Project 1 | Phase 2

DISTRIBUTED COMPUTING

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# Introduction:

For Phase 2 of this project we designed and implemented a Peer-to-Peer system. The purpose of this phase was to design a Peer-to-Peer system that allows as many pairs of nodes as possible to exchange messages. As in Phase 1, a message that is sent in lowercase is to be converted to uppercase and returned. For the implementation of our Peer-to-Peer system, we modified and used our Client-Server programs from Phase 1. We used four main modules in the implementation of our system; TCPServerRouter, SThread, TCPServer, and TCPClient. We also used our custom statistics module, called Stats, to monitor and keep track of variable data, and our main module, called Main, to dynamically run the system. More detail on each of the modules, and how they were modified from Phase 1, will be found in the Design Modules and Implementation section.

# Design Approach:

We began Phase 2 of this project with our programs from Phase 1. The basic function of our system in this phase is the same as in Phase 1; to send a message, in the form of a text file, in lowercase, convert it to uppercase, and return it. With this in mind, we simply used the TCPServerRouter, SThread, TCPServer, and TCPClient modules from Phase 1 and modified them from the Client-Server system to a Peer-to-Peer system. We also used our Stats module for data collection and our Main module to run our system. In addition to the modules we used from Phase 1, we also added another module called RoutingInfo to hold and use all of the necessary router information. As in Phase 1, we used IntelliJ IDEA as our IDE and the GitHub remote storage in order to easily and efficiently make changes to and share all of our project files between each group member.

# Design Modules and Implementation:

For our Peer-to-Peer system, we implemented 7 modules. These modules were: Main, TCPServerRouter, SThread, TCPServer, TCPClient, Stats, and RoutingInfo. To run the processes of our system, 2 or more machines are required. During the implementation and testing of our system we used 3 machines.

The execution of this system is managed by the Main module. In order to run this module, the user must first change the default IP and port of the router they wish to connect to, routers in the known subnet, the client name, and the server name. Then, when running Main, the user can select whether they want to run a router, server, or client. The user is also allowed to run multiple instances on the same machine, making it possible to run multiple routers, clients, and servers on the same machine.

We will now discuss in detail each of the modules, how they function, and how they are set up in our system, starting with the Main module.

The Main module allows users access to a very simple interface that allows them to run a router, a server, or a client. The server and client methods have the option to be run 50 times each as well. The main class allows the user to pre-setup a subnet list with IP's of known routers, as well as ports. Additionally, once the routers are configured, the users can select names for the clients and servers that they would like to connect to, as well as the input text file for the client to send.

The TCPServerRouter module sets up and runs the router on a specified port. The Subnet list is also passed through the constructor. When run, the TCPServerRouter serves as the main thread and spawns SThreads whenever a new client connects. The router then passes on the handling of the client to the SThread along with a copy of the socket, the local RoutingTable, and a RoutingInfo object for the new client.

The RoutingInfo object holds the ipAddress, port, Socket, usage status, and client name of a connecting entity (router, server, client). If the object is a router, it has a boolean called isRouter set. The object comes with getters, setters, and a dedicated toString method.

The SThread module is derived from the Thread class and it handles connections to a client for the router. The constructor takes in information about the parent router (ip, port), the local RoutingTable, and a RoutingInfo object with information on the client that has connected. The constructor creates input and output streams for the client, and sets private global variables to be used when the SThread’s run method is called. When the thread is ‘run’, it firsts attempts to get the client’s name and stores the value in the dedicated RoutingInfo object. If the connecting client is another router, we run the ‘router’ method, otherwise we run the ‘clients’ method.

For the ‘router’ method in SThread, we know that routers can only be clients if they are searching the subnet for a node, so we take in the name of the node it is looking for. If the node does not exist within our subnet (our RoutingTable), we tell the router “Bye Bye Bye”. If the node does exist within the subnet (our RoutingTable), then we set socket to read through to the connected client, setup the input and output stream, and return “RingADingDing”. This lets the connecting router know that the node was found and is ready to receive data. Then, until the client says “Bye.”, the routers act as a bridge between the nodes and pass data through.

For the ‘clients’ method in SThread, we know that the first message sent from a client/server is always the name of the destination node it wishes to connect to. So we save the client info, and wait for changes to propagate through to our routing table. If the destination exists within the subnet (our RoutingTable), then the input streams and output streams are created and a clientFound variable is set to true. If the destination is not found in the subnet, the router queries other routers that it knows of that exist within its routing table. If the node exists within other subnets, then input and output streams are created and clientFound is set to true. Otherwise, clientFound is set to false, queries are terminated and the process ends with the result that the node could not be found. Finally, if clientFound returned true throughout that process, the router begins passing data from its client to its destination node until it receives a “Bye.” At that point, the last termination message is sent, and the SThread terminates.

