Communication Networks Laboratory
The University of Kansas EECS 780
Introduction to Socket Programming

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Socket Programming
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Socket Programming
Motivation and Overview

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Motivation and Overview

Socket Programming and Applications

• Also called client/server application development
• Introduced in 4.1 BSD in 1982
• Network application implementations
  – standard network application
    • based on RFCs
    • programs conforms rules
    • port numbers should be implemented per RFC
  – proprietary network application
    • they don’t conform RFCs
    • code will not interoperate
    • don’t use standard RFC well-known port numbers (0-1023)
Motivation and Overview
E2E Application Data Flow and Sockets

- Application process send messages via sockets
- Application process is controlled by the developer
- TL (TCP, UDP) is controlled by the OS
Motivation and Overview
Sockets and Processes

- Socket is a method for Inter Process Communication
- Processes are created via client/server programs
- IPC can be done on a single host as well

Client program
Client process
Server program
Server process

read/write from/to sockets
Socket Programming
Socket Programming Stages

L2.1  Motivation and overview
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Socket Programming Stages

Planning Phase

1. Developer decides programming language and OS
   – Python, C, Java etc. and UNIX, Linux, MS etc.

2. Developer should decide:
   – to run the application on TCP
     • TCP is connection oriented, reliable byte stream channel
   – to run the application on UDP
     • UDP is connectionless service, best effort, no guarantee
   – skip transport layer to run the application
     • for hop nodes: e.g. ICMP
     • also called raw sockets

3. Developer implements the code
Socket Programming Stages

Socket Programming with TCP

• In order to establish connect. between client & server
• Server process
  – has to be ready to respond client’s requests
  – server has to have a welcoming socket
• Client process
  – creates socket
  – specifies the destination
  – 3-way handshake occurs
    • client invokes server’s welcomeSocket accept() method
    • server responds this by creating dedicated connectionSocket
    • TCP establishes pipe betw. connectionSocket-clientSocket
Socket Programming Stages
Connection-Oriented Flow Diagram

- `socket()`
- `bind()`
- `listen()`
- `accept()`
- `wait for connection`
- `read()`
- `process request`
- `write()`

Connection establishment:
- `connect()`
- `write()`
- `data (request)`
- `read()`
- `data (reply)`

Server:
- `socket()`
- `bind()`
- `listen()`
- `accept()`
- `wait for connection`
- `read()`
- `process request`
- `write()`

Client:
- `socket()`
- `connect()`
- `write()`
- `read()`

[Stevens-1990]
Socket Programming Stages

Socket Programming with UDP

- Connectionless transport between client & server
  - there is no initial handshaking
  - unlike TCP client can be started first
- Client attaches destination address to each packet
- Client process
  - creates clientSocket of type DatagramSocket
  - in TCP clientSocket is of type Socket
- Server process
  - creates serverSocket of type DatagramSocket
  - there is no welcomeSocket as in TCP
Socket Programming Stages
Connectionless Flow Diagram

- `socket()`
- `bind()`
- `recvfrom()`

`wait for client data`

`process request`

`sendto()`

**server**

`data (request)`

`data (reply)`

`recvfrom()`

**client**

- `socket()`
- `bind()`
- `sendto()`

[Stevens-1990]
Socket Programming

Socket Programming Examples

L2.1 Motivation and overview
L2.2 Socket programming stages
L2.3 Socket programming examples
L2.4 Socket programming assignment
import socket
TCP_IP = '127.0.0.1'
TCP_PORT = 5005
BUFFER_SIZE = 1024
MESSAGE = "Hello, World!

s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.connect((TCP_IP, TCP_PORT))
s.send(MESSAGE)
data = s.recv(BUFFER_SIZE)
s.close()

print "received data:", data
import socket
TCP_IP = '127.0.0.1'
TCP_PORT = 5005
BUFFER_SIZE = 1024
s = socket.socket(socket.AF_INET, socket.SOCK_STREAM)
s.bind((TCP_IP, TCP_PORT))
s.listen(1)

conn, addr = s.accept()
print 'Connection address:', addr
while 1:
    data = conn.recv(BUFFER_SIZE)
    if not data: break
    print "received data:" , data
    conn.send(data) # echo
conn.close()
Socket Programming Examples

