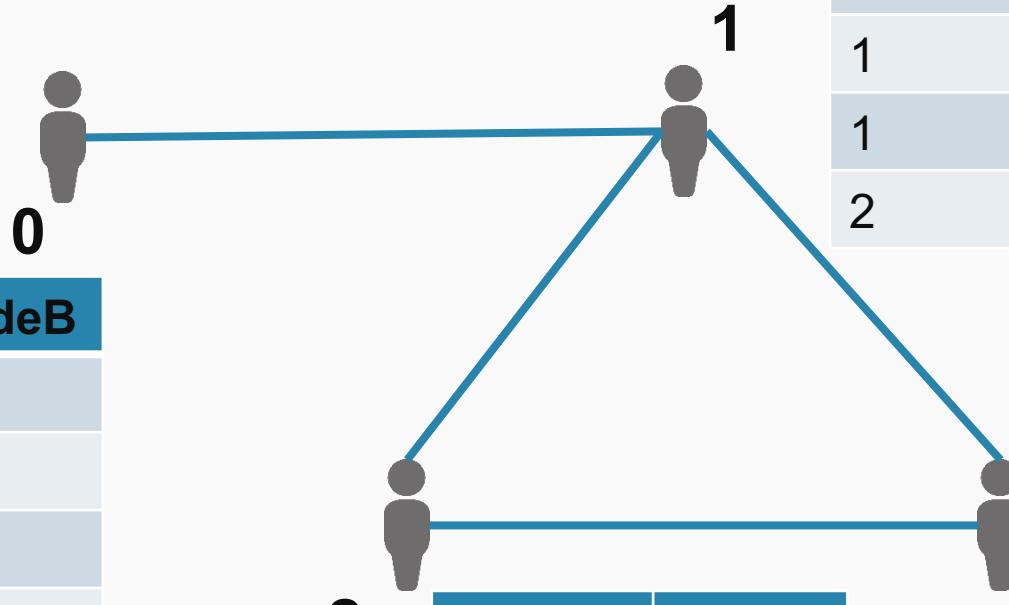
NodeA	NodeB
3	1
3	2
1	0
1	2





Alegere lider în graf

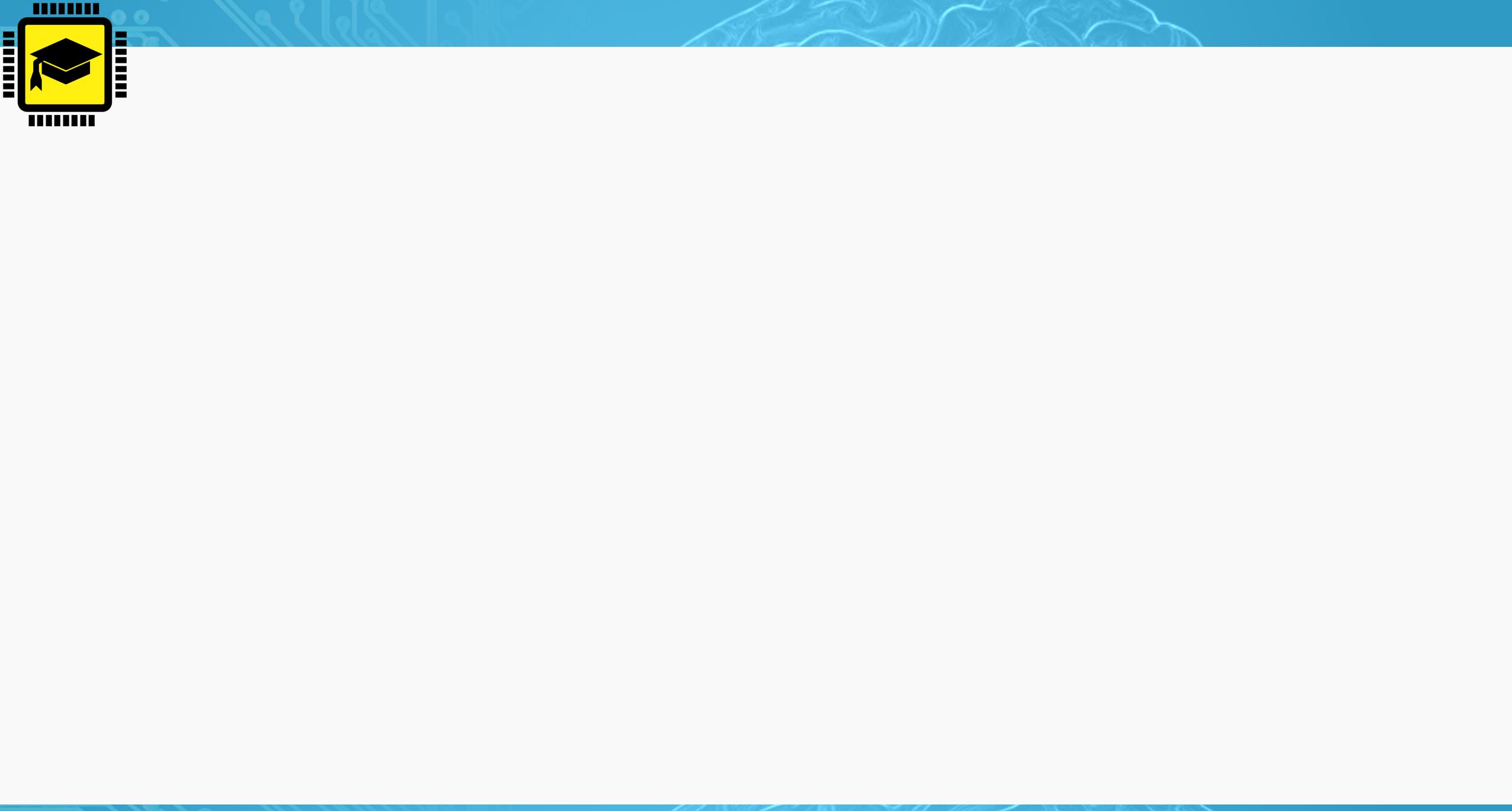
NodeA	NodeB
0	1
1	2
1	3
2	3



NodeA	NodeB
2	1
2	3
1	0
1	3

NodeA	NodeB
1	0
1	2
1	3
2	3

NodeA	NodeB
3	1
3	2
1	0
1	2





Cine a construit The World-Wide Web?



Cine a construit The World-Wide Web?

Tim Berners-Lee

Network Working Group
Request for Comments: 2068
Category: Standards Track

R. Fielding
UC Irvine
J. Gettys
J. Mogul
DEC
H. Frystyk
T. Berners-Lee
MIT/LCS
January 1997

Hypertext Transfer Protocol -- HTTP/1.1

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Abstract

The Hypertext Transfer Protocol (HTTP) is an application-level protocol for distributed, collaborative, hypermedia information systems. It is a generic, stateless, object-oriented protocol which can be used for many tasks, such as name servers and distributed object management systems, through extension of its request methods. A feature of HTTP is the typing and negotiation of data representation, allowing systems to be built independently of the data being transferred.





Cine a construit The World-Wide Web? Tim Berners-Lee

Network Working Group
Request for Comments: 1738
Category: Standards Track

T. Berners-Lee
CERN
L. Masinter
Xerox Corporation
M. McCahill
University of Minnesota
Editors
December 1994

Uniform Resource Locators (URL)

Status of this Memo

This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution of this memo is unlimited.

Abstract

This document specifies a Uniform Resource Locator (URL), the syntax and semantics of formalized information for location and access of resources via the Internet.

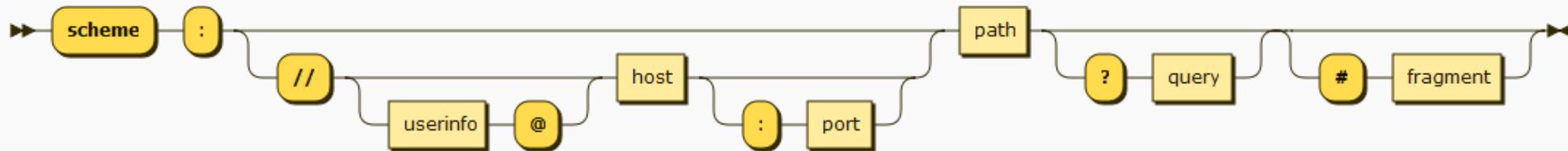
1. Introduction

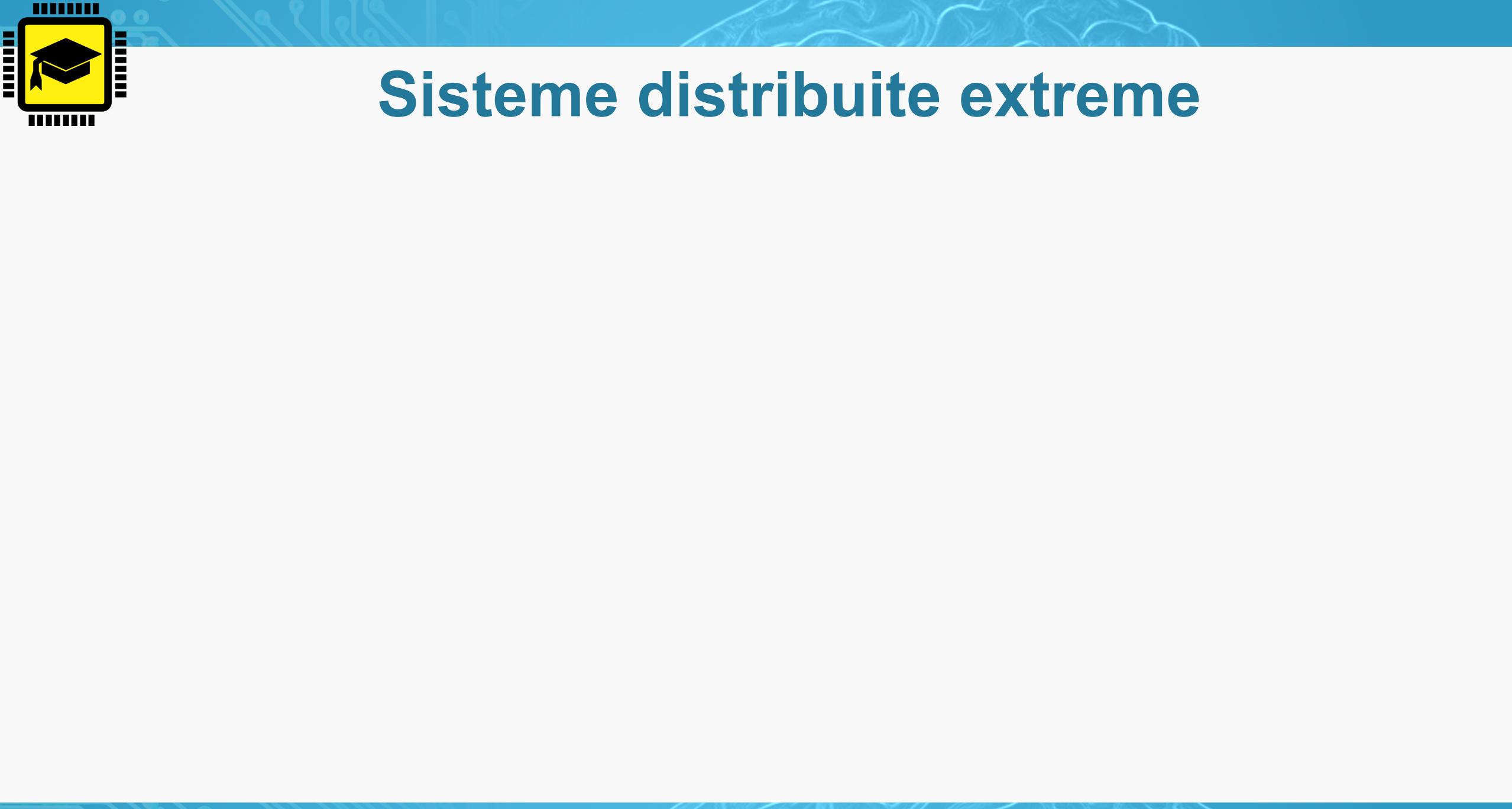
This document describes the syntax and semantics for a compact string representation for a resource available via the Internet. These

