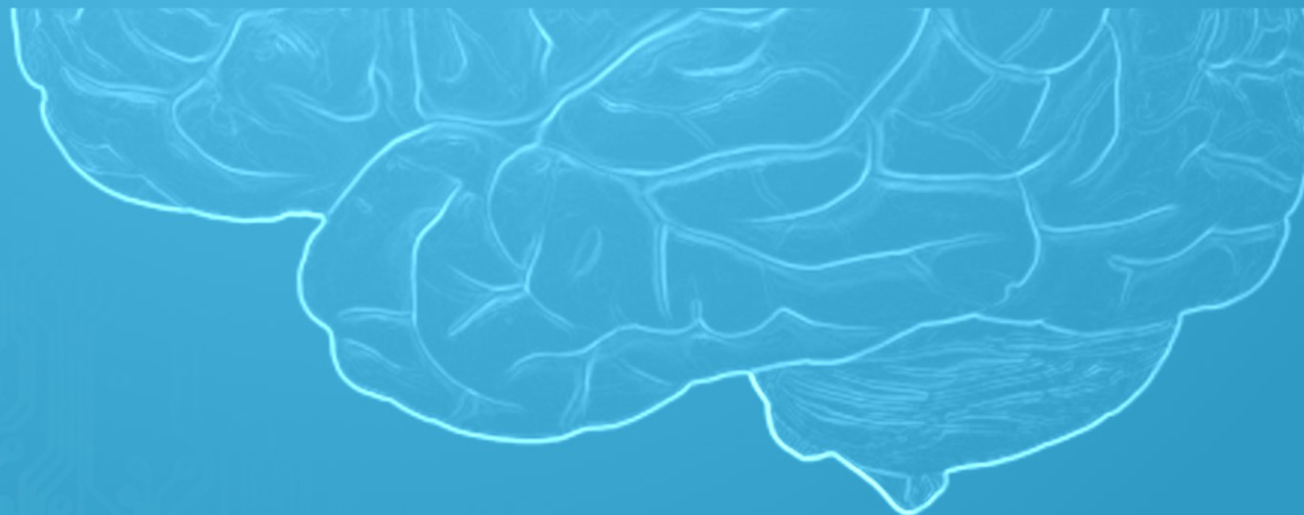




Sisteme Tolerante la Defecte Sisteme Distribuite

Lect. Dr. Ing. Cristian Chilipirea – cristian.chilipirea@mta.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?

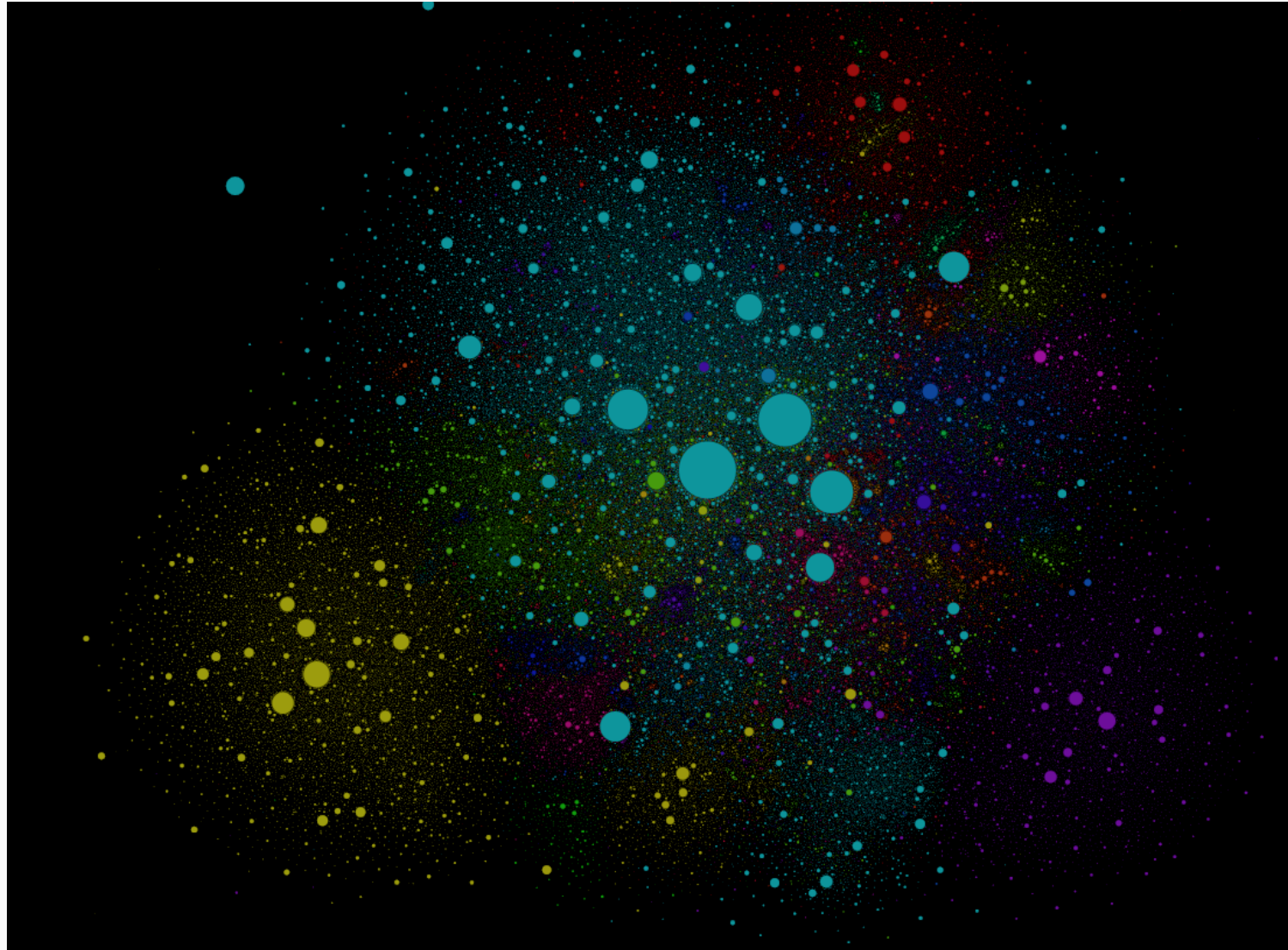
Oricând avem mai mult de un sistem



Care este cel mai mare sistem distribuit?



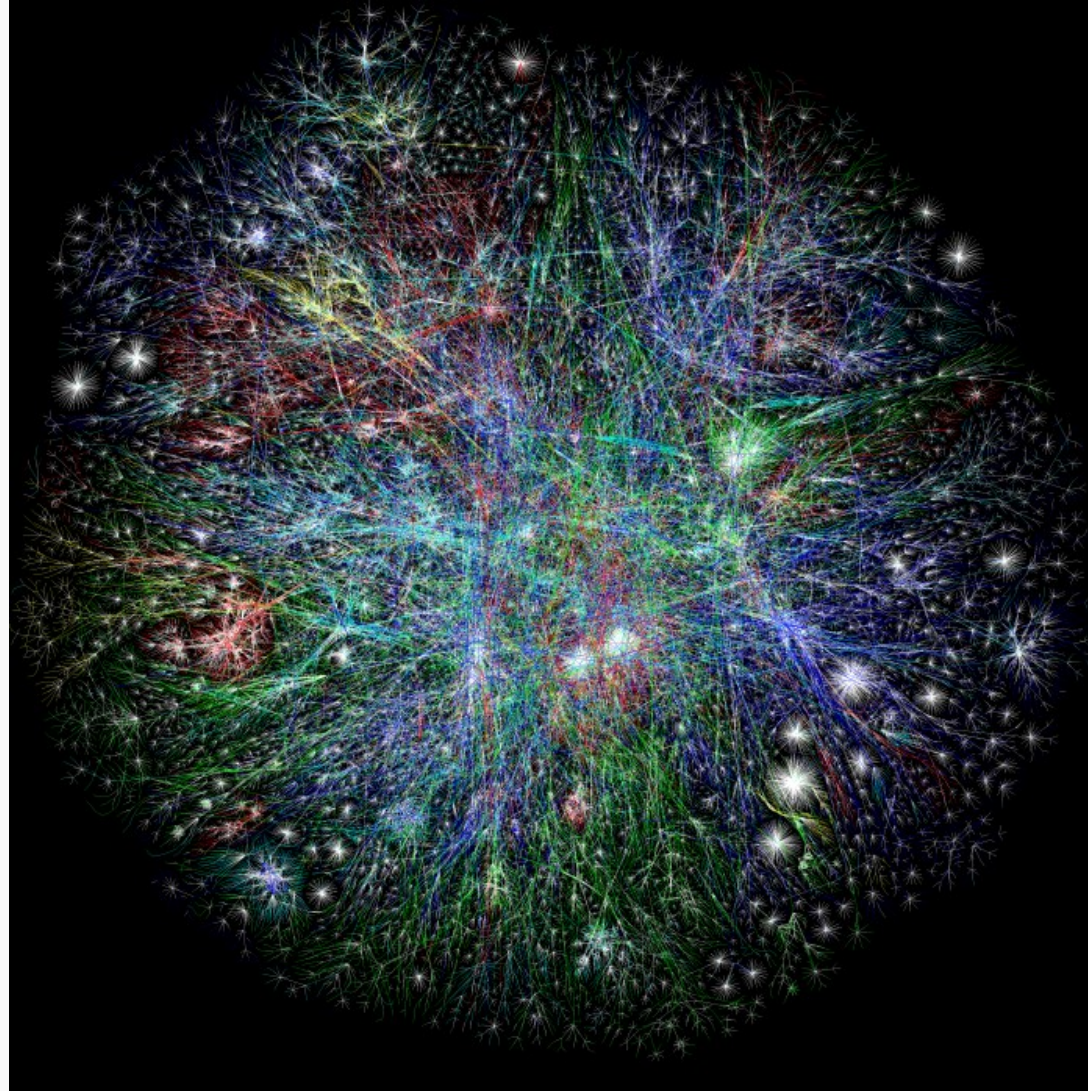
Care este cel mai mare sistem distribuit?







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?

The INTERNET



Distributed Systems – The INTERNET

DISTRIBUTED WEB-BASED SYSTEMS

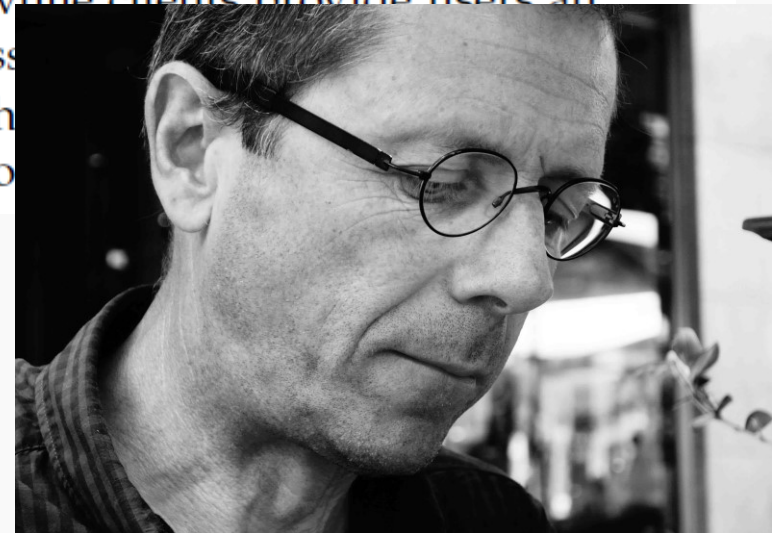
The World Wide Web (WWW) can be viewed as a huge distributed system consisting of millions of clients and servers for accessing linked documents.

Servers maintain collections of documents, while clients provide users an

easy interface for presenting and accessing these documents.

The Web started as a project at CERN, the European Organization for Nuclear Research,

located in Geneva, to let its large and geographically distributed community





Cine a construit Internetul?



Cine a construit Internetul? - Vint Cerf

A Protocol for Packet Network Intercommunication

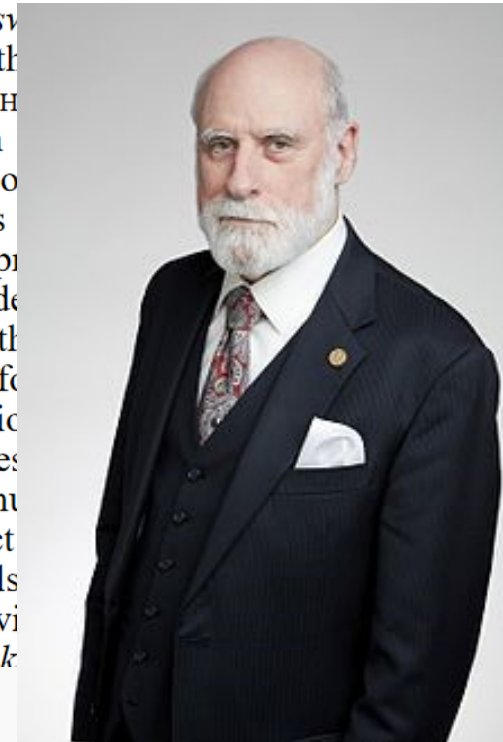
VINTON G. CERF AND ROBERT E. KAHN,
MEMBER, IEEE

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 switching* communication media through switches. Within each host exist *processes* which execute processes in their own definition of a process for purposes [13]. These processes are the ultimate source and destination of network. Typically, within a network there exists a protocol for any source and destination and destination processes; a convention for communication. Processes in two distinct networks use different protocols. An ensemble of packet switching media is called the *packet*





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



Garanții stiva TCP/IP?

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

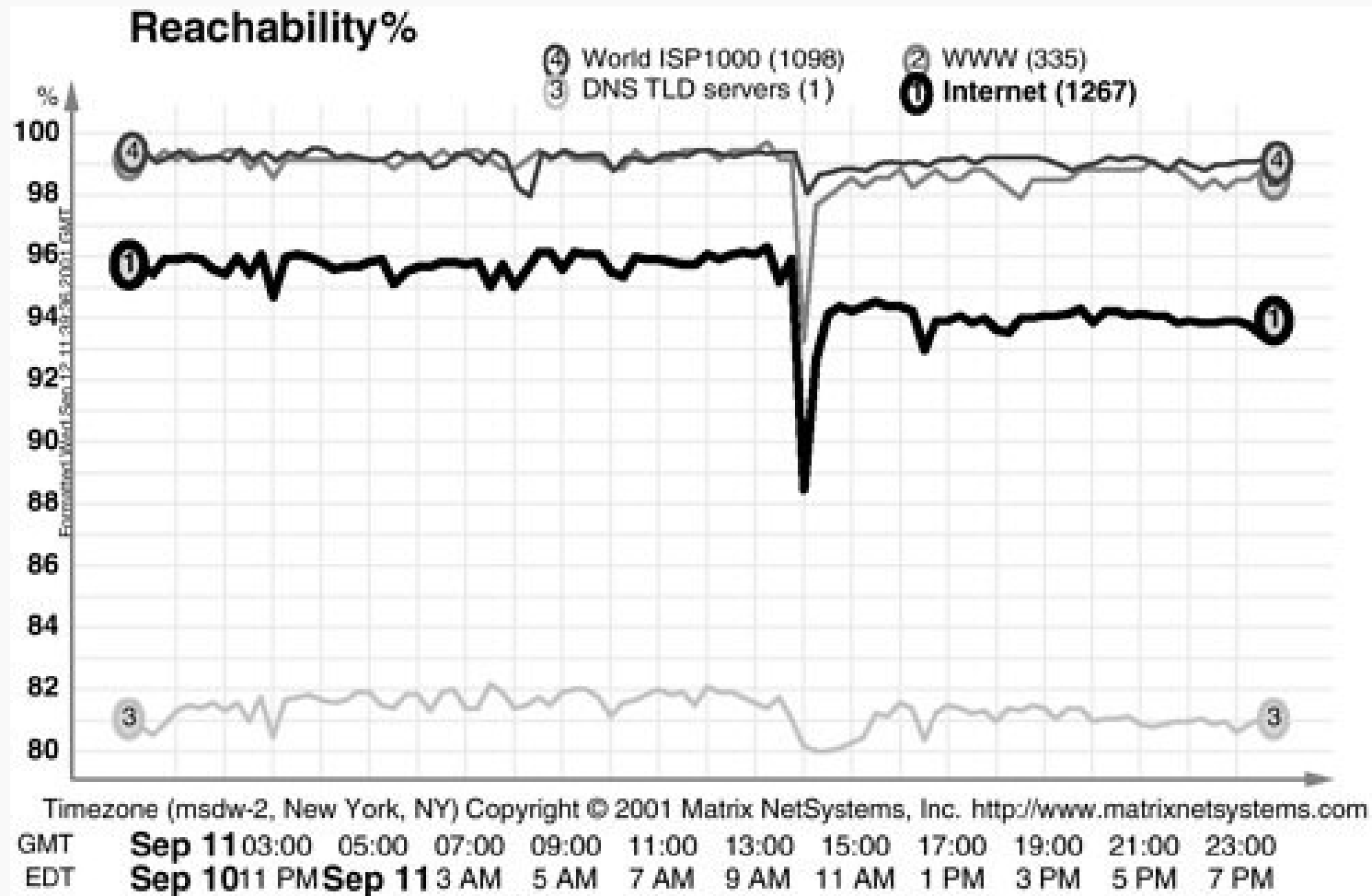


Garantii stiva TCP/IP?

OSI	TCP/IP	Garantii
Application		
Presentation		
Session	Data (HTTP)	Mesajul va fi înțeles de server/browser
Transport	TCP	Mesajul ajunge
Network	IP	Best effort ca mesajul să ajungă unde trebuie în Internet
Data link	Ethernet	Best effort 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... spectrum... tralization... networking... ing. Remot... nection of... rather larg... constructio... puting syst... pieces com... spectrum i... computers... networking

The sep... ated bit rat... vide the d... activities. T... about 1 gi... dication of... nology and

Activity

Remote netw...

