SER 321 B Session

SI Session

Sunday, November 17th 2024

7:00 pm - 8:00 pm MST

Agenda

- Concurrency Structures
- Threading the Server
  - Why a Threaded Server
  - Threaded Server Tracing
- Distributed Algorithms

SI Session Expectations

Thanks for coming to the **SER 321** SI session. We have a packed agenda and we are going to try to get through as many of our planned example problems as possible. This session will be recorded and shared with others.

- If after this you want to see additional examples, please visit the drop-in tutoring center.
- We will post the link in the chat now and at the end of the session.
  - tutoring.asu.edu
- Please keep in mind we are recording this session and it will be made available for you to review 24-48 hours after this session concludes.
- Finally, please be respectful to each other during the session.

Interact with us:

Zoom Features

Zoom Chat

- Use the chat feature to interact with the presenter and respond to presenter's questions.
- Annotations are encouraged

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Concurrency Structures

Can we name some concurrency structures?

Atomic Operations & Variables

Locks

Semaphores

Monitors

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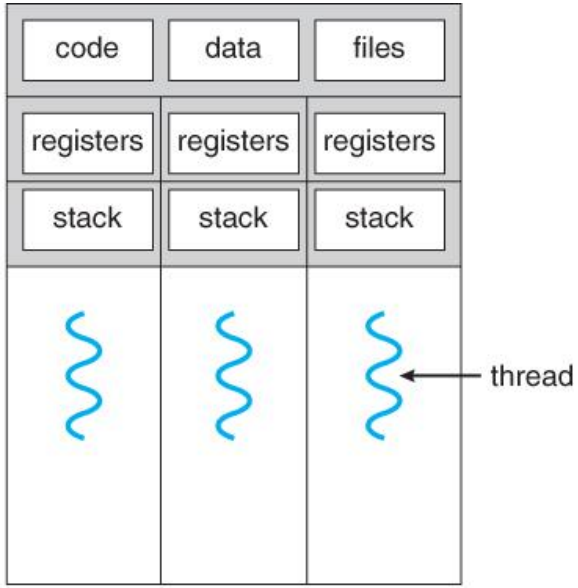
Concurrency Structures

Atomic Operations & Variables

Recall *registers*…

Ensures updates are immediately visible for the local copy in *each thread*




```
main:
    pushq   %rbp
    movq    %rsp, %rbp
    subq    $48, %rsp
    call    __main
    movl    $5, -4(%rbp)
    movl    $12, -8(%rbp)
    movl    -4(%rbp), %eax
    addl    $7, %eax
    movl    %eax, -12(%rbp)
    movl    -8(%rbp), %edx
    movl    -12(%rbp), %eax
    addl    %edx, %eax
    movl    %eax, -16(%rbp)
    movl    -16(%rbp), %eax
    movl    %eax, %edx
    leaq    .LC0(%rip), %rax
    movq    %rax, %rcx
    call    printf
    movl    $0, %eax
    addq    $48, %rsp
    popq    %rbp
    ret
```

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Concurrency Structures

Pros and Cons?

Locks

Acquire the Lock → Open & Enter

Close & Lock

Release the Lock → Unlock & Exit

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Concurrency Structures

How am I different from a lock?

Semaphores

More than one stall!

Acquire Lock ⇨ Open & Enter, Close & Lock

Release Lock ⇨ Unlock & Exit

Semaphores support ***more than one*** acquirer

When would that be beneficial?

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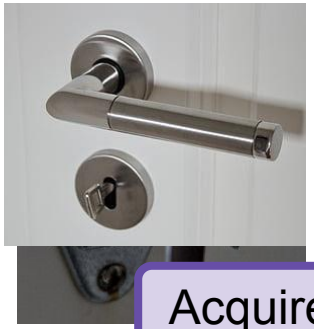
Concurrency Structures

Pros and Cons?

Monitors

You lock the main door instead!



Acquire Lock → Open & Enter
Acquire Lock → Close & Lock

Release Lock → Unlock & Exit

Covers the ***entire object***

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Concurrency Structures

RECAP

Atomic Operations & Variables

YOU control the locks directly

Locks

YOU control the locks directly

Semaphores

YOU control the locks directly

Monitors

Locks managed for you

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Concurrency Structures

Monitors

Both *bow()* and *bowBack()* are synchronized → are we good?

```
PS C:\ASU\SER321\examples_repo\ser321examples\Threads\Deadlock> gradle run
Starting a Gradle Daemon (subsequent builds will be faster)

> Task :run
Alphonse: Gaston  has bowed to me!
Gaston: waiting to bow back
Gaston: Alphonse  has bowed to me!
Alphonse: waiting to bow back
<==========----> 75% EXECUTING [17s]
> :run
```