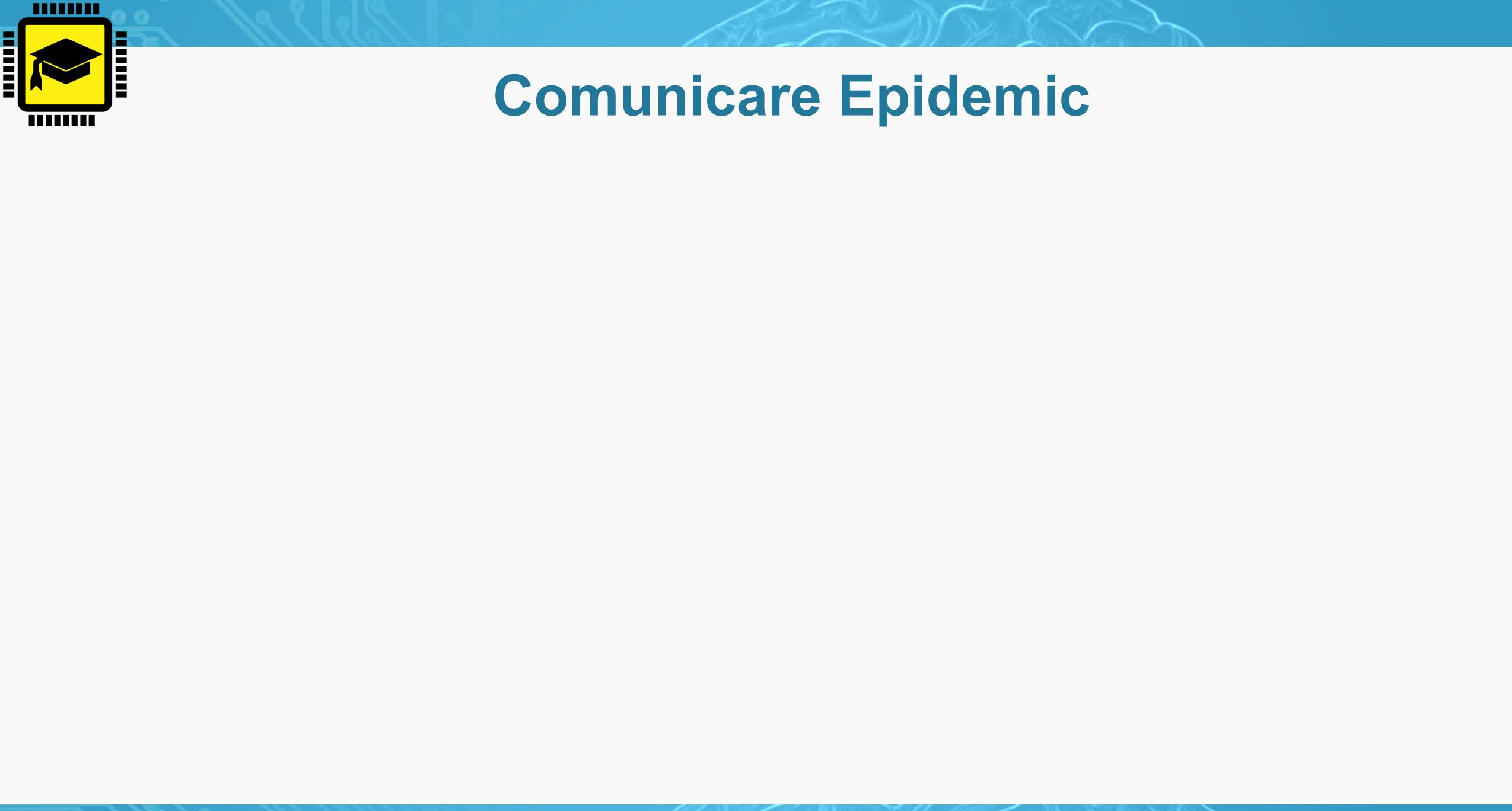




URL

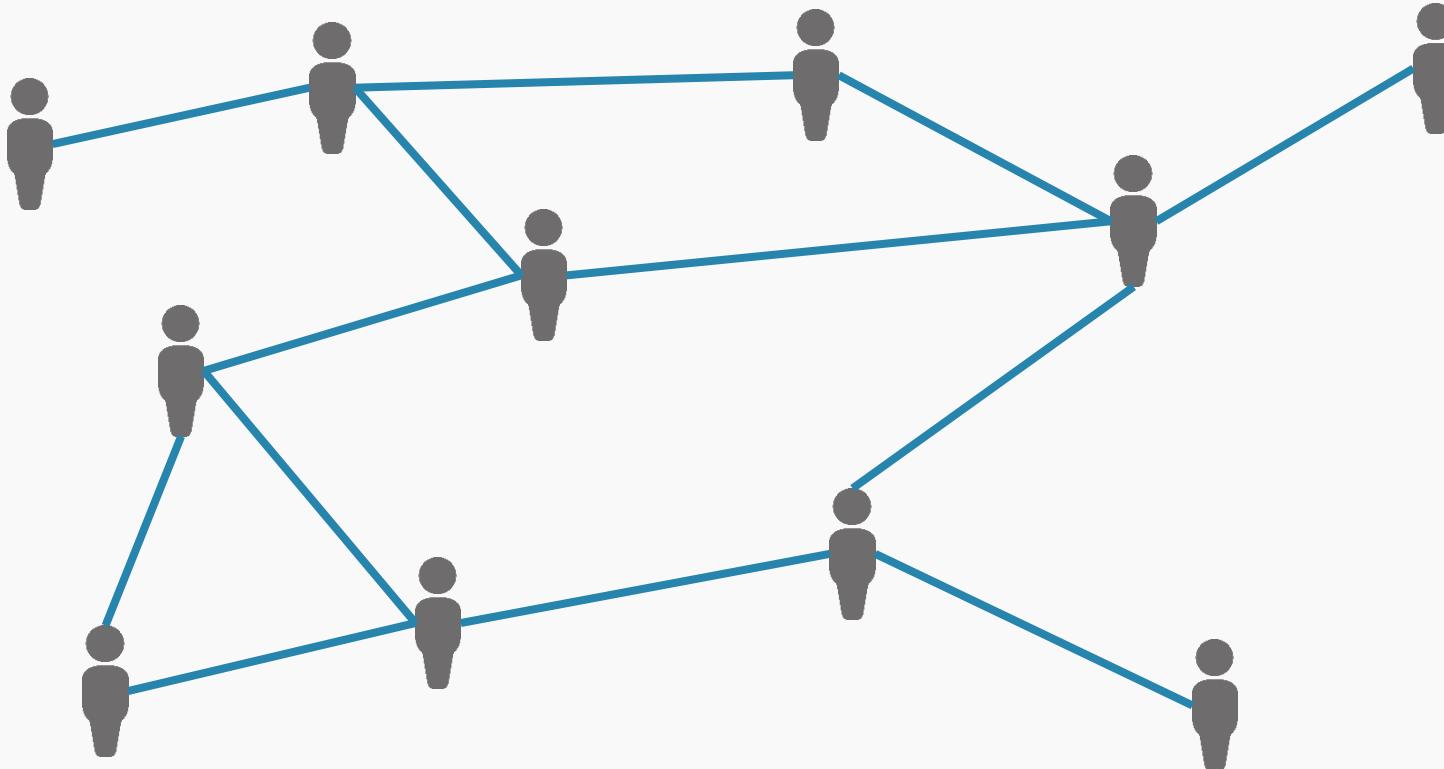








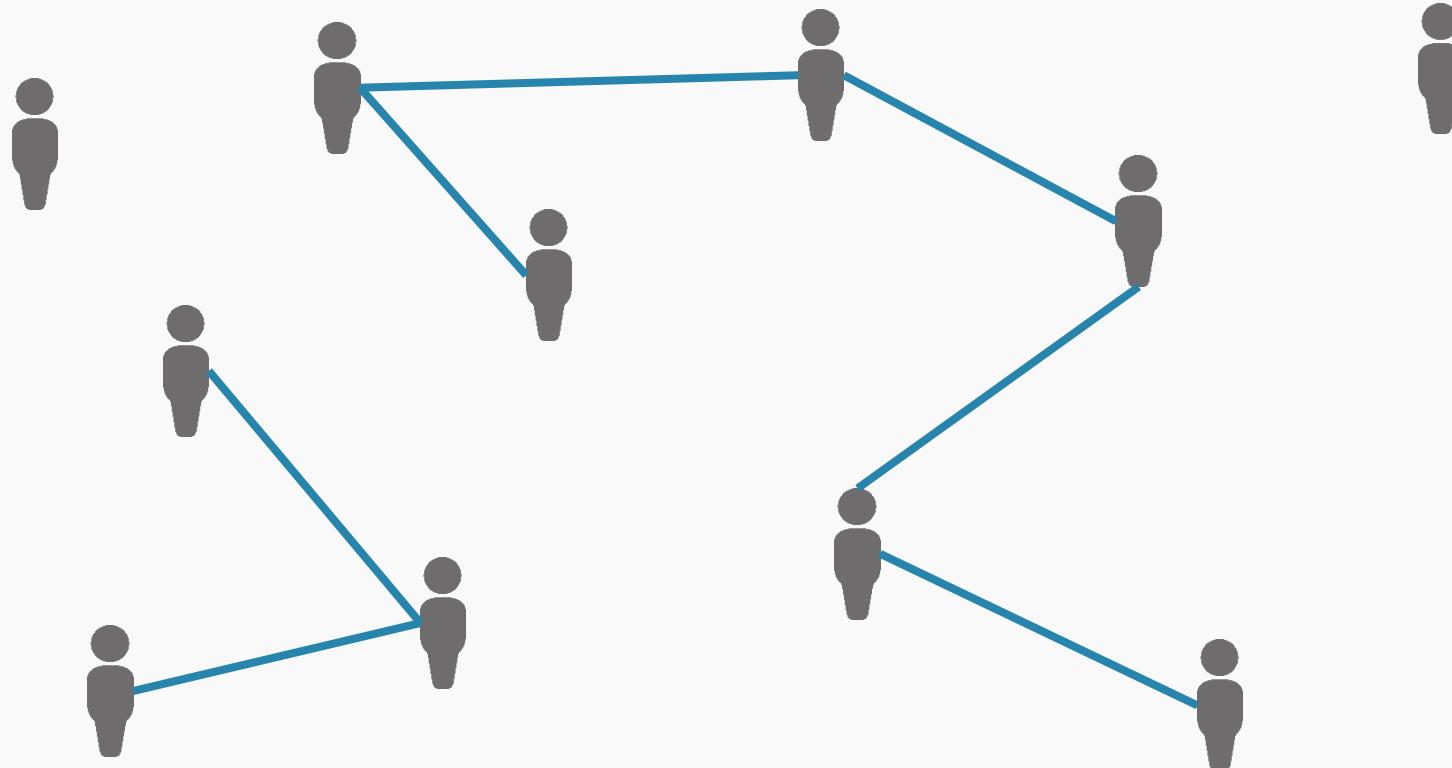
Epidemic





Comunicare Epidemic