Local networks

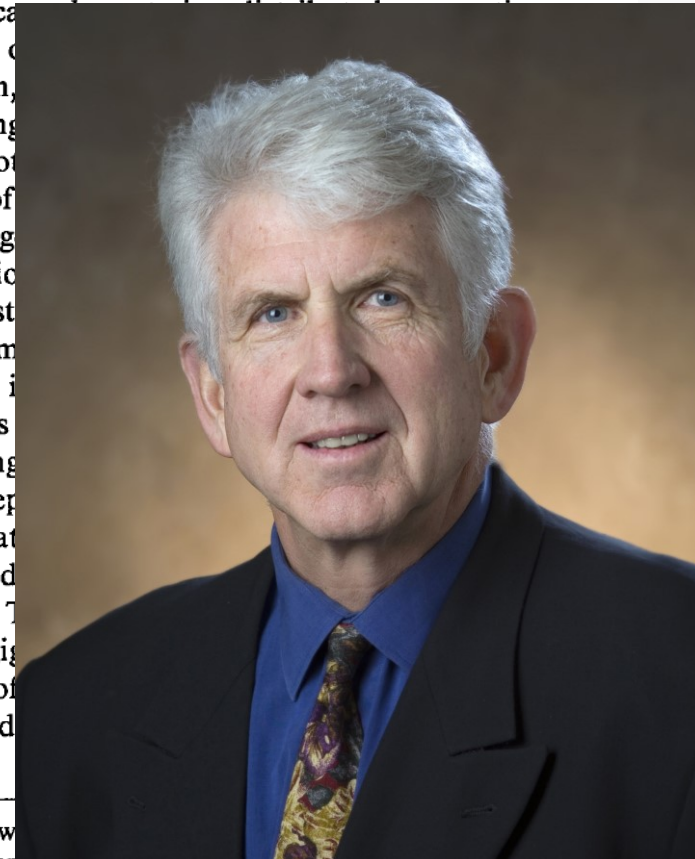
Multiprocessors

10-1 km

< .1 km

.1-10 Mbps

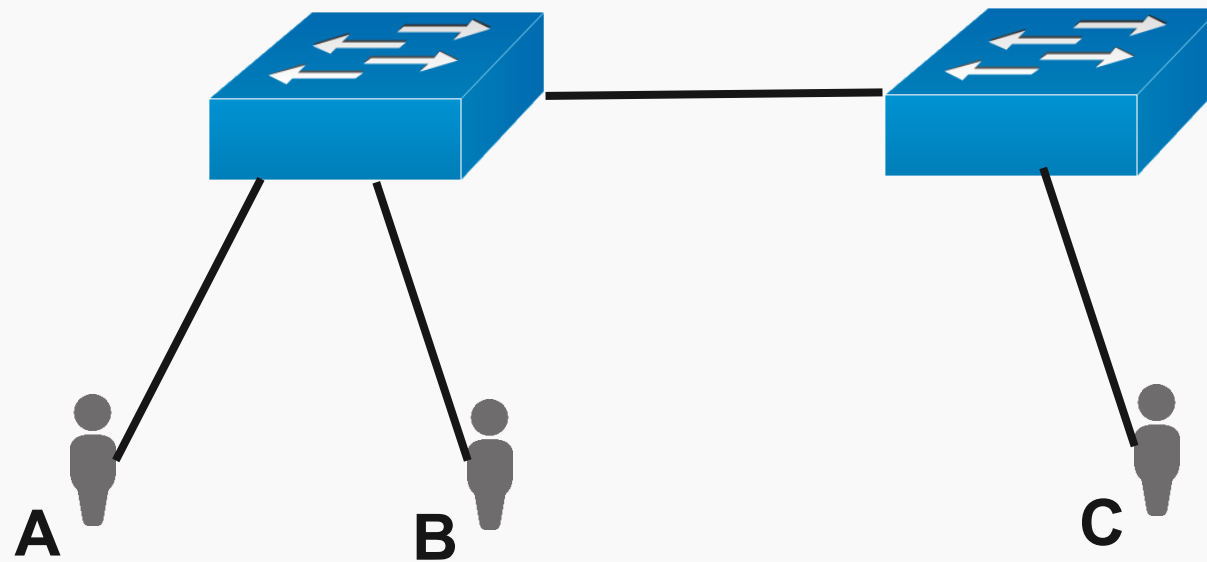
> 10 Mbps



1.1 Remote Computer Networking

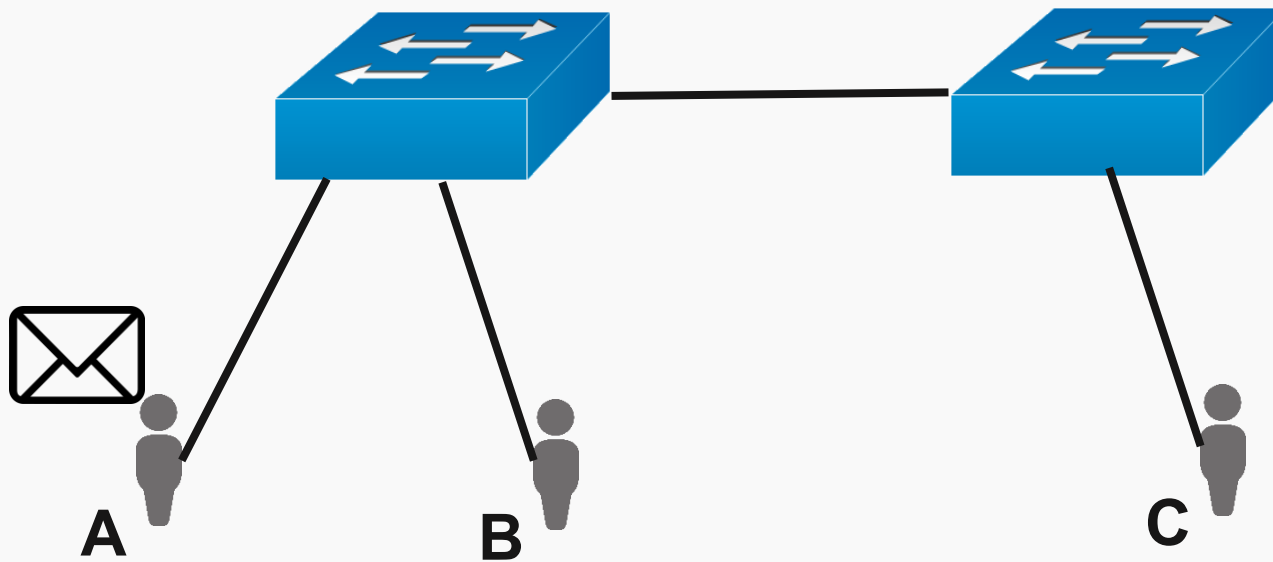


Ethernet – CAM table



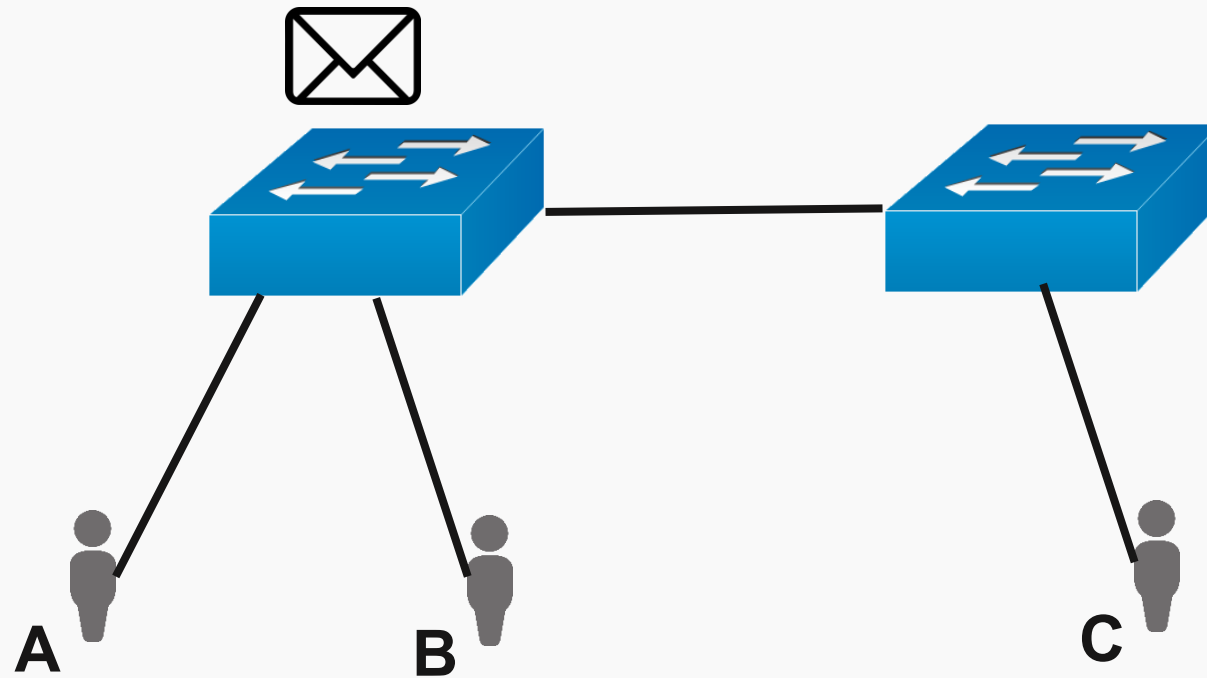


Ethernet – CAM table



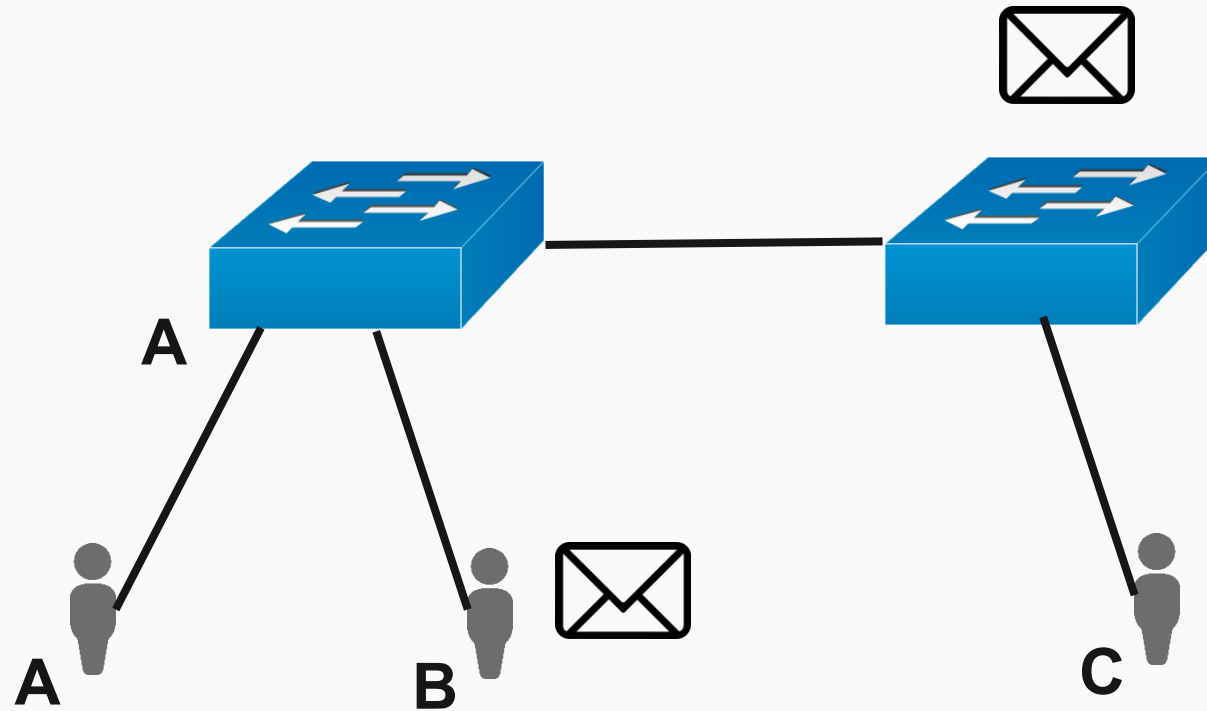


Ethernet – CAM table



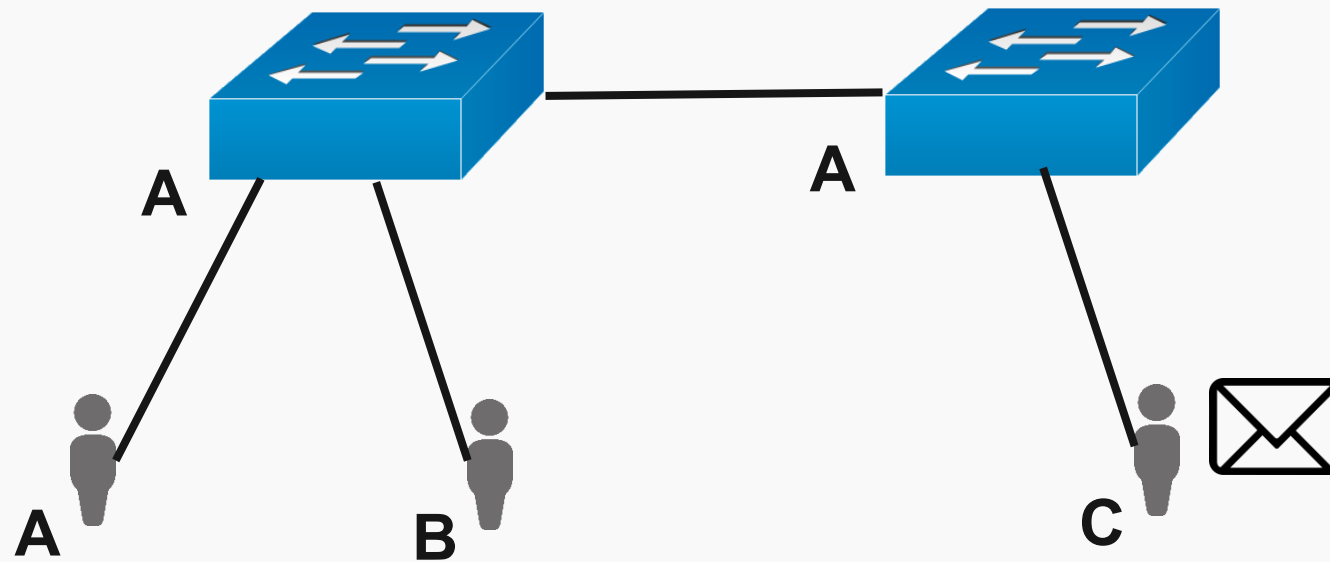


Ethernet – CAM table



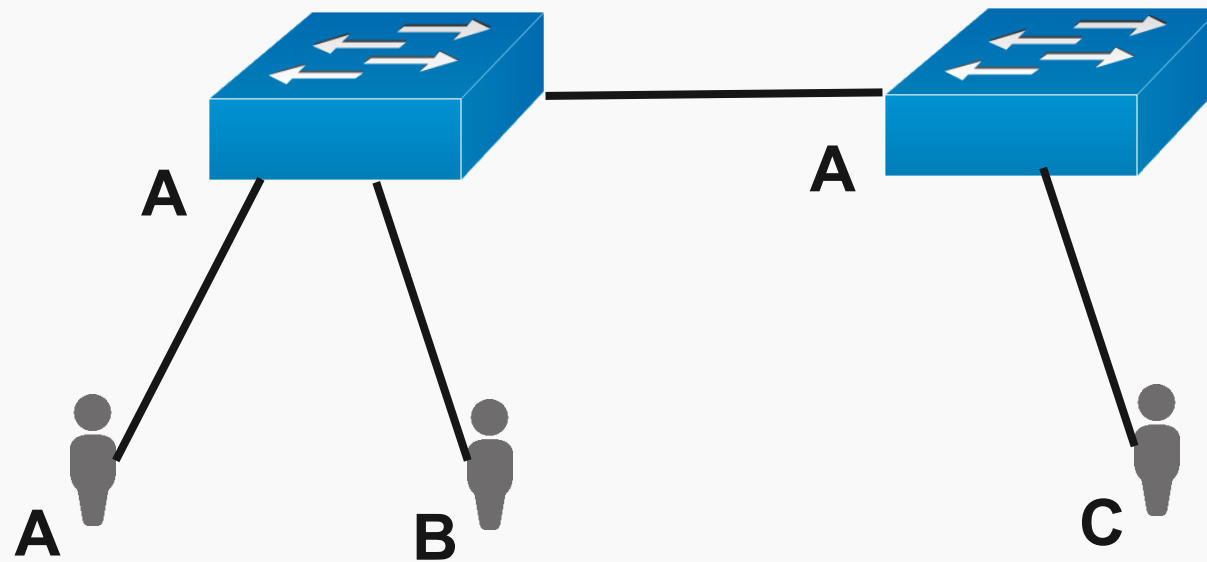


Ethernet – CAM table



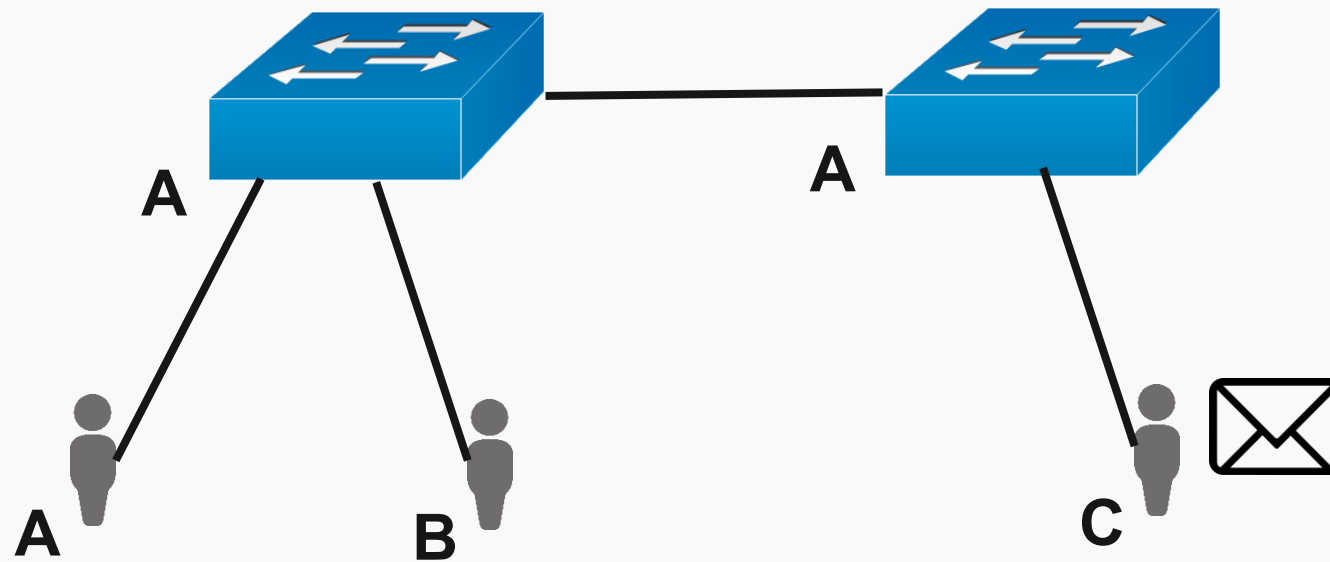


Ethernet – CAM table



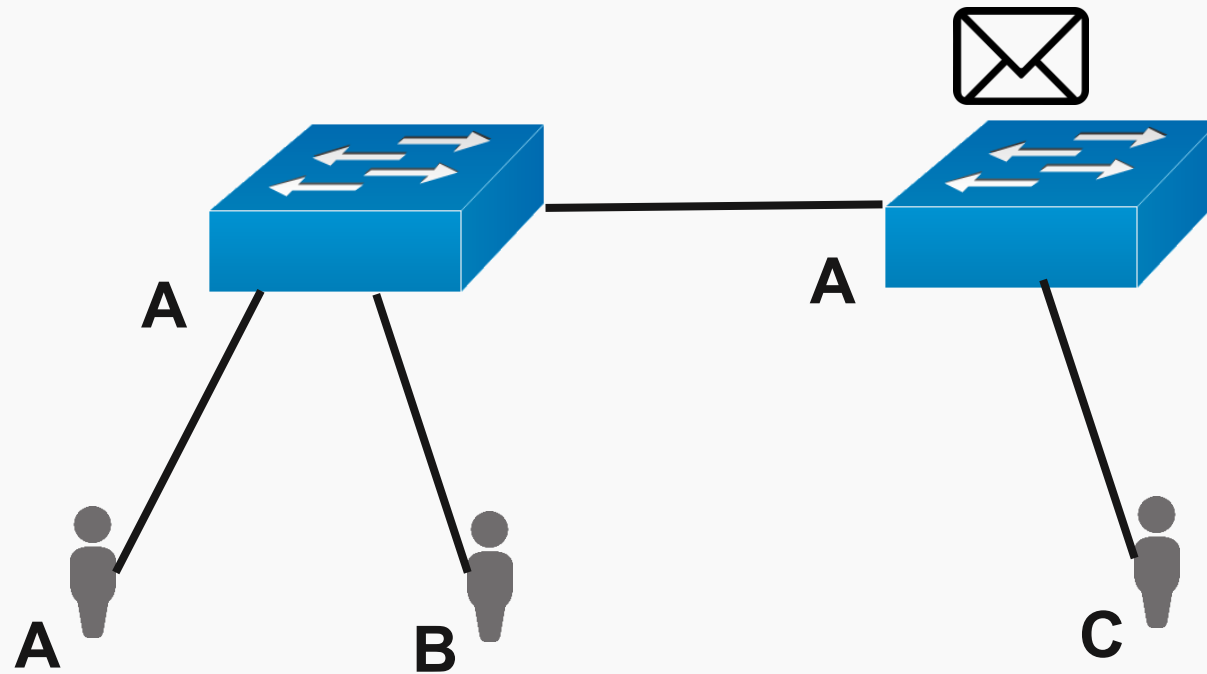


Ethernet – CAM table



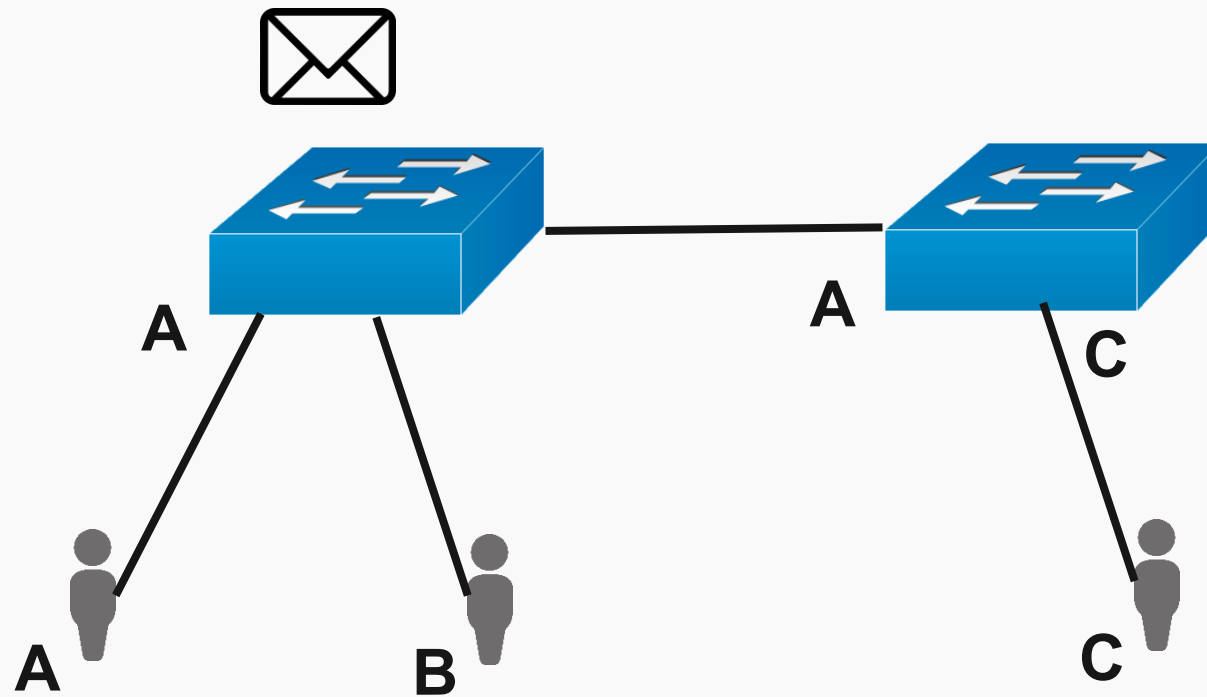


Ethernet – CAM table



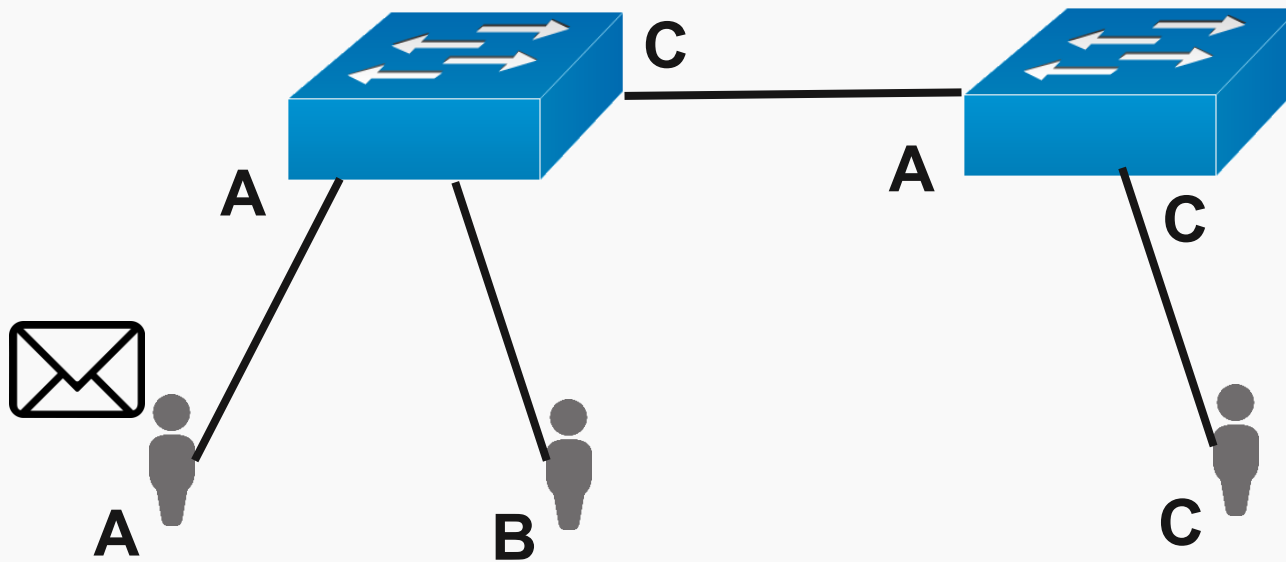


Ethernet – CAM table



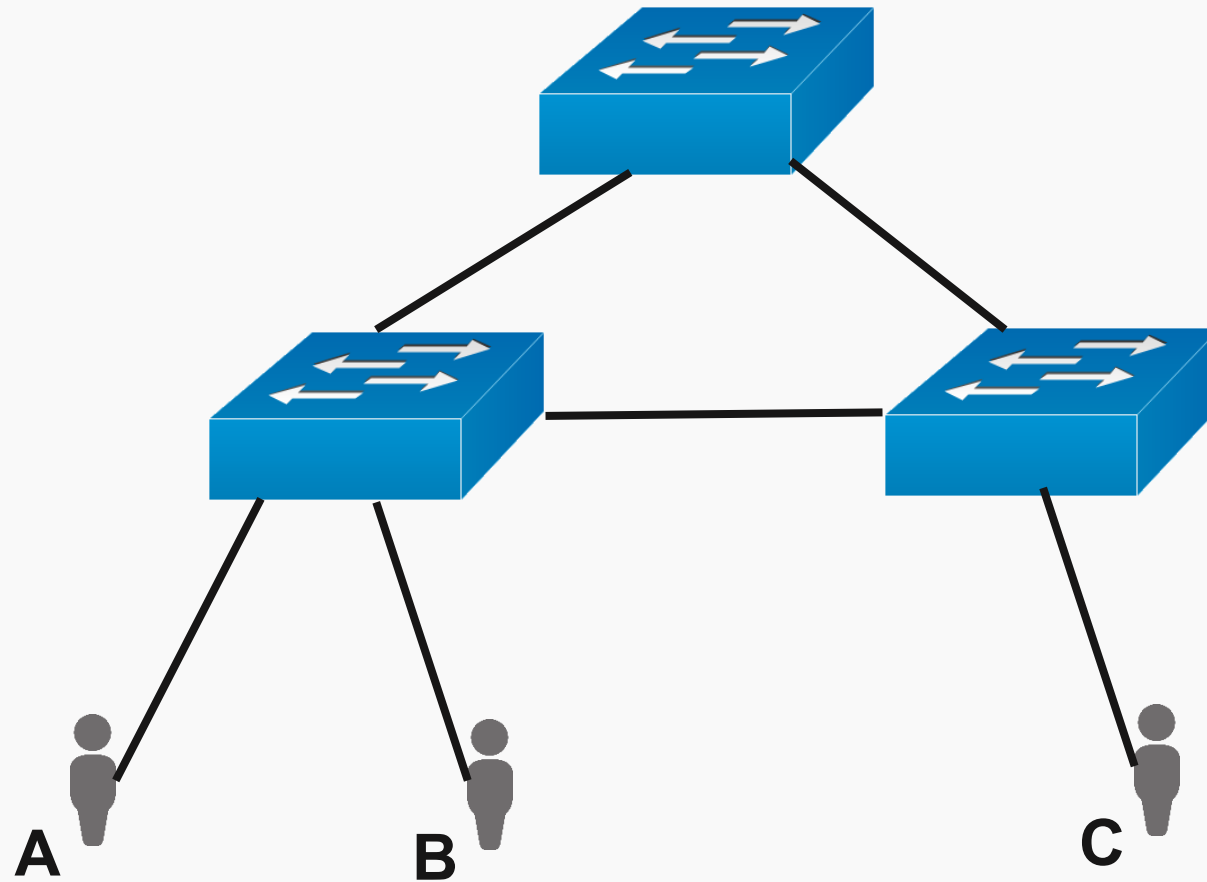