Deadlock!

```
public class Deadlock {
    static class Friend {  6 usages
        private final String name;  5 usages
        public Friend(String name) { this.name = name; }
        public String getName() { return this.name; }
        /* See the README.md for a reference on 'synchronized' methods */
        public synchronized void bow(Friend bower) {  2 usages
            System.out.format("%s: %s"
                    + "  has bowed to me!%n",
                    this.name, bower.getName());
            System.out.format("%s: waiting to bow back%n", bower.getName());
            bower.bowBack( bower: this);
        }
        public synchronized void bowBack(Friend bower) {  1 usage
            System.out.format("%s: waiting", this.name);
            System.out.format("%s: %s"
                    + " has bowed back to me!%n",
                    this.name, bower.getName());
        }
    }
    public static void main(String[] args) {
        final Friend alphonse =
                new Friend( name: "Alphonse");
        final Friend gaston =
                new Friend( name: "Gaston");
        /* start two threads - both operating on the same objects */
        new Thread(new Runnable() {
            public void run() { alphonse.bow(gaston); }
        }).start();
        new Thread(new Runnable() {
            public void run() { gaston.bow(alphonse); }
        }).start();
    }
}
```

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Concurrency Structures

Monitors manage locks for us by ***locking the entire object***

```
public class Deadlock {
```

This program demonstrate how a deadlock can be created with synchronized methods:

- https://docs.oracle.com/javase/tutorial/essential/concurrency/syncmeth.html
- https://docs.oracle.com/javase/tutorial/essential/concurrency/locksync.html

The key to why it locks can be found in this bullet point from the Tutorial:

- "When a thread invokes a synchronized method, it automatically acquires the intrinsic lock for that method's object and releases it when the method returns. The lock release occurs even if the return was caused by an uncaught exception."

Since both the `bow()` and `bowback()` method are synchronized methods, they cannot both be called on the same object at the same time, whichever is called first must complete prior to the other executing.

The key to solving this is to use a synchronized statement rather than a synchronized method. With this approach a separate lock object can be shared and keep a deadlock from occurring by not allowing the second bower to start before the first has finished.

A more sophisticated locking scheme can be accomplished with explicit Lock objects and is described here:

- https://docs.oracle.com/javase/tutorial/essential/concurrency/newlocks.html

```
> Task :run
Alphonse: Gaston  has bowed to me!
Gaston: waiting to bow back
Gaston: Alphonse  has bowed to me!
Alphonse: waiting to bow back
<==========----> 75% EXECUTING [17s]
> :run
```

```
}
```

JavaSimpleSock

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Single Threaded Server

What will happen if there are two clients?

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
<==========----> 75% EXECUTING [20s]
> :SocketServer
```

Server

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<==========----> 75% EXECUTING [14s]
> :SocketClient
```

Client 1

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
```

Client 2

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
<==========----> 75% EXECUTING [53s]
> :SocketServer
```

Server

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<<===<<==========----> 75% EXECUTING [47s]
> :SocketClient
Hello!
```

Client 1

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
Starting a Gradle Daemon, 2 busy and 4 stopped Dae
mons could not be reused, use --status for details
<==========----> 75% EXECUTING [15s]
> :SocketClient
```

Client 2

JavaSimpleSock

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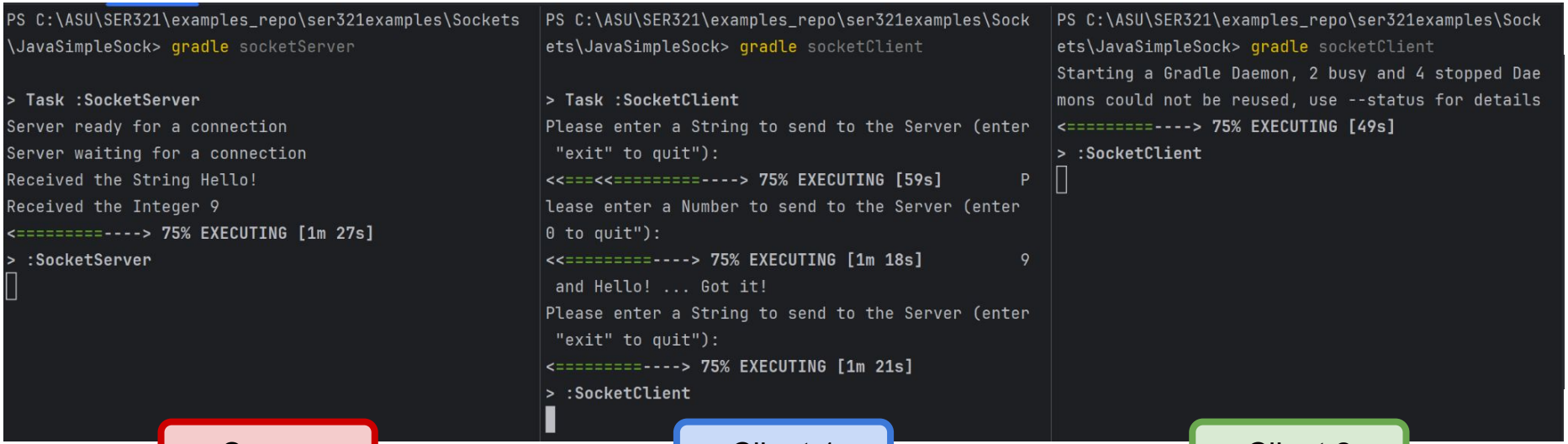
Single Threaded Server



