

Computer Networking (CSCI-330) Spring 2024 – Term Group Project P2P Messaging Application

Purpose

The objectives of this project are:

1. To promote group work and the sharing of ideas and tasks.
2. To promote life-long learning.
3. To empower students with the opportunity to realize that they are capable of attaining skill sets on their own with some effort.
4. To design and synthesize a P2P network application that requires putting together many of the concepts and elements learned throughout this semester.

Introduction and Challenge

Messaging applications has become an important part of how we communicate in real time. Most messaging apps follow a client-server architecture, where the clients sending messages are mediated by a server or servers on the Internet (see [Why You Should Use Peer-to-Peer Messaging Apps](#)). There are some options out there that implement a P2P architecture.

Your challenge is to design a P2P messaging application. The application needs to be able to, at a minimum, obtain the list of all users currently in the network and be able to send and receive text messages between users in the network. Strategies should be adopted to deal with different use cases.

NOTE: There is a 5-point extra credit if you utilize the Makerspace to design and produce an artifact that is related in some way to this project. It does not have to be used directly in the project.

Due Date

This project is group-based and requires your group to produce a functional network app, as explained below. Your group will also be required to give a ten-minute final presentation and demonstration in lieu of the final exam on Thursday, May 2nd, 2024.

About P2P Networks

In a peer-to-peer (P2P) network, a peer is a network application that can be both the client (consumer or requester) and a server (producer or provider). When a peer wants to make a resource available, it registers its content in the network. The method of registration depends on the structure of the P2P network.

Another peer requiring the resource will first locate the resource in the network through the available location services and then connect with the peer providing the resource. The peer then becomes another provider of the resource once downloaded. For example, in an unstructured centralized P2P network, a resource registration is carried out by centralized servers, called index servers, that provide indexing services to the network. When a peer, Peer A, wants to make a resource available, it registers its resource with the index server. Then, another peer, Peer B, requests the resource located on Peer A by contacting the index server and obtaining the address of Peer A. Peer B then contacts Peer A directly and downloads the resource. Now, Peer A becomes another provider of the resource. This method is scalable because as the number of requests increases for a resource, so do the number of providers. A resource may be a file, CPU sharing, storage, gaming component, web services, and new forms of content distribution, sharing, and delivery. The possibilities are endless!

P2P networks are classified as either structured or unstructured. Structured models are not robust in networks with a high rate of churn (networks in which peers enter and leave at a high rate). Unstructured networks are broken down into centralized, decentralized, and hybrid. Centralized servers (index servers) provide resource location services in a centralized network. Index servers maintain an index list of resources and update the lists as peers enter and exit the network. Centralized structured networks suffer from a single point of failure.

Decentralized networks remove the centralized services and use a flooding query mechanism to locate resources. A peer requesting a resource sends a query in the network. The query is relayed to neighboring peers, who forward it to their neighboring peers. Peers providing the resource send their responses back along the same request path. Finally, the requesting peer selects one out of the various responses received and starts the download with that peer. The decentralized architecture eliminates the centralized servers and is more reliable; however, the flooding search results in high network traffic activity. Implementing a time-to-live (TTL) mechanism, caching, and other techniques may mitigate this issue but increase the application's complexity.

A hybrid of the two models is adopted to address the issues of the centralized and distributed models. In a hybrid model, a leader, called a *supernode*, acts as an index server but can send search queries to other supernodes on behalf of peers in their group.

Project Requirement

Your challenge, which you have no choice but to accept, is to design and implement a P2P messaging application that solves a need by a certain subset, clique, or coterie of the population. The P2P application may not solve a problem that is more efficiently solved using a client-server paradigm; however, this does not mean that you cannot make a case for the P2P approach. *For*

simplicity, you may select an unstructured centralized model. Your P2P application must be able to, at a minimum,

- Allow peers to enter and exit the network
- Allow peers to register, search, send and receive messages
- Turn a peer from requester to provider
- Allow a peer to exit the network
- Send and receive error messages (if necessary)
- Work with peers within local networks (across private networks and firewalls will earn you an additional 10 points).