Ethernet – CAM table



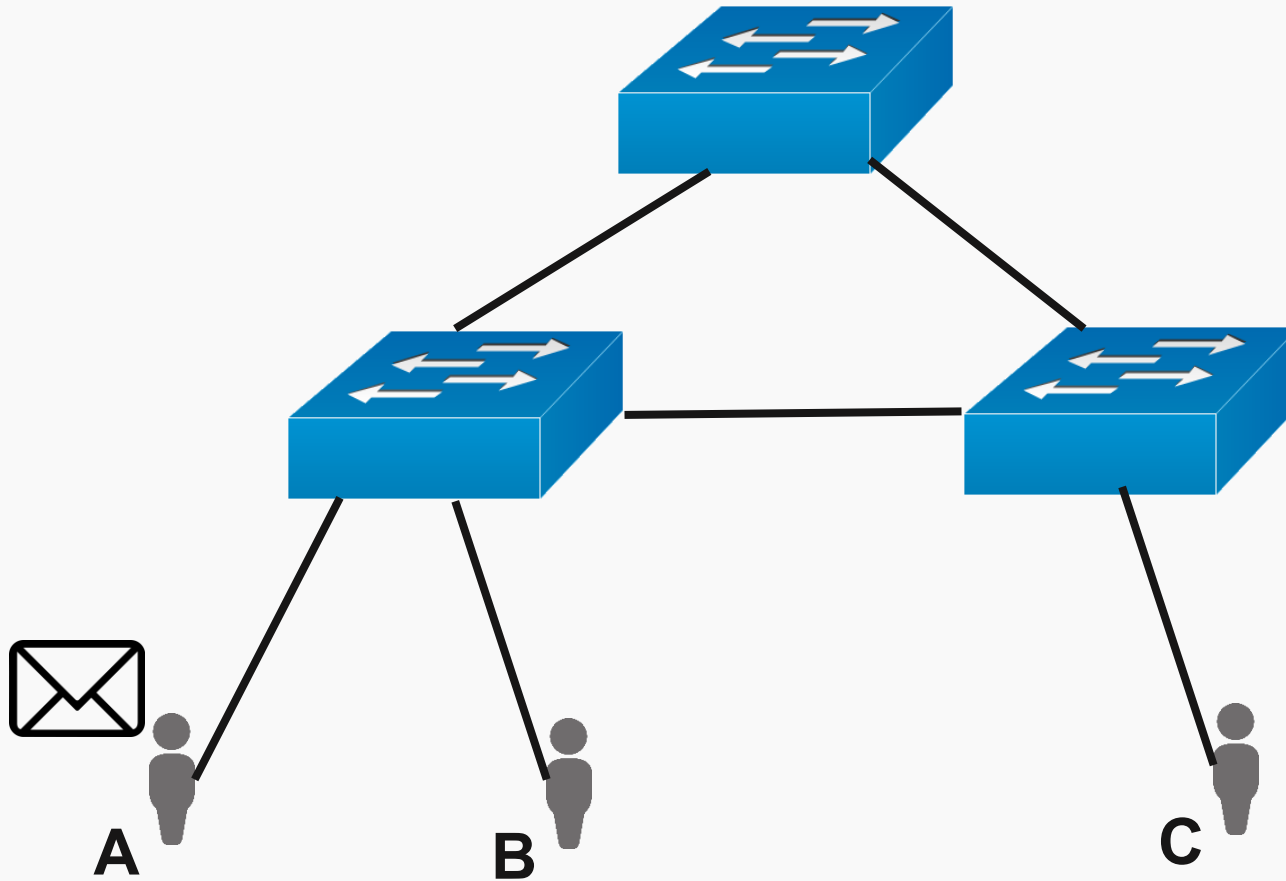


Ethernet – CAM table – Probleme cu cicluri



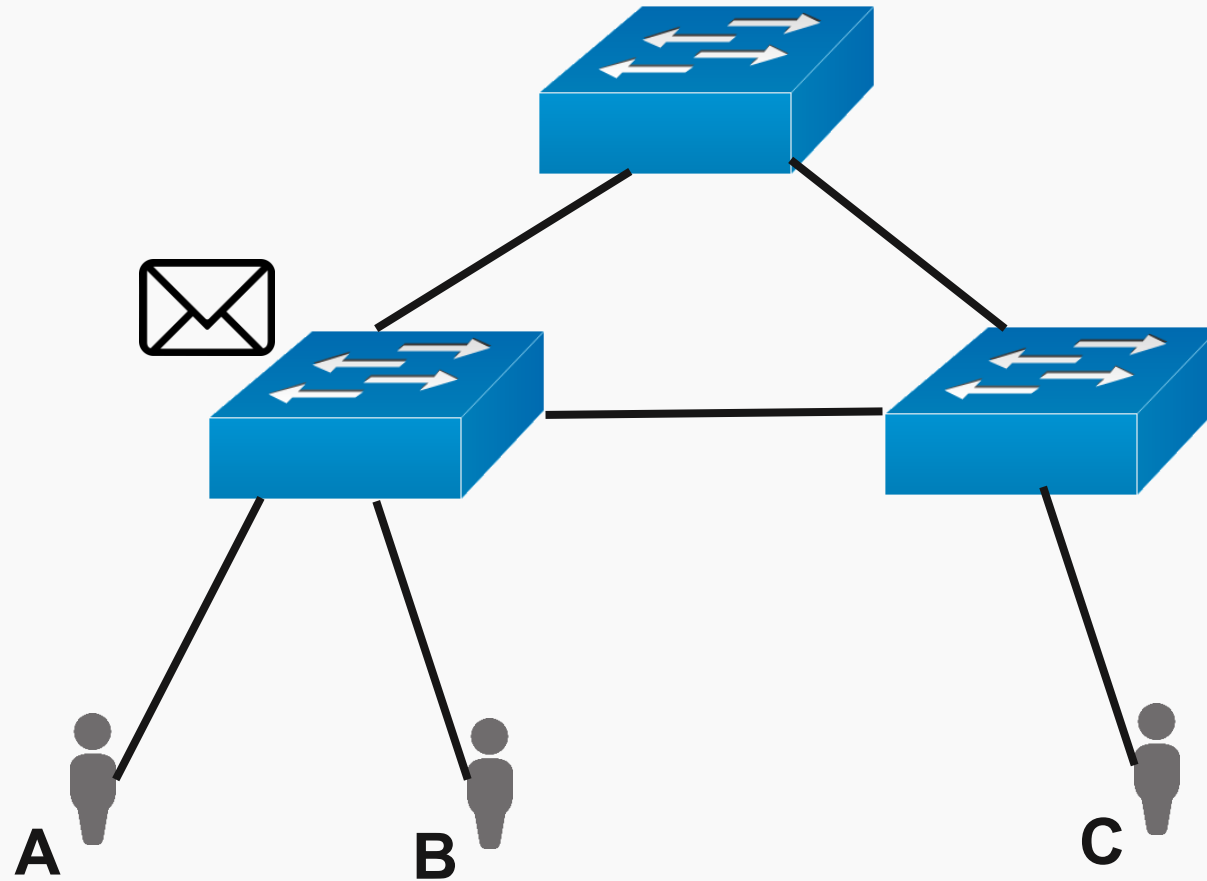


Ethernet – CAM table – Probleme cu cicluri



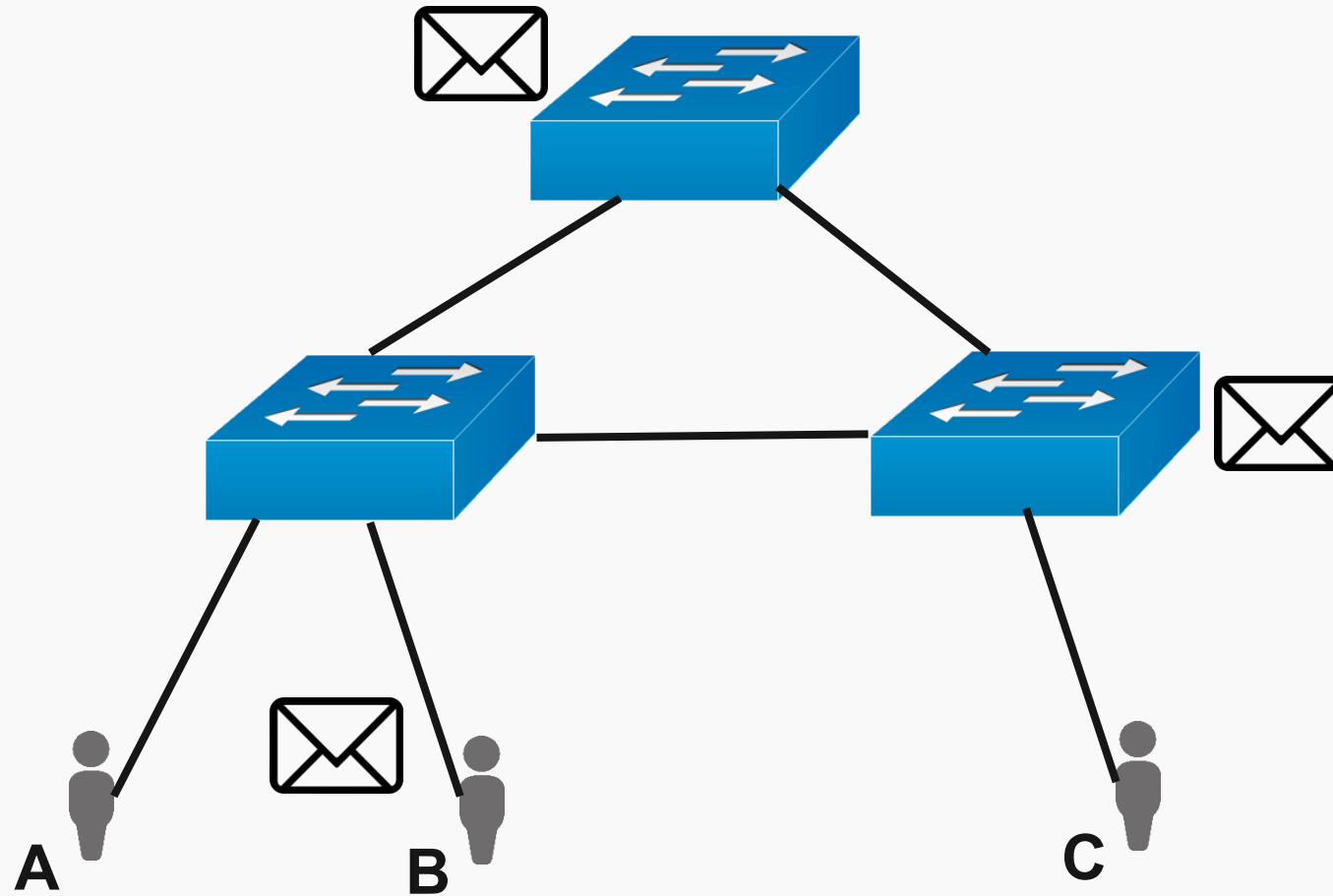


Ethernet – CAM table – Probleme cu cicluri



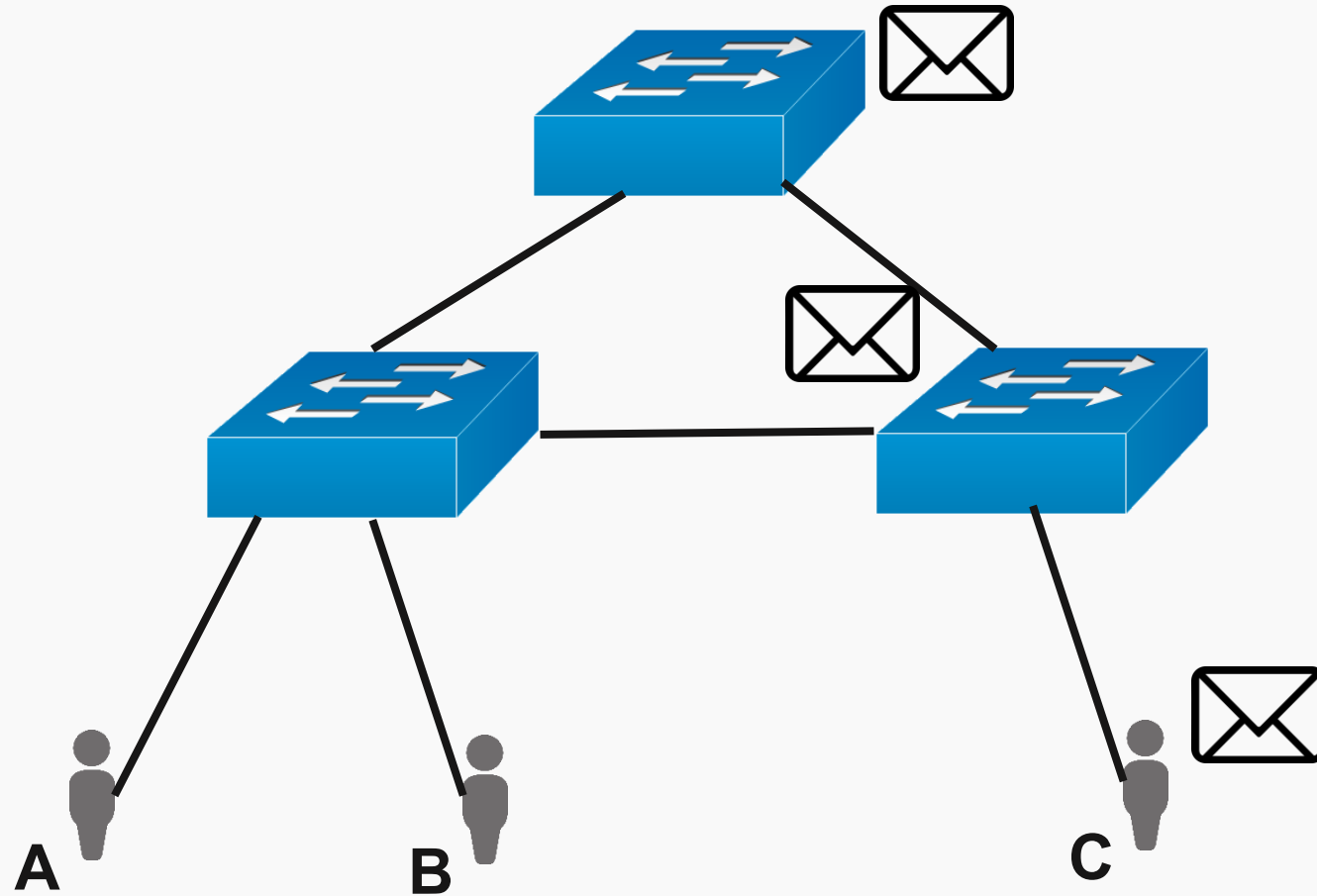


Ethernet – CAM table – Probleme cu cicluri



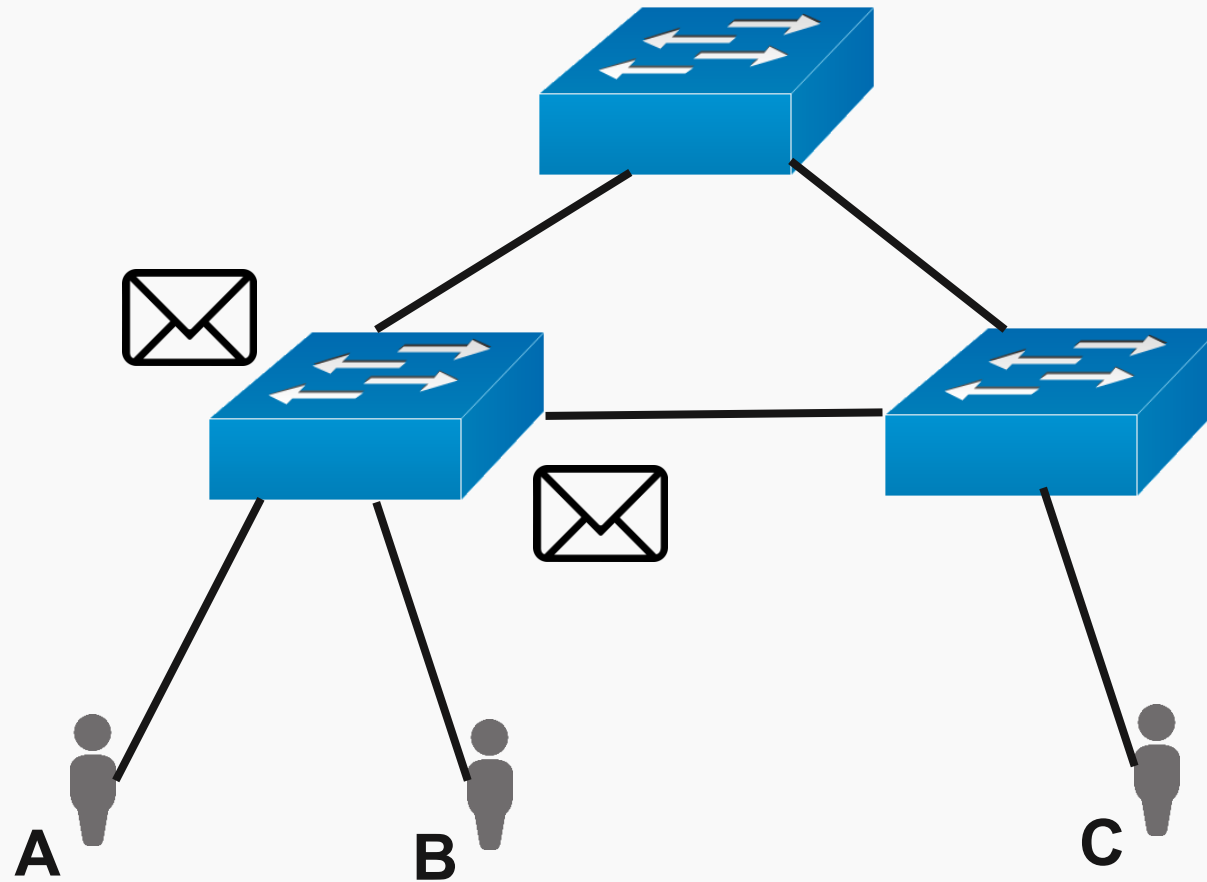


Ethernet – CAM table – Probleme cu cicluri



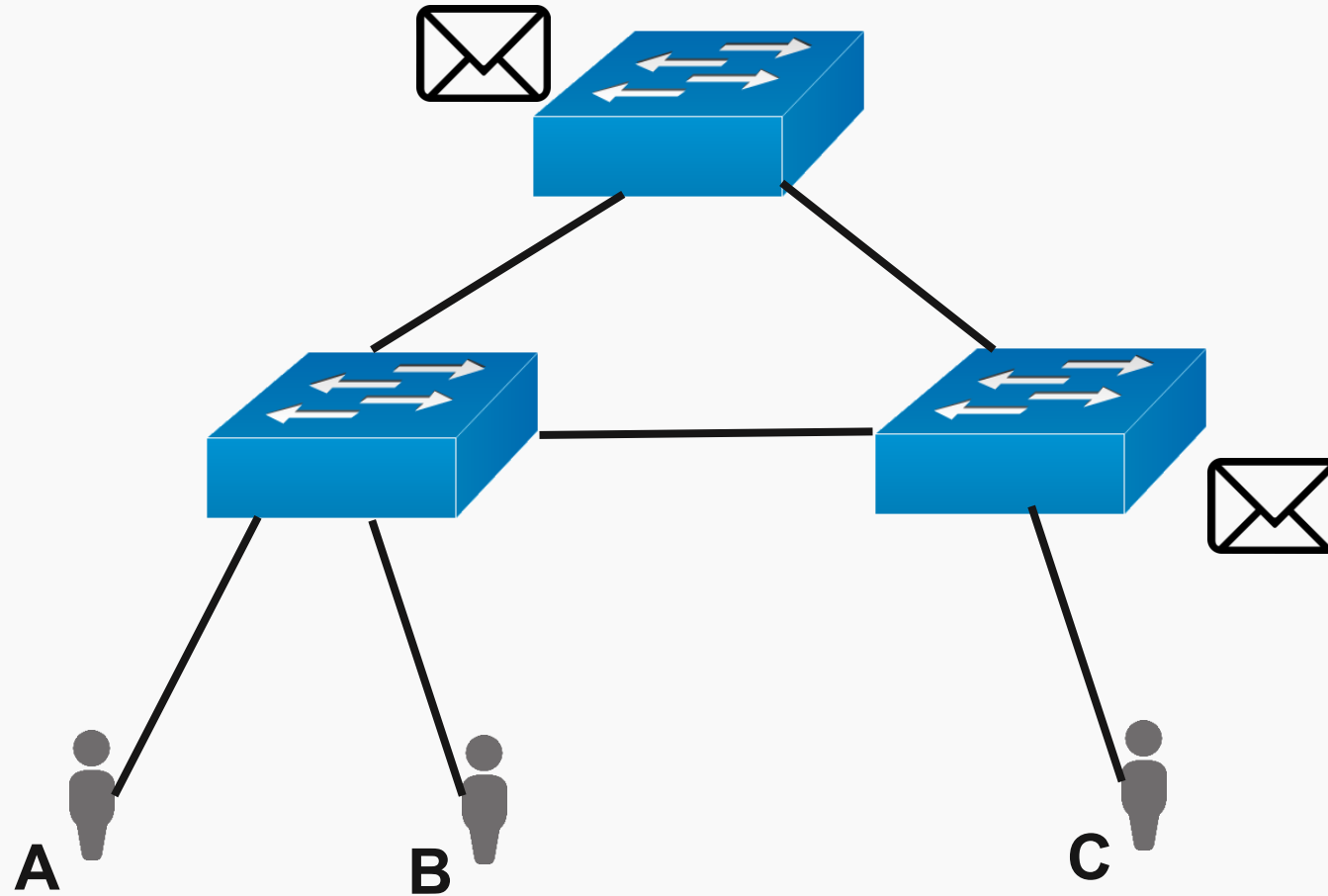


Ethernet – CAM table – Probleme cu cicluri



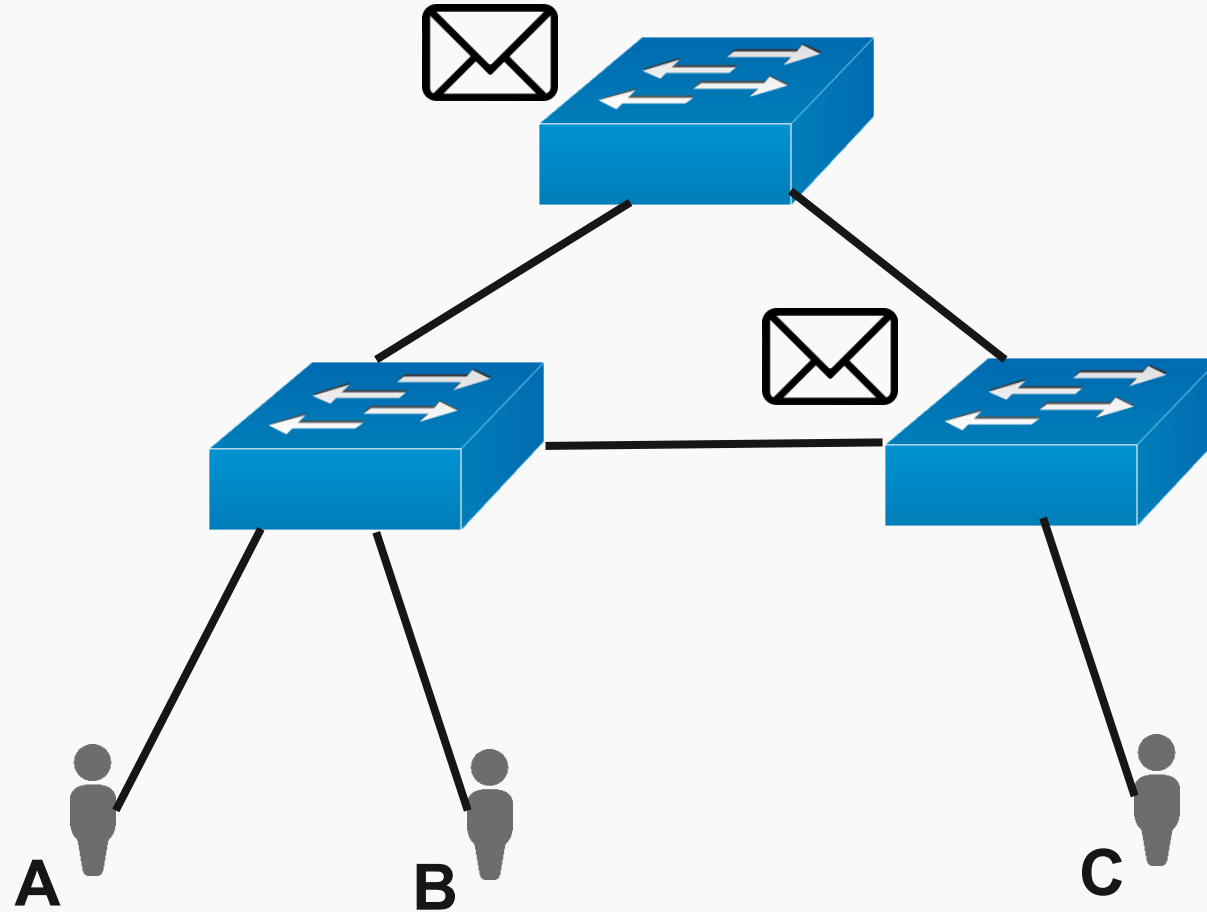


Ethernet – CAM table – Probleme cu cicluri



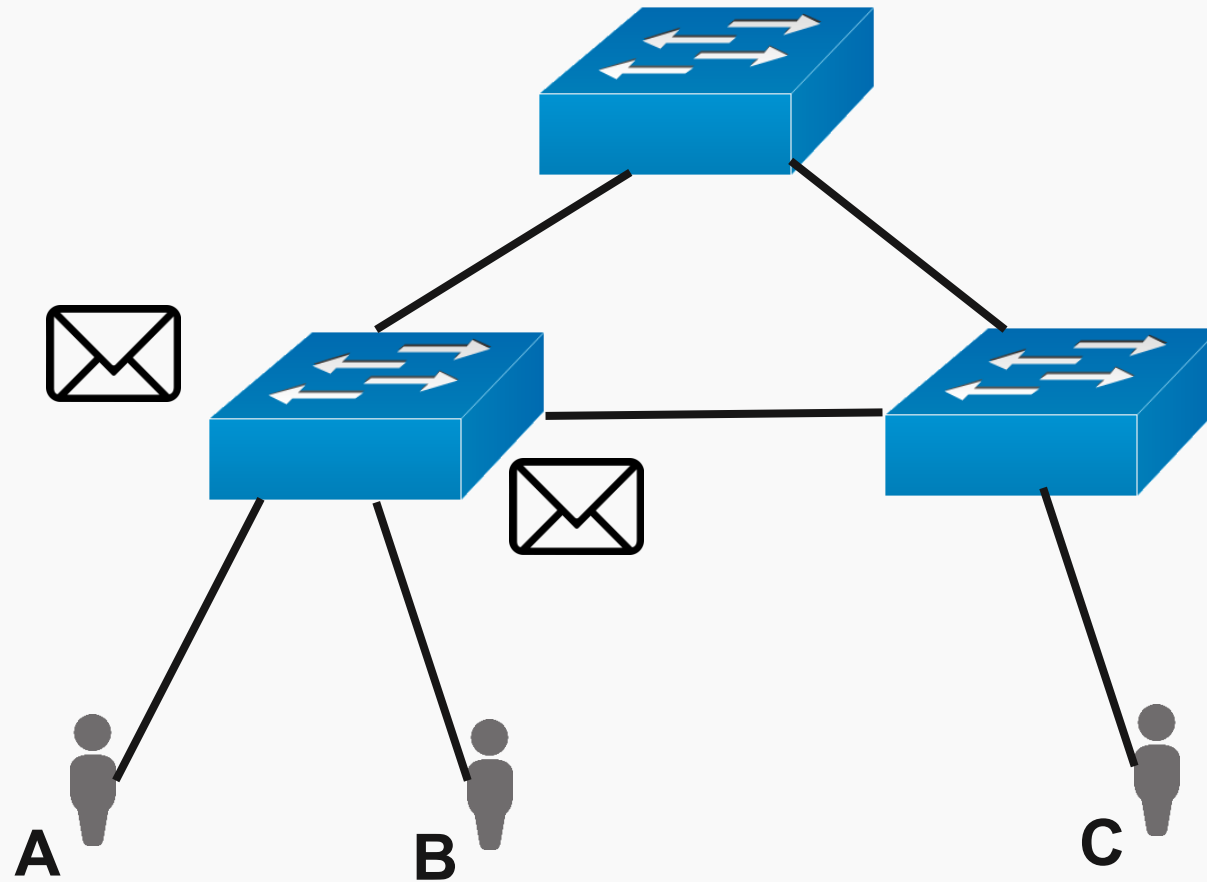


Ethernet – CAM table – Probleme cu cicluri





Ethernet – CAM table – Probleme cu cicluri





Cum eliminăm cicluri dintr-un graf?