JavaSimpleSock

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Single Threaded Server

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
Received the String Hello!
Received the Integer 9
<==========----> 75% EXECUTING [1m 55s]
> :SocketServer
```

Server

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<<===<<==========----> 75% EXECUTING [59s]        P
lease enter a Number to send to the Server (enter
0 to quit"):
<<==========----> 75% EXECUTING [1m 18s]          9
 and Hello! ... Got it!
Please enter a String to send to the Server (enter
 "exit" to quit"):
<===<==========----> 75% EXECUTING [1m 49s]
> :SocketClient
exit
```

Client 1

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
Starting a Gradle Daemon, 2 busy and 4 stopped Dae
mons could not be reused, use --status for details
<==========----> 75% EXECUTING [1m 18s]
> :SocketClient
```

Client 2

What do we think will happen?

JavaSimpleSock

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Single Threaded Server

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
Received the String Hello!
Received the Integer 9
Received the String exit
Received the Integer 0
Server waiting for a connection
<==========----> 75% EXECUTING [2m 15s]
> :SocketServer
```

Server

```
 and Hello! ... Got it!
Please enter a String to send to the Server (enter
 "exit" to quit"):
<===<==========----> 75% EXECUTING [2m 3s]        e
xitingketClient

Deprecated Gradle features were used in this build
, making it incompatible with Gradle 8.0.

You can use '--warning-mode all' to show the indiv
idual deprecation warnings and determine if they c
ome from your own scripts or plugins.

See https://docs.gradle.org/7.4.2/userguide/comman
d_line_interface.html#sec:command_line_warnings

BUILD SUCCESSFUL in 2m 5s
2 actionable tasks: 1 executed, 1 up-to-date
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock>
```

Client 1

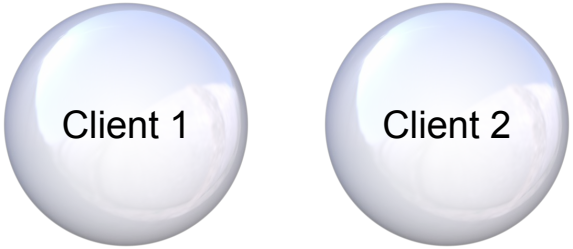
```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
Starting a Gradle Daemon, 2 busy and 4 stopped Dae
mons could not be reused, use --status for details

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<==========----> 75% EXECUTING [1m 37s]
> :SocketClient
```

Client 2

JavaSimpleSock

SER 321

Single Threaded Server




```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
Received the String Hello!
Received the Integer 9
Received the String exit
Received the Integer 0
Server waiting for a connection
Received the String Hello!
<==========----> 75% EXECUTING [3m 7s]
> :SocketServer
```

```
 and Hello! ... Got it!
Please enter a String to send to the Server (enter
 "exit" to quit"):
<===<==========----> 75% EXECUTING [2m 3s]        e
xitingketClient

Deprecated Gradle features were used in this build
, making it incompatible with Gradle 8.0.

You can use '--warning-mode all' to show the indiv
idual deprecation warnings and determine if they c
ome from your own scripts or plugins.

See https://docs.gradle.org/7.4.2/userguide/comman
d_line_interface.html#sec:command_line_warnings

BUILD SUCCESSFUL in 2m 5s
2 actionable tasks: 1 executed, 1 up-to-date
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock>
```

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
Starting a Gradle Daemon, 2 busy and 4 stopped Dae
mons could not be reused, use --status for details

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<====<<==========----> 75% EXECUTING [2m 24s]     P
lease enter a Number to send to the Server (enter
0 to quit"):
<=<==========----> 75% EXECUTING [2m 30s]
> :SocketClient
77
```

Server

Client 1

Client 2

JavaSimpleSock

SER 321

Single Threaded Server

Why?

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sockets
\JavaSimpleSock> gradle socketServer

> Task :SocketServer
Server ready for a connection
Server waiting for a connection
Received the String Hello!
Received the Integer 9
Received the String exit
Received the Integer 0
Server waiting for a connection
Received the String Hello!
<==========----> 75% EXECUTING [3m 7s]
> :SocketServer
```

1. Define Params
2. Create Socket
3-5. Mark Socket to Listen
6. Wait for Connection
7. Handle Client Connection
8. Close Client Connection
9.

```
ets\JavaSimpleSock>
```

```
PS C:\ASU\SER321\examples_repo\ser321examples\Sock
ets\JavaSimpleSock> gradle socketClient
Starting a Gradle Daemon, 2 busy and 4 stopped Dae
mons could not be reused, use --status for details

> Task :SocketClient
Please enter a String to send to the Server (enter
 "exit" to quit"):
<====<<==========----> 75% EXECUTING [2m 24s]     P
lease enter a Number to send to the Server (enter
0 to quit"):
<=<==========----> 75% EXECUTING [2m 30s]
> :SocketClient
77
```

Server

Client 1

Client 2

SER 321
Threaded Server

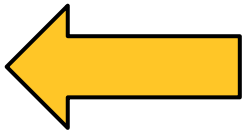
Given the standard server socket steps…

Ideas on how we could introduce threads?