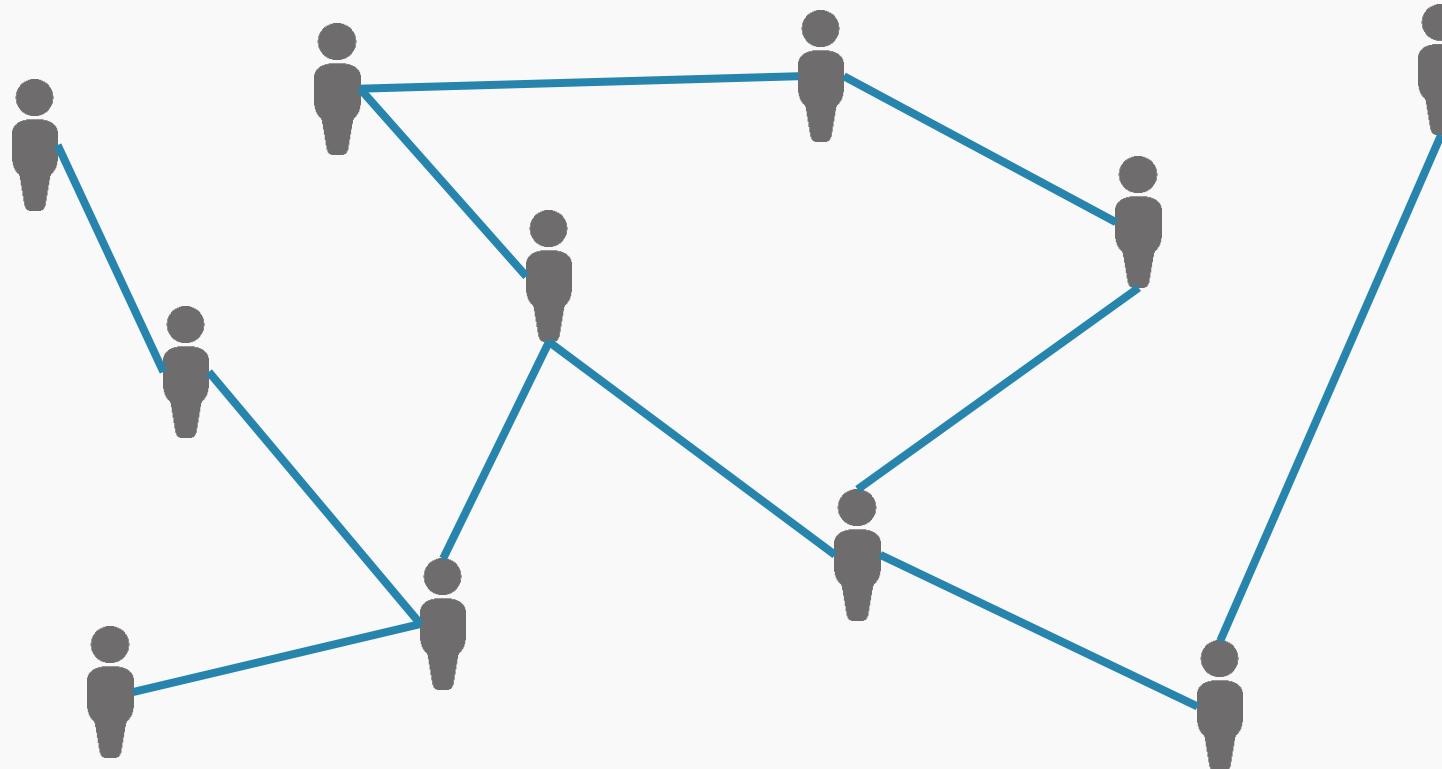
Topologia se poate schimba în orice moment





Comunicare Epidemic

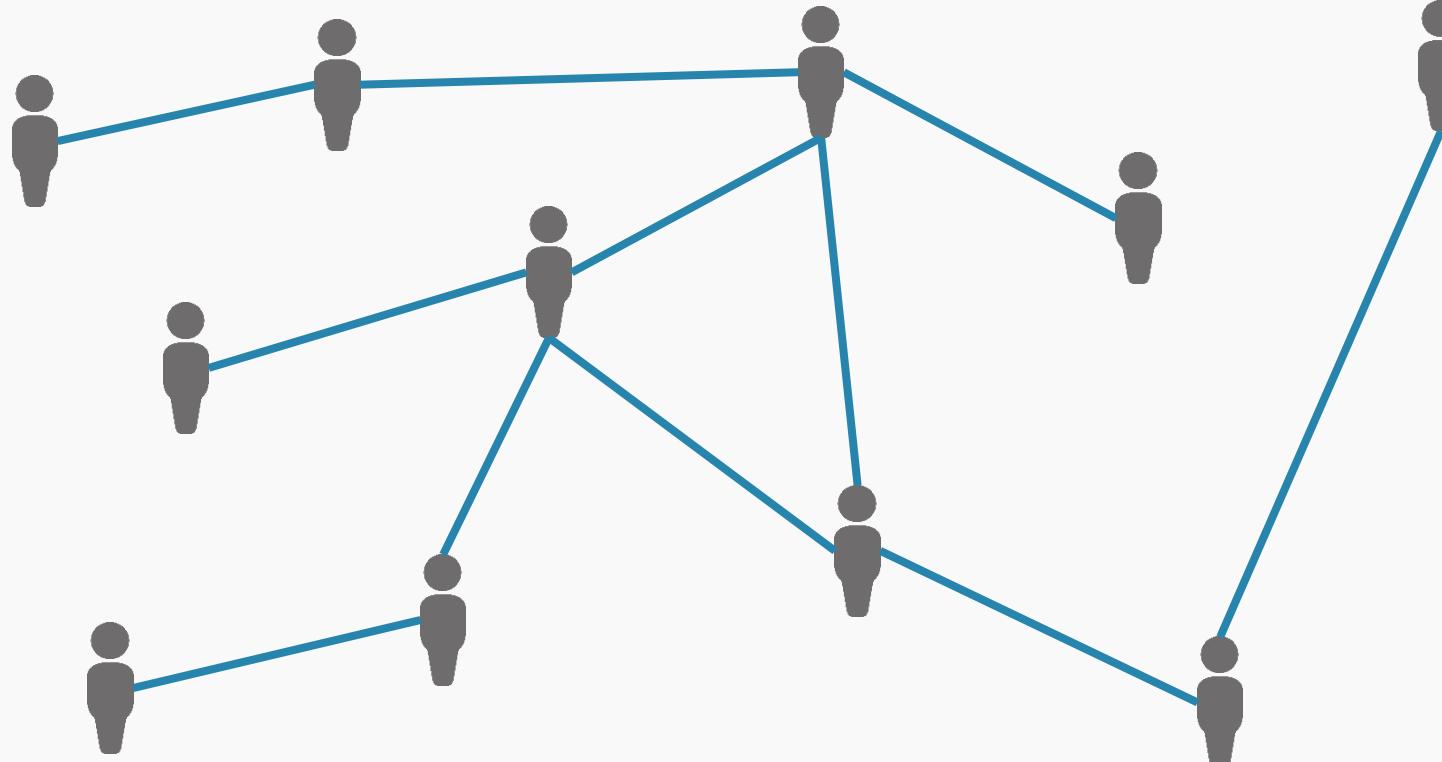
Topologia se poate schimba în orice moment





