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

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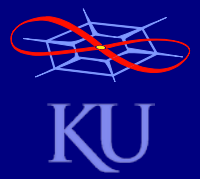

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Socket Programming
Outline

L2.1 Motivation and overview
L2.2 Socket programming stages
L2.3 Socket programming examples
L2.4 Socket programming assignment

Socket Programming
Motivation and Overview

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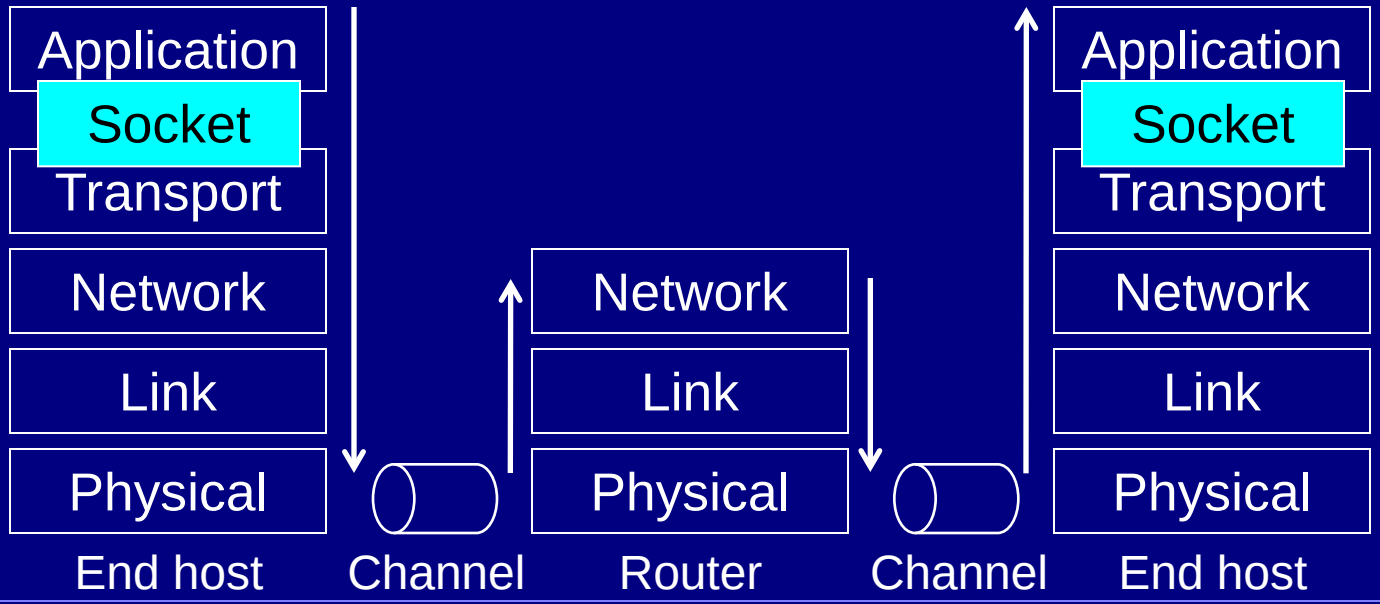
Motivation and Overview
Socket Programming and Applications

- 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)

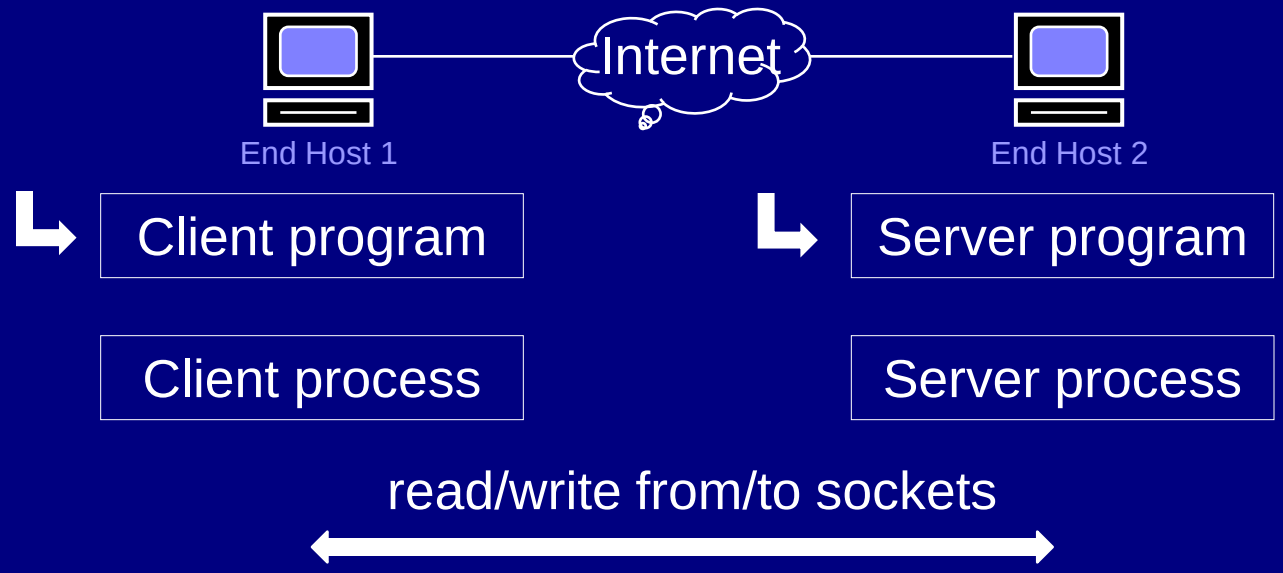
Motivation and Overview
E2E Application Data Flow and Sockets