1. Define Params
2. Create Socket

3-5. Mark Socket to Listen

6. Wait for Connection
7. Handle Client Connection
8. Close Client Connection
9. Continue Listening



Why do we send the *client socket* to the thread?

7. Send Client Socket to thread

JavaThreadSock

SER 321
Threads

1. Define Params
2. Create Socket
3-5. Mark Socket to Listen
6. Wait for Connection
7. Send Client **Socket** to Thread
8. Close Client Connection
9. Continue Listening

```
public static void main(String args[]) throws IOException {
  Socket sock = null;
  int id = 0;
  try {
    if (args.length != 1) {
      System.out.println
          ("Usage: gradle ThreadedSockServer --args=<port num>");
      System.exit( code: 0);
    }
    int portNo = Integer.parseInt(args[0]);
    if (portNo <= 1024)
      portNo = 8888;
    ServerSocket serv = new ServerSocket(portNo);

    while (true) {
      System.out.println
          ("Threaded server waiting for connects on port " + portNo);
      sock = serv.accept();
      System.out.println
          ("Threaded server connected to client-" + id);
      // create thread
      ThreadedSockServer myServerThread =
          new ThreadedSockServer(sock, id++);
      // run thread and don't care about managing it
      myServerThread.start();
    }
  } catch (Exception e) {
    e.printStackTrace();
  } finally {
    if (sock != null) sock.close();
  }
}
}
```

1

2 & 3-5

9

6

7

8

JavaThreadSock

SER 321

Threads

```
public void run() {
  try {
    // setup read/write channels for connection
    ObjectInputStream in = new ObjectInputStream(conn.getInputStream());
    ObjectOutputStream out = new ObjectOutputStream(conn.getOutputStream());

    // read the digit being send
    String s = (String) in.readObject();
    int index;
    // while client hasn't ended
    while (!s.equals("end")) {
      Boolean validInput = true;

      // checks if input only contains digits
      if (!s.matches( expr: "\\d+")) {
        validInput = false;
        out.writeObject("Not a number: https://qph.is/2yDymkn");
      }
      // if it contains only numbers
      if (validInput) {
        // convert to an integer
        index = Integer.valueOf(s);
        System.out.println("From client " + id + " get string " + index);
        if (index > -1 & index < buf.length) {
          // if valid, pull the line from the buffer array above and write it to socket
          out.writeObject(buf[index]);
        } else if (index == 5) {
          // fun surprise for mostly correct
          out.writeObject("Close but out of range: https://youtu.be/dQw4w9WgXcQ");
        } else {
          // really wrong
          out.writeObject("index out of range");
        }
      }
      //  wait for next token from the user
      s = (String) in.readObject();
    }
    // on close, clean up
    System.out.println("Client " + id + " closed connection.");
    in.close();
    out.close();
    conn.close();
  } catch (Exception e) {
    e.printStackTrace();
  }
}
```

Client A

Server

```
public static void main(String args[]) throws IOException {
  Socket sock = null;
  int id = 0;
  try {
    if (args.length != 1) {
      System.out.println
          ("Usage: gradle ThreadedSockServer --args=<port num>");
      System.exit( code: 0);
    }
    int portNo = Integer.parseInt(args[0]);
    if (portNo <= 1024)
      portNo = 8888;
    ServerSocket serv = new ServerSocket(portNo);

    while (true) {
      System.out.println
          ("Threaded server waiting for connects on port " + portNo);
      sock = serv.accept();
      System.out.println
          ("Threaded server connected to client-" + id);
      // create thread
      ThreadedSockServer myServerThread =
          new ThreadedSockServer(sock, id++);
      // run thread and don't care about managing it
      myServerThread.start();
    }
  } catch (Exception e) {
    e.printStackTrace();
  } finally {
    if (sock != null) sock.close();
  }
}
```

JavaThreadSock

SER 321

Threads

```
public void run() {
  try {
    // setup read/write channels for connection
    ObjectInputStream in = new ObjectInputStream(conn.getInputStream());
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    // read the digit being send
    String s = (String) in.readObject();
    int index;
    // while client hasn't ended
    while (!s.equals("end")) {
      Boolean validInput = true;

      // checks if input only contains digits
      if (!s.matches( expr: "\\d+")) {
        validInput = false;
        out.writeObject("Not a number: https://qph.is/2yDymkn");
      }
      // if it contains only numbers
      if (validInput) {
        // convert to an integer
        index = Integer.valueOf(s);
        System.out.println("From client " + id + " get string " + index);
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        }
      }
      //  wait for next token from the user
      s = (String) in.readObject();
    }
    // on close, clean up
    System.out.println("Client " + id + " closed connection.");
    in.close();
    out.close();
    conn.close();
  } catch (Exception e) {
    e.printStackTrace();
  }
}
```