Your documentation must clearly explain the application protocol, including the message format, order of messages sent and received among peers and servers (if applicable), and actions taken on message transmission and receipt. This should be done in a variety of formats and diagrams, including protocol activity diagrams. Your documentation should also include a network diagram of your P2P network.

Example Protocol Design¹

The following is a brief example of how you should go about documenting your protocol. Your documentation should be more detailed. Should you choose a centralized model, you could choose a fixed message format (this simplifies the implementation) to look something like the following:



The *type* field specifies the message type. The following table summarizes possible message types:

Message Type	
R	Resource registration
D	Resource deregistration
P	Request resource download
G	Get resource data
L	List of indexed resources
S	Search index server
A	Acknowledge
E	Error

Protocol Description

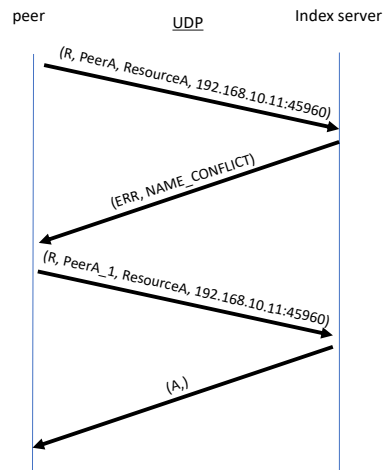
¹ Rayerson University, COE 768 project documentation.

1. Resource registration

A peer can register its resource by sending an R message to the server. The message would encapsulate the peer name, resource name, and peer address in the data part of the message.

	<===== Data =====>		
R	Peer Name	Resource Name	Peer Address

The peer uses a UDP connection with the server to accomplish the registration. The interaction diagram may look something like the following:



In the diagram, the error message was since another peer had registered the using the same name. Note that using the address alone may not be enough to specify a unique name for a peer.

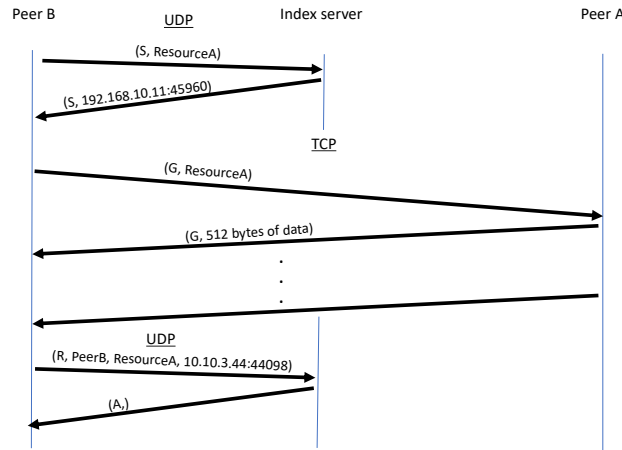
2. Resource Download

To download a resource, the peer must first send an S message to the index server with the following format:

	<===== Data =====>	
S	Peer Name	Resource Name

The index server will respond with an S message that contains the peer's address. If the resource is not in the index server, the index serve will respond with an E message.

A download interaction diagram is illustrated below.



Documentation Requirements

You are required to document the project on a blog site that should be created on the first week of the project. You will need to give read/write access to the instructor. The documentation should include at a minimum,

- A description of the design process used in this project and how your group achieved its objectives.
- A description of the architecture of the system and how elements interact with one another
- A description of the protocol used, including the syntax and semantics of messages and the rules associated with sending and receiving messages. It is essential to use diagrams to clarify meaning. You should also provide structure implementation (e.g., show the data structure used in the implementation language)
- A clear explanation of each team member's roles and how each member's strengths and weaknesses played a role in this project. The group should also explain the challenges encountered.

In addition, your application should be created and maintained on Github, and the README file should document deployment instructions. The file should also include a link to the project blog and vice versa.

Presentation Requirements

Your group will be required to give a presentation, including a PowerPoint document used to convey the ideas incorporated into your project. In addition, your group will demonstrate the project at the end of the presentation (see the section on Project Demonstration). The presentation should include the following elements:

- An introductory slide that motivates your talk and explains the importance of the topic. Your slide should answer why you should pay attention to this talk? **Note: Please DO**

NOT put on the slide or say in your presentation, why should you pay attention to my talk?

