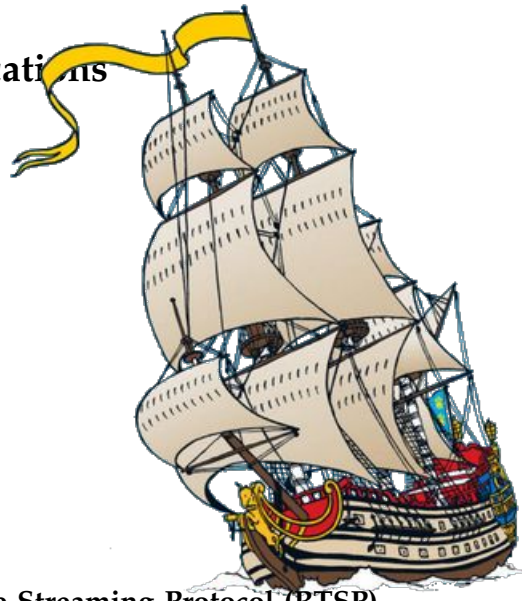
CS 447 : Networks and Data Communications

Programming Assignment #02

Total Points: 150



Assigned Date : Tuesday, October 23, 2018
Due Date : Tuesday, November 06, 2018 @ 12:29:59 p.m.

Overview

Your second programming assignment is to implement a **basic Real Time Streaming Protocol (RTSP)** application. RTSP is typically used to stream multimedia (using an end-to-end transport protocol called the **Real-Time Transport Protocol** (RTP) RFC #3550), and the corresponding RFC description – RFC #7826 – is fairly lengthy. Given our 2 week window, you are not expected to implement a fully-pledged RTSP multimedia application, but rather a simplified basic RTSP application using TCP and UDP. The objectives of this assignment are:

- to become familiar with RTSP and understand real-time end-to-end data delivery;
- to familiarize yourself with Out-of-Band protocols; and
- to gain an appreciation of the advantages of UDP over TCP;

Note: RTSP employs two separate connections – one for `control` and one for `data`. This is the same behavior you observe in FTP (which uses port 20 for data and port 21 for control). Such protocols are called out-of-band protocols.

Backstory

In his latest bid to locate the long lost *Unicorn*, captain Haddock wants to send a deep sea probe to the depths to gather data. The probe is going to stream back data from three different sensors: `oxygen-levels`, `temperature`, and `pressure`. He wants to monitor these **in real-time** to better steer the probe to find what he is looking for.

Technical Requirements

1. For this assignment, you will need to write a client-server application to support the real-time data monitoring of the probe.
2. Your application will implement a simplified subset of the RTSP specifications (RFC 7826). Instead of RTP, you will utilize TCP and UDP as specified below:

   (a) A `control` connection over TCP.

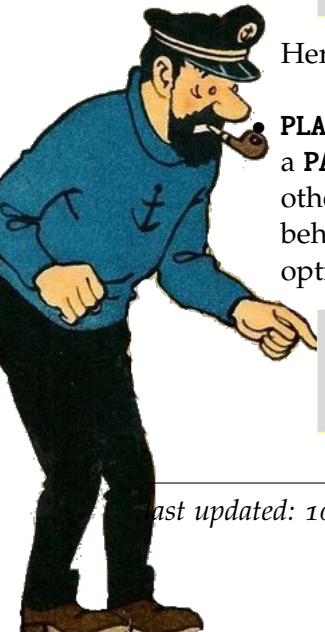
(b) A `data` connection over UDP.

3. Your application should relay 3 different types of data – {`O` `T`, and `P`} – from `server` → `client` using the `data` connection. The payload type numbers will be `O:=79`, `T:=84`, and `P:=80`.
4. The format of each data type is as follows and each packet should have only 1 reading
   - 5-bits for 1 oxygen reading. *Trivia: Dissolved Oxygen levels is a range 0 – 16* ***mg/L***.
   - 8-bit for 1 temperature reading. *Trivia: Coldest recorded Temperature on earth is -128.6* ^{o}***F***.
   - 11-bits for 1 pressure reading. *Trivia: Highest sea-level pressure recorded is 1050* ***mbar***.
5. You will have one `server` program and two `client` programs — a `data-client` (UDP) and a `control-client` (TCP).
6. Your `data-client` receives the data and should display a horizontal histogram that scrolls vertically as time goes on. Each line should be the value for one reading relative to the width of the column width, which is 20. For example, if the value for the `temperature` reading is 255 (max value), then on the line corresponding to `temperature`, you should display/print 20 $\star$s (i.e. $\star\star\star\star\cdots\star$). If it's half the maximum value for that data, then it should print only 10 $\star$s. Take care to put the right data into the right row. The order is `oxygen`, `temperature`, `pressure`.
7. There should be a separate `control-client` to issue the following commands, which should be issued using a TCP connection.
   - **`SETUP` (sec. 13.3)** — Informs the `server` the socket address used for data communication. Here's a sample **`SETUP`** message.

```
C → S: SETUP rtsp://<server-hostname>/ RTSP/2.0
       CSeq:  302
       Transport:  UDP;unicast;dest_addr":4588"
       Sensor:  *
```