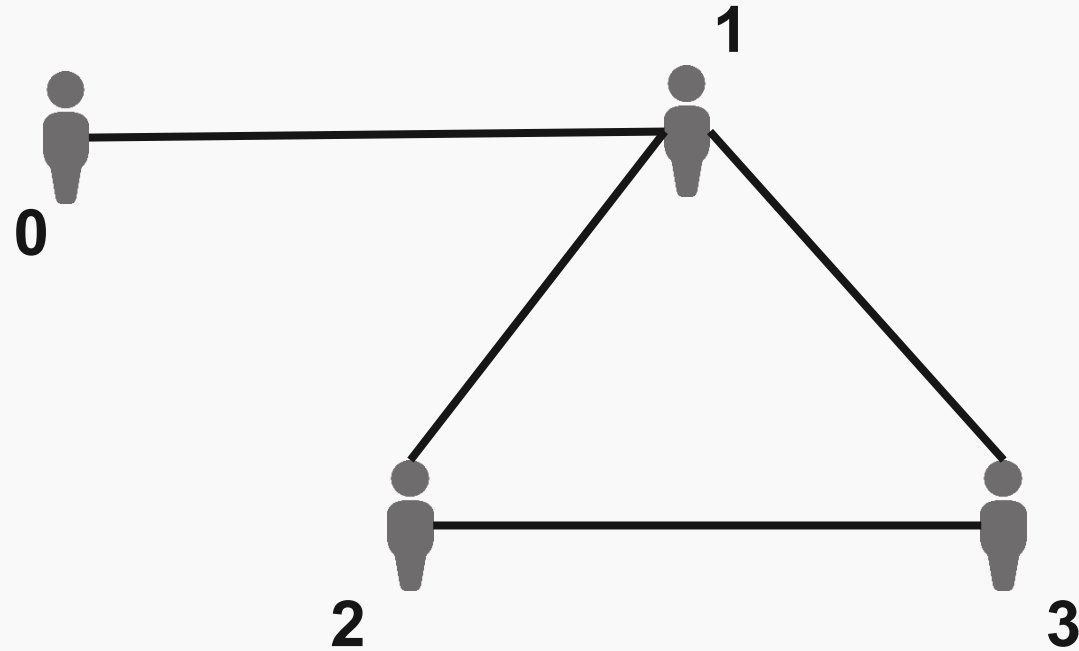


Cum eliminăm cicluri dintr-un graf?

Spanning Tree Protocol

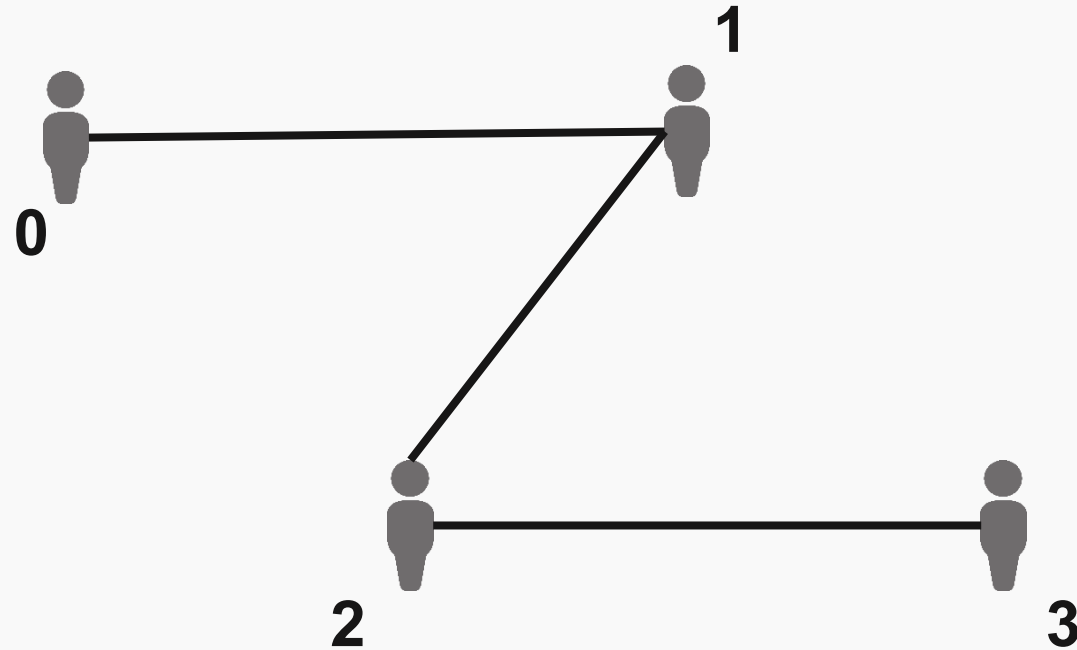


Distributed Spanning Tree



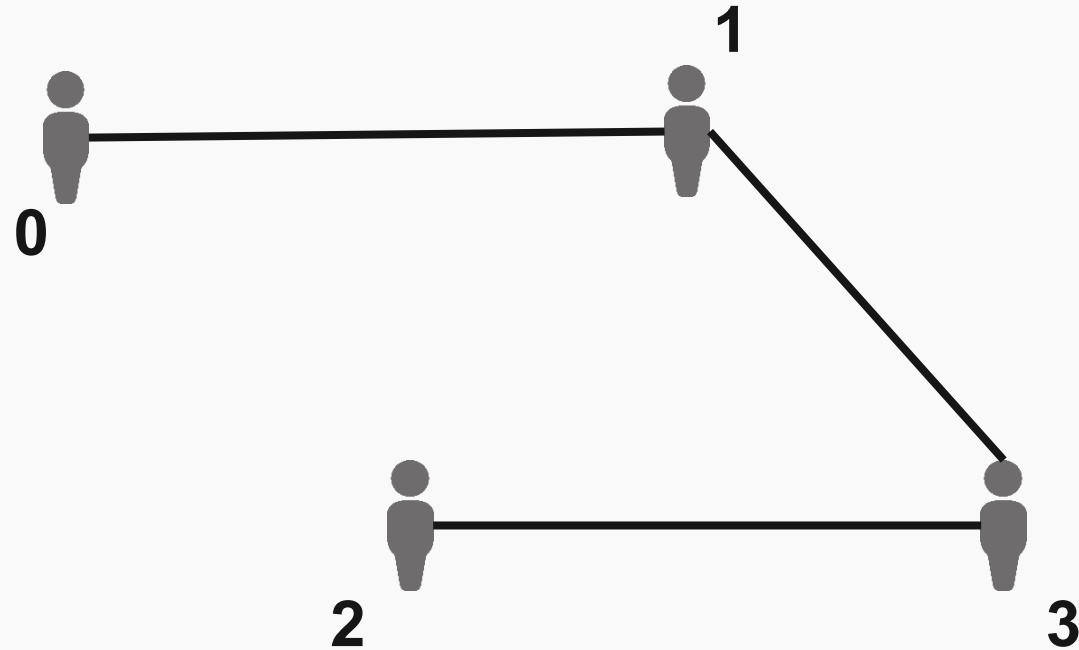


Distributed Spanning Tree – soluția



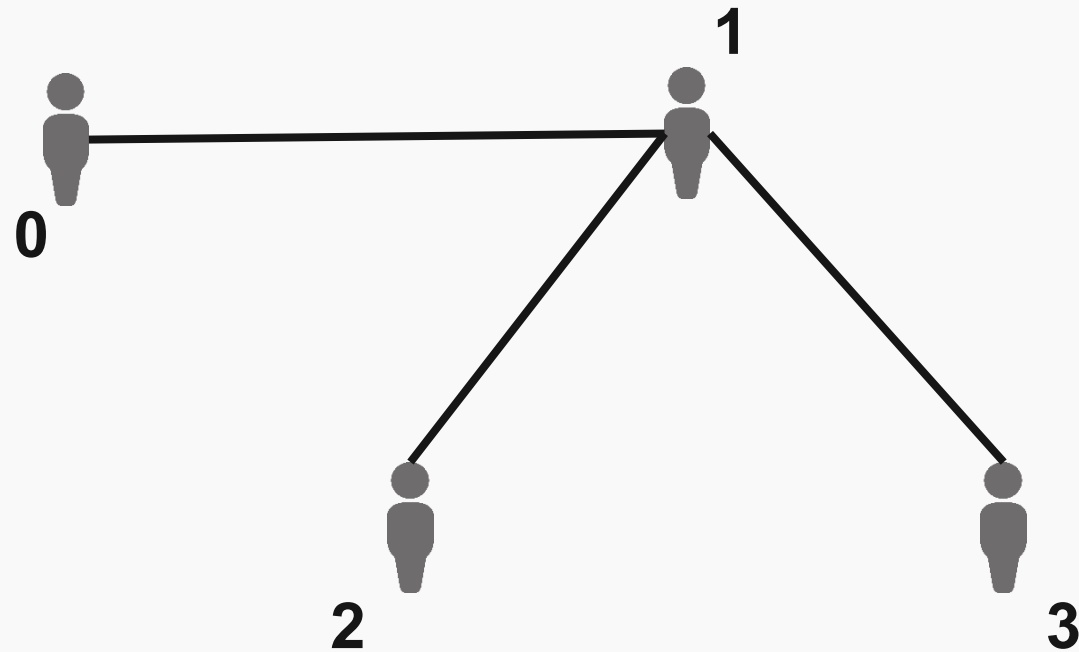


Distributed Spanning Tree - soluția





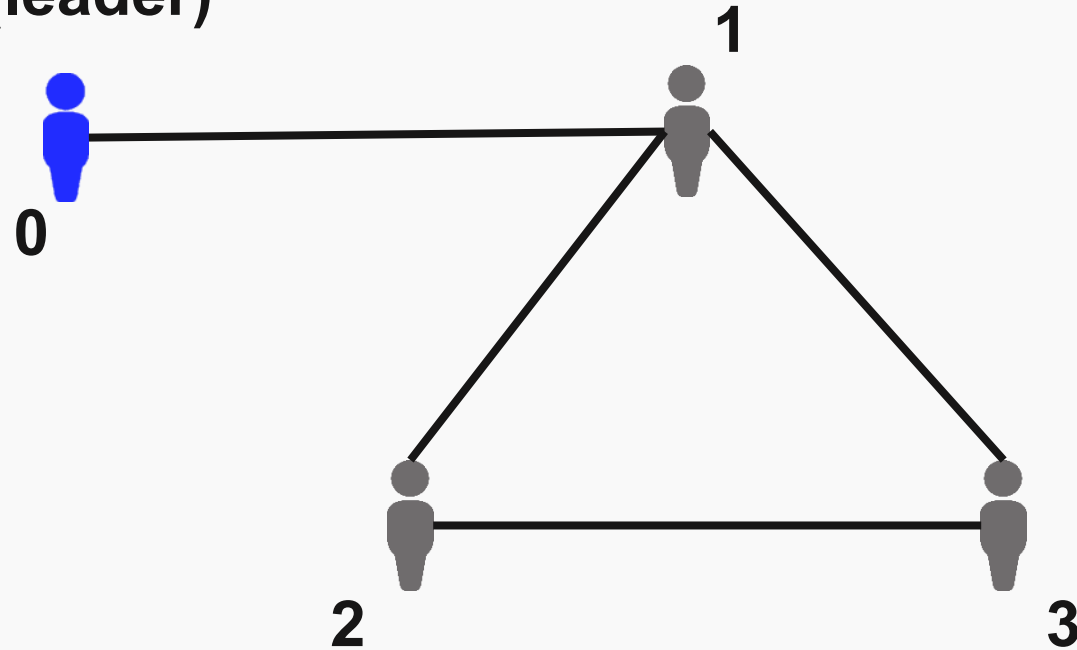
Distributed Spanning Tree - soluția





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

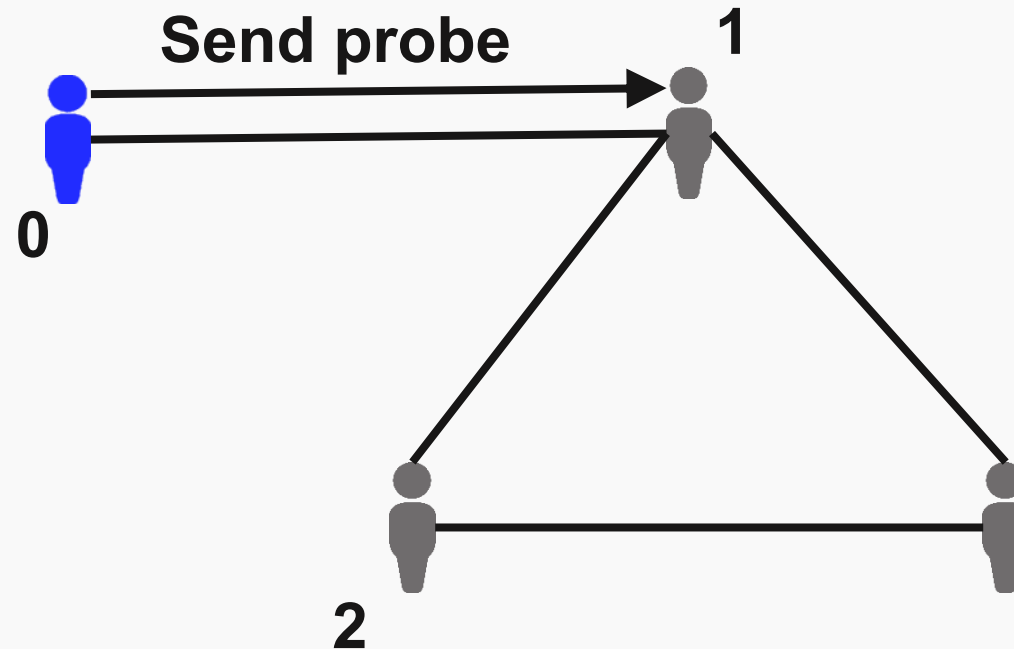
Everyone else



- 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



Node	Parent
0	-
1	
2	
3	

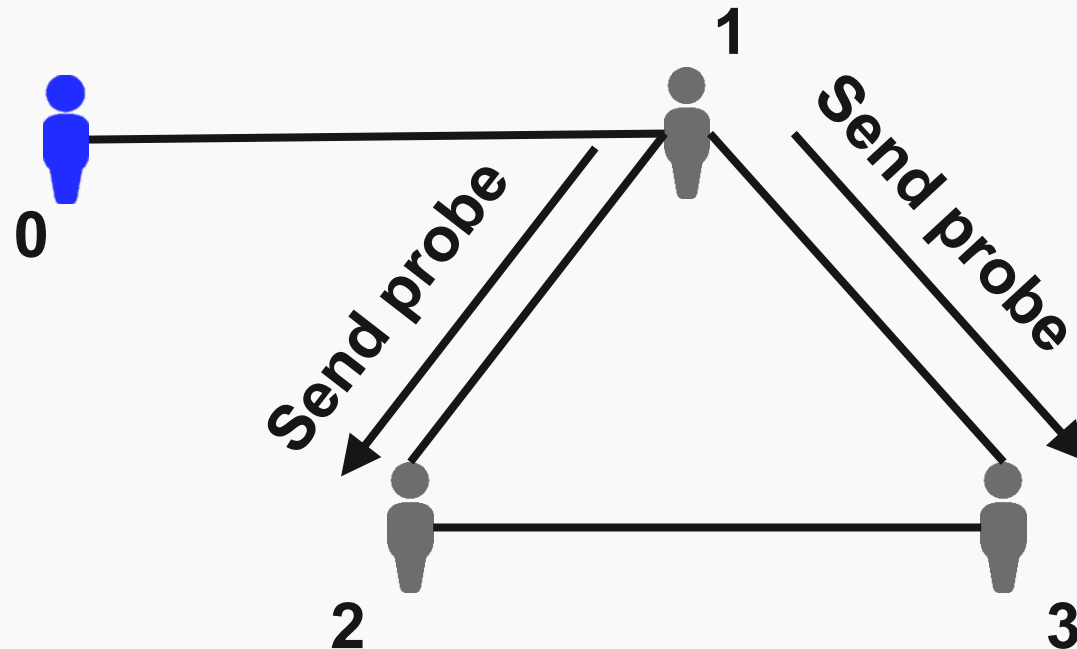
→ **Node 2**
Recv probe
Mark parent
Send probe children
Recv response children
Merge responses
Send response parent

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



Distributed Spanning Tree

Node	Parent
0	-
1	0
2	
3	



Node 2

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

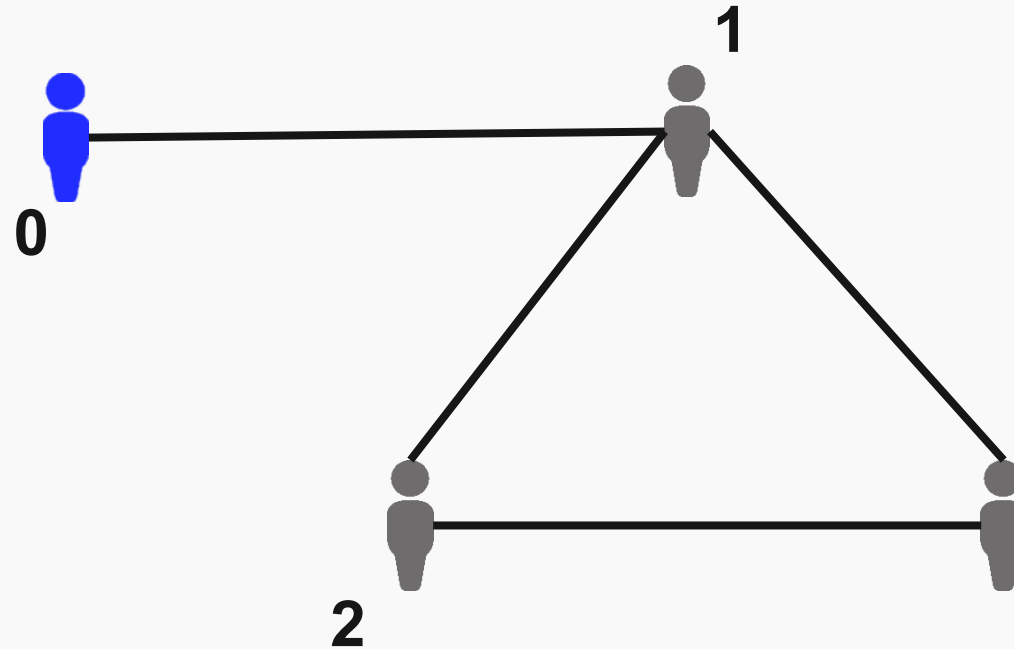
Node 3

Node 3

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



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

3

Node 3

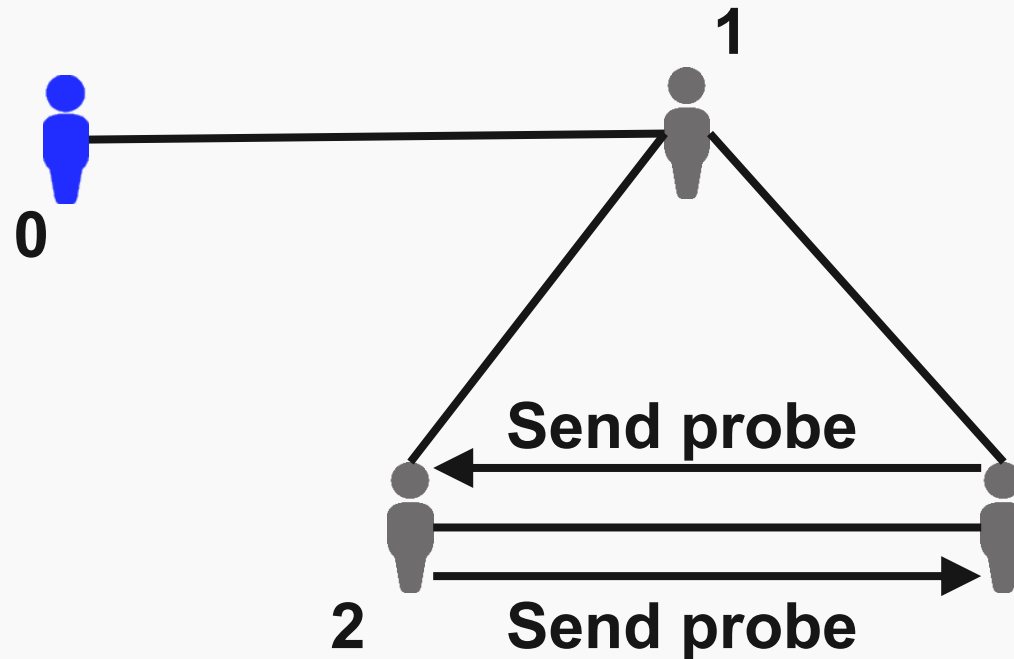
Recv probe
Mark parent
→ Send probe children
Recv response children
Merge responses
Send response parent



Distributed Spanning Tree – Inițiator

2 și 3 tratează probele unul altuia ca răspunsuri

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

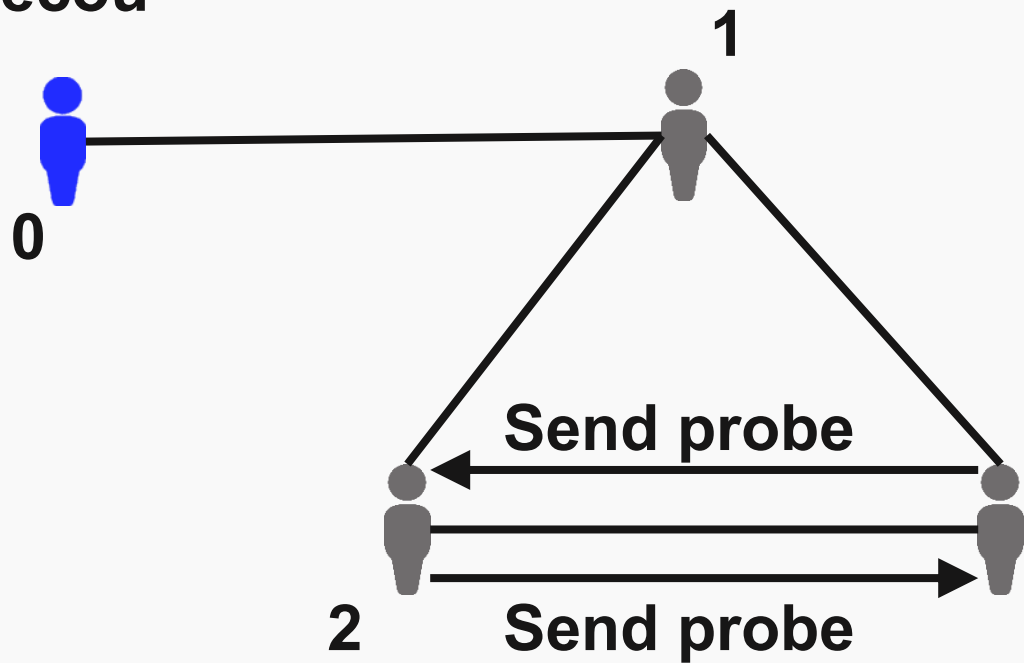
Node 3

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



Distributed Spanning Tree – Initiator

Funcționează doar dacă proba are același format ca ecou



Node	Parent
0	-
1	0
2	1
3	1

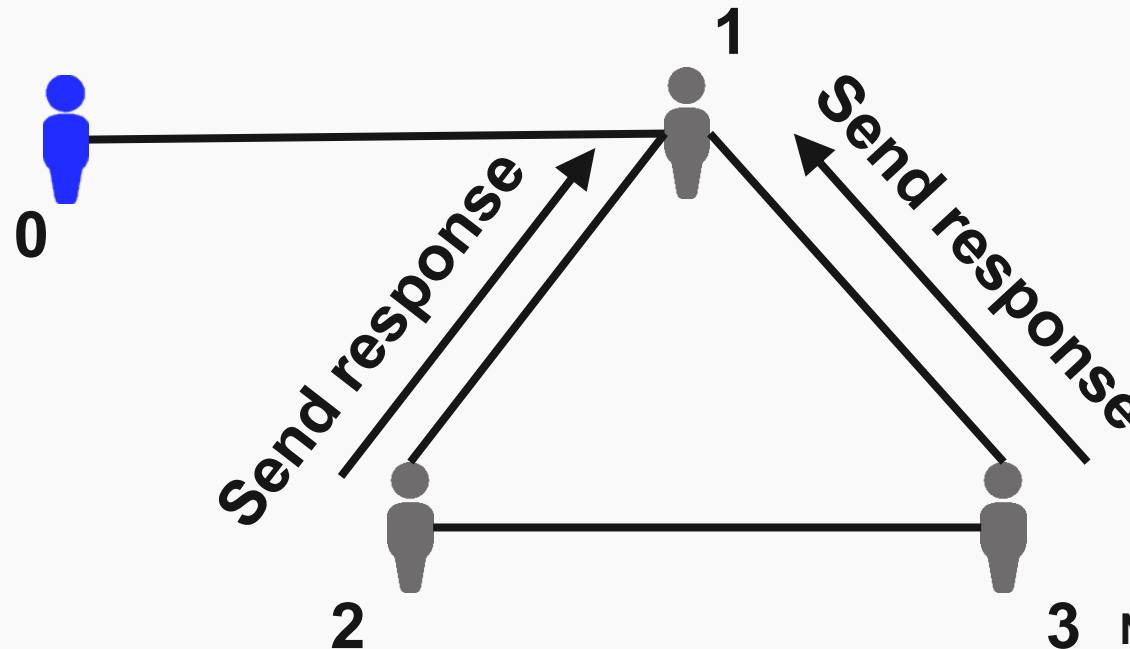
Node 2
Recv probe
Mark parent
Send probe children
Recv response children
→ Merge responses
Send response parent

