# ΔΙΚΤΥΑ ΥΠΟΛΟΓΙΣΤΩΝ 1
## ΕΡΓΑΣΙΑ ΕΞΑΜΗΝΟΥ

## ΔΙΔΑΣΚΩΝ
ΒΑΣΙΛΕΙΟΣ ΤΣΑΟΥΣΙΔΗΣ

## ΦΟΙΤΗΤΗΣ
ΣΑΒΒΑΣ ΛΙΑΠΗΣ
57403

# *Άσκηση 1.*

*AEM : 57403 :  w=7  x=4  y=0  z=3*

<div align="center">Υπόθεση :</div>

Δημιουργήστε ένα δίκτυο που αποτελείται από 2 κόμβους (n0, n1). Οι κόμβοι αυτοί συνδέονται με κανάλι PointToPoint μεταξύ τους, σχηματίζοντας την παρακάτω τοπολογία:

<div align="center">(z+1)Mbps, 10ms</div>

<div align="center">n0-----------------------n1</div>

<div align="center">Point-to-Point</div>

Στον κόμβο n0 τρέχει ένας server, ενώ στον κόμβο n1 ένας client. Χρησιμοποιώντας το παραπάνω κανάλι, θέλουμε ο client να στείλει 20 πακέτα στον server (στέλνοντας με ρυθμό 2 πακέτα/sec).

Ο server θα απαντά σε κάθε πακέτο κάνοντας "echo" το πακέτο που έλαβε. Το μέγεθος του πακέτου θα είναι 1024 Bytes.

Ο client θα ξεκινάει την αποστολή στη χρονική στιγμή t=((y+2)/2) sec και θα σταματά να τρέχει στα 20 sec. Για να γίνει αυτό, εγκαταστήστε εφαρμογές του τύπου UdpEchoServer/echoClient στους αντίστοιχους κόμβους, δίνοντάς τους τις κατάλληλες παραμέτρους.

Από τις παραμέτρους προκύπτουν :
bandwidth=3+1=4 Mbps
Start :
$$t = \frac{0+2}{2} = 1\ sec$$

<div align="center">Ζητούμενα :</div>

α) Τρέξτε την προσομοίωση.
- Ποια είναι η έξοδος που παίρνετε;
- Πόσο χρόνο χρειάζεται το κάθε πακέτο για να φτάσει από τον αποστολέα στον παραλήπτη;
- Πώς εξηγείται από τη θεωρία αυτό; (propagation delay, transmission delay, processing delay)

β) Ξανατρέξτε την προσομοίωση με  διπλάσιο, τριπλάσιο και τετραπλάσιο ρυθμό δεδομένων του καναλιού.
- Ποια είναι τα αποτελέσματα που παίρνετε;
- Ποιος είναι ο χρόνος που χρειάζεται κάθε φορά το πακέτο για να παραδοθεί στον παραλήπτη;
- Σχολιάστε το πως επηρεάζει η μεταβολή του bandwidth τα αποτελέσματα και γιατί.

## Απάντηση (1α) :

*η έξοδος που παίρνω αφου τρέξω την προσομοίωση είναι :*

savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$ ./waf --run=myfirst

Waf: Entering directory `/home/savvas/workspace/bake/source/ns-3.29/build'
Waf: Leaving directory `/home/savvas/workspace/bake/source/ns-3.29/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (35.249s)
At time 1s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 1.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 2s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 2.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 3s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 3.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 4s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 4.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 5.5s client sent 1024 bytes to 10.1.1.1 port 9

At time 5.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 6s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 6.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 7s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 7.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 8s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 8.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 9s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.01211s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.01211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.02422s client received 1024 bytes from 10.1.1.1 port 9
At time 9.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.51211s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.51211s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.52422s client received 1024 bytes from 10.1.1.1 port 9
At time 10s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.0121s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.0121s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.0242s client received 1024 bytes from 10.1.1.1 port 9
At time 10.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.5121s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.5121s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.5242s client received 1024 bytes from 10.1.1.1 port 9
savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$

*Ο χρόνος που χρειαζεται για να φτασει το κάθε πακετο των 1024 bytes από τον αποστολέα στον παραλήπτη είναι: 12.11 ms*

*Αυτό προκύπτει και ως άθροισμα των :*

- Καθυστέρηση Διάδοσης (Propagation delay). Το Propagation delay καθορίζεται στην αρχή της άσκησης 10 ms. Είναι η καθυστέρηση του σήματος μεχρι να φτάσει στον παραλήπτη, και έχει να κάνει με την απόσταση και την ταχύτητα του φωτός πανω στο συγκεκριμένο μέσο μεταφοράς.

