Sockets: The Hard Way
Introduction to Middleware

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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**

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

**Server Side Pseudocode**

```plaintext
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 ...

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Can we reuse the code for the module the contractor wrote?

No, it's not good...

---

Oh? Why?

Is it encrypted?

No

---

Is it obfuscated?

No

---

Ah, is it buggy?
Or badly documented?

No, no

---

Why isn't it any good then?

---

I don't understand it

Good code is code I can read and understand, you know?

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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
/**
 * 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
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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3. Assignment Part II
4. *Marshalling Implementation*
5. Assignment Part III
C Marshalling

**Textual Stream ?**

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

**Network Order Binary Stream ?**

```c
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 ?**

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

Serialized Stream?

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

Textual Stream?

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

Byte Stream?

```java
ByteBuffer buffer = ByteBuffer.allocate (4);
buffer.putInt (1234);
output_stream.write (buffer.array ());
```
# Python Marshalling

## Pickled Stream?

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

## JSON Stream?

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

## YAML Stream?

```python
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++**

```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**

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

**Python**

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

GitLab

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.