Comunicare Epidemic

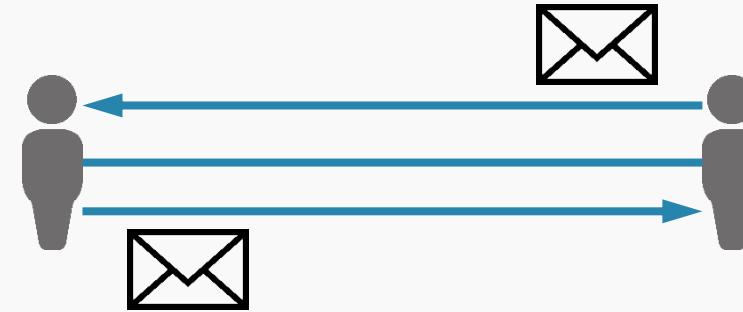
Topologia se poate schimba în orice moment





Epidemic

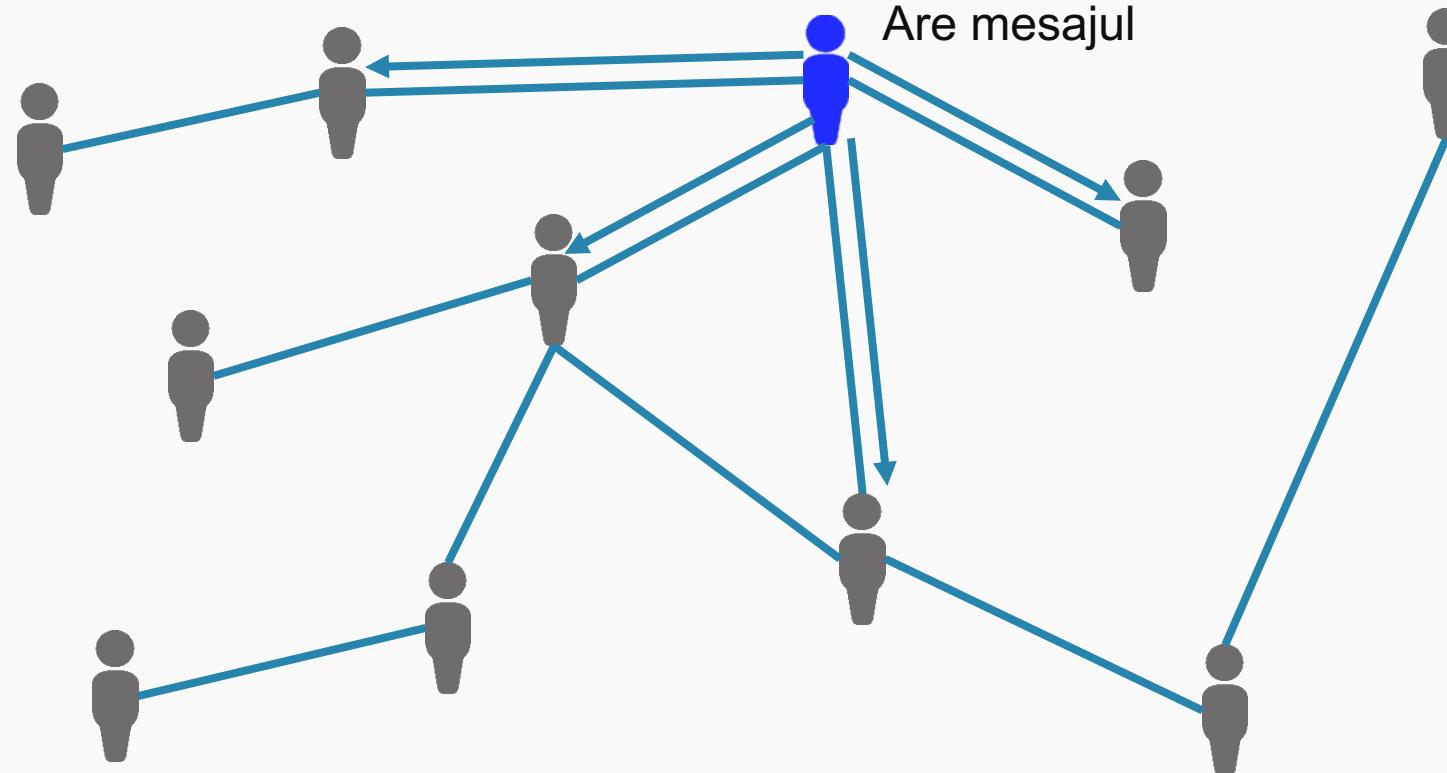
Cât timp avem conexiune nodurile schimbă mesaje.





Comunicare Epidemic

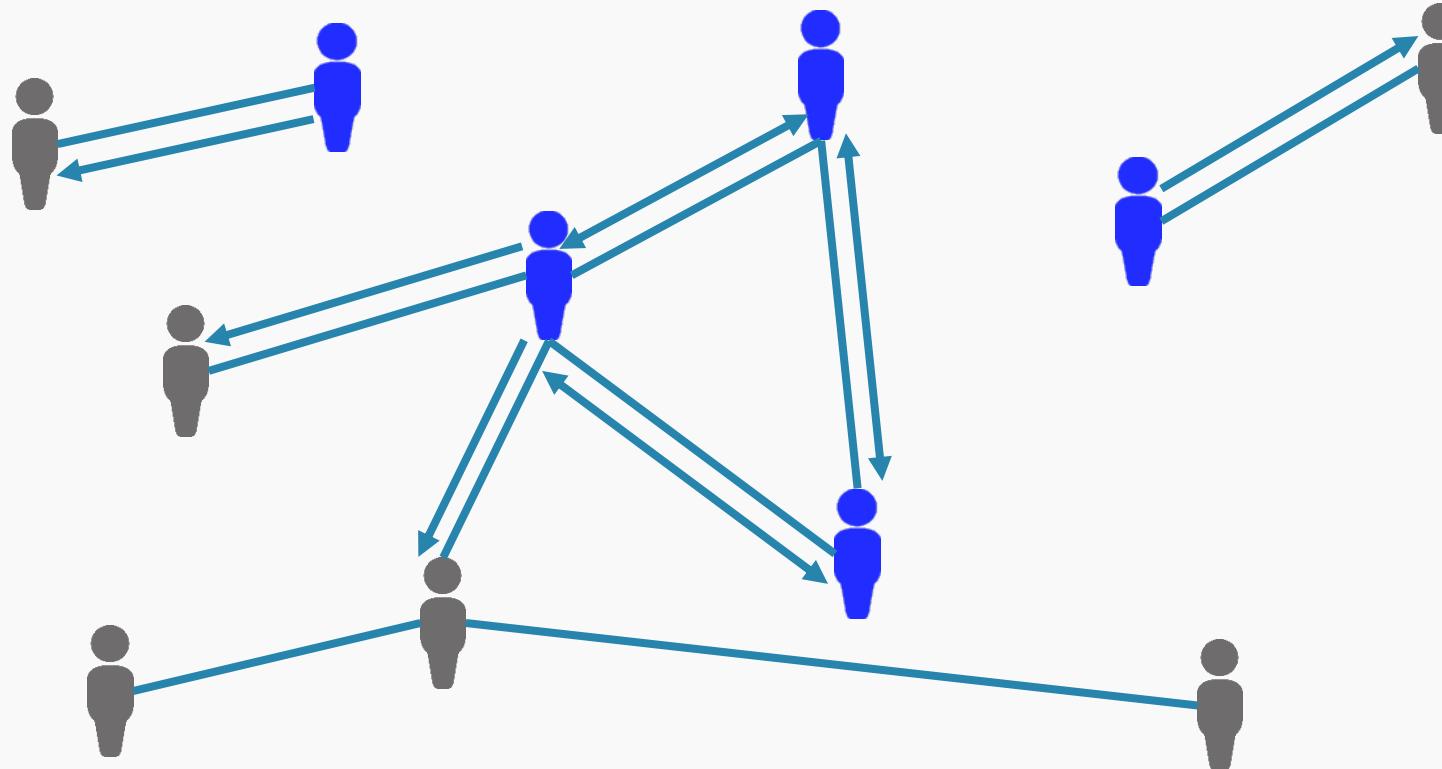
Topologia se poate schimba în orice moment





Comunicare Epidemic

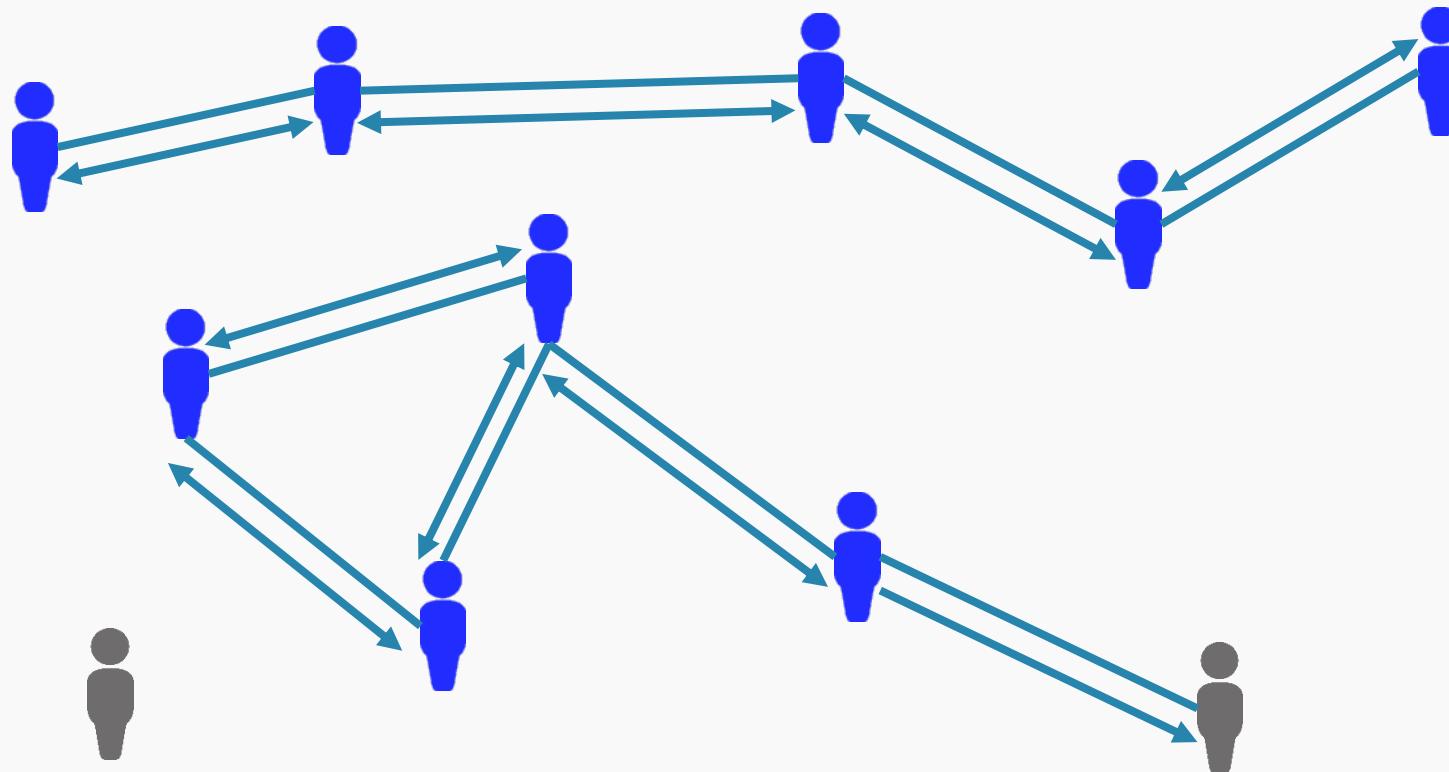
Topologia se poate schimba în orice moment





