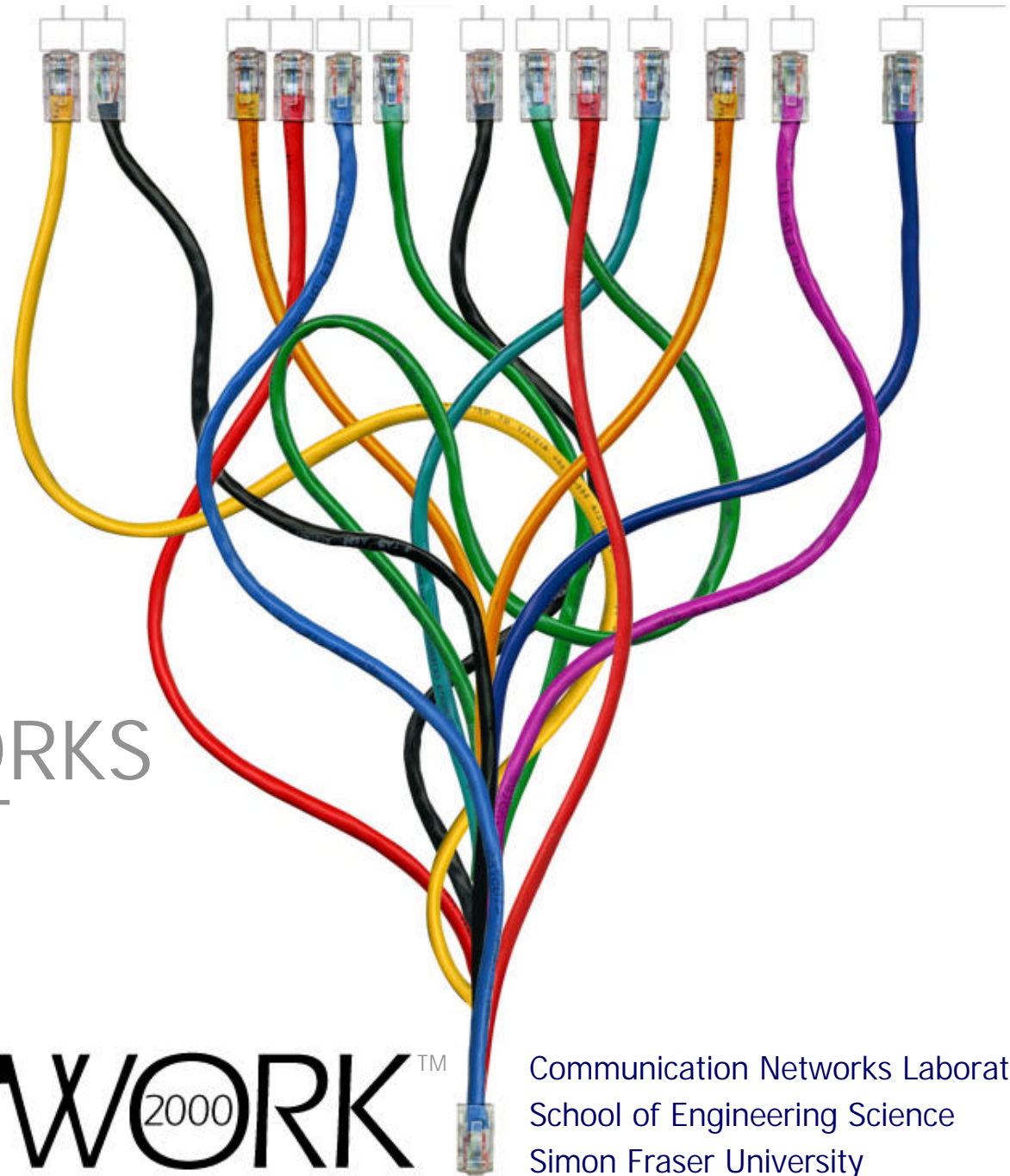


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SIMULATING  
CDPD NETWORKS  
USING OPNET



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## Road Map

- Introduction
- Simulation of the CDPD network
  - CDPD network model
  - node models: M-ES and MDDBS
  - process models: M-ES, MDDBS, and trace-driven sources
- Simulation results
- Concluding remarks
- References

## Introduction

- We use OPNET to simulate wireless data networks.
- We investigate the impact of self-similar traffic on performance of a cellular digital packet data (CDPD) network.
- OPNET Modeler was used to model and simulate the CDPD network of a local commercial service provider (Telus Mobility).
- In our simulations we used genuine traffic traces collected from the Telus Mobility CDPD network.
- Our simulation results indicate that genuine traffic traces produce:
  - longer queues
  - require larger buffers in the deployed network's switching elements.