The TCPServer module establishes and runs a “server” connection to a router of the user’s choice. First it sends the router its own name for reference, and the name of the client it wishes to connect with. Once connection is established, the only purpose of this class is to take each message it receives from the client, convert all of the text from lowercase to uppercase, and return the uppercase messages. Once it receives a “Bye.” message from the client, it exits.

The TCPClient module establishes and runs a “client” connection to a router of the user’s choice. First it sends the router its own name for reference, and the name of the server it wishes to connect with. Once connection is established, the class reads in from a pre-specified file. As long as there is data within the file, the client will continue to send data through the router to the server. Once it sends a line, it waits for the server to reply before sending another line. Once the entire file has been sent, the client sends the termination response, “Bye.”, calculates statistics, prints out the results to a CSV data file, and then terminates.

The Stats module is used to manage connectionTime, averageTransmissionInSize, averageTransmissionOutSize, AverageTransmissionSize, list of transmissionInSizes, list of transmissionOutSizes, averageTransmissionTime, list of transmissionTimes, efficiency of sending data, averageEfficiency for sending data, and the list of efficiencies for all the data sent in a run. The Stats can also print out the results as a string, as well as print the data to a CSV file for analysis using Excel or comparative software.

# Client Sample Output:

Thank you for running the Bob Ross P2P Manager

What would you like to run? ('(r)outer', '(s)erver'/ (s50), or '(c)lient'/ (c50) )

c

Running Client...

ServerRouter: Connected to the router.

Server: IT'S BOB ROSS TIME!

Cycle time: 20080

Client: How do you make a round circle with a square knife? That's your challenge for the day. All you need to paint is a few tools, a little instruction, and a vision in your mind. There comes a nice little fluffer. Everybody's different. Trees are different. Let them all be individuals. Almost everything is going to happen for you automatically - you don't have to spend any time working or worrying. With practice comes confidence. This is your world, whatever makes you happy you can put in it. Go crazy. Use absolutely no pressure. Just like an angel's wing. See there how easy that is. We artists are a different breed of people. We're a happy bunch. Everything's not great in life, but we can still find beauty in it. You create the dream - then you bring it into your world. A big strong tree needs big strong roots. All you have to learn here is how to have fun. You're the greatest thing that has ever been or ever will be. You're special. You're so very special. You're meant to have fun in life. You have freedom here. The only guide is your heart. These things happen automatically. All you have to do is just let them happen.

Server: HOW DO YOU MAKE A ROUND CIRCLE WITH A SQUARE KNIFE? THAT'S YOUR CHALLENGE FOR THE DAY. ALL YOU NEED TO PAINT IS A FEW TOOLS, A LITTLE INSTRUCTION, AND A VISION IN YOUR MIND. THERE COMES A NICE LITTLE FLUFFER. EVERYBODY'S DIFFERENT. TREES ARE DIFFERENT. LET THEM ALL BE INDIVIDUALS. ALMOST EVERYTHING IS GOING TO HAPPEN FOR YOU AUTOMATICALLY - YOU DON'T HAVE TO SPEND ANY TIME WORKING OR WORRYING. WITH PRACTICE COMES CONFIDENCE. THIS IS YOUR WORLD, WHATEVER MAKES YOU HAPPY YOU CAN PUT IN IT. GO CRAZY. USE ABSOLUTELY NO PRESSURE. JUST LIKE AN ANGEL'S WING. SEE THERE HOW EASY THAT IS. WE ARTISTS ARE A DIFFERENT BREED OF PEOPLE. WE'RE A HAPPY BUNCH. EVERYTHING'S NOT GREAT IN LIFE, BUT WE CAN STILL FIND BEAUTY IN IT. YOU CREATE THE DREAM - THEN YOU BRING IT INTO YOUR WORLD. A BIG STRONG TREE NEEDS BIG STRONG ROOTS. ALL YOU HAVE TO LEARN HERE IS HOW TO HAVE FUN. YOU'RE THE GREATEST THING THAT HAS EVER BEEN OR EVER WILL BE. YOU'RE SPECIAL. YOU'RE SO VERY SPECIAL. YOU'RE MEANT TO HAVE FUN IN LIFE. YOU HAVE FREEDOM HERE. THE ONLY GUIDE IS YOUR HEART. THESE THINGS HAPPEN AUTOMATICALLY. ALL YOU HAVE TO DO IS JUST LET THEM HAPPEN.

Cycle time: 69

Client: Everything is happy if you choose to make it that way. No pressure. Just relax and watch it happen. You want your tree to have some character. Make it special. Anything you want to do you can do here. Trees grow in all kinds of ways. They're not all perfectly straight. Not every limb is perfect. We don't make mistakes we just have happy little accidents. Here's something that's fun.