Comunicare Epidemic

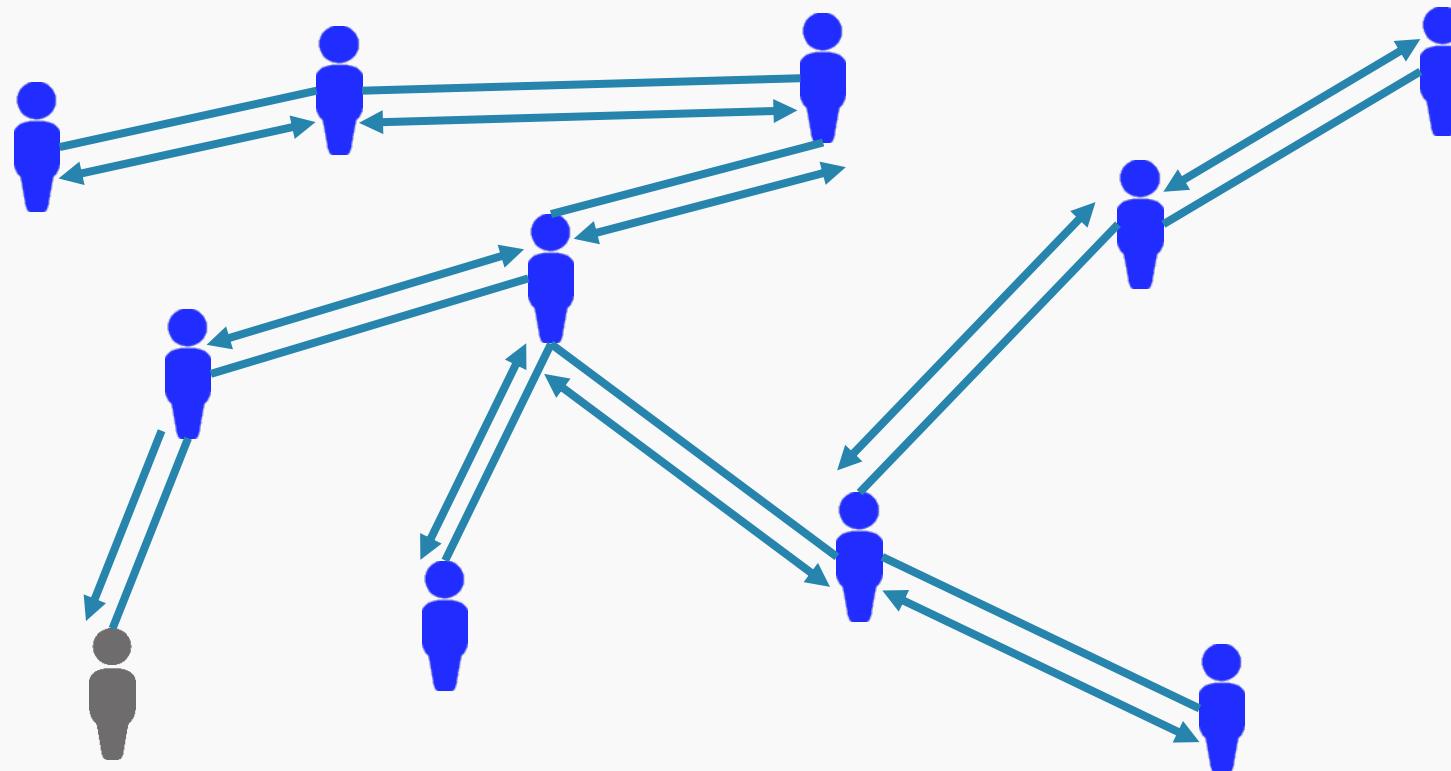
Topologia se poate schimba în orice moment





Comunicare Epidemic

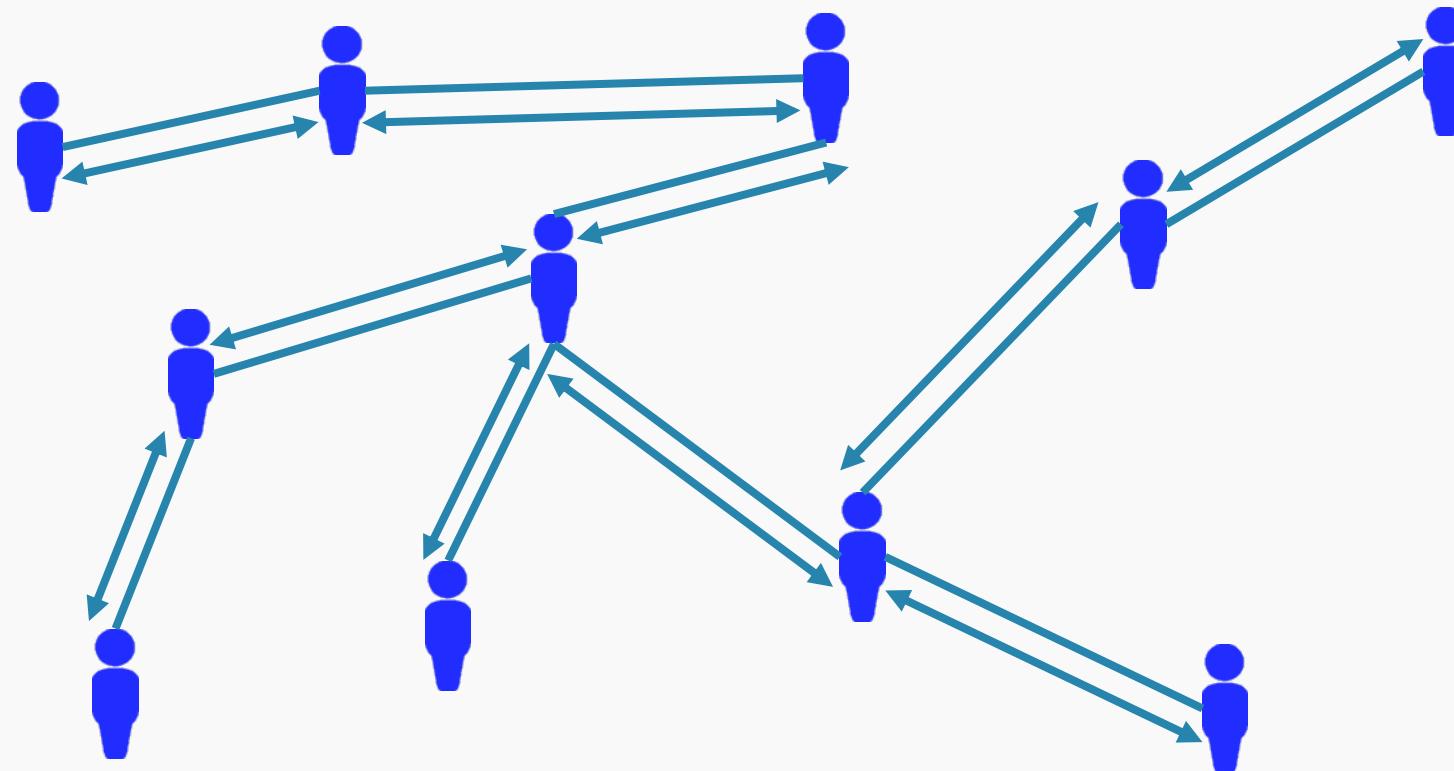
Topologia se poate schimba în orice moment