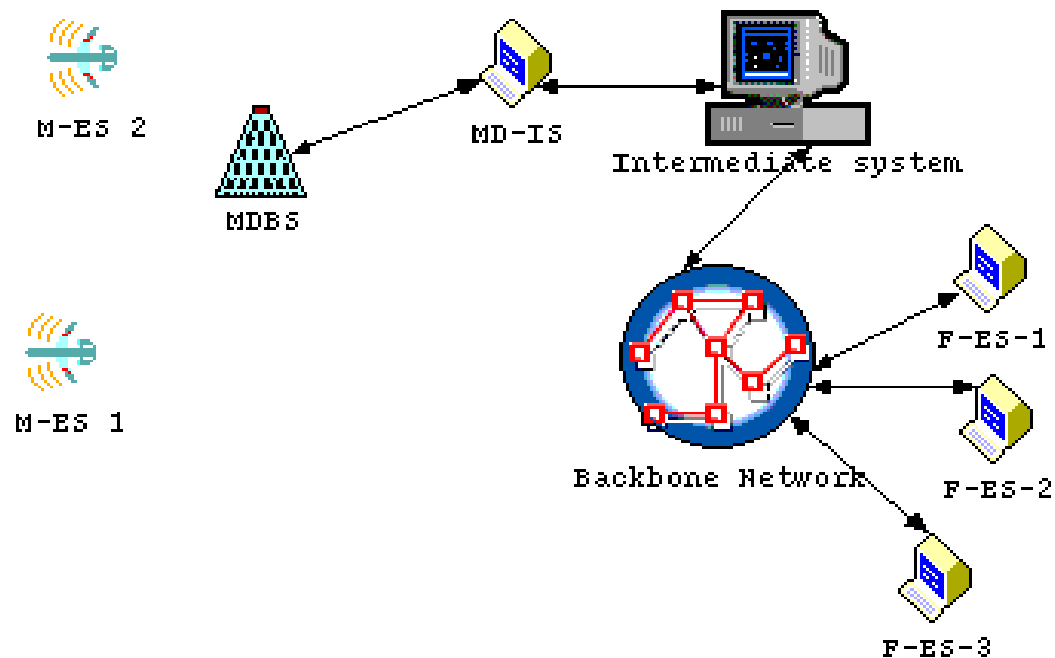
## Traffic patterns

- Traffic patterns generated by voice, data, image, and video services differ from patterns observed in circuit switched voice networks.
- Their simulations require traffic models that differ from traditional Poisson models used for voice traffic.
- Interest in self-similar traffic was first stimulated by the measurements of Ethernet traffic at Bellcore in the early 90's.
- The analysis of the collected traffic traces led to the discovery that "traffic looks the same on all time scales" (self-similar or fractal).
- This feature has been discovered in other traffic traces: TCP, MPEG video, WWW, and SS7.
- An important characteristic of self-similar traffic is its long-range dependence: the existence of correlations over a broad range of time scales.