Server: EVERYTHING IS HAPPY IF YOU CHOOSE TO MAKE IT THAT WAY. NO PRESSURE. JUST RELAX AND WATCH IT HAPPEN. YOU WANT YOUR TREE TO HAVE SOME CHARACTER. MAKE IT SPECIAL. ANYTHING YOU WANT TO DO YOU CAN DO HERE. TREES GROW IN ALL KINDS OF WAYS. THEY'RE NOT ALL PERFECTLY STRAIGHT. NOT EVERY LIMB IS PERFECT. WE DON'T MAKE MISTAKES WE JUST HAVE HAPPY LITTLE ACCIDENTS. HERE'S SOMETHING THAT'S FUN.

Cycle time: 70

Client: We tell people sometimes: we're like drug dealers, come into town and get everybody absolutely addicted to painting. It doesn't take much to get you addicted. Even trees need a friend. We all need friends. You have to make almighty decisions when you're the creator. There isn't a rule. You just practice and find out which way works best for you. This is probably the greatest thing to happen in my life - to be able to share this with you.

Server: WE TELL PEOPLE SOMETIMES: WE'RE LIKE DRUG DEALERS, COME INTO TOWN AND GET EVERYBODY ABSOLUTELY ADDICTED TO PAINTING. IT DOESN'T TAKE MUCH TO GET YOU ADDICTED. EVEN TREES NEED A FRIEND. WE ALL NEED FRIENDS. YOU HAVE TO MAKE ALMIGHTY DECISIONS WHEN YOU'RE THE CREATOR. THERE ISN'T A RULE. YOU JUST PRACTICE AND FIND OUT WHICH WAY WORKS BEST FOR YOU. THIS IS PROBABLY THE GREATEST THING TO HAPPEN IN MY LIFE - TO BE ABLE TO SHARE THIS WITH YOU.

Cycle time: 73

Client: And I know you're saying, 'Oh Bob, you've done it this time.' And you may be right. It's beautiful - and we haven't even done anything to it yet. La- da- da- da- dah. Just be happy. Remember how free clouds are. They just lay around in the sky all day long. How to paint. That's easy. What to paint. That's much harder.

Server: AND I KNOW YOU'RE SAYING, 'OH BOB, YOU'VE DONE IT THIS TIME.' AND YOU MAY BE RIGHT. IT'S BEAUTIFUL - AND WE HAVEN'T EVEN DONE ANYTHING TO IT YET. LA- DA- DA- DA- DAH. JUST BE HAPPY. REMEMBER HOW FREE CLOUDS ARE. THEY JUST LAY AROUND IN THE SKY ALL DAY LONG. HOW TO PAINT. THAT'S EASY. WHAT TO PAINT. THAT'S MUCH HARDER.

Cycle time: 72

Client: Just go out and talk to a tree. Make friends with it. Let that brush dance around there and play. If it's not what you want - stop and change it. Don't just keep going and expect it will get better. There's not a thing in the world wrong with washing your brush. This is a happy place, little squirrels live here and play. No worries. No cares. Just float and wait for the wind to blow you around. Isn't it great to do something you can't fail at? Just make a decision and let it go.

Server: JUST GO OUT AND TALK TO A TREE. MAKE FRIENDS WITH IT. LET THAT BRUSH DANCE AROUND THERE AND PLAY. IF IT'S NOT WHAT YOU WANT - STOP AND CHANGE IT. DON'T JUST KEEP GOING AND EXPECT IT WILL GET BETTER. THERE'S NOT A THING IN THE WORLD WRONG WITH WASHING YOUR BRUSH. THIS IS A HAPPY PLACE, LITTLE SQUIRRELS LIVE HERE AND PLAY. NO WORRIES. NO CARES. JUST FLOAT AND WAIT FOR THE WIND TO BLOW YOU AROUND. ISN'T IT GREAT TO DO SOMETHING YOU CAN'T FAIL AT? JUST MAKE A DECISION AND LET IT GO.

Cycle time: 74

Client: I can't think of anything more rewarding than being able to express yourself to others through painting. In your world you have total and absolute power. Even the worst thing we can do here is good. We have no limits to our world. We're only limited by our imagination. Now, we're going to fluff this cloud. Nothing wrong with washing your brush There are no mistakes. You can fix anything that happens. Life is too short to be alone, too precious. Share it with a friend. I really believe that if you practice enough you could paint the 'Mona Lisa' with a two-inch brush.