Comunicare Epidemic

Topologia se poate schimba în orice moment





Epidemic – Avantaje

Nu mai există entități centralizate gen ISP

Funcționează în cazuri extreme
(cutremur/potop) când cablurile ar putea fi rupte



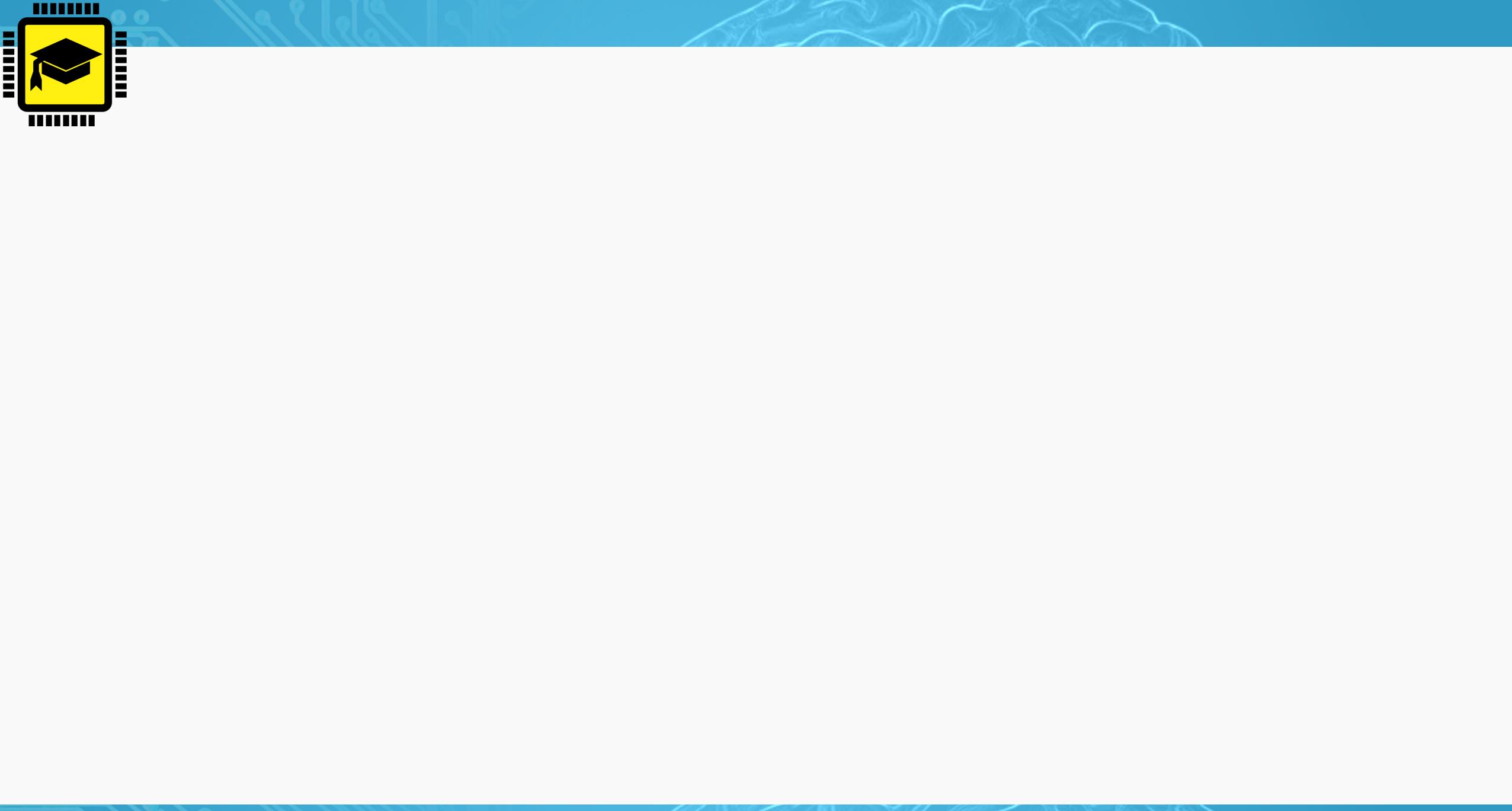
Epidemic – De ce nu e folosit în loc de IP?



Epidemic – De ce nu e folosit în loc de IP?

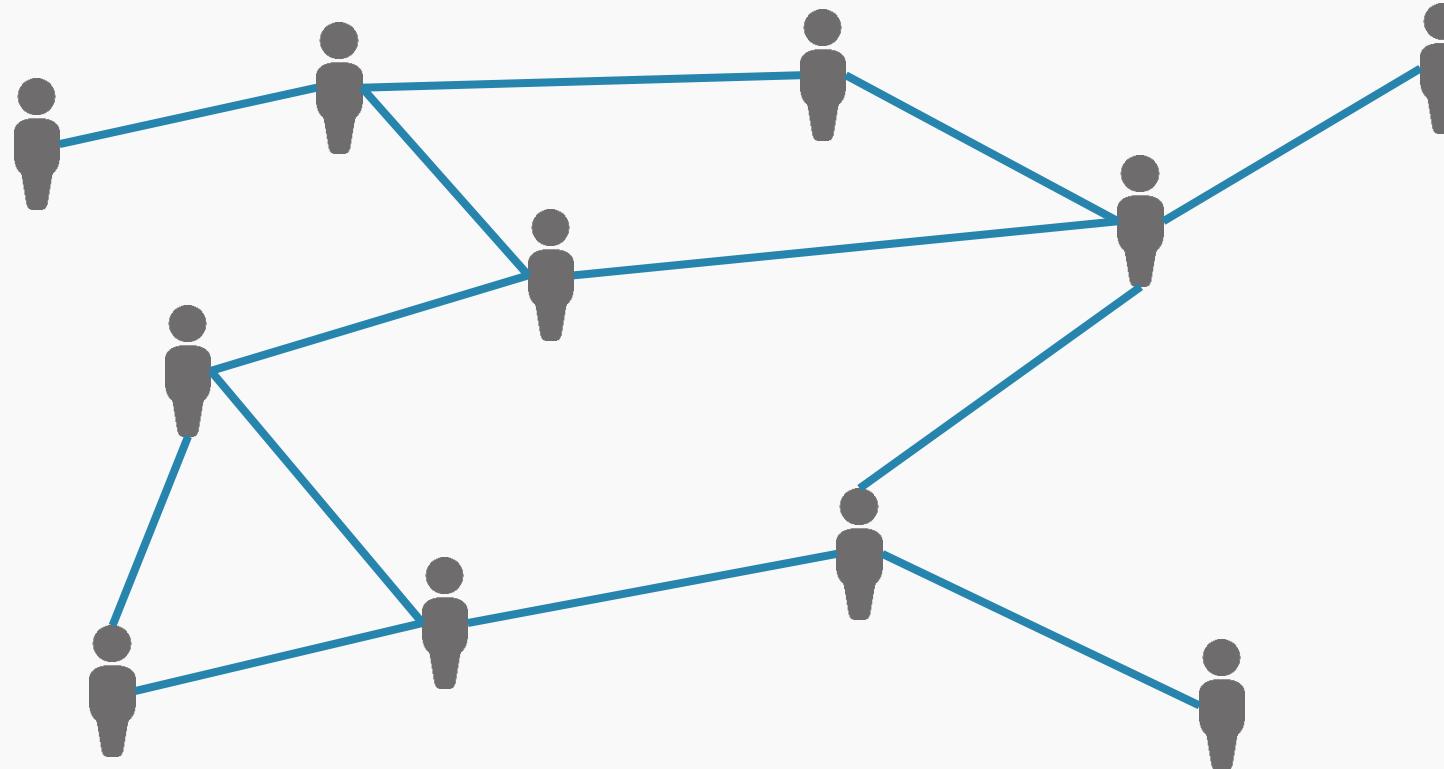
Necesită multe transmisii inutile pentru orice mesaj