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



Distributed Spanning Tree

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



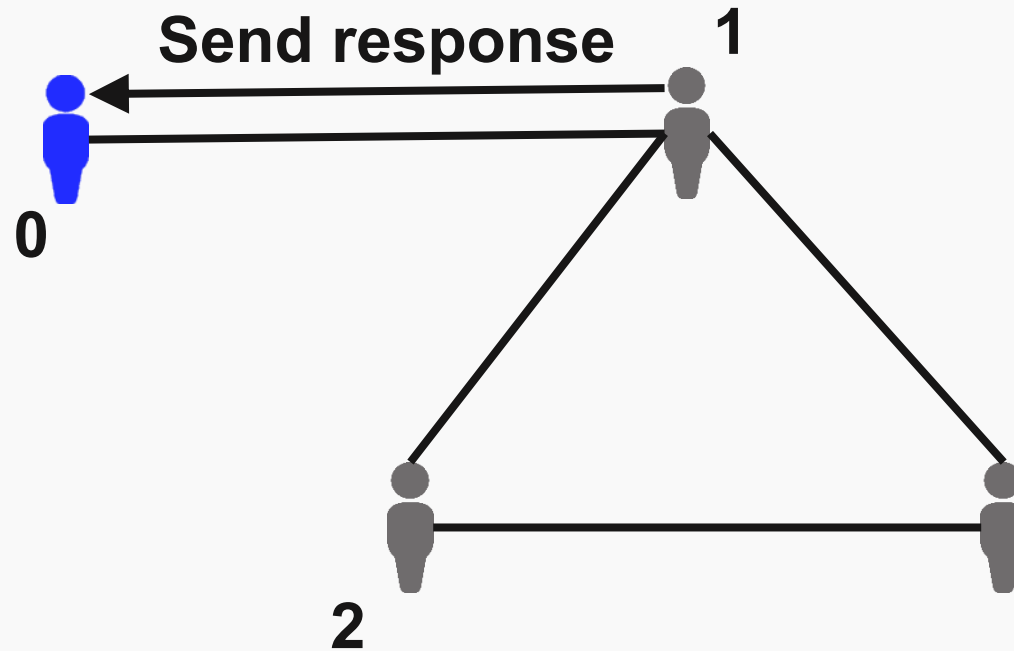
Node 3

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





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

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





Distributed Spanning Tree

Comunicație full sincronă



Distributed Spanning Tree

0 

Cum alegem inițiatorul?



Alegere lider



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

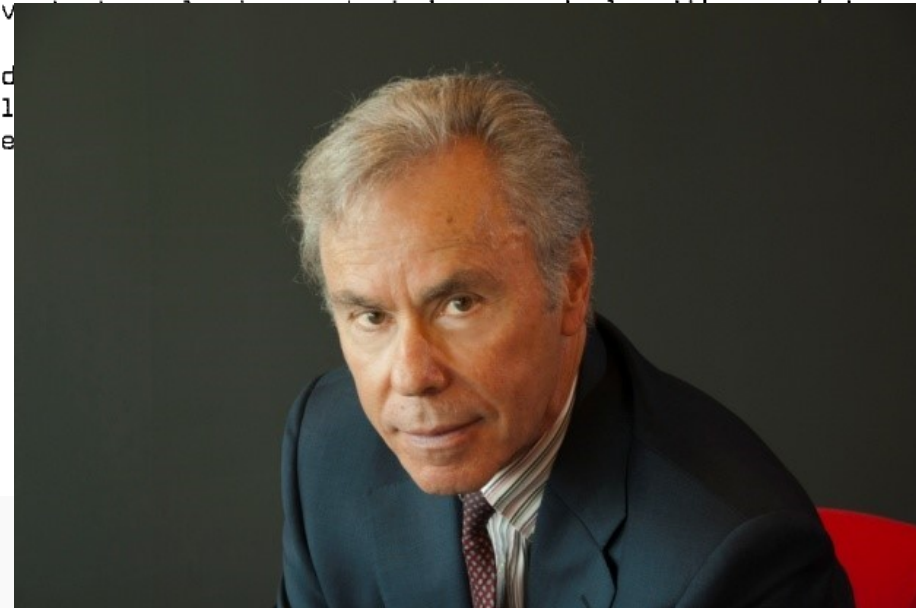
DISTRIBUTED SYSTEMS—TOWARDS A FORMAL APPROACH

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 devised to operate such distributed systems in a variety of contexts, the characteristics of distributed systems are analysed and fundamental results are shown that distributed systems are not just simple extensions of centralized systems. The techniques used in some planned or existing systems to solve some of the problems is illustrated by the study of a mutual exclusion problem in a distributed environment.

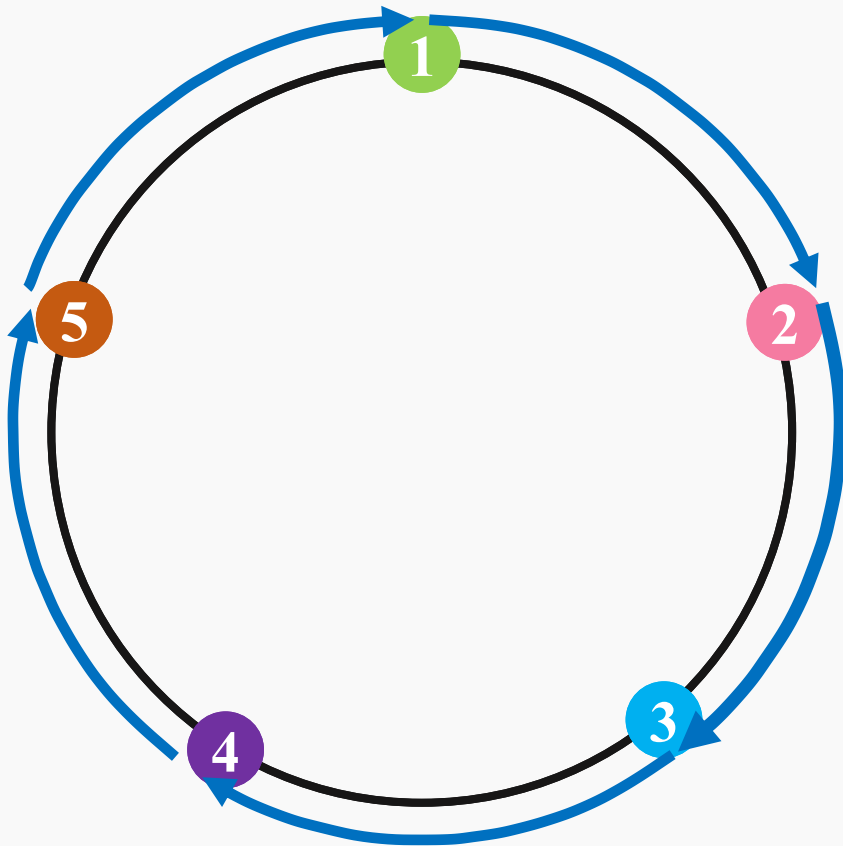
1. INTRODUCTION

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





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

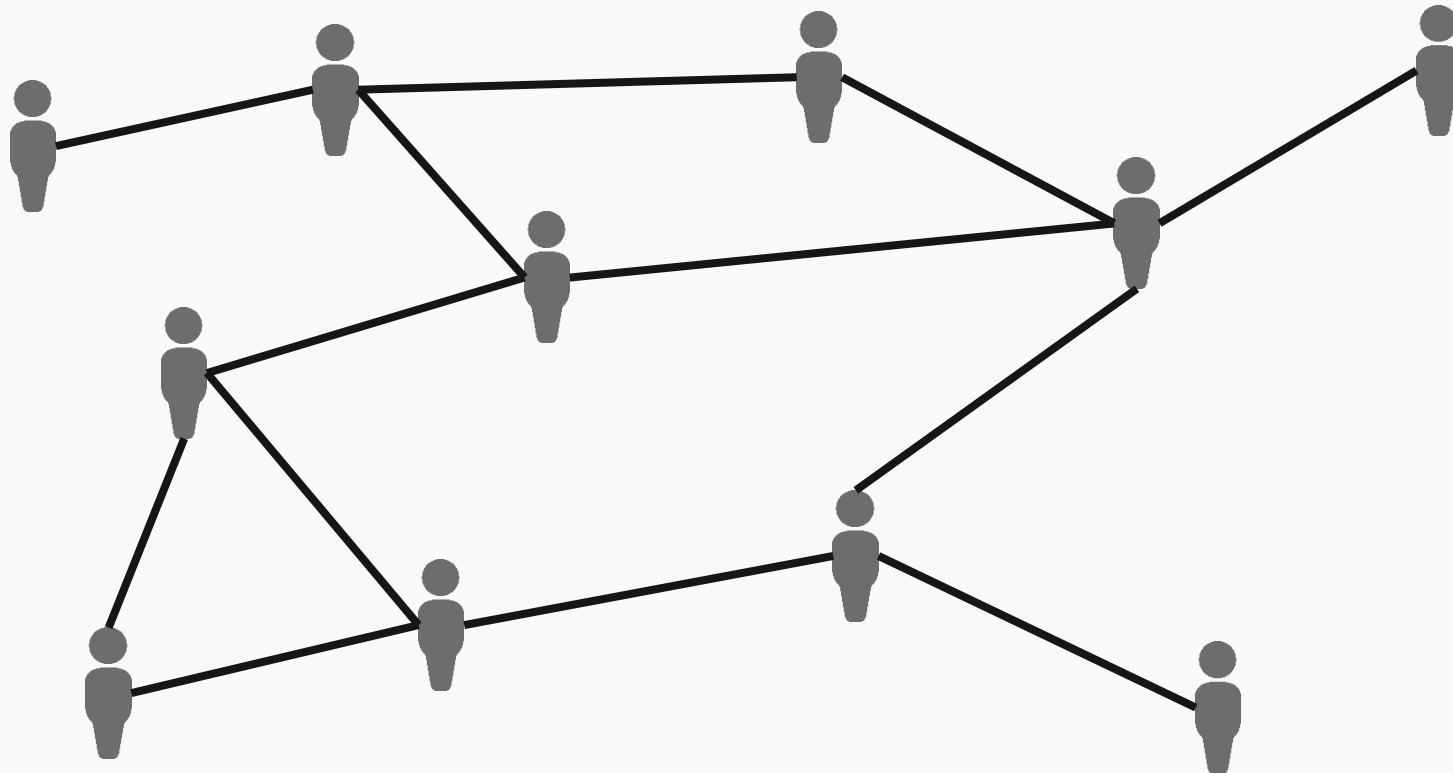
Cel mai mare/mic/etc. este ales lider



De ce mai discutăm despre topologii inel?

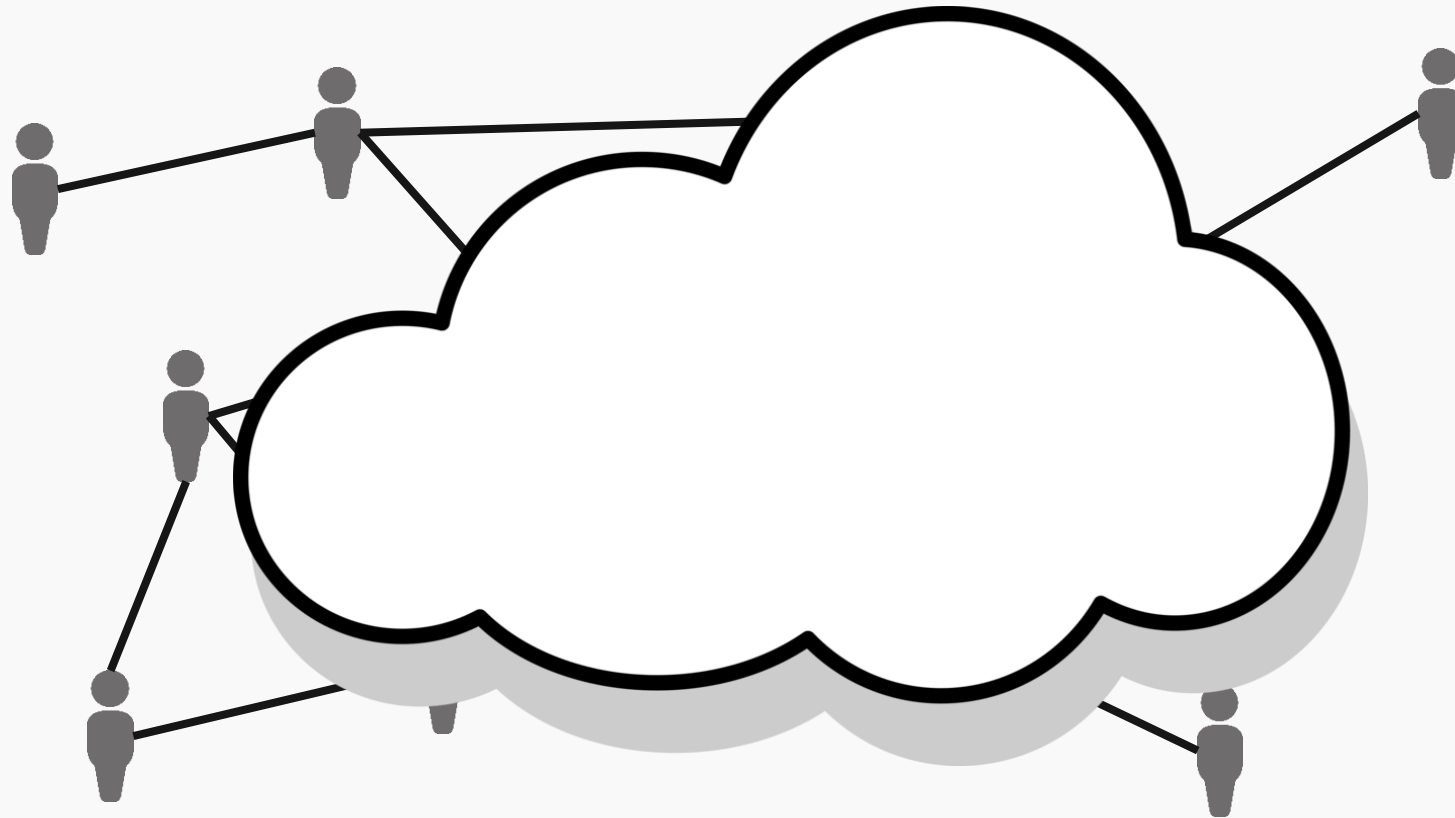


Una e topologia fizică





Una e topologia fizică





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





Algoritmi de stabilire rute în IP?

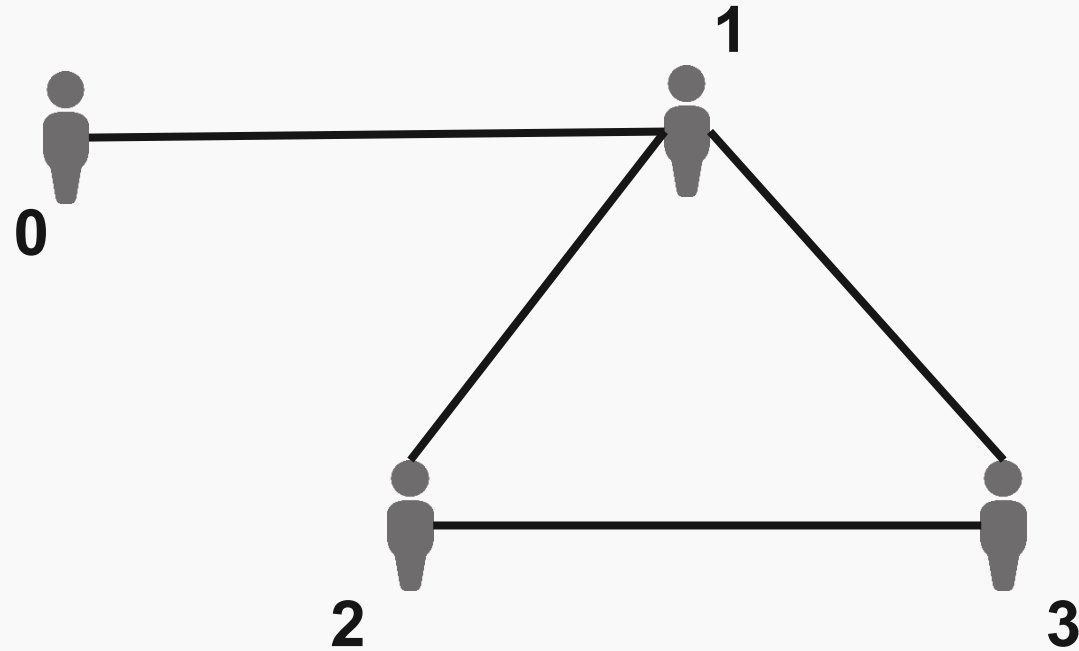


Algoritmi de stabilire rute în IP?

- 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

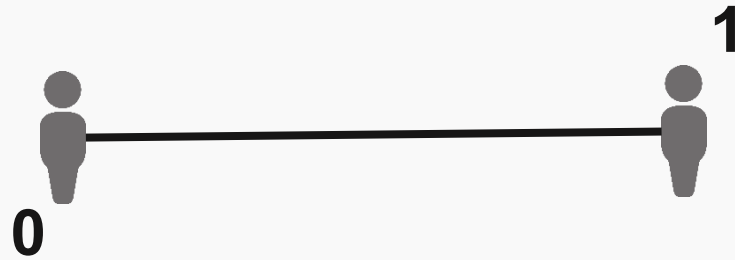


Trimite topologie cunoscută tuturor vecinilor
Primește de la toți vecinii topologiile cunoscute de ei
Adaugă informații la topologia cunoscută.

Dacă topologia s-a modificat, repetă.