Client A

Client B

Server

```
public static void main(String args[]) throws IOException {
  Socket sock = null;
  int id = 0;
  try {
    if (args.length != 1) {
      System.out.println
          ("Usage: gradle ThreadedSockServer --args=<port num>");
      System.exit( code: 0);
    }
    int portNo = Integer.parseInt(args[0]);
    if (portNo <= 1024)
      portNo = 8888;
    ServerSocket serv = new ServerSocket(portNo);

    while (true) {
      System.out.println
          ("Threaded server waiting for connects on port " + portNo);
      sock = serv.accept();
      System.out.println
          ("Threaded server connected to client-" + id);
      // create thread
      ThreadedSockServer myServerThread =
          new ThreadedSockServer(sock, id++);
      // run thread and don't care about managing it
      myServerThread.start();
    }
  } catch (Exception e) {
    e.printStackTrace();
  } finally {
    if (sock != null) sock.close();
  }
}
```

JavaThreadSock

SER 321

Threads

```
public void run() {
  try {
    // setup read/write channels for connection
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    ObjectOutputStream out = new ObjectOutputStream(conn.getOutputStream
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    String s = (String) in.readObject();
    int index;
    // while client hasn't ended
    while (!s.equals("end")) {
      Boolean validInput = true;
      // checks if input only contains digits
      if (!s.matches( expr: "\\d+")) {
        validInput = false;
        out.writeObject("Not a number: https://qph.is/2yDymkn");
      }
      // if it contains only numbers
      if (validInput) {
        // convert to an integer
        index = Integer.valueOf(s);
        System.out.println("From client " + id + " get string " + index);
        if (index > -1 & index < buf.length) {
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        } else {
          // really wrong
          out.writeObject("index out of range");
        }
      }
      //  wait for next token from the user
      s = (String) in.readObject();
    }
    // on close, clean up
    System.out.println("Client " + id + " closed connection.");
    in.close();
    out.close();
    conn.close();
  } catch (Exception e) {
    e.printStackTrace();
  }
}
```