## Traffic in CDPD networks

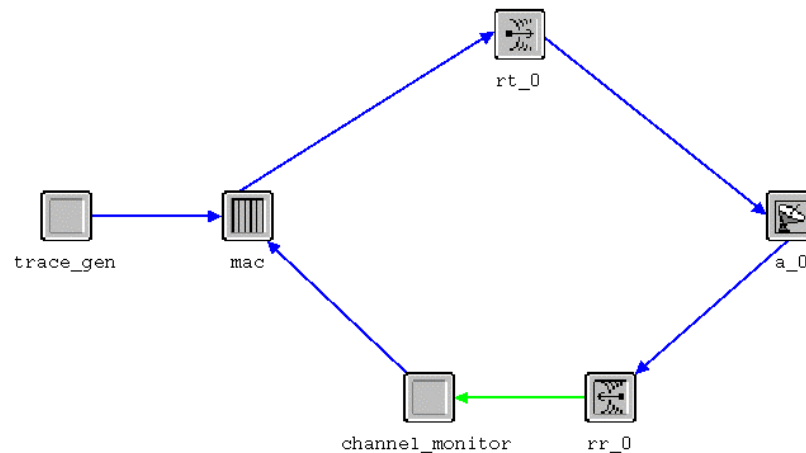
- Most network traffic measurements were performed on wired networks.
- Questions:
  - Does the traffic in wireless data networks exhibit self-similar behavior?
  - If so, do traffic characteristics affect the provisioning and designing of wireless data networks?
- Our initial statistical analysis results indicate that traffic traces collected from the Telus Mobility CDPD network exhibit a certain degree of self-similarity.

# CDPD network model



Each mobile end station (M-ES) is connected to the backbone network through the mobile data base station (MDBS). Mobile data intermediate system (MD-IS) and fixed end systems (F-ES) are connected to the wired backbone network.

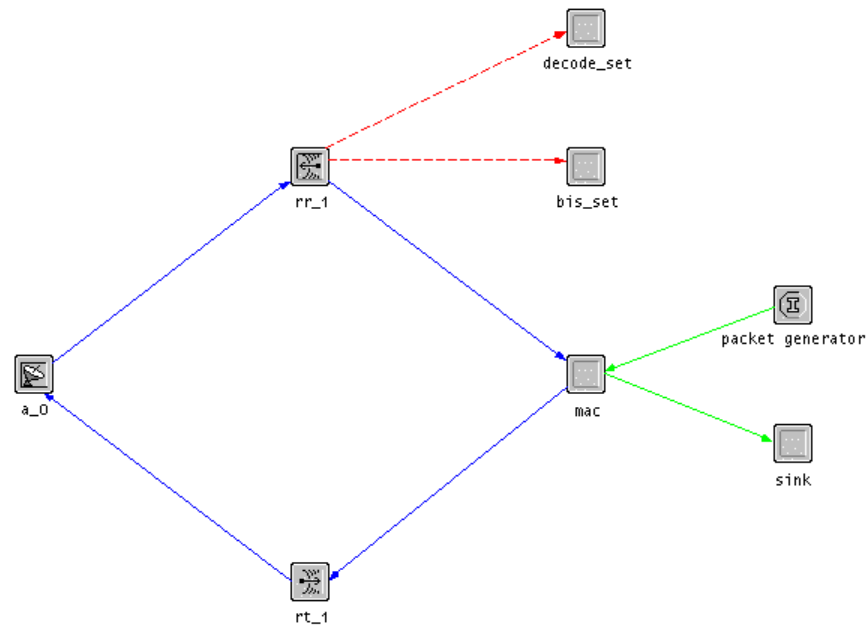
## Mobile end system (M-ES) node model



The radio transmitters and receivers are operating at a center frequencies of 825 MHz and 870 MHz, respectively. Both have bandwidth of 30 kHz.