   In this example, the `client` informs the `server` that it is requesting data from all three sensors (default behavior) accepting on UDP port 4588. The optional `Sensor` header can be used to request particular sensor data (comma separated if more than one). A sample server response would look similar to the following.

```
S → C: RTSP/2.0 200 OK
       CSeq:  302
       Date:  Tue, 23 Oct 2018 12:29:29 -0500
       Transport:  UDP;unicast;dest_addr=":4588";
                   src_addr="146.163.150.1:6256"
```



   Here, the server identifies the server side socket ID for data transfer.

   - **`PLAY` (sec. 13.4)** — Informs the `server` to start sending data (or resume sending in the case of a **`PAUSE`**). The `server` keeps sending data at a steady rate of every 3 seconds. until instructed otherwise. The received data is displayed on the `data-client` as a histogram. The default behavior is the request for all three sensor data. This behavior can be modified using the optional `Sensor` header.

```
C → S: PLAY rtsp://<server-hostname> RTSP/2.0
       CSeq:  836
       Sensor:  *
```

```
S → C: RTSP/2.0 200 OK
       CSeq:  836
       Date:  Tue, 23 Oct 2018 12:31:45 -0500
```

Over the data connnection:

```
S → R: 79:11111;84:11111111;80:11111111111
```

- **PAUSE (sec. 13.6)** — Informs the `server` to stop sending data. Correspondingly, the `data-client` will pause as it is no longer receiving data.

```
C → S: PAUSE rtsp://<server-hostname> RTSP/2.0
       CSeq:  834
```

```
S → C: RTSP/2.0 200 OK
       CSeq:  834
       Date:  Tue, 23 Oct 2018 12:48:23 -0500
```

- **TEARDOWN (sec. 13.7)** — Ends the streaming session for all programs involved. This is effectively a **QUIT** command for both clients and both the `data-client` and the `control-client` should exit gracefully. Your server should handle this without issue and be ready to receive more **SETUP** commands.

```
C → S: TEARDOWN rtsp://<server-hostname> RTSP/2.0
       CSeq:  892
```

```
S → C: RTSP/2.0 200 OK
       CSeq:  892
```

- Read relevant sections on the RFC for more information on these commands.

8. Your `server` should send appropriate response codes to the `control-client`. Use sec. 17: Status Code Definitions on RFC #7826 to guide your choices. Make sure to appropriately justify your choices in your report.
9. Your `data-client` should take as a command line argument of the desired UDP port to receive data that comes from the server.

```
e.g. ./receiver <receiver-port>
```

Note: Your `data-client` is effectively on a listen-and-display mode. It should not be used to send any commands to the `server`.

10. Your `control-client` should take the `hostname/ip address` and the TCP port number which the server is listening on for control commands, and a third argument to identify the UDP port for the data connection (through your `data-client`).

```
e.g. ./controller <server-ip> <server-port> <receiver-port>
```

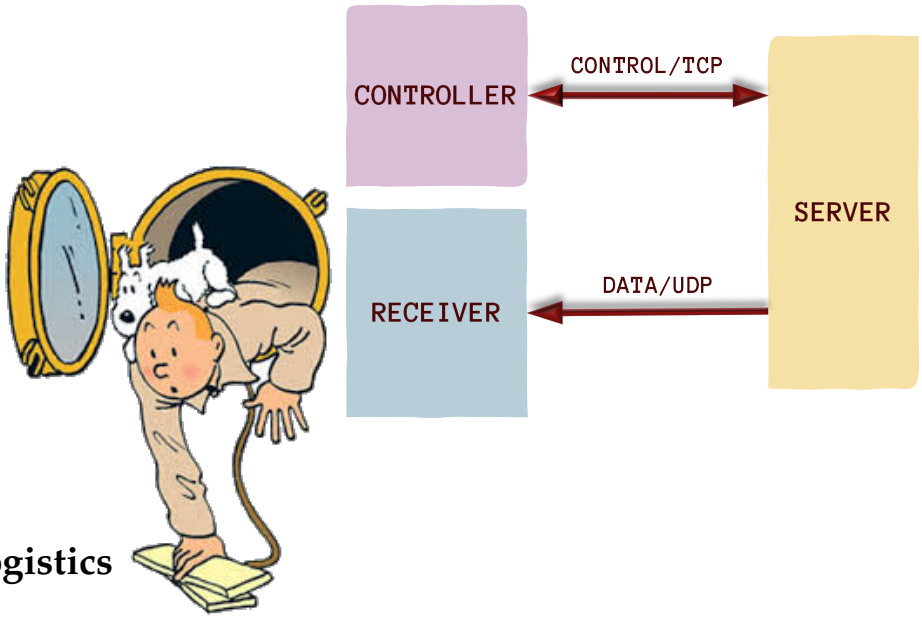
It is assumed that `receiver` and `controller` are running on the same machine, but the `server`

will be running on a separate machine.