Server: I CAN'T THINK OF ANYTHING MORE REWARDING THAN BEING ABLE TO EXPRESS YOURSELF TO OTHERS THROUGH PAINTING. IN YOUR WORLD YOU HAVE TOTAL AND ABSOLUTE POWER. EVEN THE WORST THING WE CAN DO HERE IS GOOD. WE HAVE NO LIMITS TO OUR WORLD. WE'RE ONLY LIMITED BY OUR IMAGINATION. NOW, WE'RE GOING TO FLUFF THIS CLOUD. NOTHING WRONG WITH WASHING YOUR BRUSH THERE ARE NO MISTAKES. YOU CAN FIX ANYTHING THAT HAPPENS. LIFE IS TOO SHORT TO BE ALONE, TOO PRECIOUS. SHARE IT WITH A FRIEND. I REALLY BELIEVE THAT IF YOU PRACTICE ENOUGH YOU COULD PAINT THE 'MONA LISA' WITH A TWO-INCH BRUSH.

Cycle time: 73

Client: From all of us here, I want to wish you happy painting and God bless, my friends. Go out on a limb - that's where the fruit is. You can create anything that makes you happy. Don't hurry. Take your time and enjoy. See there, told you that would be easy. Let all these little things happen. Don't fight them. Learn to use them. Let's do it again then, what the heck. Every single thing in the world has its own personality - and it is up to you to make friends with the little rascals. Look around. Look at what we have. Beauty is everywhere you only have to look to see it. You can do anything here - the only pre-requisite is that it makes you happy.

Server: FROM ALL OF US HERE, I WANT TO WISH YOU HAPPY PAINTING AND GOD BLESS, MY FRIENDS. GO OUT ON A LIMB - THAT'S WHERE THE FRUIT IS. YOU CAN CREATE ANYTHING THAT MAKES YOU HAPPY. DON'T HURRY. TAKE YOUR TIME AND ENJOY. SEE THERE, TOLD YOU THAT WOULD BE EASY. LET ALL THESE LITTLE THINGS HAPPEN. DON'T FIGHT THEM. LEARN TO USE THEM. LET'S DO IT AGAIN THEN, WHAT THE HECK. EVERY SINGLE THING IN THE WORLD HAS ITS OWN PERSONALITY - AND IT IS UP TO YOU TO MAKE FRIENDS WITH THE LITTLE RASCALS. LOOK AROUND. LOOK AT WHAT WE HAVE. BEAUTY IS EVERYWHERE YOU ONLY HAVE TO LOOK TO SEE IT. YOU CAN DO ANYTHING HERE - THE ONLY PRE-REQUISITE IS THAT IT MAKES YOU HAPPY.

Cycle time: 70

Client: Everybody needs a friend. Water's like me. It's laaazy ... Boy, it always looks for the easiest way to do things You've got to learn to fight the temptation to resist these things. Just let them happen. Take your time. Speed will come later. This is your creation - and it's just as unique and special as you are. I like to beat the brush. This is an example of what you can do with just a few things, a little imagination and a happy dream in your heart. You can create the world you want to see and be a part of. You have that power. Just beat the devil out of it.

Server: EVERYBODY NEEDS A FRIEND. WATER'S LIKE ME. IT'S LAAAZY ... BOY, IT ALWAYS LOOKS FOR THE EASIEST WAY TO DO THINGS YOU'VE GOT TO LEARN TO FIGHT THE TEMPTATION TO RESIST THESE THINGS. JUST LET THEM HAPPEN. TAKE YOUR TIME. SPEED WILL COME LATER. THIS IS YOUR CREATION - AND IT'S JUST AS UNIQUE AND SPECIAL AS YOU ARE. I LIKE TO BEAT THE BRUSH. THIS IS AN EXAMPLE OF WHAT YOU CAN DO WITH JUST A FEW THINGS, A LITTLE IMAGINATION AND A HAPPY DREAM IN YOUR HEART. YOU CAN CREATE THE WORLD YOU WANT TO SEE AND BE A PART OF. YOU HAVE THAT POWER. JUST BEAT THE DEVIL OUT OF IT.

Cycle time: 72

Client: All you have to do is let your imagination go wild. Work on one thing at a time. Don't get carried away - we have plenty of time. Follow the lay of the land. It's most important. Making all those little fluffies that live in the clouds. This present moment is perfect simply due to the fact you're experiencing it. Trees cover up a multitude of sins. We'll put all the little clouds in and let them dance around and have fun. We'll paint one happy little tree right here. That's what makes life fun. That you can make these decisions. That you can create the world that you want.