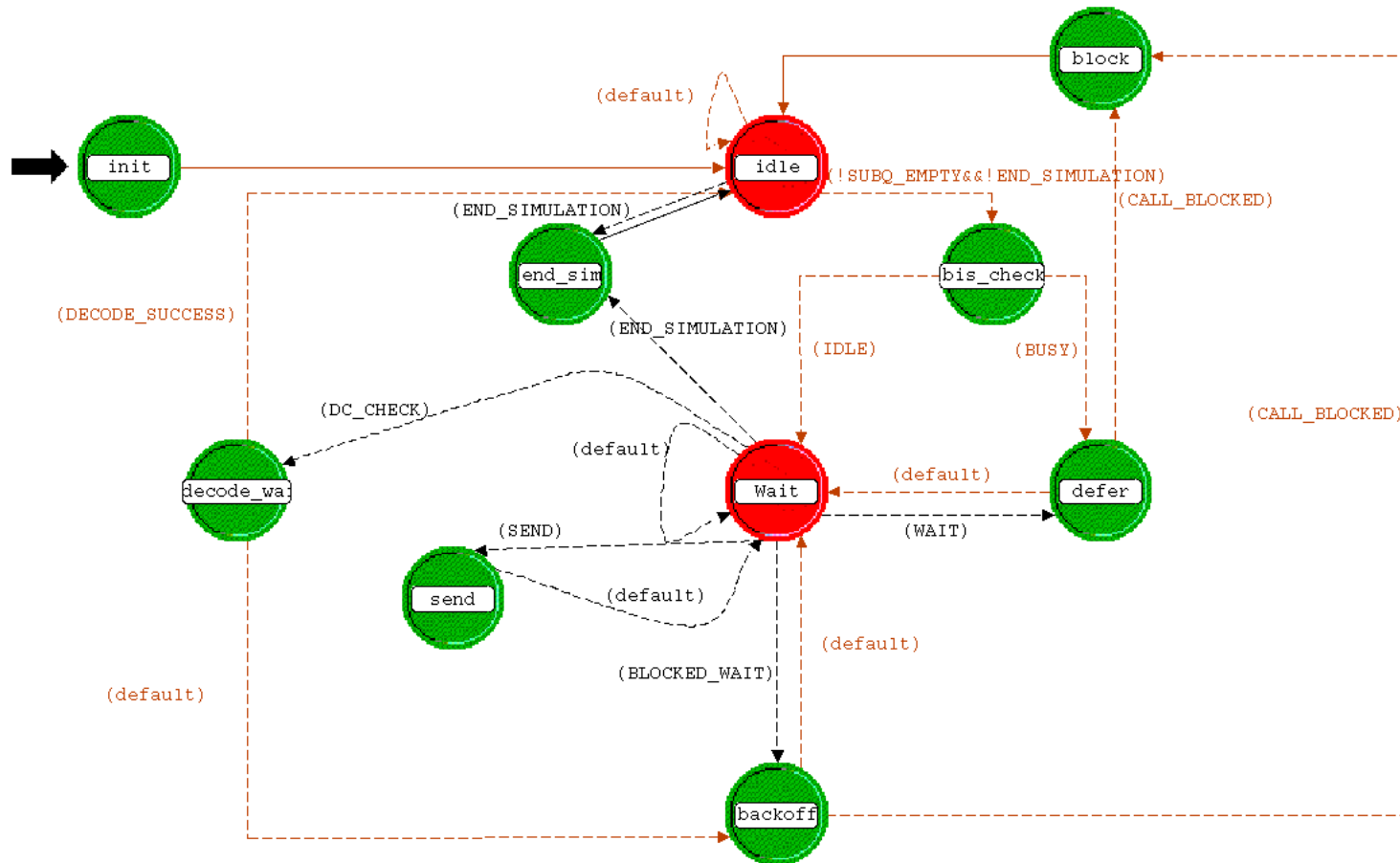
The source generates packets according to a genuine traffic trace, bursty ON/OFF traffic model, or traditional traffic models supported by OPNET libraries.

## Mobile data base station (MDBS) node model



This is the interface between the wireless and the wired sections of a CDPD network. MDBS sets the *busy/idle* and *decode status* flags on the forward channel according to the status of the reverse channel. It also receives the packets and collects statistics: the RF power level, bit error rate (BER), signal-to-noise ratio (SNR), and end-to-end delay.