Necesită spațiu de stocare mare pe fiecare dispozitiv pentru a evita cicluri





Epidemic – numărare nodurilor





Epidemic – numărare nodurilor



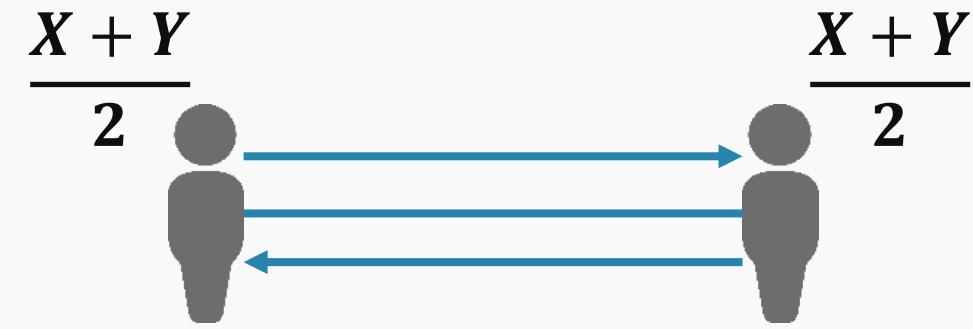


Epidemic – numărare nodurilor



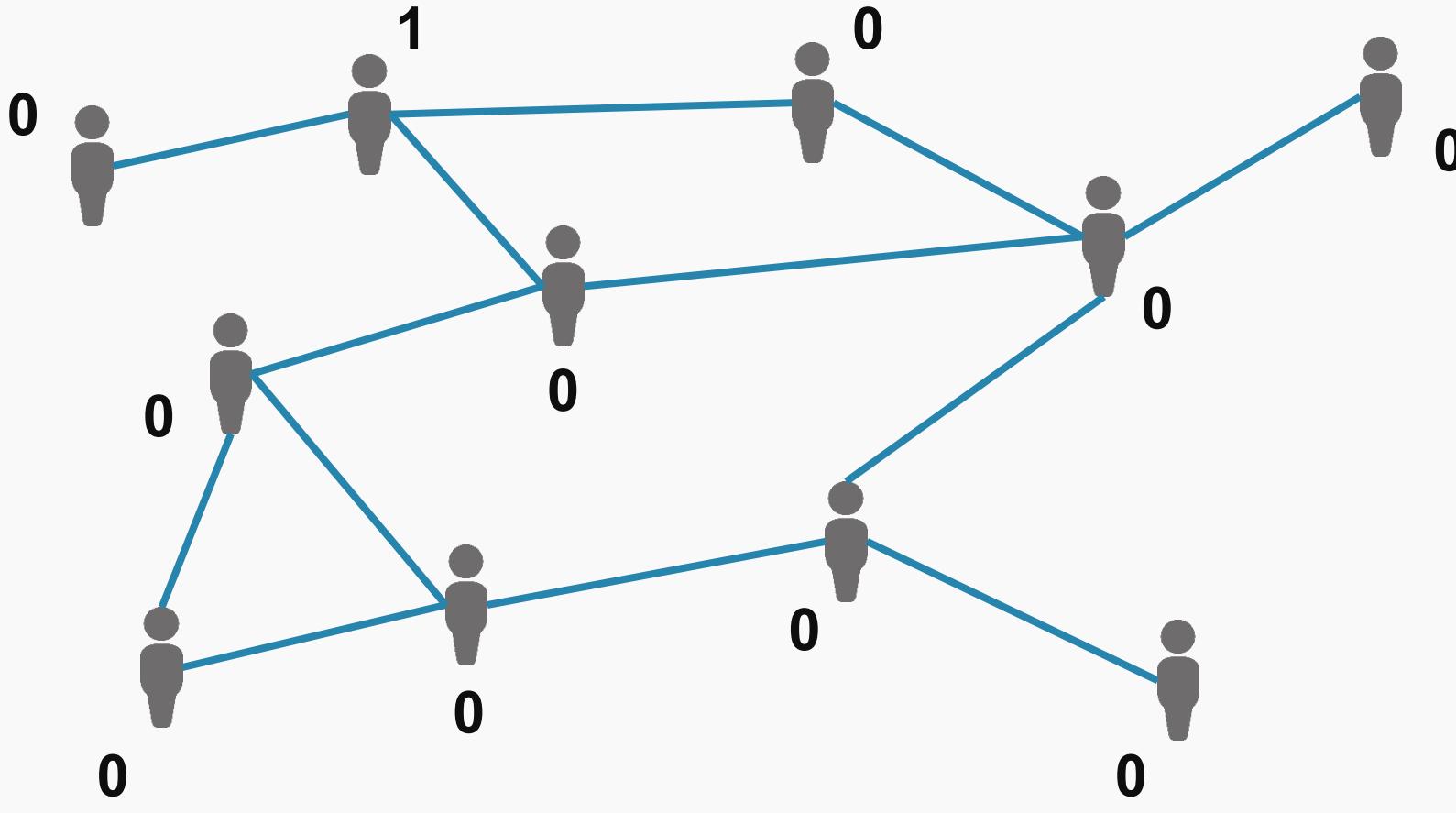


Epidemic – numărare nodurilor





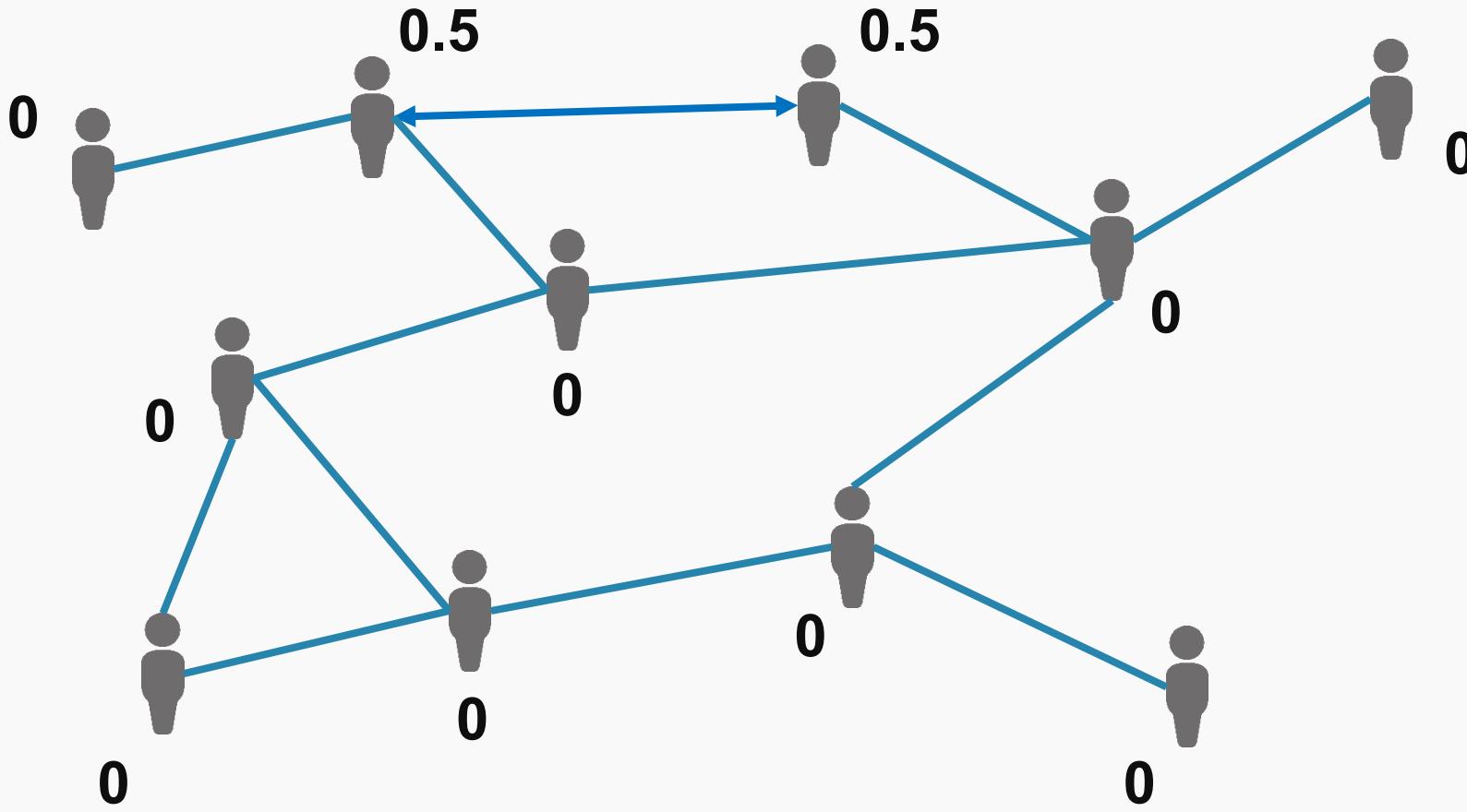
Epidemic – numărare nodurilor



Sum of all = 1



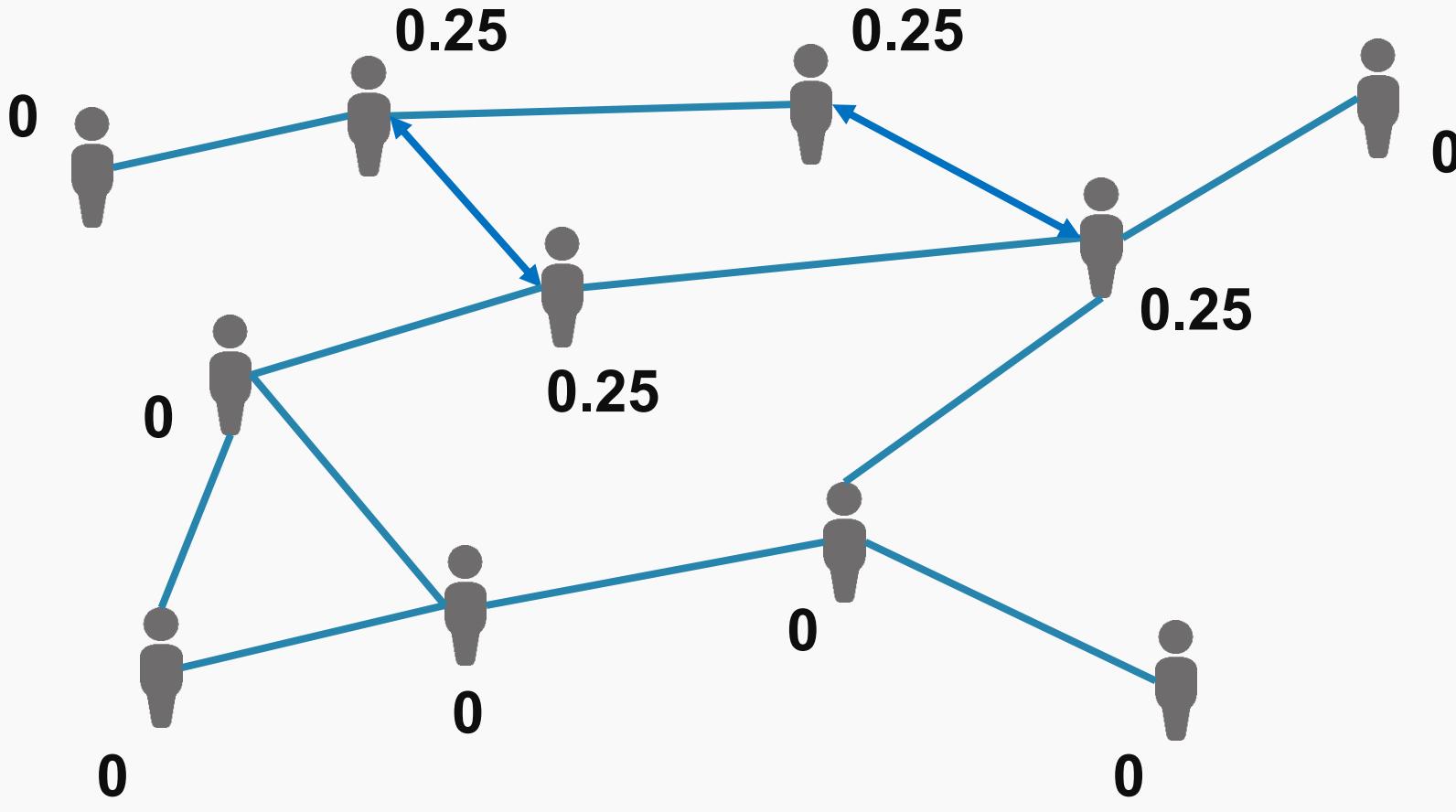
Epidemic – numărare nodurilor