Client A

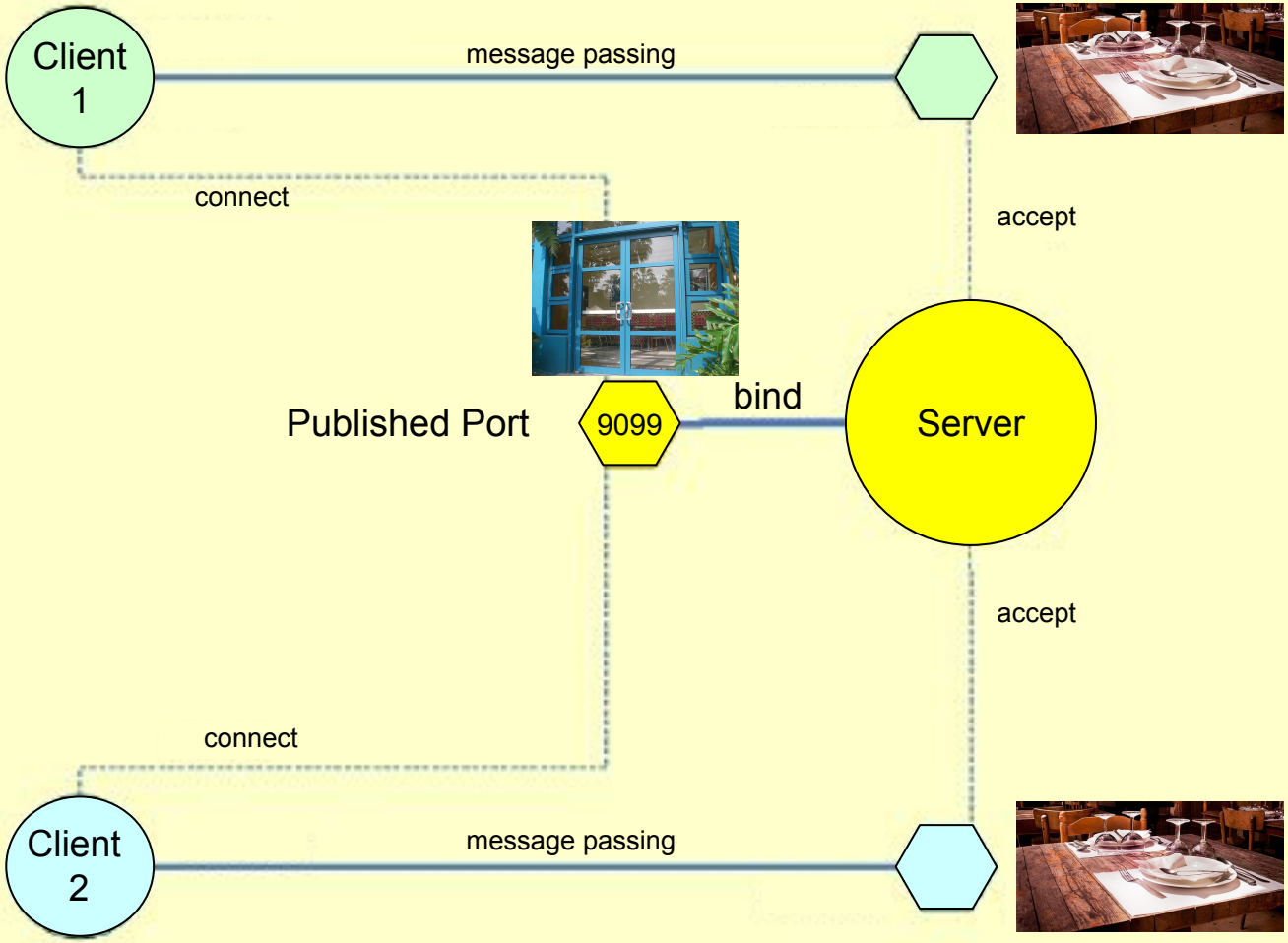
Server

Client B

```
public static void main(String args[]) throws IOException {
  Socket sock = null;
  int id = 0;
  try {
    if (args.length != 1) {
      System.out.println
          ("Usage: gradle ThreadedSockServer --args=<port num>");
      System.exit( code: 0);
    }
    int portNo = Integer.parseInt(args[0]);
    if (portNo <= 1024)
      portNo = 8888;
    ServerSocket serv = new ServerSocket(portNo);

    while (true) {
      System.out.println
          ("Threaded server waiting for connects on port " + portNo);
      sock = serv.accept();
      System.out.println
          ("Threaded server connected to client-" + id);
      // create thread
      ThreadedSockServer myServerThread =
          new ThreadedSockServer(sock, id++);
      // run thread and don't care about managing it
      myServerThread.start();
    }
  } catch (Exception e) {
    e.printStackTrace();
  } finally {
    if (sock != null) sock.close();
  }
}
```

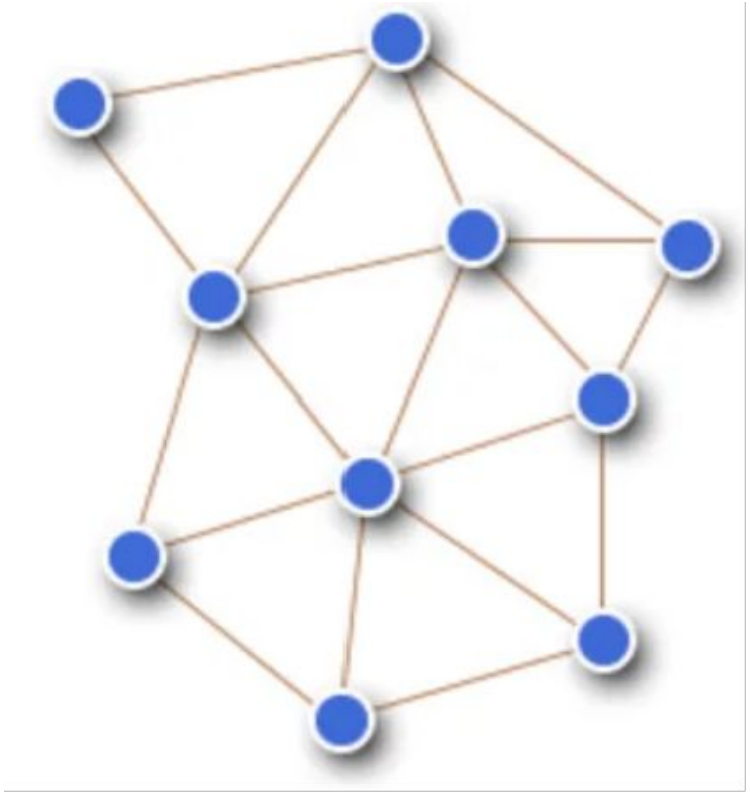
SER 321
Sockets!



