Sockets: The Hard Way

Introduction to Middleware

Vojtěch Horký Petr Tůma

Department of Distributed and Dependable Systems
Faculty of Mathematics and Physics
Charles University

2010 – 2022

Outline

1. Berkeley Socket Interface
2. Assignment Part I
3. Assignment Part II
4. Marshalling Implementation
5. Assignment Part III

Interface Overview

Socket

An abstraction representing a (network) communication channel.
Both stream oriented and message oriented channels.
Spectrum of supported protocols.

Stream Oriented Channel

Socket on *client side* initiates outgoing connections.
Socket on *server side* waits for incoming connections.
Data flows in both directions after connection established.

Message Oriented Channel

No connection established.
Sender and receiver roles symmetrical.

Examples To Play With ...

```
> git clone http://github.com/d-iii-s/teaching-introduction-middleware.git
```

C

```
> cd teaching-introduction-middleware/src/sockets-basic-server/c
> cat README.md
```

Java

```
> cd teaching-introduction-middleware/src/sockets-basic-server/java
> cat README.md
```

Python

```
> cd teaching-introduction-middleware/src/sockets-basic-server/python
> cat README.md
```

Stream Oriented Channel

Client Side Pseudocode

```
socket = CreateSocket (comms_domain, socket_type);
ConnectToServer (socket, server_address);
... Write (socket, data);
... Read (socket, data);
Shutdown (socket);
Close (socket);
```

Server Side Pseudocode

```
server_socket = CreateSocket (comms_domain, socket_type);
BindToLocalAddress (socket, address);
PermitListeningOnSocket (socket, backlog);
client_socket, client_address = AcceptIncomingConnection (socket);
... Write (client_socket, data);
... Read (client_socket, data);
Shutdown (client_socket);
Close (client_socket);
```

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Assignment

Server

Implement a server that will:

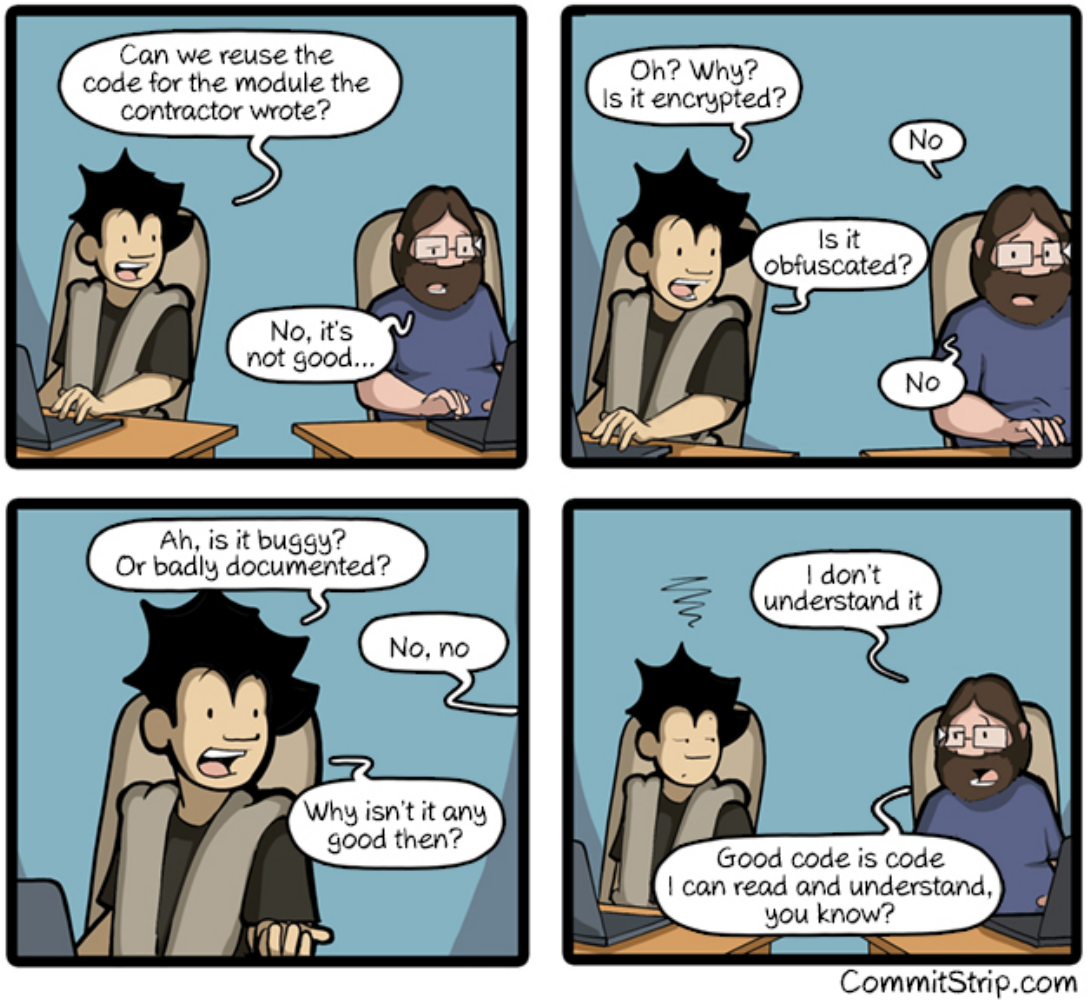
- Listen for incoming connections.
- Provide information on current time to connected clients.