- Καθυστέρηση Μετάδοσης (Transmission delay) είναι η καθυστέρηση που οφείλεται στην ταχύτητα μετάδοσης δεδομένων και την ταχυτητα μετάδοσης του καναλιού. Πιο συνοπτικά: μεταδιδόμενα δεδομένα /bandwidth.

  Στην συγκεκριμενη άσκηση προκύπτει :
  $$transmission\ delay = \frac{1024 * 8}{4MB} = 2.048\ ms$$

- Καθυστέρηση επεξεργασίας (processing delay) είναι η καθυστέρηση που οφείλεται στην προσθήκη κεφαλιδων, στην υλοποίηση του δικτύου και στην ενδοεπικοινωνία διαφορετικών πρωτοκόλλων μέχρι να εισέλθουν τα δεδομένα στο δίκτυο. Στην συγκεκριμενη περιπτωση είναι 0.062 ms.

*Απάντηση (1β):*

*Τα αποτελέσματα που παίρνω για bandwidth 8Mbps :*

savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$ ./waf --run=myfirst
Waf: Entering directory `/home/savvas/workspace/bake/source/ns-3.29/build'
[2688/2764] Compiling scratch/myfirst.cc
[2723/2764] Linking build/scratch/myfirst
Waf: Leaving directory `/home/savvas/workspace/bake/source/ns-3.29/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (42.097s)
At time 1s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 1.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 2s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 2.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 3s client sent 1024 bytes to 10.1.1.1 port 9

At time 3.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 3.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 4s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 4.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 5.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 6s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 6.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 7s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 7.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 8s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.01105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 8.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 9s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.01105s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.01105s server sent 1024 bytes to 10.1.1.2 port 49153

At time 9.02211s client received 1024 bytes from 10.1.1.1 port 9
At time 9.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.51105s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.51105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.52211s client received 1024 bytes from 10.1.1.1 port 9
At time 10s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.0111s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.0111s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.0221s client received 1024 bytes from 10.1.1.1 port 9
At time 10.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.5111s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.5111s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.5221s client received 1024 bytes from 10.1.1.1 port 9
savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$

*Τα αποτελέσματα που παίρνω για bandwidth  12Mbps  :*

savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$ ./waf --run=myfirst
Waf: Entering directory `/home/savvas/workspace/bake/source/ns-3.29/build'
[2688/2764] Compiling scratch/myfirst.cc
[2723/2764] Linking build/scratch/myfirst
Waf: Leaving directory `/home/savvas/workspace/bake/source/ns-3.29/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (50.838s)
At time 1s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 1.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 2s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 2.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 3s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 3.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 4s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.0107s server received 1024 bytes from 10.1.1.2 port 49153

At time 4.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 4.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 5.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 6s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 6.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 7s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 7.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 8s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 8.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 9s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.02141s client received 1024 bytes from 10.1.1.1 port 9
At time 9.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.52141s client received 1024 bytes from 10.1.1.1 port 9
At time 10s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.0107s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.0107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.0214s client received 1024 bytes from 10.1.1.1 port 9

At time 10.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.5107s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.5107s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.5214s client received 1024 bytes from 10.1.1.1 port 9
savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$