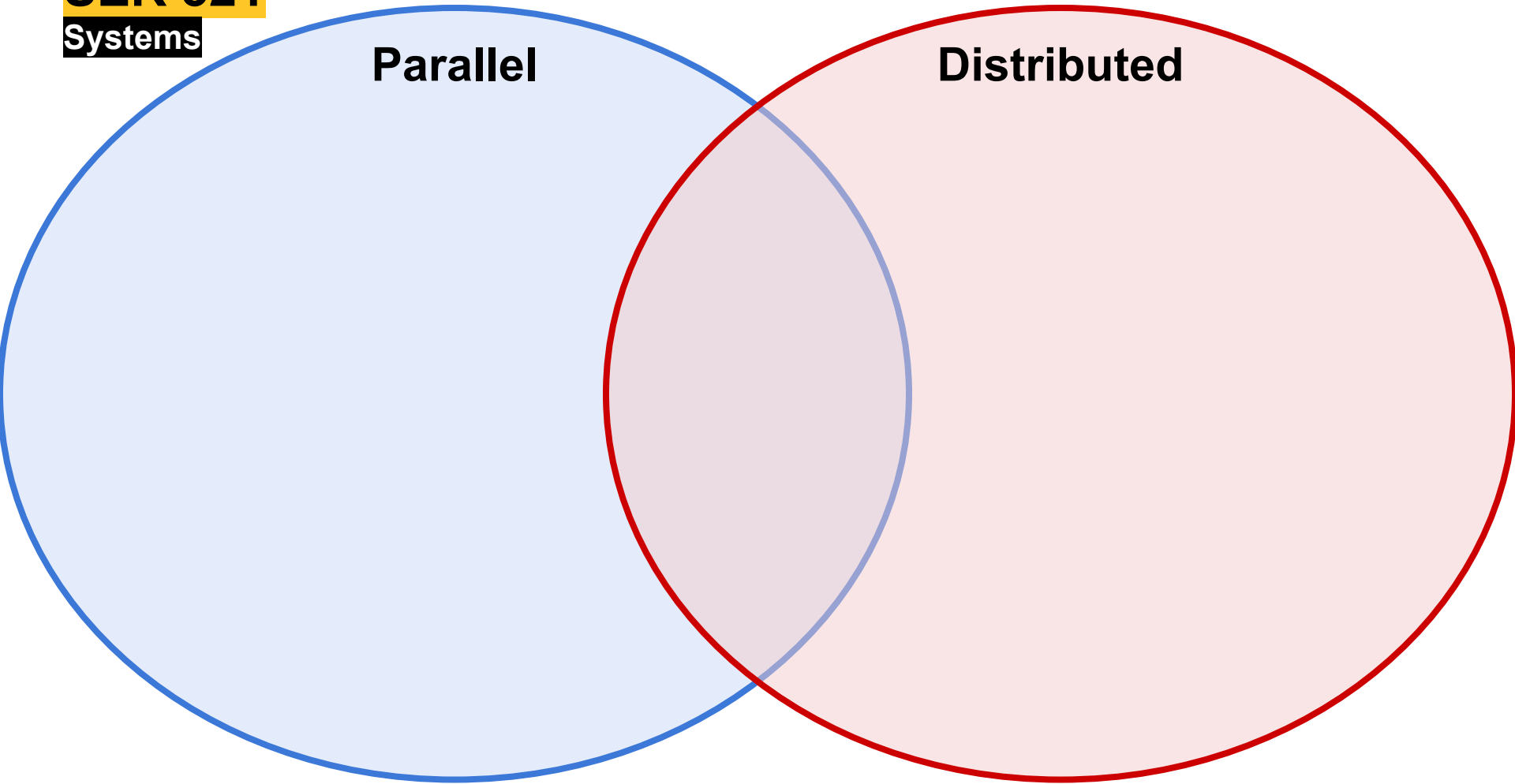
Design of an RFID Vehicle Authentication System: A Case Study for Al-Nahrain University Campus - Scientific Figure on ResearchGate. Available from: https://www.researchgate.net/figure/Client-and-Server-Socket-Ports_fig4_282671198

SER 321
Distributed Systems

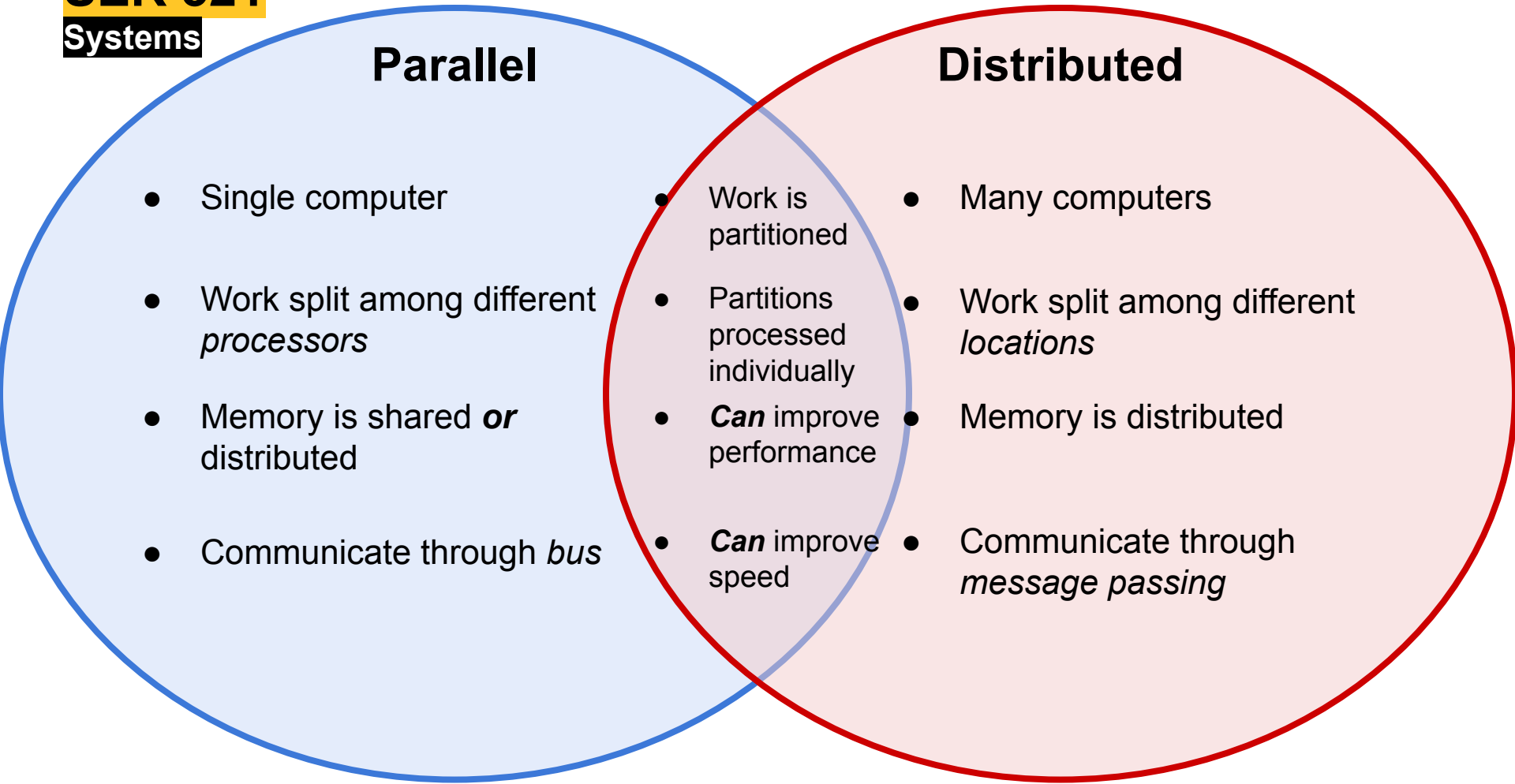
What do we mean by
"Distributed Systems"
or
"Distributed Algorithms"?