Client

Implement a client that will:

- Connect to the server described above.
- Query information on current time.
- Print the time.

Code Now ...



http://www.commitstrip.com/en/2016/06/07/good-code

Show Your Code ...

Query Host Name

```
> hostname
u1-22
```

Run Screen Sharing

```
> x11vnc -viewonly
```

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Assignment

Server

Implement a server that will provide information on current time.

- The server should accept a spec of what fields to return.
- Fields should be standard YYYY-MM-DD HH:MM:SS.

Client

Implement a client that will query server time:

- Pick a random combination of fields.
- Query information on current time.
- Wrap all this in a local function.
- Print the time.

C Local Function

```
/**
 * Return server time in standard structure.
 * \param result Caller allocated structure to fill.
 * \return Zero for success, non zero error code otherwise.
 */
int server_time (struct tm *result);

struct tm {
    int tm_sec;    // Seconds (0-60)
    int tm_min;    // Minutes (0-59)
    int tm_hour;   // Hours (0-23)
    int tm_mday;   // Day of the month (1-31)
    int tm_mon;    // Month (0-11)
    int tm_year;   // Year - 1900
    int tm_wday;   // Day of the week (0-6, Sunday = 0)
    int tm_yday;   // Day in the year (0-365, 1 Jan = 0)
    int tm_isdst;  // Daylight saving time
};
```

... man localtime

Java Local Function

```
/**
 * Access server time in standard structure.
 */
public interface ServerTime {
    int getSecond ();           // Gets the second-of-minute field.
    int getMinute ();           // Gets the minute-of-hour field.
    int getHour ();             // Gets the hour-of-day field.
    int getDayOfMonth ();       // Gets the day-of-month field.
    Month getMonth ();          // Gets the month-of-year field.
    int getYear ();             // Gets the year field.
    DayOfWeek getDayOfWeek ();  // Gets the day-of-week field.
    int getDayOfYear ();        // Gets the day-of-year field.
}
```

... javadoc `LocalDateTime`

Python Local Function

```
def server_time ():
    """Returns server time in datetime.datetime class."""
    ...

# Instance attributes (read-only):
#
#     datetime.year
#         Between MINYEAR and MAXYEAR inclusive.
#     datetime.month
#         Between 1 and 12 inclusive.
#     datetime.day
#         Between 1 and the number of days in the given month of the given year.
#     datetime.hour
#         In range(24).
#     datetime.minute
#         In range(60).
#     datetime.second
#         In range(60).
```

... help (datetime.datetime)

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C Marshalling

Textual Stream ?

```
int sprintf (char *str, const char *format, ...);
int sscanf (const char *str, const char *format, ...);
```

Network Order Binary Stream ?

```
uint32_t htonl (uint32_t hostlong);
uint16_t htons (uint16_t hostshort);
uint32_t ntohl (uint32_t netlong);
uint16_t ntohs (uint16_t netshort);
```

Native Order Binary Stream ?

```
char buffer [1024];
int *address = (int *) &buffer [16];
*address = 1234;
```

Java Marshalling

Serialized Stream ?

```
output_stream = socket.getOutputStream ();
object_stream = new ObjectOutputStream (output_stream);
object_stream.writeInt (1234);
object_stream.writeObject (...);
```

Textual Stream ?

```
PrintWriter writer = new PrintWriter (output_stream, true);
writer.println ("...");
```

Byte Stream ?

```
ByteBuffer buffer = ByteBuffer.allocate (4);
buffer.putInt (1234);
output_stream.write (buffer.array ());
```

Python Marshalling

Pickled Stream ?

```
import pickle
with socket.makefile () as file_object:
    pickle.dump (..., file_object)
```

JSON Stream ?

```
import json
with socket.makefile () as file_object:
    json.dump (..., file_object)
```

YAML Stream ?

```
import yaml
with socket.makefile () as file_object:
    yaml.dump (..., file_object)
```

Python Marshalling

Byte Stream ?

```
data = 1234
socket.send (data.to_bytes (4, 'little'))
```

Byte Stream ?

```
from struct import *
data = pack ('bhiq', 1, 2, 3, 4)
socket.send (data)
```

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Assignment

Interoperability

Implement compatible clients and servers in two languages.

Performance

Measure the performance of your implementation.

Experiment Design

Stick to the following, or provide arguments for why not:

- Random field mix, each field with probability 1/2.
- Measure at least two minutes long traffic.
- Report average invocation throughput.
- No printing during measurement.

Measuring Time

C++

```
#include <time.h>
#include <stdint.h>
struct timespec time;
clock_gettime (CLOCK_MONOTONIC_RAW, &time);
uint64_t nanoseconds =
    (uint64_t) time.tv_sec * 1000000000 +
    (uint64_t) time.tv_nsec;
```

Java

```
long nanoseconds = System.nanoTime ();
```

Python

```
import time
nanoseconds = time.clock_gettime (time.CLOCK_MONOTONIC_RAW) * 1000000000
```

Submission

GitLab

Use your personal GitLab repository under `https://gitlab.mff.cuni.cz/teaching/nswi163/2022`.

Requirements

- Use the assignment subdirectory.
- Write brief report in `SOLUTION.md`.
- Include build scripts with instructions.
- Do not commit binaries or temporary build artifacts.
- Tag your solution with `task-01` and push the tag.