3. The body of your talk should address the following:
 - a. A description of how your group achieved the objective(s)
 - b. A description of the design process used in this project
 - c. A description of system's architecture and how elements interact with one another
 - d. A description of the protocol used, including the syntax and semantics of messages and the rules associated with sending and receiving messages. Use diagrams here and not code or text.
 - e. A clear explanation of each team member's roles and how each member's strengths and weaknesses played a role in this project. The group should also explain the challenges encountered (**DO NOT INCLUDE TIME COORDINATION** as you have all night to meet if your day is busy!)
4. A conclusion or summary slide that winds down your talk appropriately.

A couple of recommendations on making and using PowerPoint slides:

- Slides should not be cluttered with a lot of wording. Instead, use short phrased (two to four words) bullet points to guide you and the audience. The audience should be listening to you. If a bullet point is lengthy, the audience will stop listening to you and begin reading.
- Whenever possible, use graphical illustrations to communicate your ideas and concepts. Illustrations are a powerful way of communicating abstract or complex concepts.
- Use animation only when appropriate. Overuse of animation can detract from your message and come across as pompous.

Please make sure that the presentation is prepared well in advance of the talk. A good strategy is to build your presentation as you work on the project. Do not worry about look or feel; focus on the content at this stage of the process. Ensure that your presentation covers all the elements discussed above and those in the rubrics (available at the end of this document). Make sure that every member is familiar with all aspects of the project. Those working on specific tasks in the project will be the group's experts on those specific tasks. ***However, each member must program some component in this project. You may help each other with the coding.*** Your group should use some agile methodology to realize this project. Coordinate well during meetings and present this in your talk logically.

As in everything, practice makes perfect! Groups should practice their presentation before and after receiving feedback. Make sure that everyone knows their role. The audience should not have to see the group figure things out during the presentation. If this happens, your group will surely lose points!

Project Demonstration

The presentation time should include the demonstration of your application. The demonstration of the application should be planned carefully. A video recording of the application demonstration may be prudent in case there are technical issues on presentation day.

Group Work

Since this is a group and a software development project, you should follow an agile methodology. You are free to choose any method; however, you will need to inform your instructor about the choice, and you will need to include at least one slide on the methodology.

Submitting Your Work

You are required to submit the following documents:

1. The documentation of the project (i.e the blog link or on GitHub).
2. The link to the completed project, including the code and any other files needed to run the project. Your Github README.md file should include instructions on deployment of the application.
3. The PowerPoint presentation used in the talk.

Any member of the group may be delegated to submit on behalf of the group.

If your group does not present, then the entire group will receive no credit on the presentation part of your grade. If you do not submit your work by the submission deadline, then the entire group will receive no credit on the group project. If a team member is not present for the presentation, that team member will receive a zero (0) for the presentation, and the instructor will scrutinize their work on the project.

Logically organize item 1 above so that the reader has clarity and continuity. Document all design work on the group's page. The group should establish the blog site and give access to the instructor. Documentation of the process should begin immediately. ***Please see the attached rubric for how the project will be graded.*** Please use Grammarly to ensure that your documentation is grammatically correct.

/170

Delaware State University
Department of Computer and Information Sciences
Term Project Rubric