*Τα αποτελέσματα που παίρνω για bandwidth  16Mbps  :*

savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$ ./waf --run=myfirst
Waf: Entering directory `/home/savvas/workspace/bake/source/ns-3.29/build'
[2688/2764] Compiling scratch/myfirst.cc
[2724/2764] Linking build/scratch/myfirst
Waf: Leaving directory `/home/savvas/workspace/bake/source/ns-3.29/build'
Build commands will be stored in build/compile_commands.json
'build' finished successfully (50.968s)
At time 1s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 1.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 1.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 1.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 1.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 2s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 2.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 2.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 2.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 2.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 3s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 3.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 3.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 3.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 3.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 4s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 4.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 4.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 4.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 4.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.01053s server received 1024 bytes from 10.1.1.2 port 49153

At time 5.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 5.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 5.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 5.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 5.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 6s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 6.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 6.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 6.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 6.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 7s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 7.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 7.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 7.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 7.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 8s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 8.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 8.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 8.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 8.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 9s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.01053s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.01053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.02105s client received 1024 bytes from 10.1.1.1 port 9
At time 9.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 9.51053s server received 1024 bytes from 10.1.1.2 port 49153
At time 9.51053s server sent 1024 bytes to 10.1.1.2 port 49153
At time 9.52105s client received 1024 bytes from 10.1.1.1 port 9
At time 10s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.0105s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.0105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.0211s client received 1024 bytes from 10.1.1.1 port 9
At time 10.5s client sent 1024 bytes to 10.1.1.1 port 9
At time 10.5105s server received 1024 bytes from 10.1.1.2 port 49153
At time 10.5105s server sent 1024 bytes to 10.1.1.2 port 49153
At time 10.5211s client received 1024 bytes from 10.1.1.1 port 9
savvas@savvas-VirtualBox:~/workspace/bake/source/ns-3.29$

*Ο χρόνος που χρειάζεται κάθε φορά το πακέτο για να παραδοθεί στον παραλήπτη:*

- για bandwidth 2*4=8 Mbps : 11.05 ms
- για bandwidth 3*4=12 Mbps : 10.7 ms
- για bandwidth 4*4=16 Mbps : 10.53 ms

Παρατηρούμε ότι με την άυξηση του bandwidth ο χρόνος που χρειάζεται ένα πακέτο για να μεταδωθεί μειώνεται. Αυτό εξηγείται από την ίδια την έννοια του bandwidth. Γνωρίζουμε ότι bandwidth είναι η Θεωρητική ταχύτητα ροής δεδομένων μέσα σε ένα κανάλι (bit/second) ή καλύτερα η χωρητικότητα μιάς τομής του καναλιού σε bit. Οπότε, πολύ απλά, όσο αυξάνεται το bandwidth είναι εφικτό να σταλούν περισσότερα bit στην μονάδα του χρόνου ή αντίστροφα ένα πακέτο συγκεκριμένου μεγέθους bit χρειάζεται λιγότερο χρόνο για να σταλεί αφού στην ουσία το κανάλι χωράει περισσοτερα bit.

# *Ασκηση 2.*

Υπόθεση :

Δημιουργήστε ένα δίκτυο που αποτελείται από 4 κόμβους (n0, n1, n2, n3) σύμφωνα με τις οδηγίες του παραρτήματος. Οι κόμβοι αυτοί συνδέονται με κανάλια PointToPoint μεταξύ τους, σχηματίζοντας την παρακάτω τοπολογία:

```
         0.5Mbps, 10ms      0.5Mbps, 10ms      0.5Mbps, 10ms
n0--------------------n1--------------------n2-------------------n3
      Point-to-Point      Point-to-Point      Point-to-Point
```

Στον κόμβο n0 δημιουργούμε μια εφαρμογή (sender) η οποία θα στείλει ένα αρχείο μεγέθους 300KB στον n3 (sink), χρησιμοποιώντας TCP sockets. Το μέγεθος πακέτου ορίζεται στα 1040 bytes.