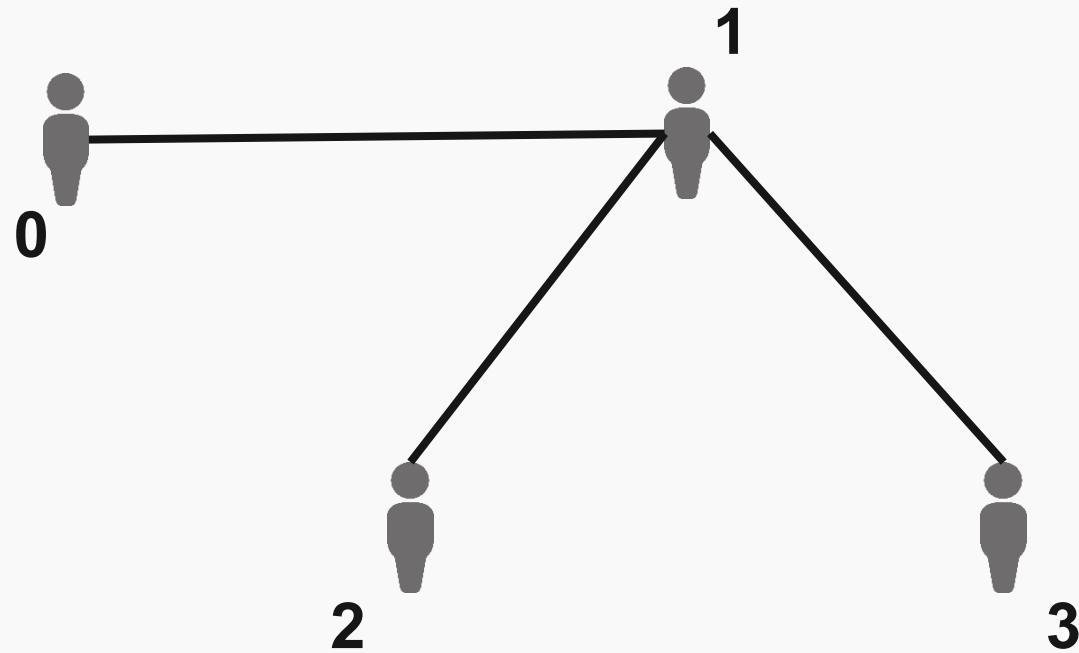


Topologii inițiale - 0



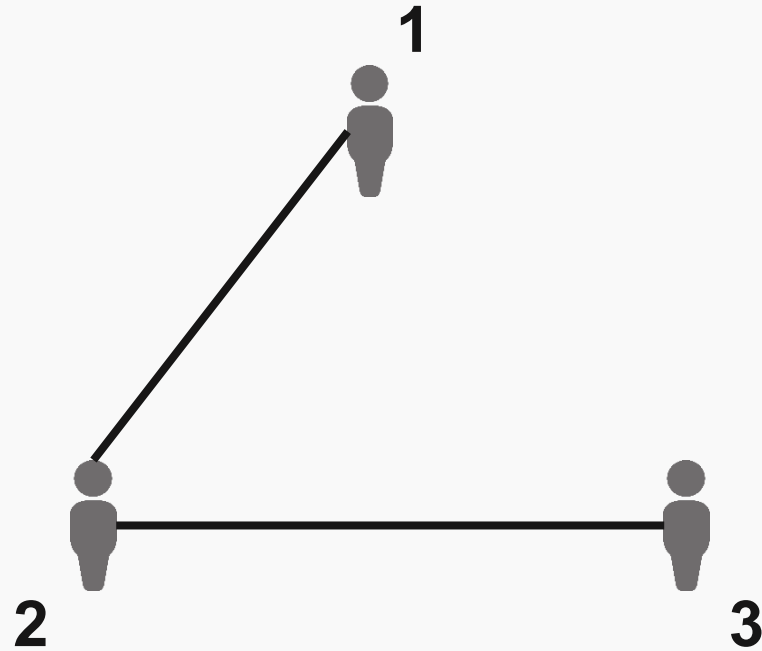


Topologii inițiale - 1



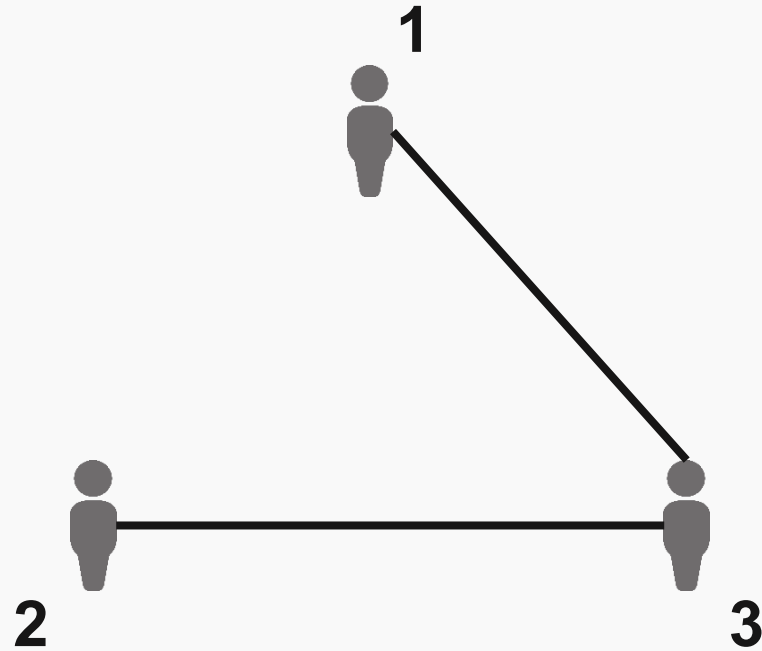


Topologii inițiale - 2



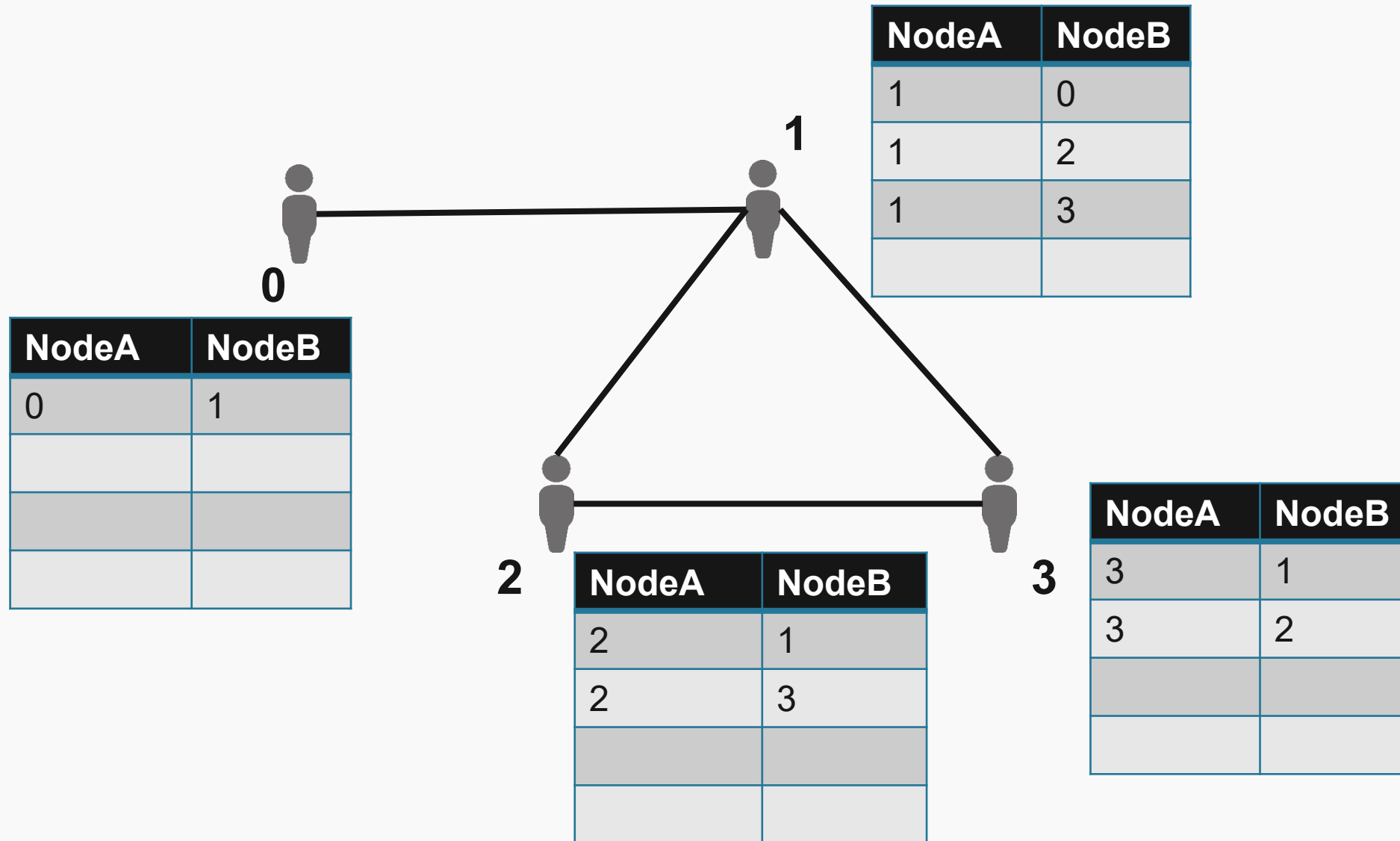


Topologii inițiale - 3



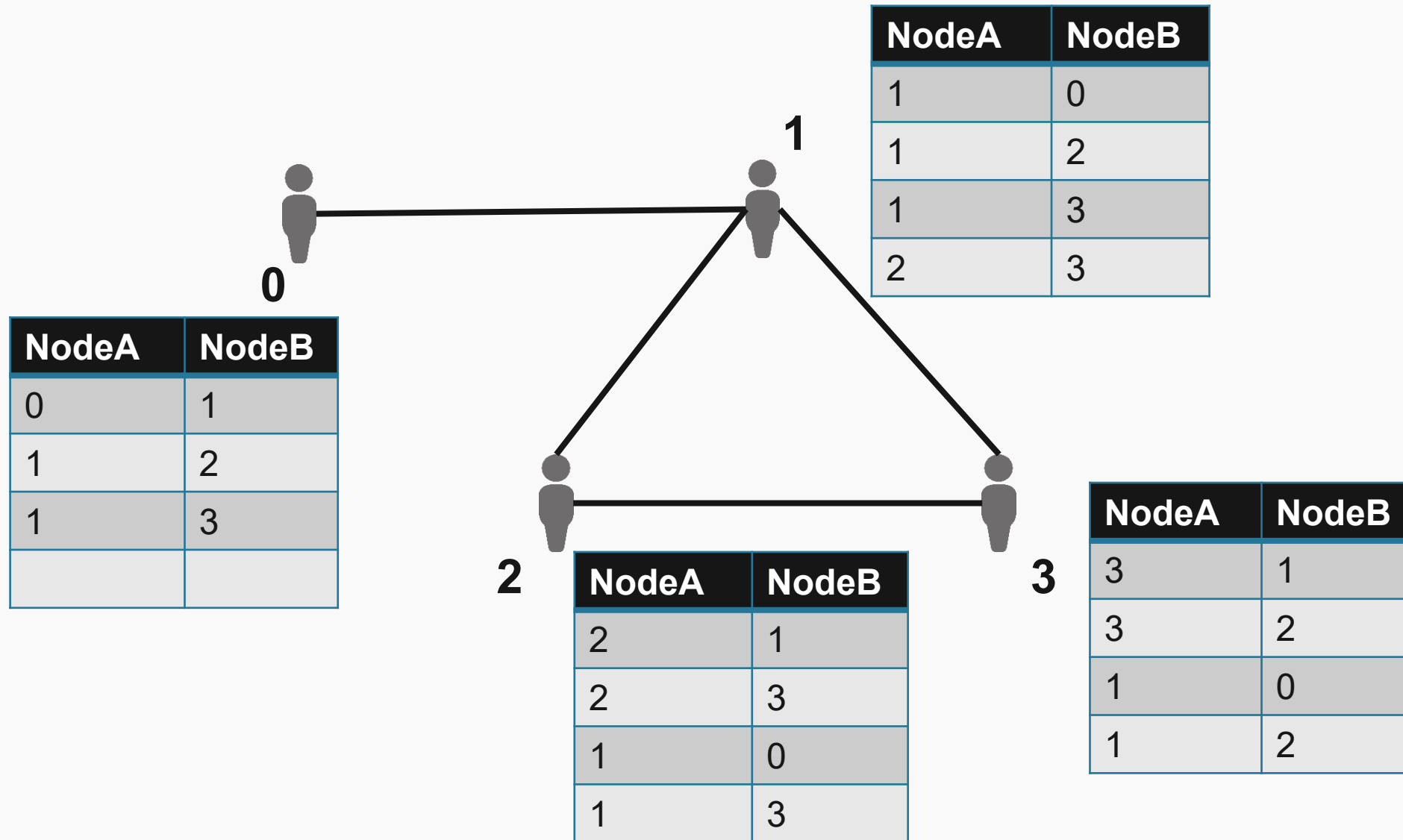


Algoritm stabilire topologie



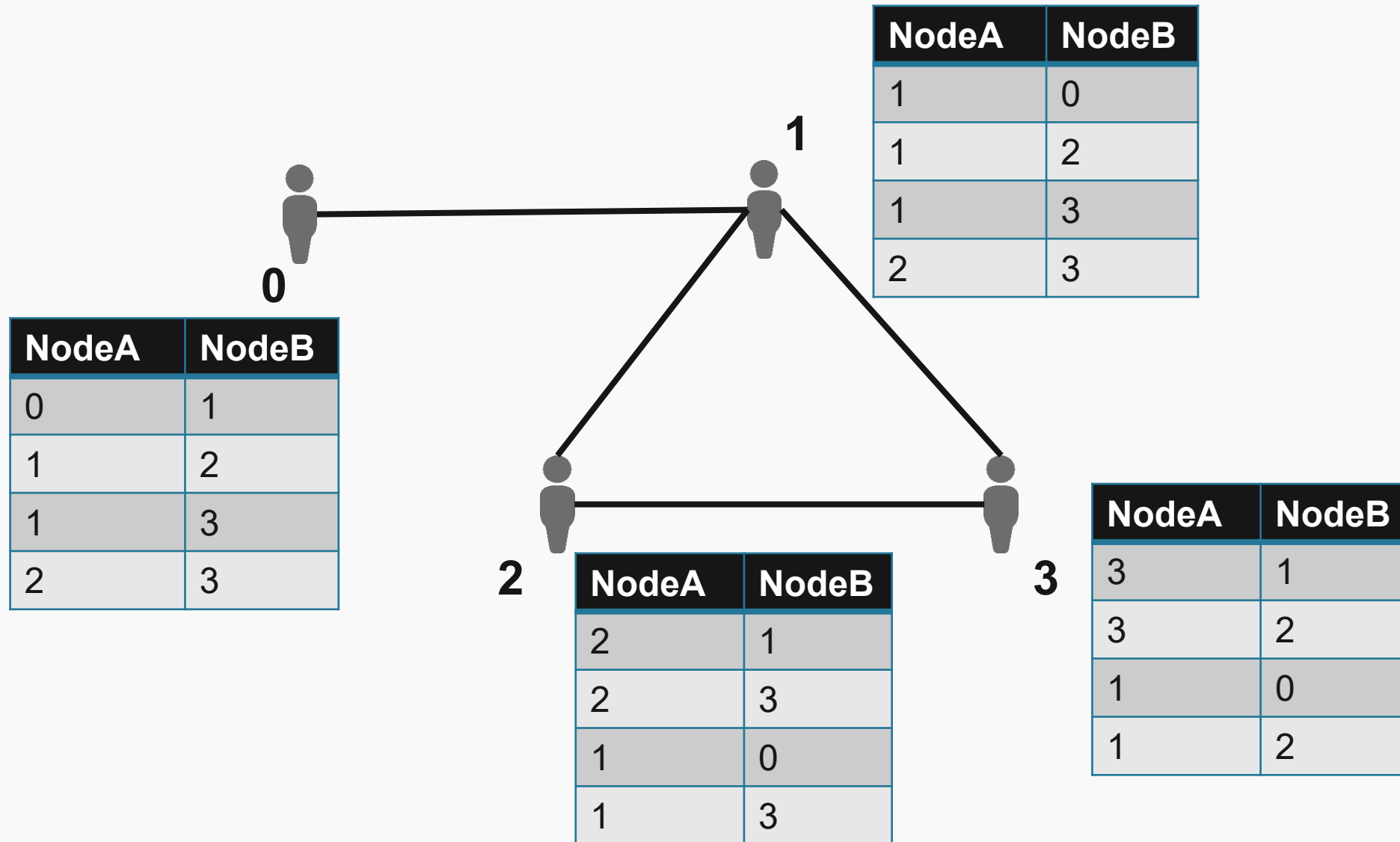


Algoritm stabilire topologie





Algoritm stabilire topologie

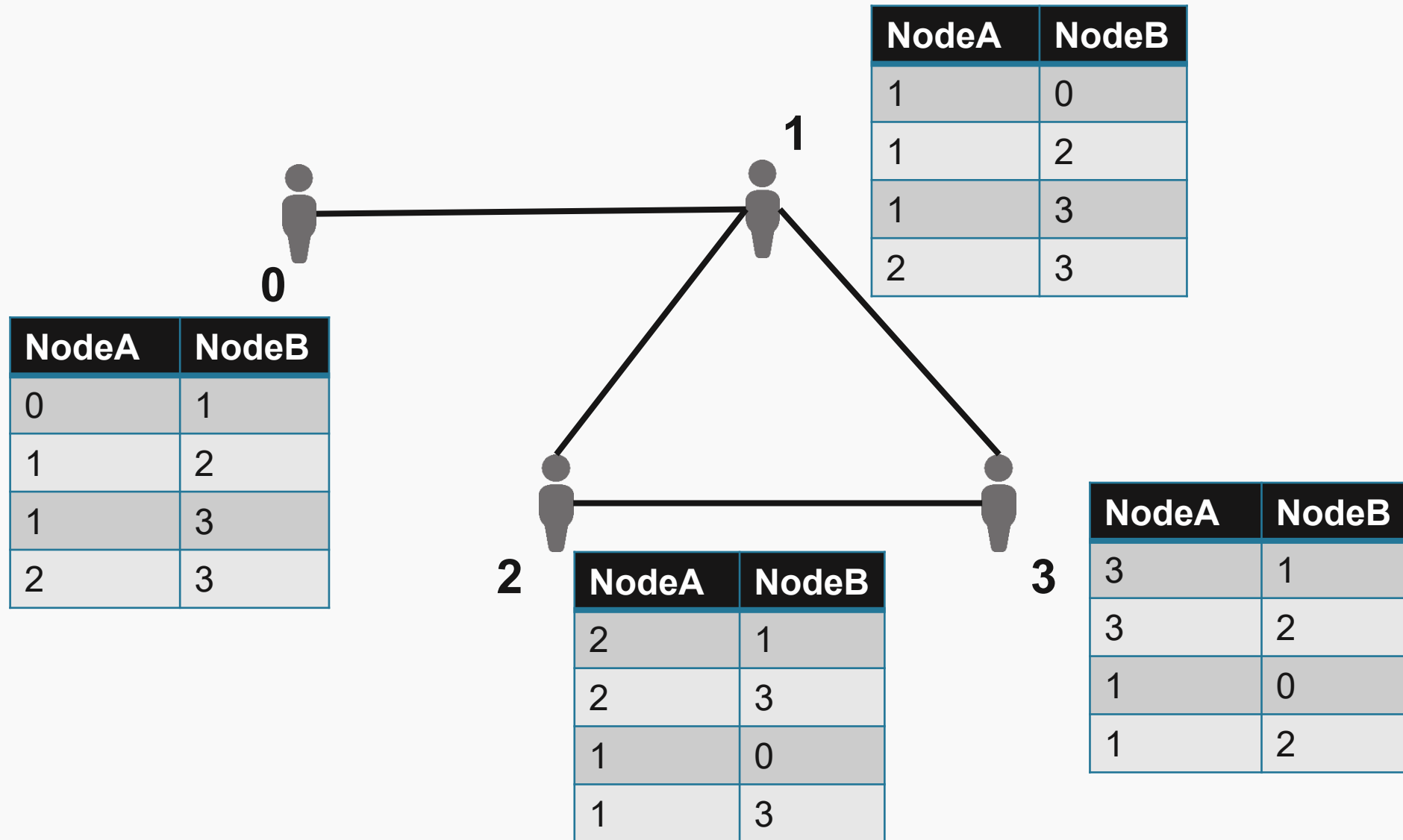




Alegere lider în graf



Alegere lider în graf







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

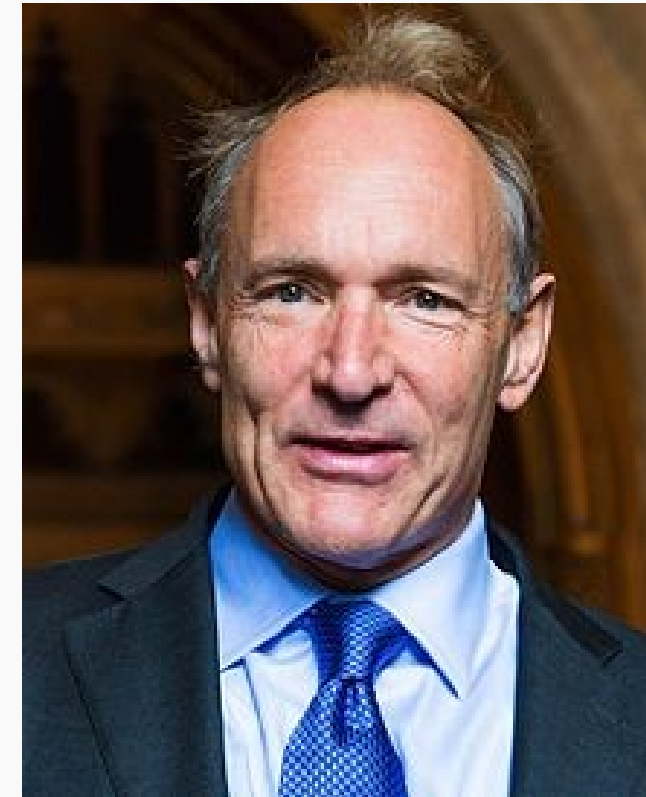
Hypertext Transfer Protocol -- HTTP/1.1

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

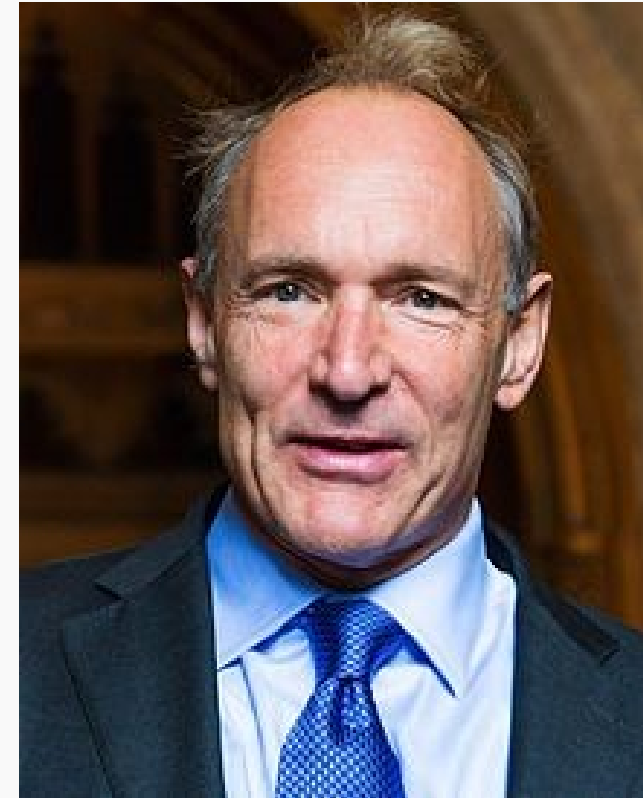
This document specifies an Internet standards track protocol for the Internet community, and requests discussion and suggestions for improvements. Please refer to the current edition of the "Internet Official Protocol Standards" (STD 1) for the standardization state and status of this protocol. Distribution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