Sum of all = 1



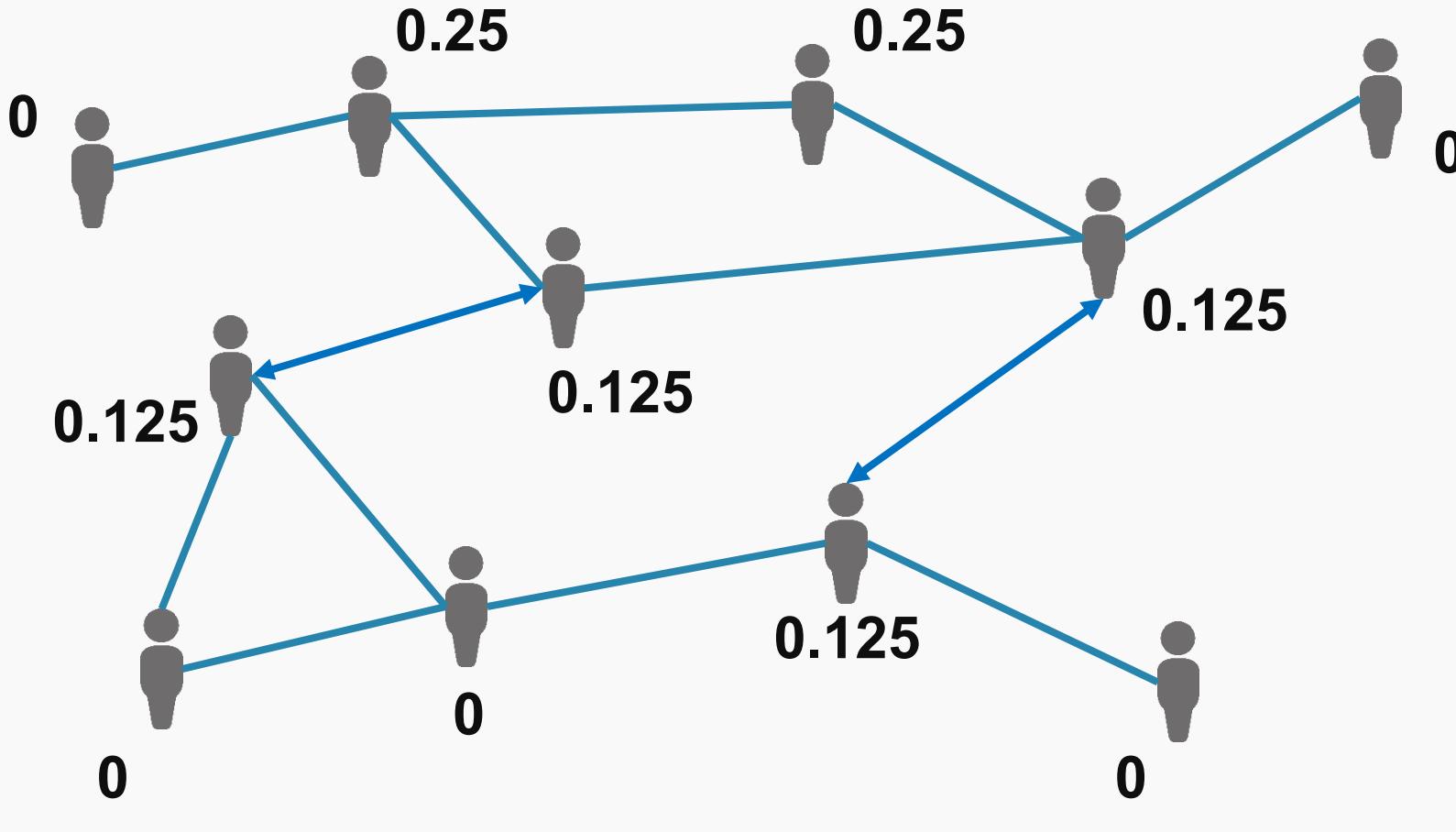
Epidemic – numărare nodurilor



Sum of all = 1

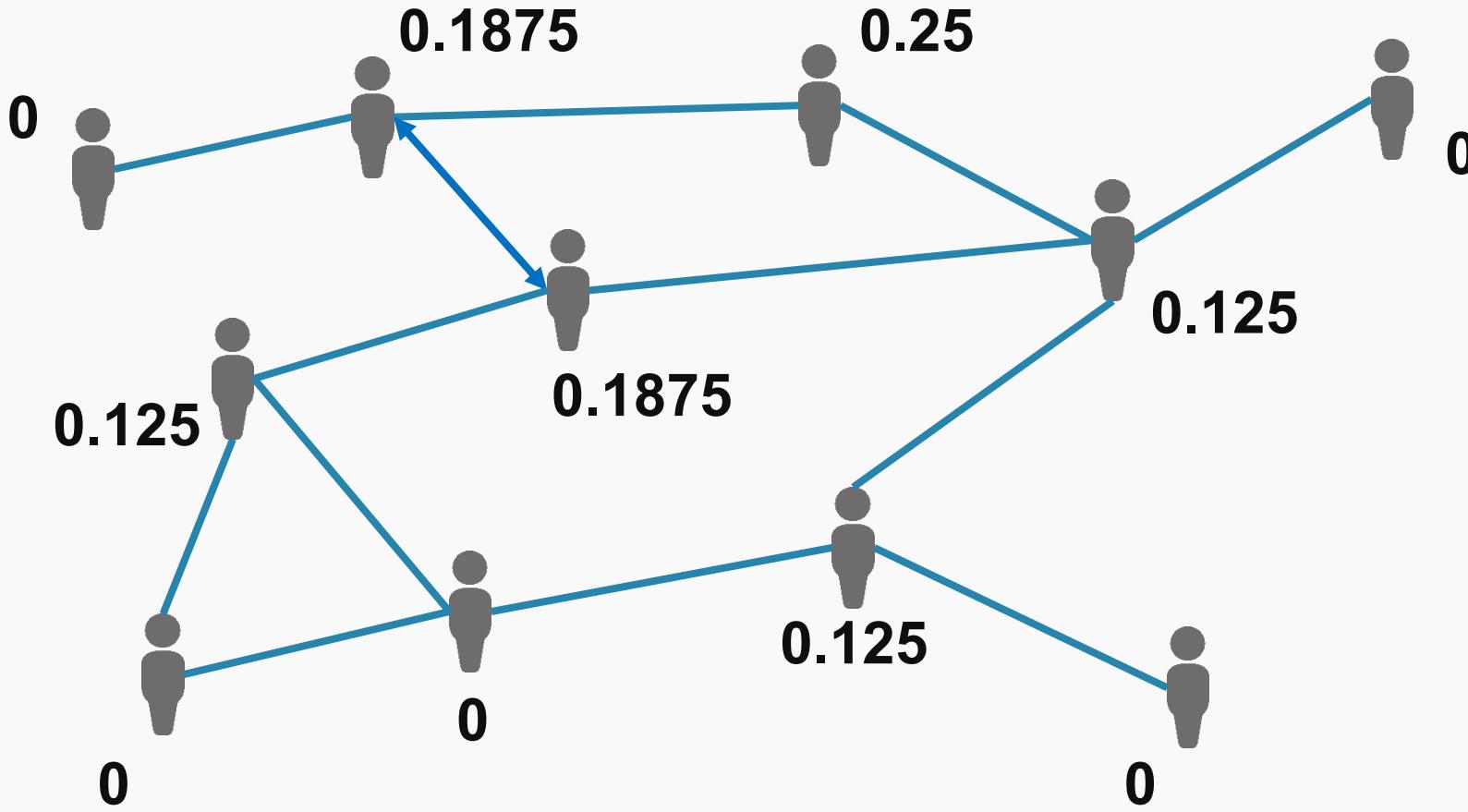


Epidemic – numărare nodurilor





Epidemic – numărare nodurilor



Sum of all = 1

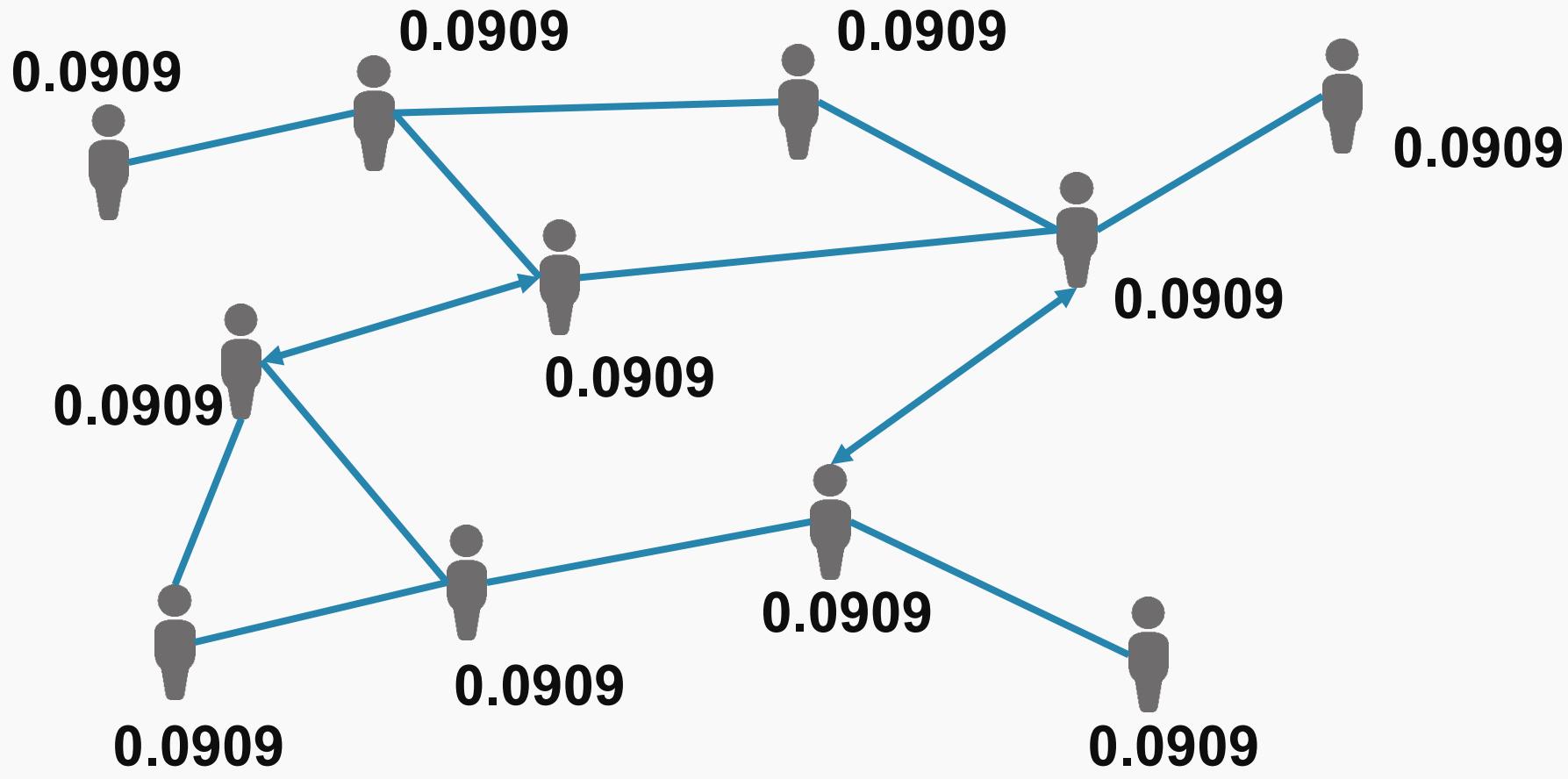


Epidemic – numărare nodurilor

Şi tot aşa...



Epidemic – numărare nodurilor





Epidemic – numărare nodurilor

$$\frac{1}{0.0909} = 11(\text{numărul nodurilor})$$