- 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



Socket Programming
Socket Programming Stages

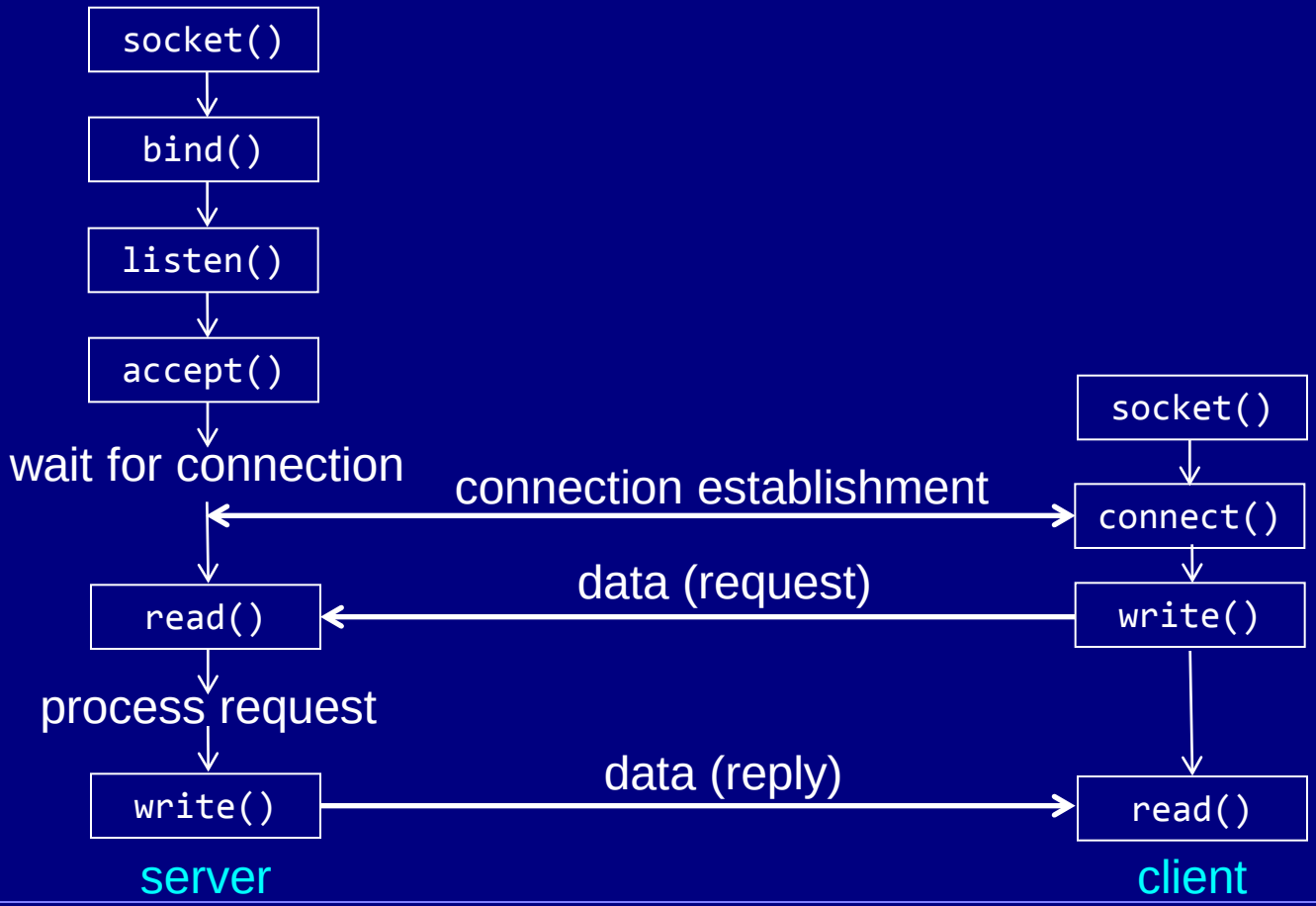
Socket Programming Stages
Planning Phase