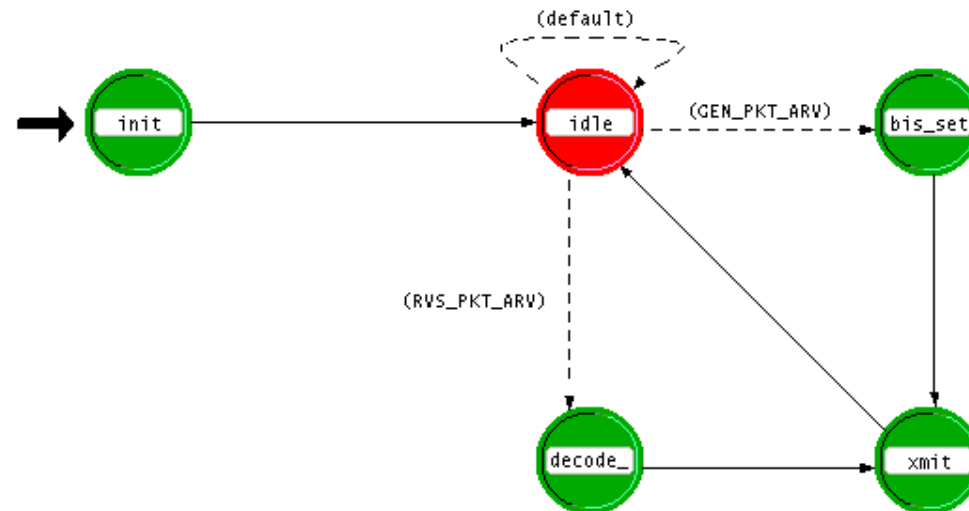
# M-ES process model



## M-ES process model (cont.)

- This finite state machine (FSM) performs media access control for the CDPD MAC interface in M-ES.
- The role of M-ES is to:
  - accept data packets from higher layer protocols
  - encapsulate this data into MAC frames
  - transmit these frames through the reverse channel to the MDBS using first-in-first-out scheduling scheme.

## MDBS process model



This FSM performs media access control for the CDPD MAC interface in MDBS.

The role of MDBS is to:

- notify the listening M-ES's of the presence of data on the reverse channel.
- performs notification of the decode status of the incoming data blocks from the reverse channel by using the *busy/idle* and the *decode status* flags in the forward channel stream.

## Process model for trace-driven sources



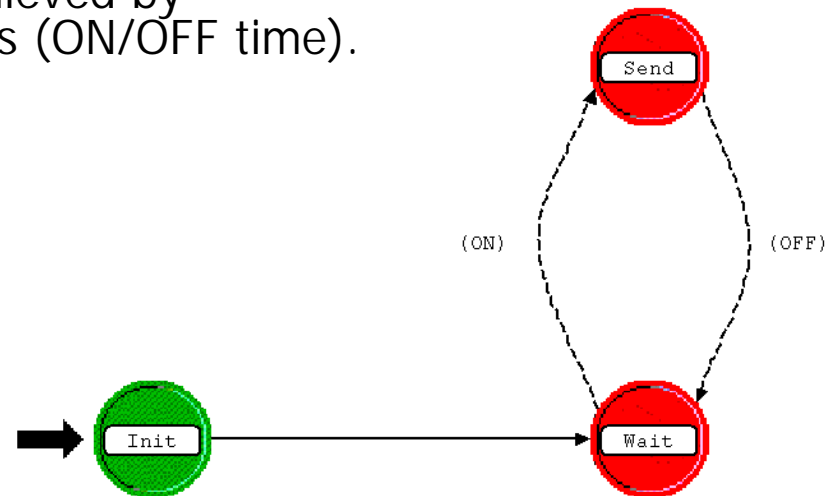
This is FSM of the source process model inside M-ES. It incorporates a loop where it keeps sending packets to the network according to the information (packet arrival time and packet size) read from traffic trace files.

Traffic trace files were created from the CDPD traffic data, and were put in the format that OPNET can recognize.