Python UDP Client

```python
import socket

UDP_IP = "127.0.0.1"
UDP_PORT = 5005
MESSAGE = "Hello, World!"

print "UDP target IP:" , UDP_IP
print "UDP target port:" , UDP_PORT
print "message:" , MESSAGE

sock = socket.socket(socket.AF_INET, # Internet
                      socket.SOCK_DGRAM) # UDP
sock.sendto(MESSAGE, (UDP_IP, UDP_PORT))
```
import socket

UDP_IP = "127.0.0.1"
UDP_PORT = 5005

sock = socket.socket(socket.AF_INET, # Internet
                      socket.SOCK_DGRAM) # UDP
sock.bind((UDP_IP, UDP_PORT))

while True:
    data, addr = sock.recvfrom(1024) # buffer size is 1024 bytes
    print "received message:", data
Socket Programming
Lab Report Submission Requirement

L2.1  Motivation and overview
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Socket Programming Assignment

Program Output Requirement

• Create an application that will
  – convert lowercase letters to uppercase
    • e.g. [a...z] to [A...Z]
    • the code will not change any special characters
    • e.g. &*!
  – if the character is in uppercase, the program will not alter it

• Create socket API both for
  – reliable-byte stream
  – datagram services

• Must take the server address and port from the CLI
Socket Programming Assignment

Example for UDP

- Server side:
  python LastName_UDP_server.py 5050

- Client side:
  python LastName_UDP_server.py 127.0.0.1 5050
  Please enter the statement: eecs780
  return text from the server: EECS780
  Please enter the statement:

- The program should keep asking the user until it forced to exit, i.e., ctrl+c
Socket Programming Assignment

Questions to Answer

• What are the example applications that use TCP and UDP? Give two example for each protocol

• What are the port numbers those applications use?
  – use examples from well-known port number range

• Can you use those port numbers in the application you developed? Why or why not? Explain.

• In the application you developed how many simultaneous client/server connections are possible for each transport protocol? Are the port numbers same for a given protocol for each connection?
  – support you answer with `netstat` command output
Socket Programming Assignment

Extra Credit

- For client/server programs, print local and foreign address using functions
- What is the largest datagram size can you send and receive using UDP socket? Verify it experimentally
Socket Programming Assignment
Submission Requirements

- Follow instructions on submission requirements page
  - http://www.ittc.ku.edu/~jpgs/courses/homework.html

- You need to submit:
  - client file for reliable byte-stream service
  - server file for reliable byte-stream service
  - client file for datagram service
  - server file for datagram service
  - PDF file for additional questions

- Use Python
Socket Programming Assignment
Submission Requirements

- Folder name: LastName_socket_programming
- Folder contains:
  - LastName_TCP_server.py
  - LastName_TCP_client.py
  - LastName_UDP_server.py
  - LastName_UDP_client.py
  - LastName_report.pdf
- Subject: “EECS780 – programming 1”
- attachment: LastName_socket_programming.zip
  - zip the whole folder
Socket Programming

Acknowledgements

Some material in these foils comes from the textbook supplementary materials:

- Kurose & Ross,
  Computer Networking:
  A Top-Down Approach, 5th ed.
  http://wps.aw.com/aw_kurose_network_5

- Stevens,
  UNIX Network Programming
  Prentice Hall, 1990
  http://www.kohala.com/start/unp.html
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Acknowledgements


- Python.org http://wiki.python.org/moin/TcpCommunication
- Python.org http://wiki.python.org/moin/UdpCommunication
Socket Programming

Additional Reading

Some material in these foils comes from the textbook supplementary materials:

- http://www.cs.utsa.edu/~korkmaz/teaching/cn-resources/programs/capitalize-udp/
- http://gaia.cs.umass.edu/ntu_socket/
- http://beej.us/guide/bgnet/
- http://java.sun.com/docs/books/tutorial/networking/sockets/
- http://www.iana.org/assignments/port-numbers