Ζητούμενα :

α) Τρέξτε την προσομοίωση.
- Πόσο χρόνο κάνει για να ολοκληρωθεί η μεταφορά του αρχείου;
- Ποιο είναι το πραγματικό throughput του δικτύου;
- Ανταποκρίνονται τα αποτελέσματα σε αυτό που θα περιμένατε να δείτε από τη θεωρία;

β) Τρέξτε στο terminal την εντολή:  ping www.youtube.com . Μόλις στείλατε ένα πακέτο στον server της youtube και σας απάντησε αντίστοιχα (αυτό επαναλαμβάνεται μέχρι να σταματήσετε την εντολή πατώντας ctrl+c). Όταν τη σταματήσετε, θα εμφανιστεί μια έξοδος της παρακάτω μορφής:    rtt min/avg/max/mdev = 37.963/38.479/39.681/0.623 ms. Η έξοδος αυτή μας δίνει το Round-Trip Time (RTT) μεταξύ του υπολογιστή μας και του server της youtube, δηλ. το χρόνο που χρειάζεται για να σταλεί ένα πακέτο σε αυτόν και να επιστρέψει.
- Ποιο είναι το RTT και ποιο το delay της δικής σας σύνδεσης; (σαν min δηλώνεται το ελάχιστο RTT, avg ο μέσος όρος και max το μέγιστο).

γ) Ορίστε την καθυστέρηση του τελευταίου καναλιού ίση με το average delay της σύνδεσής σας και ξανατρέξτε την προσομοίωση.
- Πόσο χρόνο χρειάζεται τώρα το πακέτο για να φτάσει από τον αποστολέα στον παραλήπτη;
- Σχολιάστε τα αποτελέσματα, όσον αφορά την επίδραση της μεταβολής του delay στην τελική καθυστέρηση.

## Απαντήση(2α):

Το throughput είναι ουσιαστικά η απόδοση του δικτύου . Είναι η μεγαλύτερη ταχύτητα που θα μετρηθεί όταν πάντα υπάρχουν δεδομένα προς αποστολή κατά την μετρηση. Throughput= δεδομένα (byte) / Χρόνος μεταφοράς (second).

Ο χρόνος μεταφοράς περιλαμβάνει όχι μόνο τον λανθάνων χρόνο απλής καθυστέρησης, αλλά επίσης περιλαμβάνει οποιοδήποτε επιπλέον χρονικό διάστημα που δαπανάται για την αίτηση η την διαμόρφωση της μεταφοράς.
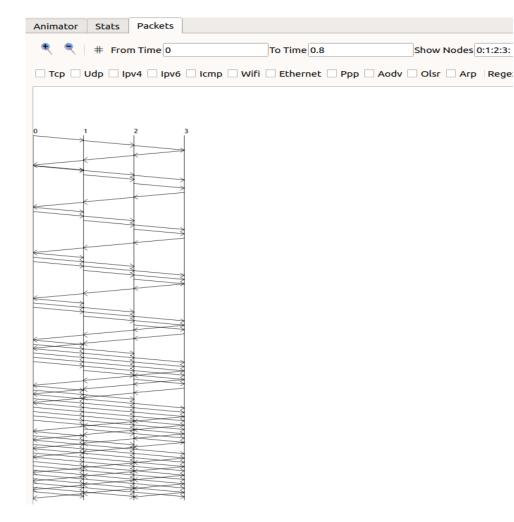
Στην προσομοίωση η μεταφορα του αρχειου χρειάζεται 5.9137 sec για να ολοκλήρωθεί.Οπότε :

$$Throughput = \frac{data\ in\ bytes}{time} = \frac{300 * 1024}{5.9137} = 51,95 KBps$$

Ο θεωρητικός χρόνος μεταφοράς θα είναι το συνολικό propagation delay + το συνολικό transmission delay (+ το συνολικό processing delay+ queuing delay για τα οποία όμως δεν μας δίνεται καμία πληροφορία οπότε θα θεωρήσουμε ότι είναι αμεηλητέα):

Total propagation delay = 10+10+10+10+10+10=60 ms (για ένα πακέτο )

$$Transmission\ Delay = \frac{data}{bandwidth} = \frac{1040*8}{500000} = 0.016sec\ (για\ ένα\ πακέτο)$$

Τα πακέτα που θα σταλούν θεωρητικά είναι :

$\frac{μεγεθος\ αρχείου}{μέγεθος\ πακέτου} = \frac{300*1024}{1040} = 295.38 = 296\ πακέτα$

Αρα συνολικος χρονος : (0,06+0,016)*296=22.5sec.