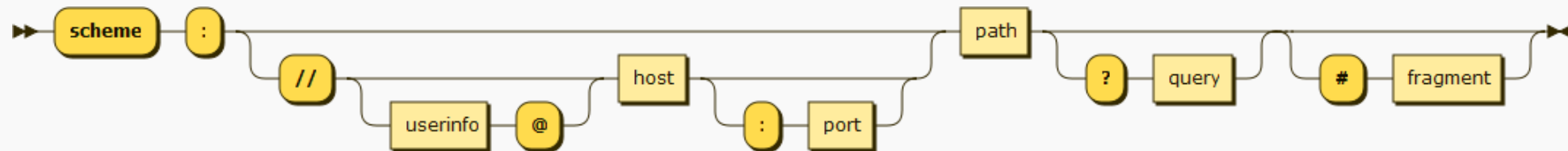
1. Introduction

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





URL





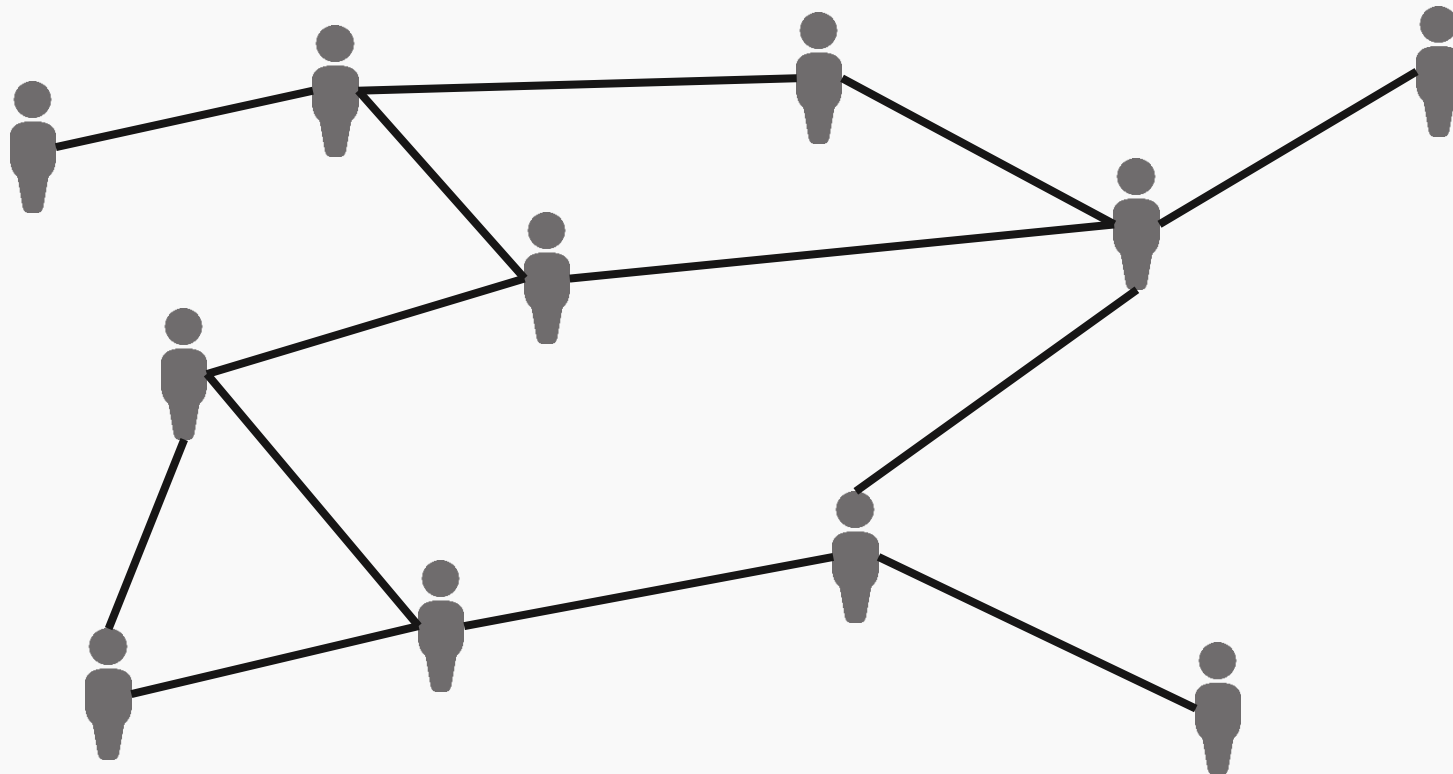
Sisteme distribuite extreme



Comunicare Epidemic



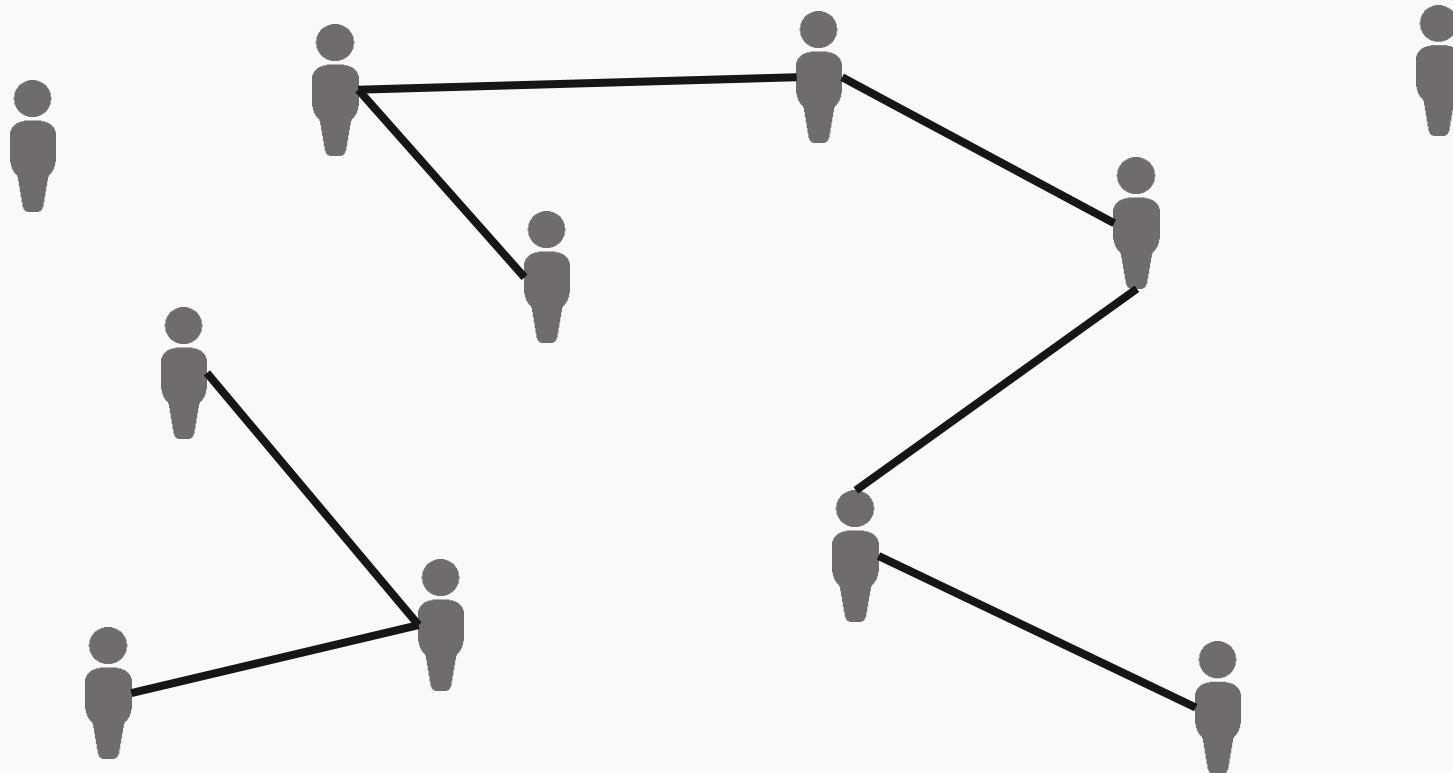
Epidemic





Comunicare Epidemic

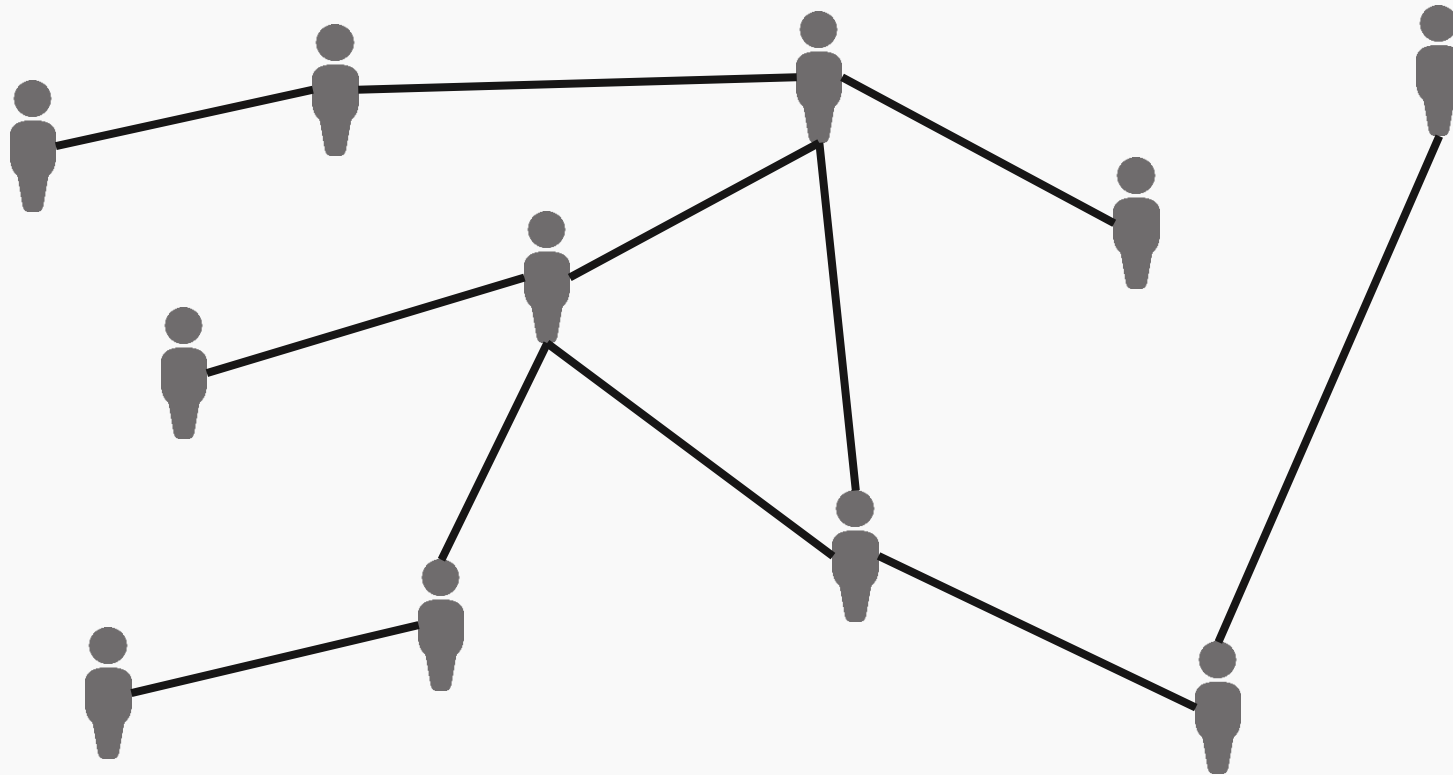
Topologia se poate schimba în orice moment





Comunicare Epidemic

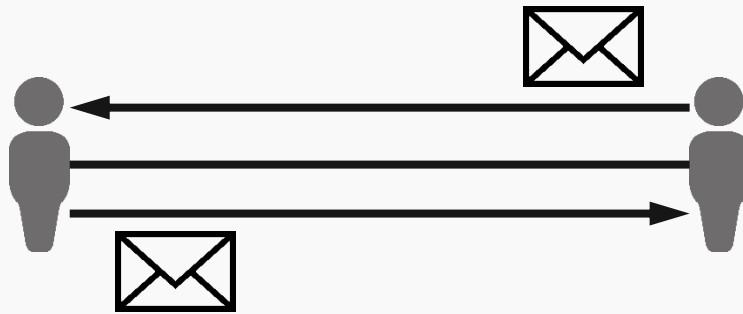
Topologia se poate schimba în orice moment





Epidemic

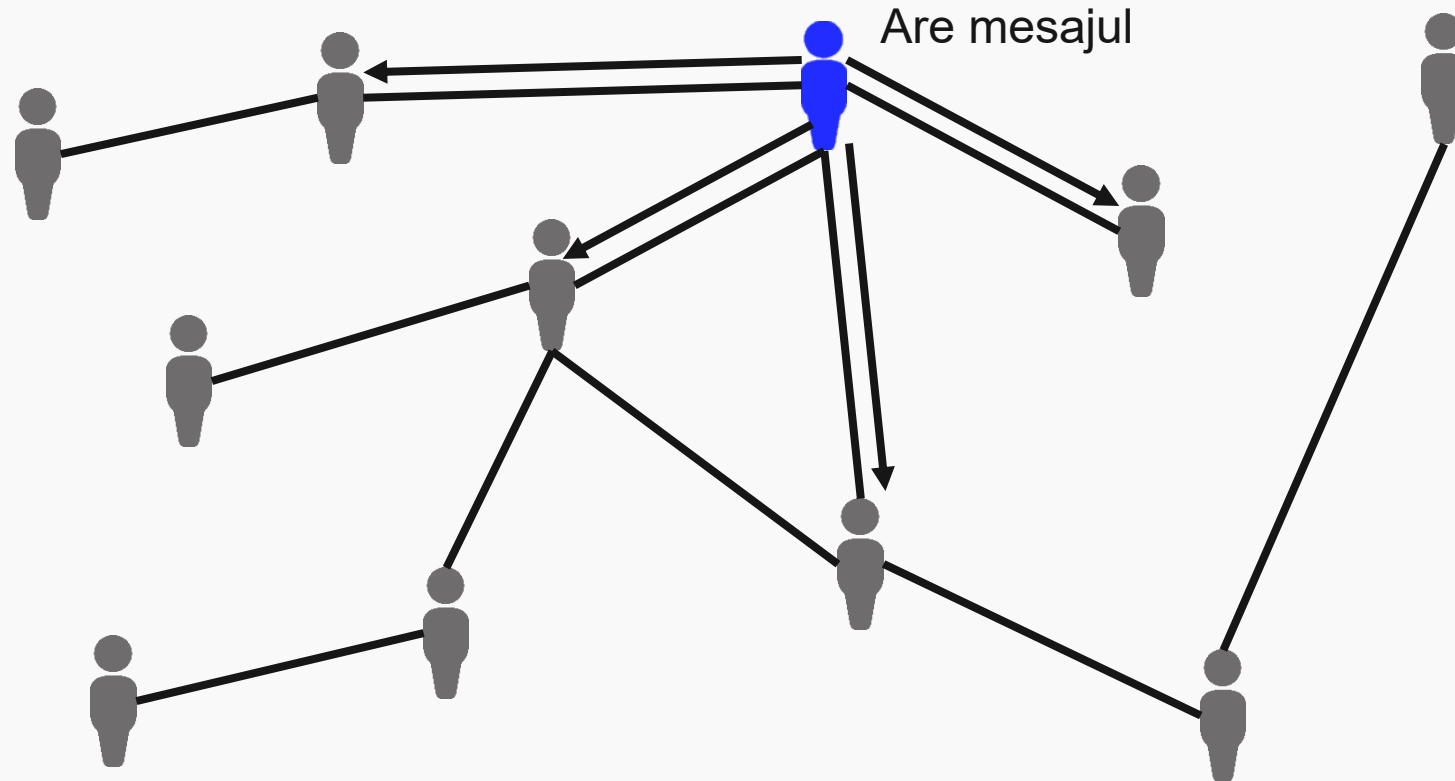
Cât timp avem conexiune nodurile schimbă mesaje.





Comunicare Epidemic

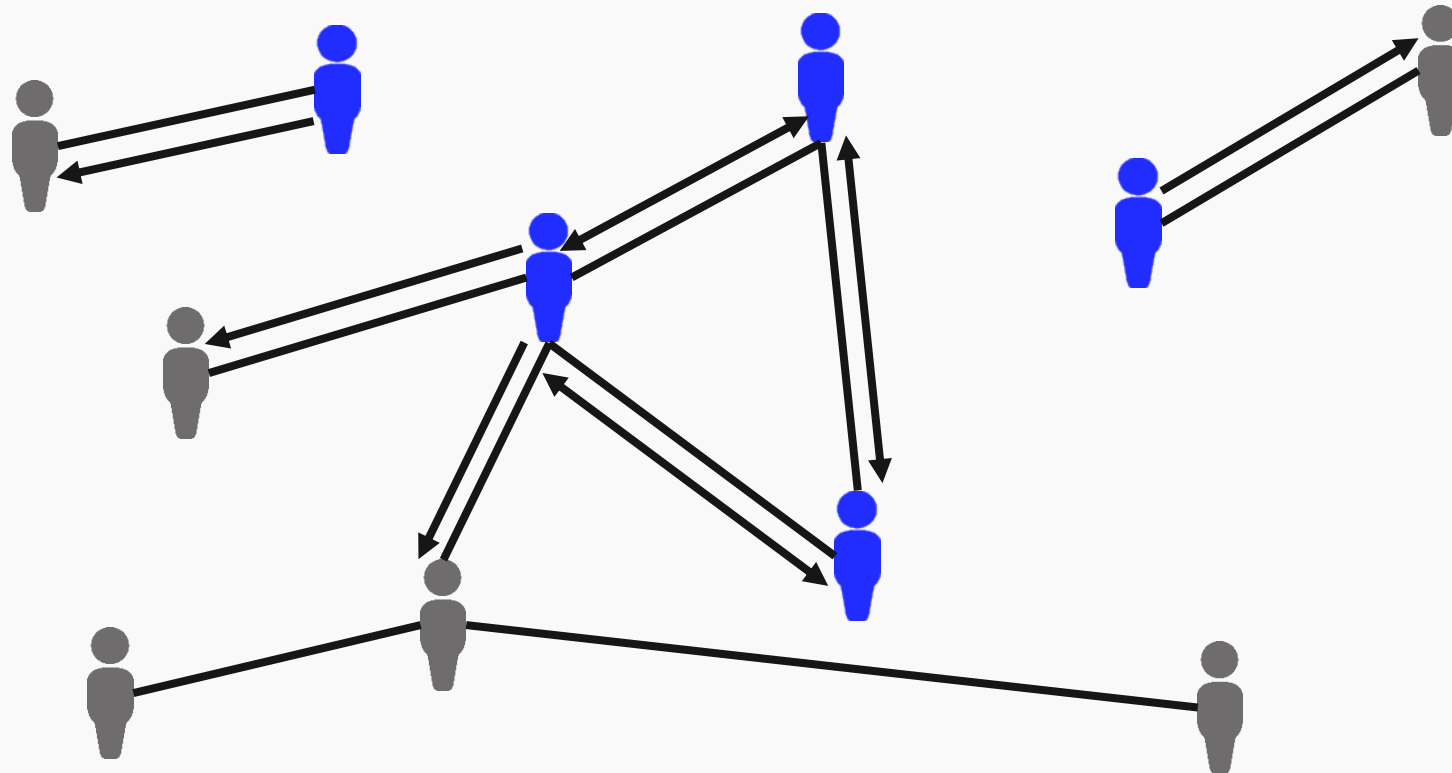
Topologia se poate schimba în orice moment





Comunicare Epidemic

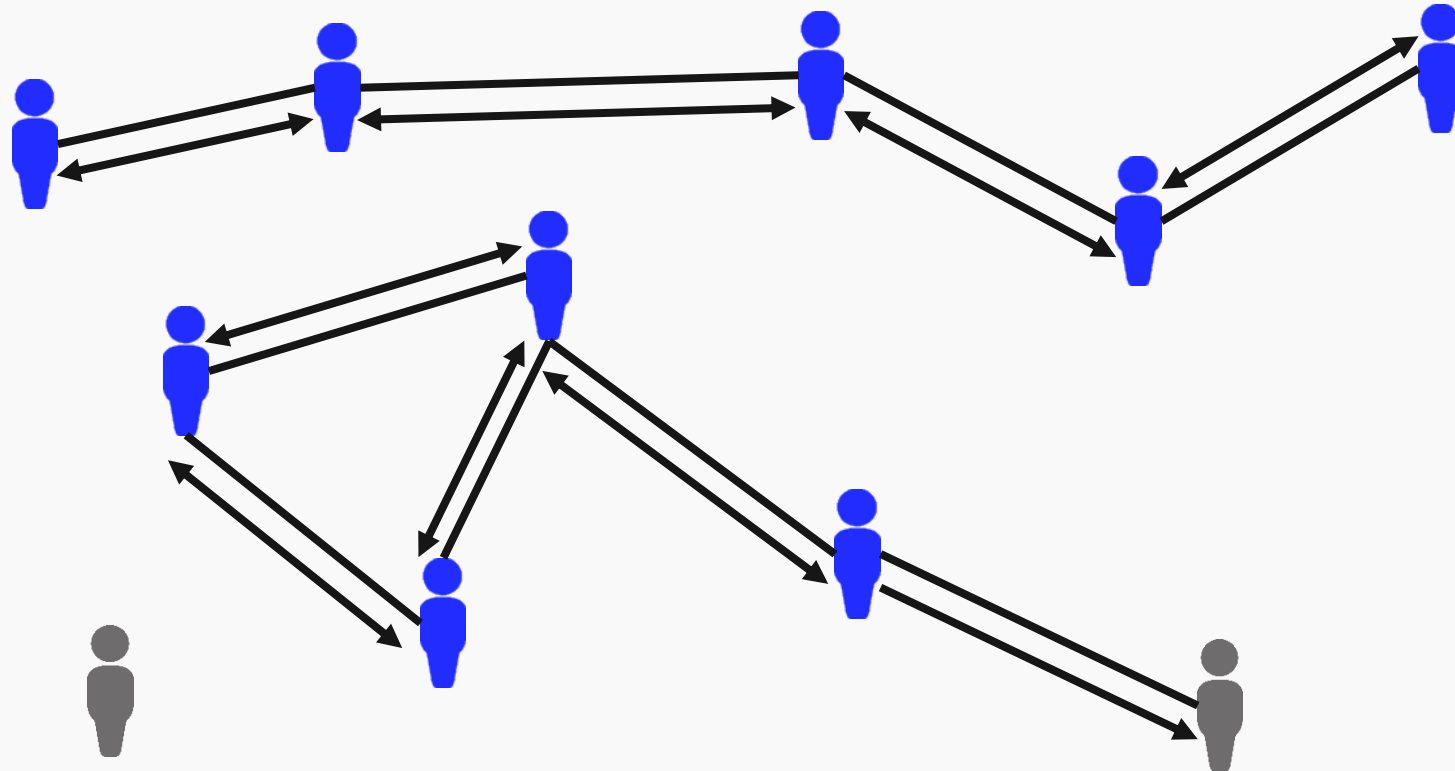
Topologia se poate schimba în orice moment





Comunicare Epidemic

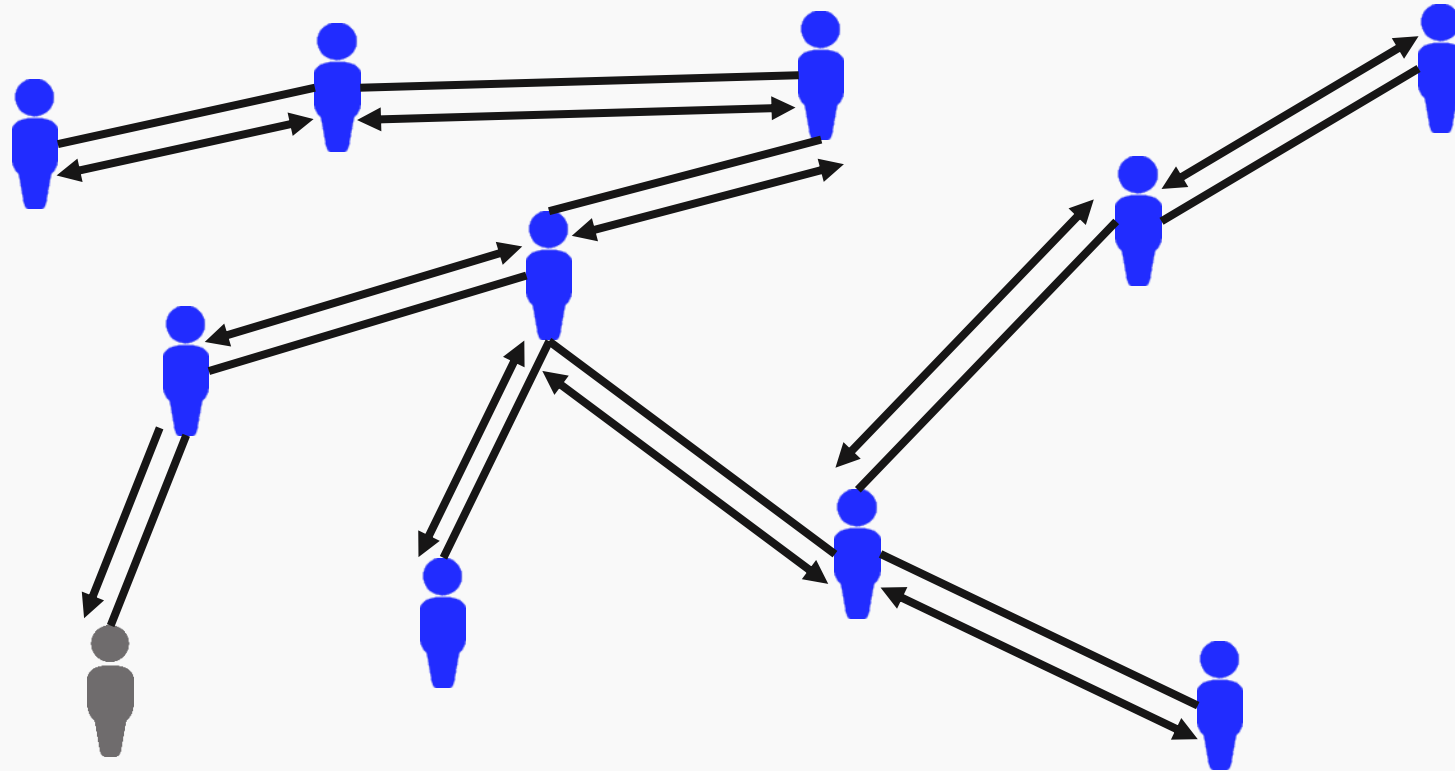
Topologia se poate schimba în orice moment





Comunicare Epidemic

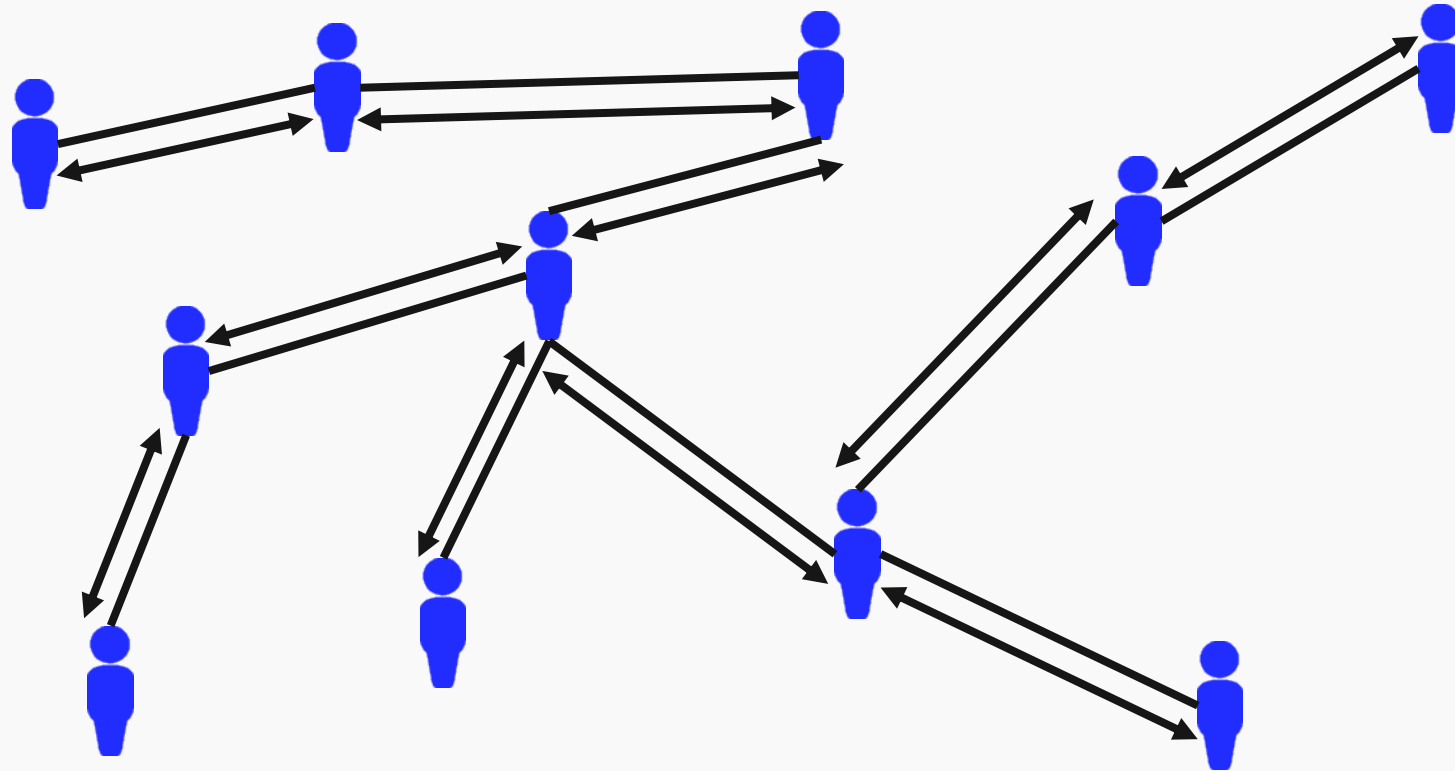
Topologia se poate schimba în orice moment





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?