Server: ALL YOU HAVE TO DO IS LET YOUR IMAGINATION GO WILD. WORK ON ONE THING AT A TIME. DON'T GET CARRIED AWAY - WE HAVE PLENTY OF TIME. FOLLOW THE LAY OF THE LAND. IT'S MOST IMPORTANT. MAKING ALL THOSE LITTLE FLUFFIES THAT LIVE IN THE CLOUDS. THIS PRESENT MOMENT IS PERFECT SIMPLY DUE TO THE FACT YOU'RE EXPERIENCING IT. TREES COVER UP A MULTITUDE OF SINS. WE'LL PUT ALL THE LITTLE CLOUDS IN AND LET THEM DANCE AROUND AND HAVE FUN. WE'LL PAINT ONE HAPPY LITTLE TREE RIGHT HERE. THAT'S WHAT MAKES LIFE FUN. THAT YOU CAN MAKE THESE DECISIONS. THAT YOU CAN CREATE THE WORLD THAT YOU WANT.

Cycle time: 71

Client: You have to make those little noises or it won't work. Clouds are free. They just float around the sky all day and have fun. Just pretend you are a whisper floating across a mountain. We can fix anything Just let go - and fall like a little waterfall. A happy cloud. Pretend you're water. Just floating without any effort. Having a good day. I guess I'm a little weird. I like to talk to trees and animals. That's okay though; I have more fun than most people. If we're going to have animals around we all have to be concerned about them and take care of them.

Server: YOU HAVE TO MAKE THOSE LITTLE NOISES OR IT WON'T WORK. CLOUDS ARE FREE. THEY JUST FLOAT AROUND THE SKY ALL DAY AND HAVE FUN. JUST PRETEND YOU ARE A WHISPER FLOATING ACROSS A MOUNTAIN. WE CAN FIX ANYTHING JUST LET GO - AND FALL LIKE A LITTLE WATERFALL. A HAPPY CLOUD. PRETEND YOU'RE WATER. JUST FLOATING WITHOUT ANY EFFORT. HAVING A GOOD DAY. I GUESS I'M A LITTLE WEIRD. I LIKE TO TALK TO TREES AND ANIMALS. THAT'S OKAY THOUGH; I HAVE MORE FUN THAN MOST PEOPLE. IF WE'RE GOING TO HAVE ANIMALS AROUND WE ALL HAVE TO BE CONCERNED ABOUT THEM AND TAKE CARE OF THEM.

Cycle time: 73

Client: Talent is a pursued interest. That is to say, anything you practice you can do. Only God can make a tree - but you can paint one. Exercising the imagination, experimenting with talents, being creative; these things, to me, are truly the windows to your soul. Don't be afraid to make these big decisions. Once you start, they sort of just make themselves. There are no limits in this world. I get carried away with this brush cleaning Paint anything you want on the canvas. Create your own world. Be careful. You can always add more - but you can't take it away.

Server: TALENT IS A PURSUED INTEREST. THAT IS TO SAY, ANYTHING YOU PRACTICE YOU CAN DO. ONLY GOD CAN MAKE A TREE - BUT YOU CAN PAINT ONE. EXERCISING THE IMAGINATION, EXPERIMENTING WITH TALENTS, BEING CREATIVE; THESE THINGS, TO ME, ARE TRULY THE WINDOWS TO YOUR SOUL. DON'T BE AFRAID TO MAKE THESE BIG DECISIONS. ONCE YOU START, THEY SORT OF JUST MAKE THEMSELVES. THERE ARE NO LIMITS IN THIS WORLD. I GET CARRIED AWAY WITH THIS BRUSH CLEANING PAINT ANYTHING YOU WANT ON THE CANVAS. CREATE YOUR OWN WORLD. BE CAREFUL. YOU CAN ALWAYS ADD MORE - BUT YOU CAN'T TAKE IT AWAY.

Cycle time: 71

Client: In nature, dead trees are just as normal as live trees. If I paint something, I don't want to have to explain what it is. Didn't you know you had that much power? You can move mountains. You can do anything. You can't make a mistake. Anything that happens you can learn to use - and make something beautiful out of it. This is the fun part Be so very light. Be a gentle whisper. And that's when it becomes fun - you don't have to spend your time thinking about what's happening - you just let it happen. A thin paint will stick to a thick paint. A tree needs to be your friend if you're going to paint him.

Server: IN NATURE, DEAD TREES ARE JUST AS NORMAL AS LIVE TREES. IF I PAINT SOMETHING, I DON'T WANT TO HAVE TO EXPLAIN WHAT IT IS. DIDN'T YOU KNOW YOU HAD THAT MUCH POWER? YOU CAN MOVE MOUNTAINS. YOU CAN DO ANYTHING. YOU CAN'T MAKE A MISTAKE. ANYTHING THAT HAPPENS YOU CAN LEARN TO USE - AND MAKE SOMETHING BEAUTIFUL OUT OF IT. THIS IS THE FUN PART BE SO VERY LIGHT. BE A GENTLE WHISPER. AND THAT'S WHEN IT BECOMES FUN - YOU DON'T HAVE TO SPEND YOUR TIME THINKING ABOUT WHAT'S HAPPENING - YOU JUST LET IT HAPPEN. A THIN PAINT WILL STICK TO A THICK PAINT. A TREE NEEDS TO BE YOUR FRIEND IF YOU'RE GOING TO PAINT HIM.

