Telecommunication Networks - AA 2014/2015
Homework 3: Protocol design and implementation

Andrea Zanella

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1 System specifications

This HW has to be done in groups of 2 or 3 students.
The purpose is to design, implement, and test an *overlay transport network* (OTN), which must be realized upon the UDP transport service. The OTN is composed by three modules, namely:

1. `Data Sender` (DS): it is in charge of correctly delivering a data file to the Data Receiver, through an unreliable Transport Channel (TC).
2. `Data Receiver` (DR): it collects the data sent by DS through the TC, and sends back control information (ACK or anything else required by the designed protocol).
3. `Transport Channel` (TC): it receives packets from DS and forwards it to DR, with a forwarding probability and delay that are determined as described below.

The functionalities of the different components are detailed below.

1.1 Data Sender

DS needs to perform the following tasks.

1. Require a file to be transmitted to DR.
2. Split the data file in UDP datagrams of proper size, to be sent to DR through the TC service.
3. Make use of feedback packets returned by DR to retransmit dropped packets.

1.2 Data Receiver

DR needs to perform the following tasks.

1. Receive datagrams sent by DR (through TC).
2. Check whether all data have been received and, in case, notify DS of the successful data transfer.
3. Send back control packets to DS according to the design protocol.

1.3 Transport Channel

TC is a traffic shaper that acts according to the following rules.

1. Receive packets from pre-defined port $\chi = 65432$.
2. Determine payload length L, in bytes.
3. Determine socket address of destination (either DS or DR).
4. Drop the packet with probability $P_{loss}(L) = 1 - \exp(-L/1024)$.
5. If packet is not dropped, schedule it for forwarding to the destination with a *(pseudo)random delay* taken from an *exponential probability distribution* with mean $\bar{\tau}(L) = \frac{1024}{\ln(L)}$ [ms].
6. Transmit packets to DR according to their scheduling time.

1.4 Suggestions

1. For debugging purposes, DS, DR and TC services may be run on the same host, using the IP loopback addresses. However, the OTN shall be working even when the three components are run in different hosts, possibly belonging to different networks.

2. The PDU of the overlay data transport service shall entail an header that contains the IP address and port number of the final destination, in order to allow the TC module to correctly propagate each datagram towards the correct host and service. For instance, suppose that DS runs on Host 1 with IP = x and port number $\chi = 65432$, TC runs on Host 2 having IP = y and port number γ, and DR runs on Host 3 with IP = z and port number ζ. Then, each packet sent by DS shall actually be addressed to the socket $< y, \gamma >$ but the first 4 bytes of payload shall be equal to $< z, \zeta >$. TC shall then forward the UDP datagram to the UDP socket $< z, \zeta >$. Return packets generated by DR shall be addressed to the UDP socket $< y, \gamma >$ and carry in the first 4 bytes of payload the socket address of DS, i.e., $< x, \chi >$.

3. The generation of (pseudo)random numbers with exponential probability distribution of mean $\bar{\tau}$ can be realized as follows

$$\tau = -\bar{\tau} \ln(\texttt{rand})$$

where `rand` is the built-in generator of uniform random variables in the interval $[0, 1]$, which is typically provided (possibly with different names) by the major programming languages.

2 Protocol design, implementation & Testing

- Define the data transfer protocol implemented by DS and DR with the aim of minimizing the file transfer time.
- Implement the DS, DR and TC modules that realize the designed service.
- **Remark**: TC shall be considered as an interchangeable module: the data transfer service must work with the TC developed by any other group!
- Test the TC module to empirically show it works as expected.
- Test the DS and DR modules by assessing the transfer time of files of different sizes, each transmitted multiple times.
- If possible, repeat the test using the TC developed by another group.

3 Technical Report

Produce a technical report of **no more than 3 pages** that describes what follows:

- The transfer protocol (use flow-charts to describe the protocol at the sender and receiver modules).
- The testing results for TC module.
- The testing results for the DR/DS modules.