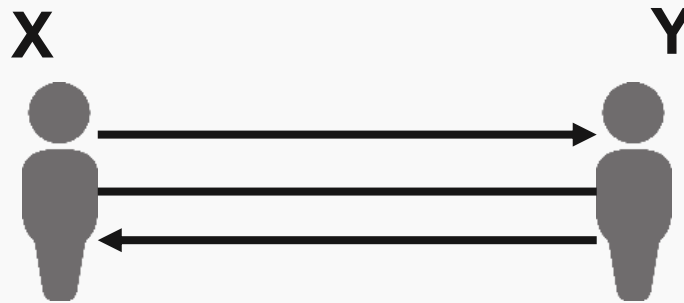
Necesită multe transmisii inutile
pentru orice mesaj

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



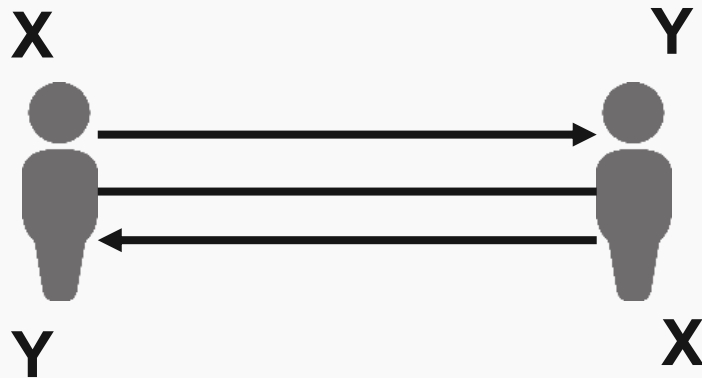


Epidemic – numărare nodurilor



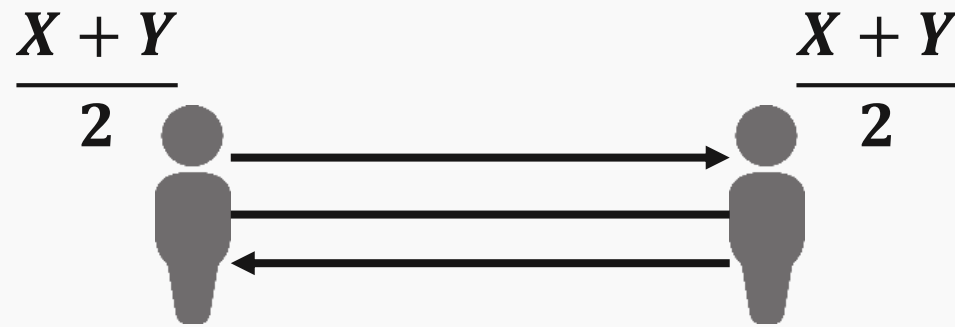


Epidemic – numărare nodurilor



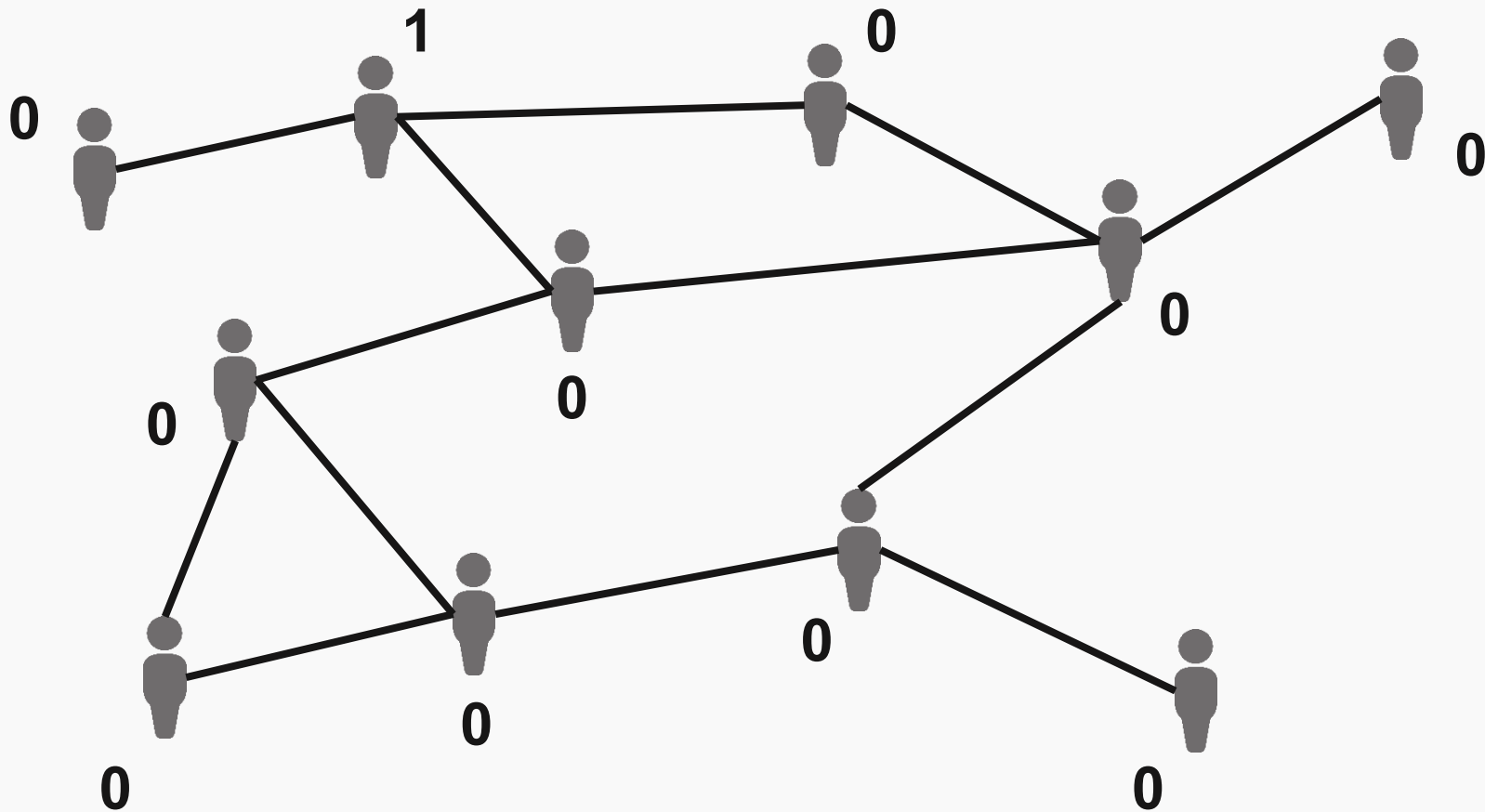


Epidemic – numărare nodurilor





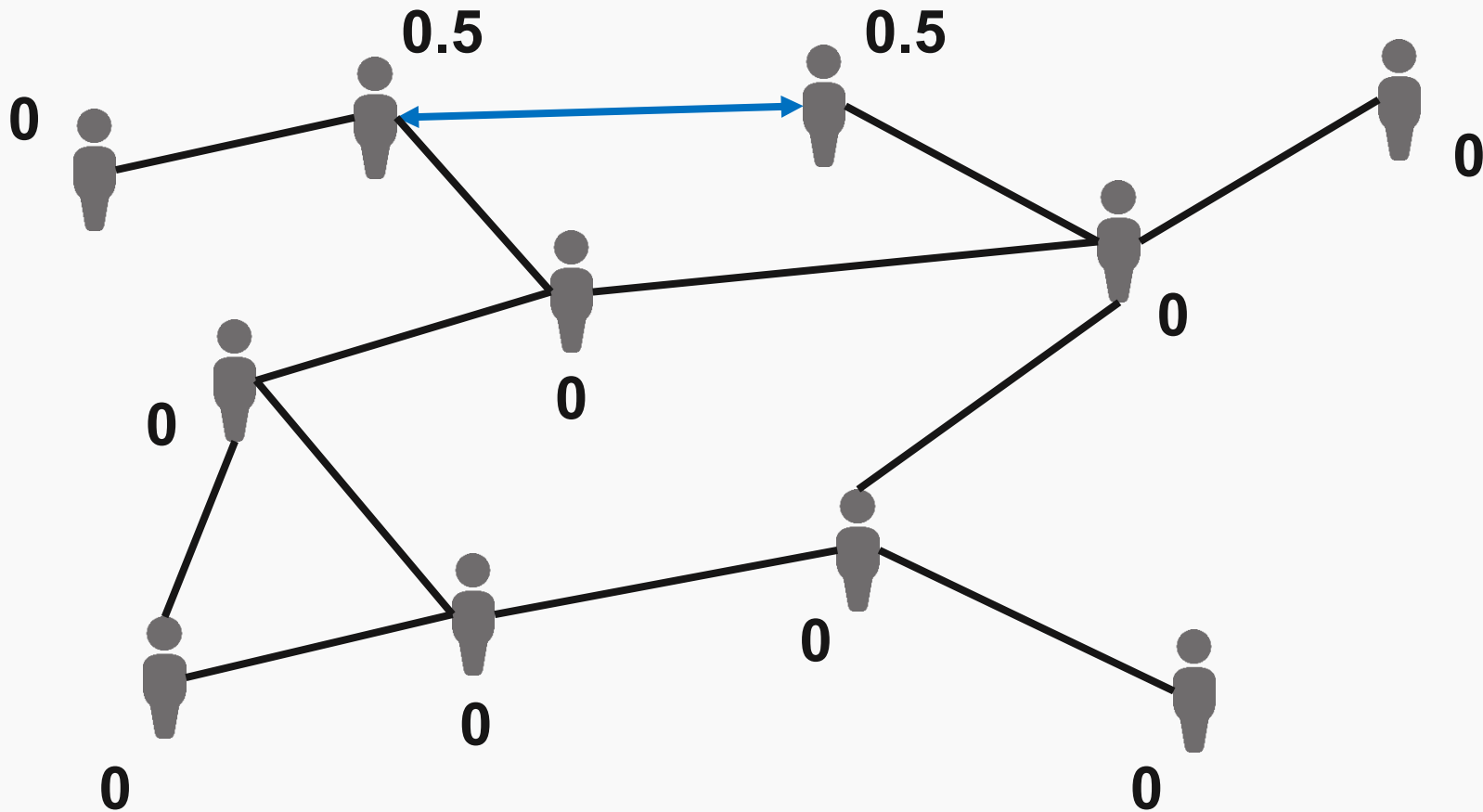
Epidemic – numărare nodurilor



Sum of all = 1



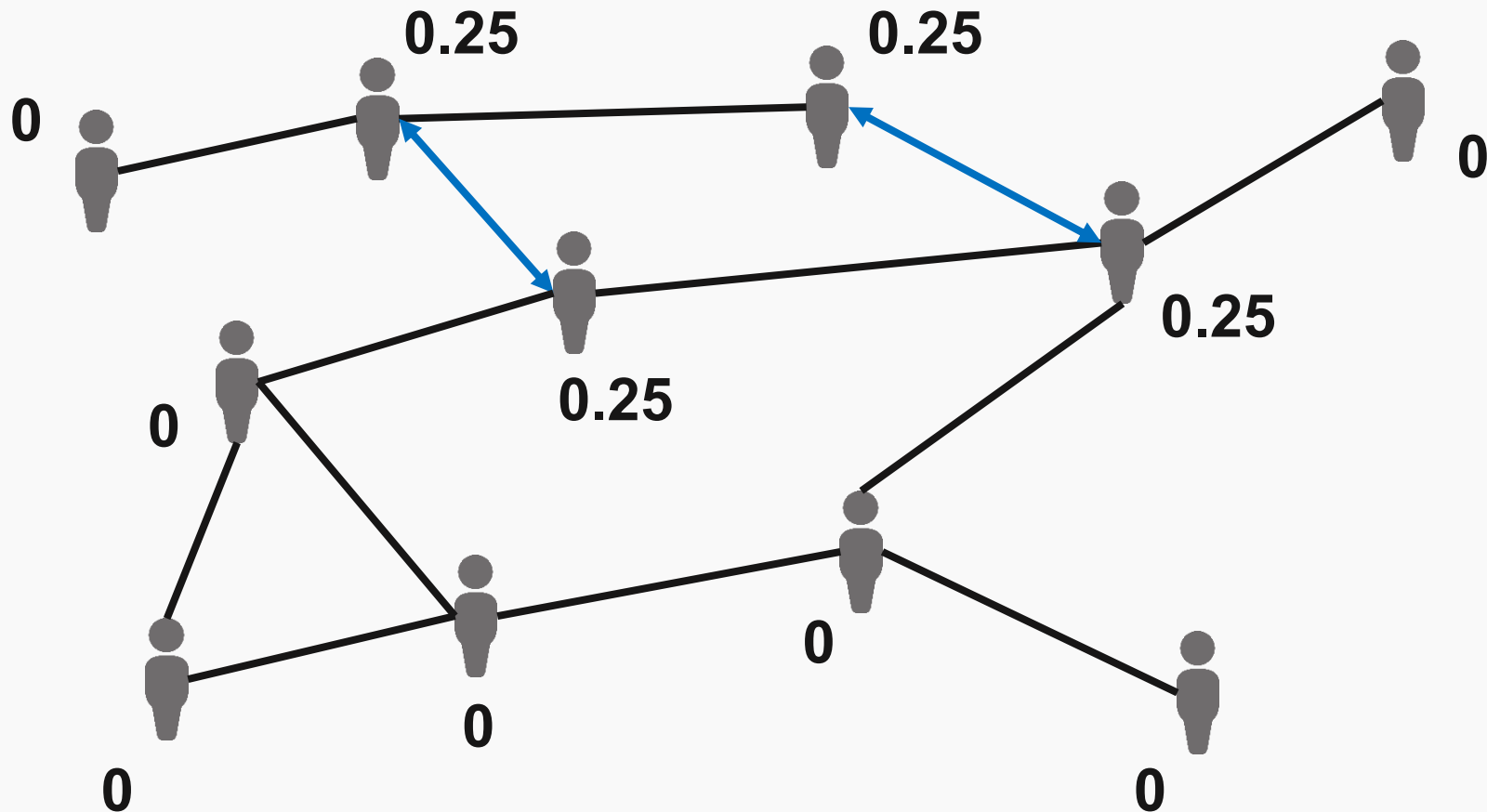
Epidemic – numărare nodurilor



Sum of all = 1



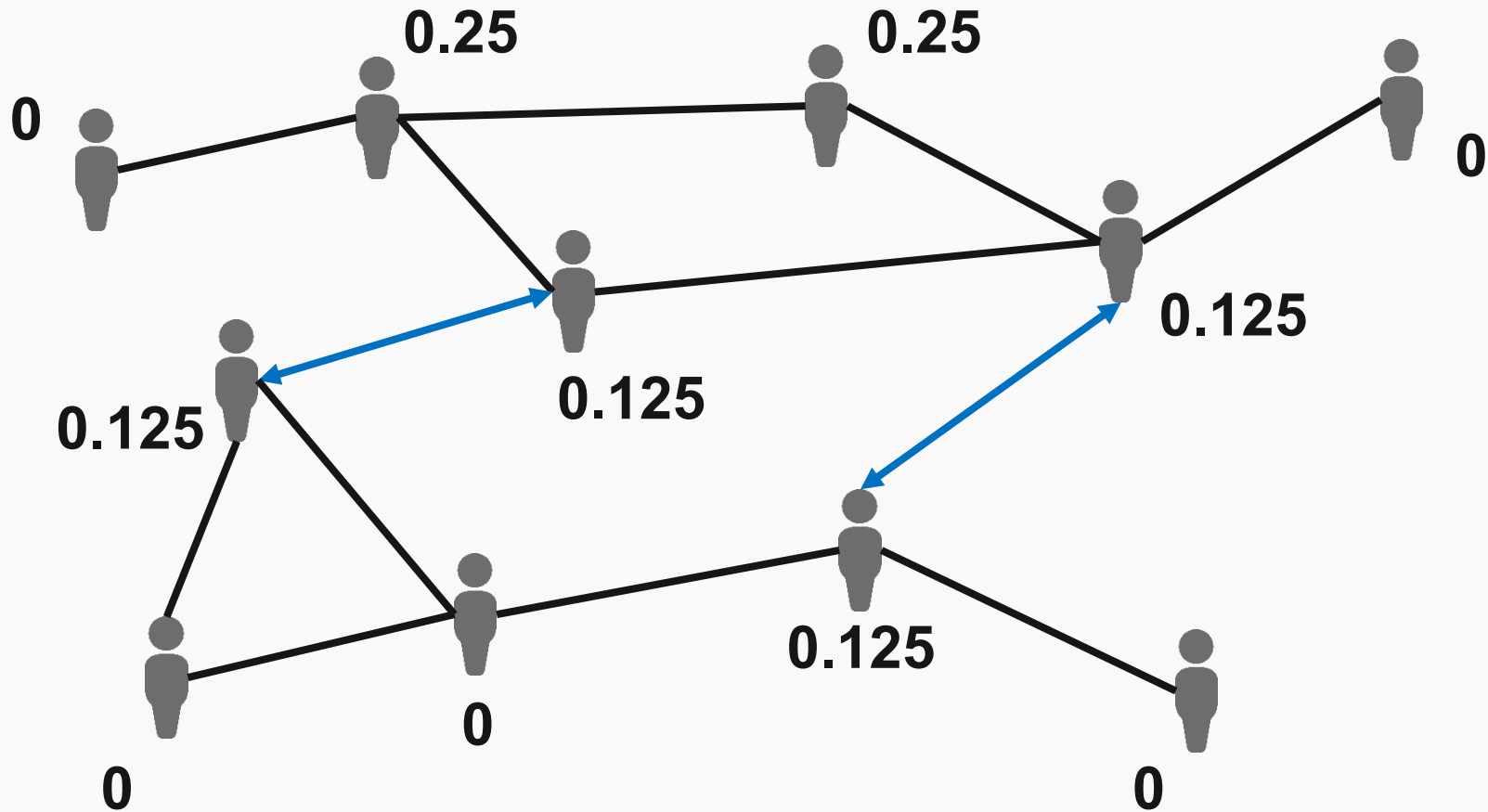
Epidemic – numărare nodurilor



Sum of all = 1



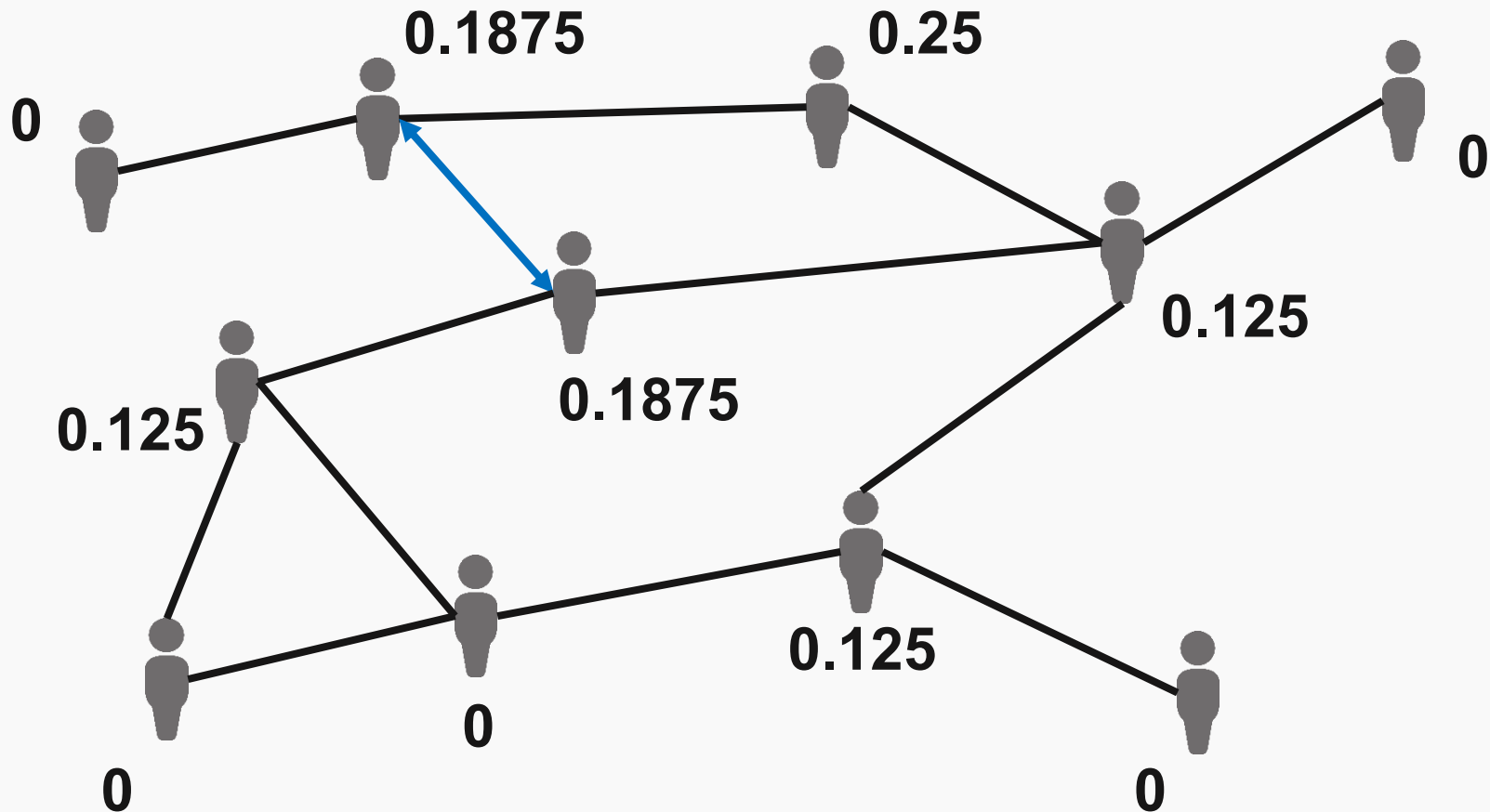
Epidemic – numărare nodurilor



Sum of all = 1



Epidemic – numărare nodurilor



Sum of all = 1

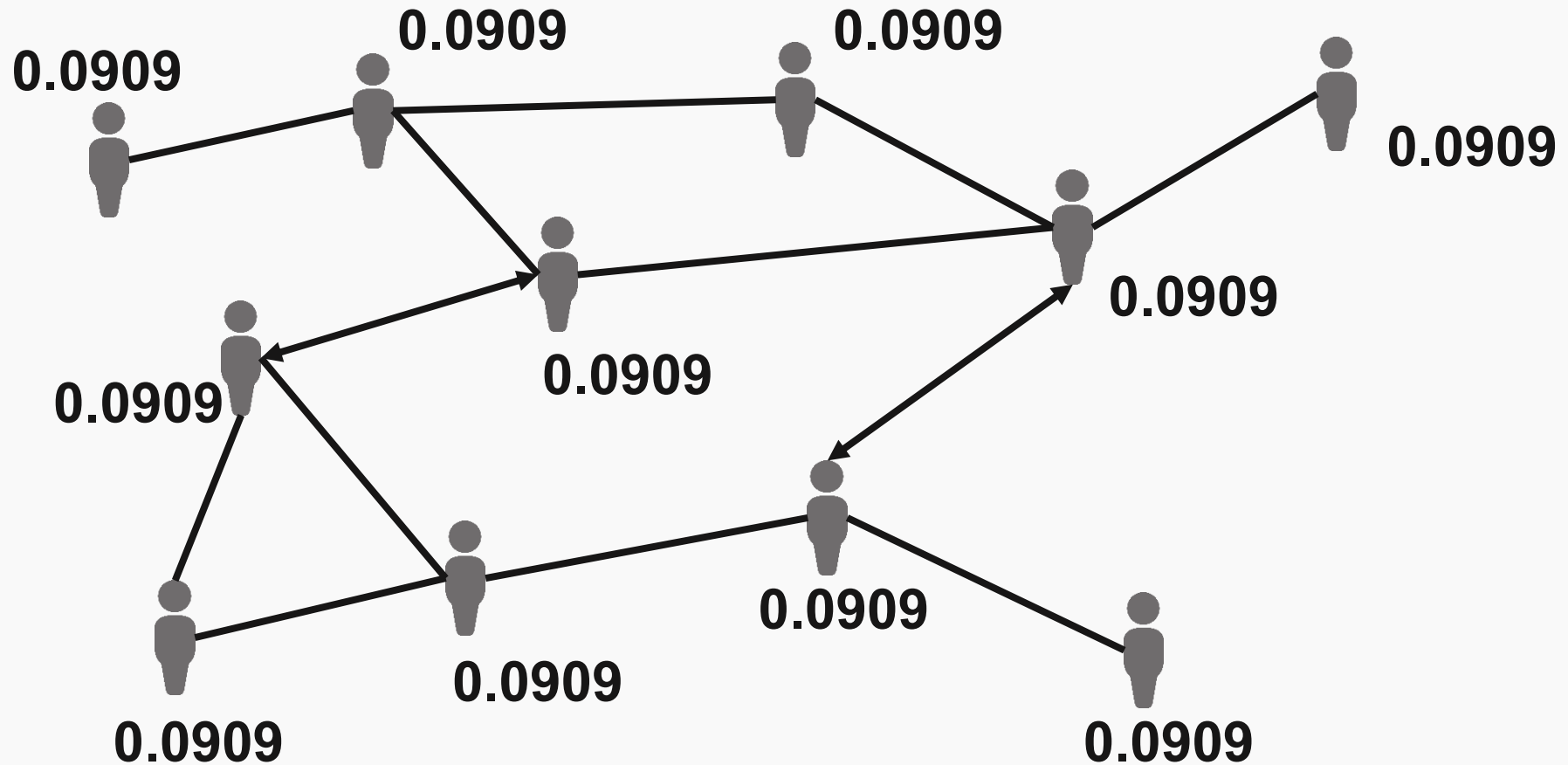


Epidemic – numărare nodurilor

Și tot așa...



Epidemic – numărare nodurilor



Sum of all = 1



Epidemic – numărare nodurilor

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