Cycle time: 71

Client: We don't need any guidelines or formats. All we need to do is just let it flow right out of us. You need the dark in order to show the light. When you do it your way you can go anywhere you choose. Every time you practice, you learn more Isn't it fantastic that you can change your mind and create all these happy things? It's hard to see things when you're too close. Take a step back and look. There's nothing wrong with having a tree as a friend. Think about a cloud. Just float around and be there.

Server: WE DON'T NEED ANY GUIDELINES OR FORMATS. ALL WE NEED TO DO IS JUST LET IT FLOW RIGHT OUT OF US. YOU NEED THE DARK IN ORDER TO SHOW THE LIGHT. WHEN YOU DO IT YOUR WAY YOU CAN GO ANYWHERE YOU CHOOSE. EVERY TIME YOU PRACTICE, YOU LEARN MORE ISN'T IT FANTASTIC THAT YOU CAN CHANGE YOUR MIND AND CREATE ALL THESE HAPPY THINGS? IT'S HARD TO SEE THINGS WHEN YOU'RE TOO CLOSE. TAKE A STEP BACK AND LOOK. THERE'S NOTHING WRONG WITH HAVING A TREE AS A FRIEND. THINK ABOUT A CLOUD. JUST FLOAT AROUND AND BE THERE.

Cycle time: 73

Client: You can do anything here. So don't worry about it. In your imagination you can go anywhere you want. The least little bit can do so much. That's a crooked tree. We'll send him to Washington. It's a super day, so why not make a beautiful sky? Everyone needs a friend. Friends are the most valuable things in the world. The man who does the best job is the one who is happy at his job. We spend so much of our life looking - but never seeing.

Server: YOU CAN DO ANYTHING HERE. SO DON'T WORRY ABOUT IT. IN YOUR IMAGINATION YOU CAN GO ANYWHERE YOU WANT. THE LEAST LITTLE BIT CAN DO SO MUCH. THAT'S A CROOKED TREE. WE'LL SEND HIM TO WASHINGTON. IT'S A SUPER DAY, SO WHY NOT MAKE A BEAUTIFUL SKY? EVERYONE NEEDS A FRIEND. FRIENDS ARE THE MOST VALUABLE THINGS IN THE WORLD. THE MAN WHO DOES THE BEST JOB IS THE ONE WHO IS HAPPY AT HIS JOB. WE SPEND SO MUCH OF OUR LIFE LOOKING - BUT NEVER SEEING.

Cycle time: 75

Client: It's life. It's interesting. It's fun. You could sit here for weeks with your one hair brush trying to do that - or you could do it with one stroke with an almighty brush. Any little thing can be your friend if you let it be. Just relax and let it flow. That easy. A tree cannot be straight if it has a crooked trunk. The light is your friend. Preserve it.

Server: IT'S LIFE. IT'S INTERESTING. IT'S FUN. YOU COULD SIT HERE FOR WEEKS WITH YOUR ONE HAIR BRUSH TRYING TO DO THAT - OR YOU COULD DO IT WITH ONE STROKE WITH AN ALMIGHTY BRUSH. ANY LITTLE THING CAN BE YOUR FRIEND IF YOU LET IT BE. JUST RELAX AND LET IT FLOW. THAT EASY. A TREE CANNOT BE STRAIGHT IF IT HAS A CROOKED TRUNK. THE LIGHT IS YOUR FRIEND. PRESERVE IT.

Cycle time: 72

Client: Everyone wants to enjoy the good parts - but you have to build the framework first. In life you need colors. That's why I paint - because I can create the kind of world I want - and I can make this world as happy as I want it. Just let your mind wander and enjoy. This should make you happy. You have to allow the paint to break to make it beautiful. God gave you this gift of imagination. Use it. That's a son of a gun of a cloud. In painting, you have unlimited power. You have the ability to move mountains. You can bend rivers. But when I get home, the only thing I have power over is the garbage. That is when you can experience true joy, when you have no fear.