11. The `server` program should accept four command line arguments: port to use to listen to TCP connections, oxygen data file, pressure data file, and temperature data file, all of which will be binary files.

```
e.g. ./server <server-port> <oxygen.bin> <temp.bin> <pressure.bin>
```

This will start the `server` listening on `<server-port>` for `control` connections, and will use the binary data from the `*.bin` files to stream data back to clients over `data` connections. Here's an architectural figure of the overall interaction.



Logistics

- IPs and ports should in no way be hard coded. They should be given as command line arguments when launching the program
- Your `server` and `receiver` will need to be started first in the prescribed setup, and then your `controller` after since it must connect to both of them.
- Include a `wireshark` screenshot (wireshark capture files, `.pcap` files, are also acceptable) showing a sample interaction between your client(s) and server. Your screenshot should clearly depict the expected RTSP message headers outlined in Technical requirements item #7 above.

Instructions

- This is an individual assignment. **Do your own work**.
- **Start early!! Take backups of your code often!!**. Use of a version control software is highly recommended!
- Make sure to test your program properly before your final submission. It is **highly** recommended to test build and run your submission on the home server, **home.cs.siue.edu**.
- You may use any programming language of your choice out of `C`, `C++`, `Java`, `Python` or `Go` as these are all available on the home server. However, you **must** make sure that your code compiles and runs on a typical Linux machine. Absolutely **DO NOT** include executables with your submissions.

- A **Makefile** is mandatory. Whether or not your program needs to be compiled, have it echo instructions to run the program.
- Follow a good coding standard. Use the Google C++ coding standard found here `http://goo.gl/1rC1o`, if you don't already follow one.
- The report part of your solution must be produced using a word processor. LaTeX is highly recommended but not a requirement.
- Your final report should be in **PDF** format. No exceptions.
- Any figures, graphs, plots, etc., should also be produced using appropriate computer applications. If using LaTeX, the pgfplots package is very useful for making all sorts of graphs.
- You are strongly encouraged to answer your own design and/or implementation questions based on the the RFCs, rather than defaulting to the instructor immediately. Make sure to properly document any such choices in your report and be as much descriptive as possible with proper sectional citation(s) from the relevant RFCs (*that way I will know why you did what you did*).
- The due date of this assignment is **Tuesday, November 06, 2018 @ 12:29:59 p.m.** A dropbox will be opened for submission on Moodle.

Deliverables

A complete solution comprises of:

- A short report of the design and implementation of your system. The report should be **PDF** format. At minimum, your report should include the following sections:
  - Introduction: Your objective and what you hope to gain from assignment.
  - Overall design, specific design choices, and reply codes used.
  - The output of a sample run (including screenshots where applicable). See Logistics requirement above.
  - Summary and Issues encountered. What you were able to achieve from your own objectives (from the introduction) as well as project specifications. Make sure to explicitly list functionality you failed to implement (or buggy).
- A compressed tarball that contains:
  - a directory containing (only) your source code. **Do not** include executables, folders created by your programs, or any other files not specifically listed here as required.
  - A short `readme` file with compilation instructions.
  - A `makefile` to automate compilation. A (except python).

To create a compressed tarball of the directory source, use the following command:
`tar -zcvf siue-id-pr2.tar.gz source/`. e.g. `tar -zcvf tgamage-pr2.tar.gz PR02/`

Collaborating on ideas or answering each others questions is always encouraged. Most times, I find that you learn a lot from your peers. However, do not share/copy/duplicate code from others including online sources. The exercise is meant for you to learn network programming, not to test your googling abilities. Issues related to academic integrity and plagiarism have **ZERO** tolerance.

Extra Credit

- Enable multiple concurrent clients to independently interact with the server [**25 points**]

- Improve user friendliness of your implementation using a text-based UI such as `ncurses` https://www.gnu.org/software/ncurses/ [**20 points**]
  Note: If you take any of the extra credit options, you must explicitly list that in your documentation including your report, and readme.

Useful Resources

- Linux Man pages – found in all linux distributions
- Beej's Guide to Network Programming – A pretty thorough free online tutorial on basic network programming http://beej.us/guide/bgnet/output/print/bgnet_USLetter.pdf
- Real Time Streaming Protocol
  RFC #7826 https://tools.ietf.org/pdf/rfc7826.pdf