Τωρα το θεωρητικό throughput που προκύπτει είναι :

$$Throughput = \frac{data\ in\ bytes}{time} = \frac{300 * 1024}{22.496} = 13,65\ KBps$$

Τα αποτελέσματα που προκύπτουν από την προσομοίωση με τα αποτελέσματα που έχουμε βρει θεωρητικά αποκλίνουν σημαντικά.Σε αυτό συμβάλλουν διάφοροι παράγοντες. Αρχικά τα πακέτα που στέλνονται κατά την διάρκεια της προσομοίωσης είναι 288 .Αν συμβουλευτούμε και το animation της προσομοίωσης λαμβάνουμε κάτι σαν αυτό :

Από από αυτό το σχήμα είναι πολύ εύκολο να παρατηρήσει κανείς ήδη από τα πρώτα 0.8 sec της προσομοίωσης ότι από τον node 3 δεν στέλνονται συνέχεια aknowledgements. Αντιθέτως όσο περνάει η ώρα το ποσοστό των acknowledgements ως προς τα πακέτα που φτάνουν στον 3 μειώνεται. (αν αναλογιστούμε οτί ένα acknowledgement «κοστίζει» 30ms)Αυτό σημαίνει ότι ένα μεγάλο μέρος του χρόνου που εμείς υπολογίσαμε, δεν υφίσταται πρακτικά.Αυτό επιβεβαιώνεται και από την λογική του sliding window όπου αρκεί να φτάσει μία επιβεβαίωση για να επιβεβαιωθεί η λήψη όλων των προηγούμενων πακέτων.

## Απαντήση(2β):

*Αφού εκτελέσω την εντολή ping www.youtube.com η έξοδος που μου εμφανίζεται είναι :*

--- youtube-ui.l.google.com ping statistics --- 13 packets transmitted, 13 received, 0% packet loss, time 21138ms
rtt min/avg/max/mdev = 49.693/60.631/97.352/14.748 msping
Το bandwidth και το μέγεθος του αρχείου δεν αλλάζει.΄Αρα το transmission delay παραμενει ίδιο. Transmission delay=16ms. rrt=2*propagation delay +transmission delay => delay=rrt/2 +transmission delay/2.
Συνεπώς:

- rtt min = 49.693 ms  =>  min delay=49.693/2 +16/2=32.84ms
- rtt avg= 60.631 ms => average delay=60.631/2 +8=38.32ms
- rtt max=97.352 ms => max delay=97.352/2 +8= 56.68ms
- rtt mdev=14.748 ms => mdev delay=14.748/2 +8=15.37 ms

Με το νέο delay του καναλιού n2n3 ίσο με το average delay της σύνδεσής μου (rtt average=60.631ms, άρα) average delay =38.32, η μεταφορά του αρχείου ολοκληρώνεται σε 6.39533 second.

Από τα αποτελέσματα της άσκησης γίνεται σαφές ότι το delay είναι ένας δραστικός παράγοντας στην ταχύτητα του δικτύου. Με το νέο propagation delay βλέπουμε ότι η αποστολή του αρχείου καθυστέρησε κατά 482ms (6,39533-5,9137=0,48163), ποσότητα που δεν μπορεί να θεωρηθεί αμελητέα. Βλέπουμε λοιπόν ότι το delay είναι ένας από τους βασικούς παράγοντες στην αποδοτικότητα ενός δικτύου. Συγκεκριμένα για το propagation delay ,το οποίο μεταβάλλαμε στο τρίτο κανάλι, πέρα από την απόσταση την οποία δεν είναι στο χέρι μας να καθορίσουμε, είναι πολύ σημαντικό να ξέρουμε να καθορίζουμε το σωστότερο μέσο διάδοσης αν ήταν στο χέρι μας, διότι για μια μικρή διαφορά στην καθυστέριση διάδοσης, η συνολική καθυστέρηση είναι σημαντικά μεγαλύτερη.

# ΠΗΓΕΣ :

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*Διαφάνειες εργαστηρίου Δικτυα Υπολογιστών 1:*
https://eclass.duth.gr/modules/document/index.php?course=TMA181&openDir=/5dc953b7JjT3