Server: EVERYONE WANTS TO ENJOY THE GOOD PARTS - BUT YOU HAVE TO BUILD THE FRAMEWORK FIRST. IN LIFE YOU NEED COLORS. THAT'S WHY I PAINT - BECAUSE I CAN CREATE THE KIND OF WORLD I WANT - AND I CAN MAKE THIS WORLD AS HAPPY AS I WANT IT. JUST LET YOUR MIND WANDER AND ENJOY. THIS SHOULD MAKE YOU HAPPY. YOU HAVE TO ALLOW THE PAINT TO BREAK TO MAKE IT BEAUTIFUL. GOD GAVE YOU THIS GIFT OF IMAGINATION. USE IT. THAT'S A SON OF A GUN OF A CLOUD. IN PAINTING, YOU HAVE UNLIMITED POWER. YOU HAVE THE ABILITY TO MOVE MOUNTAINS. YOU CAN BEND RIVERS. BUT WHEN I GET HOME, THE ONLY THING I HAVE POWER OVER IS THE GARBAGE. THAT IS WHEN YOU CAN EXPERIENCE TRUE JOY, WHEN YOU HAVE NO FEAR.

Cycle time: 74

Client: We don't have to be concerned about it. We just have to let it fall where it will. You can't have light without dark. You can't know happiness unless you've known sorrow. I sincerely wish for you every possible joy life could bring. Put light against light - you have nothing. Put dark against dark - you have nothing. It's the contrast of light and dark that each give the other one meaning. That's the way I look when I get home late; black and blue. The first step to doing anything is to believe you can do it. See it finished in your mind before you ever start. They say everything looks better with odd numbers of things. But sometimes I put even numbers�just to upset the critics. It just happens - whether or not you worried about it or tried to plan it. Everyone is going to see things differently - and that's the way it should be.

Server: WE DON'T HAVE TO BE CONCERNED ABOUT IT. WE JUST HAVE TO LET IT FALL WHERE IT WILL. YOU CAN'T HAVE LIGHT WITHOUT DARK. YOU CAN'T KNOW HAPPINESS UNLESS YOU'VE KNOWN SORROW. I SINCERELY WISH FOR YOU EVERY POSSIBLE JOY LIFE COULD BRING. PUT LIGHT AGAINST LIGHT - YOU HAVE NOTHING. PUT DARK AGAINST DARK - YOU HAVE NOTHING. IT'S THE CONTRAST OF LIGHT AND DARK THAT EACH GIVE THE OTHER ONE MEANING. THAT'S THE WAY I LOOK WHEN I GET HOME LATE; BLACK AND BLUE. THE FIRST STEP TO DOING ANYTHING IS TO BELIEVE YOU CAN DO IT. SEE IT FINISHED IN YOUR MIND BEFORE YOU EVER START. THEY SAY EVERYTHING LOOKS BETTER WITH ODD NUMBERS OF THINGS. BUT SOMETIMES I PUT EVEN NUMBERS�JUST TO UPSET THE CRITICS. IT JUST HAPPENS - WHETHER OR NOT YOU WORRIED ABOUT IT OR TRIED TO PLAN IT. EVERYONE IS GOING TO SEE THINGS DIFFERENTLY - AND THAT'S THE WAY IT SHOULD BE.

Cycle time: 71

Client: We can always carry this a step further. There's really no end to this. Trees grow however makes them happy. If you do too much it's going to lose its effectiveness. The secret to doing anything is believing that you can do it. Anything that you believe you can do strong enough, you can do. Anything. As long as you believe. Let's get crazy. The very fact that you're aware of suffering is enough reason to be overjoyed that you're alive and can experience it.

Server: WE CAN ALWAYS CARRY THIS A STEP FURTHER. THERE'S REALLY NO END TO THIS. TREES GROW HOWEVER MAKES THEM HAPPY. IF YOU DO TOO MUCH IT'S GOING TO LOSE ITS EFFECTIVENESS. THE SECRET TO DOING ANYTHING IS BELIEVING THAT YOU CAN DO IT. ANYTHING THAT YOU BELIEVE YOU CAN DO STRONG ENOUGH, YOU CAN DO. ANYTHING. AS LONG AS YOU BELIEVE. LET'S GET CRAZY. THE VERY FACT THAT YOU'RE AWARE OF SUFFERING IS ENOUGH REASON TO BE OVERJOYED THAT YOU'RE ALIVE AND CAN EXPERIENCE IT.

Cycle time: 71

Client: You can do anything your heart can imagine. Let's make some happy little clouds in our world It's amazing what you can do with a little love in your heart. The more we do this - the more it will do good things to our heart. In this world, everything can be happy. If what you're doing doesn't make you happy - you're doing the wrong thing. But we're not there yet, so we don't need to worry about it. Anytime you learn something your time and energy are not wasted. We want to use a lot pressure while using no pressure at all. Don't kill all your dark areas - you need them to show the light.