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

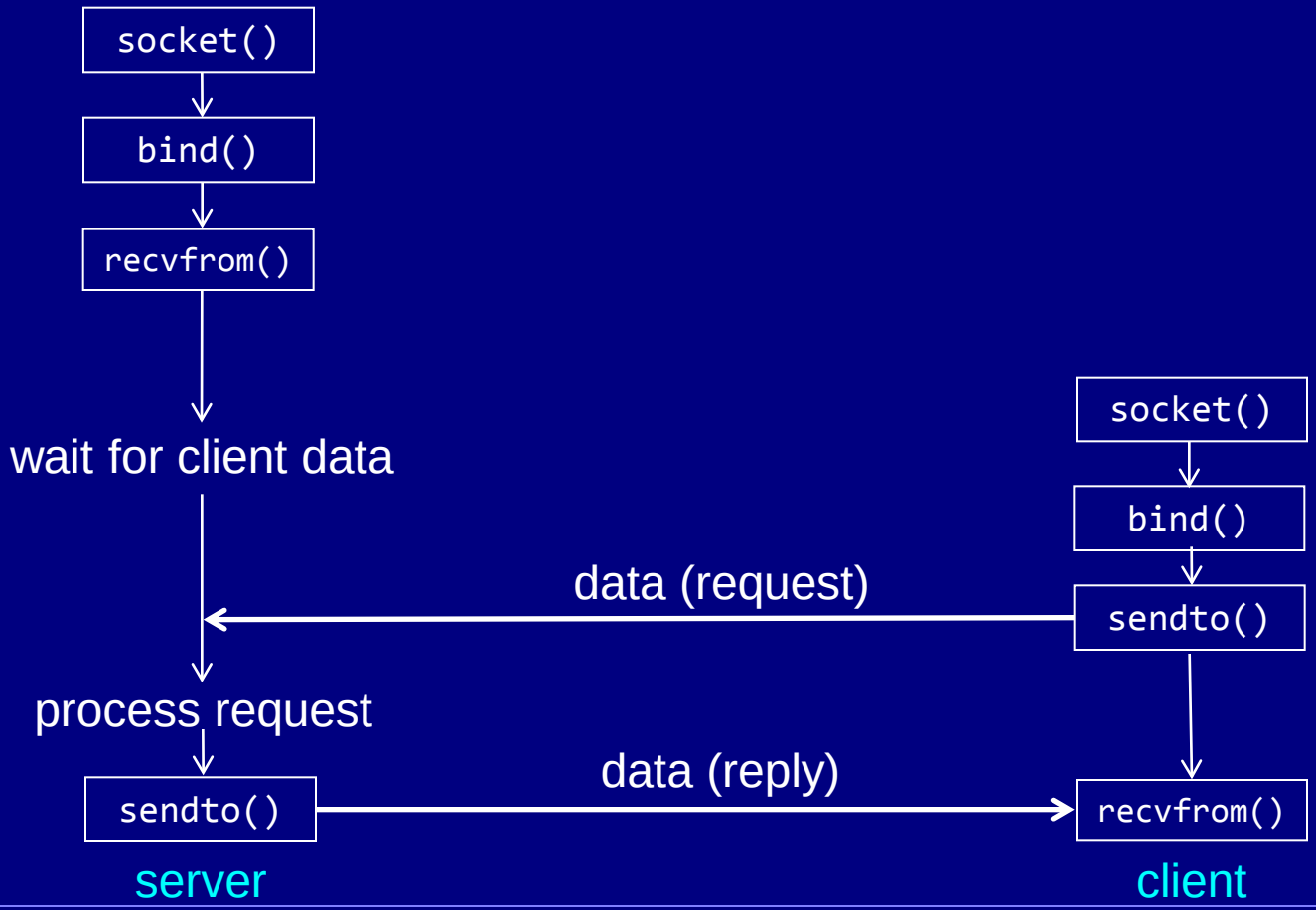


[Stevens-1990]

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



[Stevens-1990]

Socket Programming
Socket Programming Examples

Socket Programming Examples
Python TCP Client

```
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
```

Socket Programming Examples
Python TCP Server

```
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

```
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))
```

Socket Programming Examples
Python UDP Server

```
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
L2.2 Socket programming stages
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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[1]

- 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[2]

- 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

Socket Programming
Acknowledgements

- Donahoo & Calvert,
  TCP/IP Sockets in C: Practical Guide for Programmers, 2nd ed.
  http://cs.ecs.baylor.edu/~donahoo/practical/CSockets/

- Donahoo & Calvert,
  TCP/IP Sockets in Java: Practical Guide for Programmers, 2nd ed.
  Morgan Kaufmann, 2008
  http://cs.ecs.baylor.edu/~donahoo/practical/JavaSockets/

- 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-tcp/
- 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.faqs.org/faqs/unix-faq/socket/
- http://www.iana.org/assignments/port-numbers
- http://docs.freebsd.org/44doc/psd/20.ipctut/paper.pdf
- http://docs.freebsd.org/44doc/psd/21.ipc/paper.pdf