Category	0 Not Available	1 Incomplete	2 Developing	3 Accomplished	4 Exemplary	Score
Design						
Problem Statement (12 Points) 3	Nothing Available	The statement does not follow the POV structure, specifying user, needs, and insight; POV as written does not address the problem described.	The statement does have some semblance of the POV structure, but needs and insight are not clearly articulated.	The statement does have the expected POV structure, specifying user, needs, or insight, but the needs or insights could be articulated better.	The statement follows the POV structure, specifying user, needs, or insight, and the needs or insights are articulated well.	
Ideation (12 Points) 3	Nothing Available	The group did not seem to work well on ideation and developed a small quantity and low quality ideas.	The group did not seem to work well on ideation and developed a medium number of ideas with very small number of quality ideas.	The group did work well on ideation and developed a medium number of ideas with very small number of quality ideas.	The group did work well on ideation and developed a many ideas, many of which were of quality.	
Prototyping (20 Points) 5	Nothing Available	The group ended with a very low fidelity prototype, even after multiple iterations.	The group ended with a medium fidelity prototype, even after multiple iterations; however, their prototype did not work as expected.	The group ended with a high fidelity prototype; however, their prototype had some functional glitches.	The group ended with a high fidelity prototype and the prototype worked as expected.	
Testing and Validating (12 Points) 3	Nothing Available	The group did very little testing and no validation of their prototype.	The group did some testing and little to no validation of their prototype.	The group did testing and some validation of prototype.	The group did extensive testing and validation of prototype.	
System Architecture (12 Points) 3	Nothing Available	The system is not illustrated, nor a plan is provided; The subsystem interfaces and interaction are not provided.	The system is somewhat illustrated, or a plan is provided; The subsystem interfaces and interaction are not properly designed.	The system is somewhat illustrated, or a plan is provided; The subsystem interfaces and interactions are not complete but acceptable.	The system is illustrated, and a very well documented plan is provided; The subsystem interfaces and interactions are properly designed and well documented.	
Protocol Choice (12 Points) 3	Nothing submitted	The design choice of the protocol is completely inappropriate for the application.	The design choice of the communication protocol is somewhat inappropriate for the application.	The design choice of the communication protocol is mostly appropriate for the application.	The design choice of the protocol is very appropriate for the application.	
Protocol Message Design (12 Points) 3	Nothing submitted	The protocol message structure is not clear due to lack of documentation or clarity.	The protocol message structure is somewhat understandable yet suffers from poor documentation.	The protocol message structure is clear yet could have been documented better with cleared diagrams and better sentence structure.	The protocol message structure is clearly communicated.	

Protocol rules (10 Points) 2.5	Nothing submitted	The protocol rules are not explained in the documentation.	The protocol rules are not clear and there is no structure to the rules.	The protocol rules are documented well but need to be thought out a little more.	The protocol rules are well thought out and clearly documented.	
Creativity of Design (12 Points) 3	Nothing implemented	Vaguely demonstrates creative ability; fails to utilize the creative process when addressing problem or on project; exhibits little or no originality or imagination in work.	Demonstrates some creative ability; Attempts to utilize the creative process when addressing problem or on project; exhibits some originality or imagination.	Adequately demonstrates creative ability; exhibits originality or imagination in problems or projects; applies creative process to work.	Demonstrates creative ability; utilizes the creative process when addressing problems or on projects; exhibits high level of originality and imagination in work	
Implementation						
Implementation of Software Components (12 Points) 3	Nothing submitted	The implementation of the software components is wrought with errors resulting in the application not working.	The implementation of the software components has some errors resulting in some aspects of the application not working properly.	The implementation of the software components has some minor errors resulting in some aspects of the application not working properly.	The implementation of the Behavior/Finite State Machines is correct.	
Implementation of the System Architecture (12 Points) 3	Nothing submitted	The application components are not constructed to implement the system architecture.	Some of the application components implement some aspect of the system architecture.	Most of the application components implement most of the system architecture.	The application components implement the system architecture as specified.	
Implementation of Communication Protocols (12 Points) 3	Nothing submitted	The implementation of the communication protocols is completely incorrect or not implemented.	The implementation of the communication protocols is somewhat incorrect.	The implementation of the communication protocols is mostly correct.	The implementation of the communication protocols is correct.	
General Documentation of Project						
Documentation site documents well the group's efforts (12 Points) 3	No link provided or no documentation provided	Very little documentation is provided as to the process the group took in designing the solution.	Some documentation is provided as to the process the group took in designing the solution; however, not all critical components are present or the documentation is confusing.	Some documentation is provided as to the process the group took in designing the solution; however, some critical components are not present	Clear documentation is provided as to the process the group took in designing the solution	
Structure and Organization (8 Points) 2	Nothing submitted	Unclear structure with paragraphs lacking cohesion and failing to support major points; transition between paragraphs lack coherence and may have one or more digressions.	Inconsistent organization with occasional support of major points but unclear and/or incoherent transition between paragraphs	Competent organization with paragraphs that support major points. Appropriate transitions between paragraphs	Organization is sequential and appropriate to the assignment. Paragraphs are appropriate and purposeful. Ideas are logically presented and interrelated; transitions are linked with smooth and effective transitions.	