Server: YOU CAN DO ANYTHING YOUR HEART CAN IMAGINE. LET'S MAKE SOME HAPPY LITTLE CLOUDS IN OUR WORLD IT'S AMAZING WHAT YOU CAN DO WITH A LITTLE LOVE IN YOUR HEART. THE MORE WE DO THIS - THE MORE IT WILL DO GOOD THINGS TO OUR HEART. IN THIS WORLD, EVERYTHING CAN BE HAPPY. IF WHAT YOU'RE DOING DOESN'T MAKE YOU HAPPY - YOU'RE DOING THE WRONG THING. BUT WE'RE NOT THERE YET, SO WE DON'T NEED TO WORRY ABOUT IT. ANYTIME YOU LEARN SOMETHING YOUR TIME AND ENERGY ARE NOT WASTED. WE WANT TO USE A LOT PRESSURE WHILE USING NO PRESSURE AT ALL. DON'T KILL ALL YOUR DARK AREAS - YOU NEED THEM TO SHOW THE LIGHT.

Cycle time: 72

Client: Bye.

Server: Bye.

Cycle time: 73

Stats {

ConnectionTime: 20080 ms.

Average Transmission In Size: 535 chars.

Average Transmission Out Size: 535 chars.

Average Transmission Time: 72 ms.

Average Efficiency: 535 chars/ms.

}

Process finished with exit code 0

# Data and Analysis:

For this analysis, we used two different text files to test the efficiency of our program. This would give us an idea of how the network could potentially affect the statics of our program and using different file sizes. The first text file (we will refer to this as File 1) we used was 6 Kilobytes and the second (we will refer to this as File 2) was 11 Kilobytes, almost twice as big as the first file. The data we collected from executions of the code were outputted to an excel file and contained the values: Connection Time, Transmission Out Time, Average Transmission In Time, Average Transmission Time, and Average Efficiency. For our analysis of the data we recorded, we calculated ranges, averages, and modes (which value occurred the most frequently) of the data values.

The connection time is the first statistic recorded, since connecting is the first action that takes place in the program. For File 1, the range on the data for connection time was from 9991 to 10137 milliseconds. The mode was 10003ms and average was approximately 10014ms. For File 2, the range on the data for connection time was from 20080 to 23025 milliseconds. The mode was 20083ms and the average was approximately 20194ms. We believe the greatest influence on the differences of connection times was due to the network. During the testing for File 1, all the clients were on the same subnet. While, for File 2, the clients were on different subnets.

Phase 1 | Phase 2

Trials

Milliseconds

Next, we will look at Transmission Times. For File 1, the Average Transmission In and Average Transmission Out Sizes were static at 267 characters. The Transmission Time ranged from 3 to 55 milliseconds. The mode was 3ms and the average was approximately 7ms. For File 2, the Average Transmission In and Average Transmission Out Sizes were static at 535 characters. The Transmission Time ranged from 60 to 126 milliseconds. The mode was 63ms and the average was approximately 75ms. The Transmission Sizes for both files were static due to the nature of the program, since the returned transmission is just a conversion to all capital letters of the client’s data. The differences in Transmission Time is most likely related to the differences in character/ file sizes, with the possibility of minor network constraints.

Phase 1 | Phase 2

Milliseconds

Trials

Lastly, we analyzed the efficiency of the program. For File 1, the efficiency ranged from 248 to 267 characters/ milliseconds. The mode was 267 chars/ms and the average was approximately 266 chars/ms. For File 2, the efficiency ranged from 523 to 535 characters/millisecond. The mode was 535 chars/ms and the average was approximately 535 chars/ms. We ran into an error here with calculating our efficiency for our execution. The code was executing so fast that all the data was being sent in less than a second, which resulted in a divide by zero error. This explains the differences in efficiency compared to transmission times for both files. The differences in the efficiency of the program of the two files is most likely due to the differences in character/ file sizes, with the possibility of minor network constraints as well.

Phase 1 | Phase 2

Trials

Characters Per Second

In conclusion, the majority of the differences in statistical data for the two files are largely due to the differences in file sizes and possible network constraints. There were correlation in amongst the data as well, such as a jump in the connection time resulted in a dip in the average efficiency during one execution. Another obvious correlation was the jump across all data when the larger File 2 was used for the input file instead of the smaller File 1. There appeared to be very few outliers among all of data as well. We believe most of the spikes in our data, besides when the input files were changed, is largely due to network constraints.

Phase 1 | Phase 2

Milliseconds

Trials

# Conclusion:

In Phase 2 of this project we implemented and analyzed a Peer-to-Peer distributed system that allows multiple pairs of nodes to exchange messages over a server-router bridge. By incorporating our programs from Phase 1, we were able to see the similarities and differences between the Client-Server system and the Peer-to-Peer system. Our data and analysis showed how the multiple pairs of nodes connect in the system and how the performance and efficiency of the system is affected by various factors. The major factors that affected our system were the different file sizes we were using, network constraints, and whether all of the clients were on the same subnet or on different subnets. The completion of this phase of the project has provided us with more knowledge and a better understanding of the Peer-to-Peer paradigm, and of distributed systems overall.