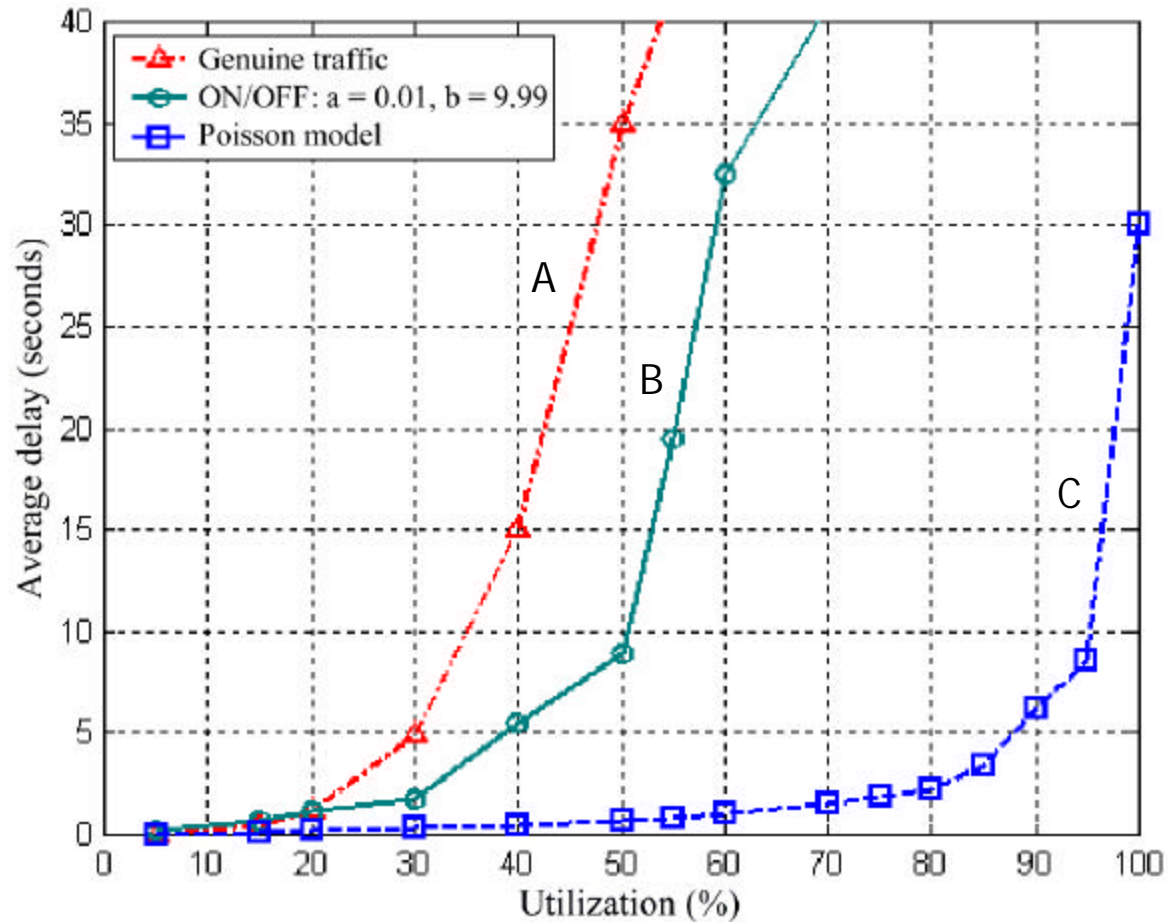
## ON/OFF OPNET traffic source model inside M-ES

The source generates packets in the "send" state and rests in the "wait" state.

Adjustment of the traffic burstiness is achieved by modifying the duration of these two states (ON/OFF time).



# Average delay vs. utilization



## Simulation results

- We evaluated the queueing performance of a CDPD network with various input traffic types.
- The plots show the average delays for:
  - actual traffic data (graph A)
  - traffic trace generated by our ON/OFF source (graph B)
  - Poisson source (graph C).
- Assumption: infinite buffer size.
- The queueing performance of the traffic generated by an ON/OFF source (graph B) is closer to the network performance observed with collected traffic data (graph A).
- This is to be expected, since ON/OFF sources reflect the bursty nature of the genuine network traffic better than Poisson sources (graph C).

## Concluding remarks

- We used trace-driven simulation experiments to demonstrate that long-range dependence is an important traffic characteristic.
- The delay performance obtained with the genuine traffic trace is qualitatively different from the performance predicted by Poisson arrival processes.
- In the case of moderate and high network utilizations, short-range dependent traffic source models (Poisson arrivals) underestimate queueing delays.
- OPNET CDPD model named “cdpd” has been deposited into the OPNET Contributed Model Depot.

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