Sentence Structure and Grammar (8 Points) 2	Nothing submitted	Simple sentences used almost exclusively with frequent errors in sentence structure; Contains many errors in punctuation, spelling and capitalization; errors significantly interfere with meaning and formatting is weak.	Varied sentences with occasional errors in sentence structure; shows insufficient effort in proofreading to identify errors in spelling, punctuation, capitalization, grammar and syntax errors and/or use of colloquialisms	Effective and varied sentences with infrequent errors due to lack of proofreading, syntax errors and/or use of colloquialisms; infrequent errors in punctuation, spelling and capitalization	Each sentence is effectively structured, using a rich and well-chosen variety of sentence styles and length. Free of punctuation, spelling and capitalization errors; appropriate forms and presentation for assignment.	
Vocabulary and Usage (8 Points) 2	Nothing submitted	Extremely limited or inappropriate vocabulary which lack a grasp of diction. Inaccurate usage	Range of vocabulary that is limited and inconsistent usage	Good range of vocabulary with accurate usage	Exceptional vocabulary range with accuracy and effective word usage	

Delaware State University
Department of Computer and Information Sciences
Group Presentation Rubric

Presenters' names: _____

	1 Incomplete	2 Developing	3 Accomplished	4 Exemplary	Comments
Organization	Audience cannot understand presentation because <i>there is no sequence of information</i> .	Audience has difficulty following the presentation because the <i>sequence of information is haphazard</i> .	The group presents information in a <i>logical sequence</i> , which audience can follow.	The group presents information in a <i>logical and interesting sequence</i> , which the audience can follow	
Content Knowledge	Members of the group <i>do not have an understanding</i> of the topic. They <i>cannot answer any questions</i> .	<i>Some members</i> of the group are <i>uncomfortable</i> with the topic and are <i>only able to answer rudimentary questions</i> .	<i>Most members</i> of the group are <i>at ease with content</i> , but <i>do not always elaborate on questions</i> .	<i>All students</i> in the group <i>demonstrate full knowledge with explanations and elaboration</i> .	
Supporting Material	Students used <i>no graphs, figures, statistics, or data</i> .	Students <i>occasionally used graphs, figures, statistics, or data</i> , but <i>not effectively</i> .	Students <i>used graphs, figures, statistics, or data effectively</i> .	Students <i>used graphs, figures, statistics, or data in a compelling and informative way</i> .	
Mechanics	The material was <i>illegible, contained many errors</i> and/or was <i>presented too quickly to see</i> .	The material was <i>legible</i> , but <i>contained some errors or too much information to read</i> at the pace of the presentation.	The material was <i>easy to read</i> , had <i>few errors</i> and was presented at a pace that was <i>easy to follow</i> .	The material was <i>easy to read</i> , and <i>organized well</i> , with <i>no errors</i> . Presented at pace that <i>maintained interest</i> in the subject.	
Delivery	Presenters <i>mumble</i> and/or <i>speak too quietly</i> . <i>Lack of enthusiasm</i> and/or <i>interest</i> . <i>No eye contact</i> , read directly from notes. <i>Members of the group do not interact at all</i> .	Presenters <i>occasionally speak too quietly</i> . <i>Lack energy</i> . <i>Infrequent eye contact</i> , heavily rely on notes. <i>Members of the group interact ineffectively</i> . <i>Some members dominate</i> .	Presenters <i>speak clearly</i> and <i>show interest</i> . <i>Make eye contact with some of the audience</i> . <i>Members of the group interact well and share the delivery equally</i> .	Presenters <i>speak clearly</i> and <i>show enthusiasm</i> . <i>Hold attention by direct eye contact with all parts of the audience</i> . <i>Members of the group interact dynamically as a group in a way that enhances understanding and clarity</i> .	