SER 321
Systems

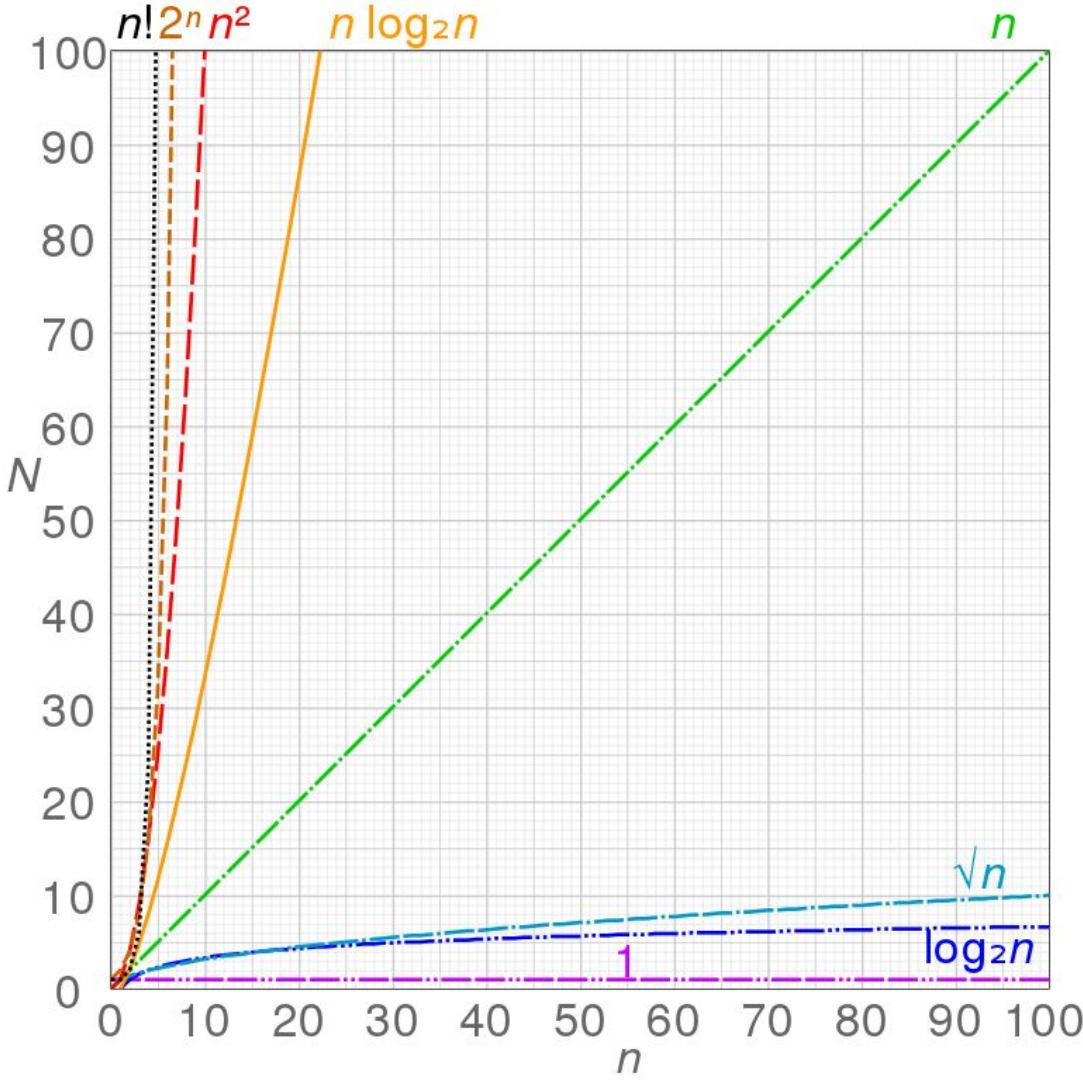


SER 321
Systems



SER 321
Distributed Systems

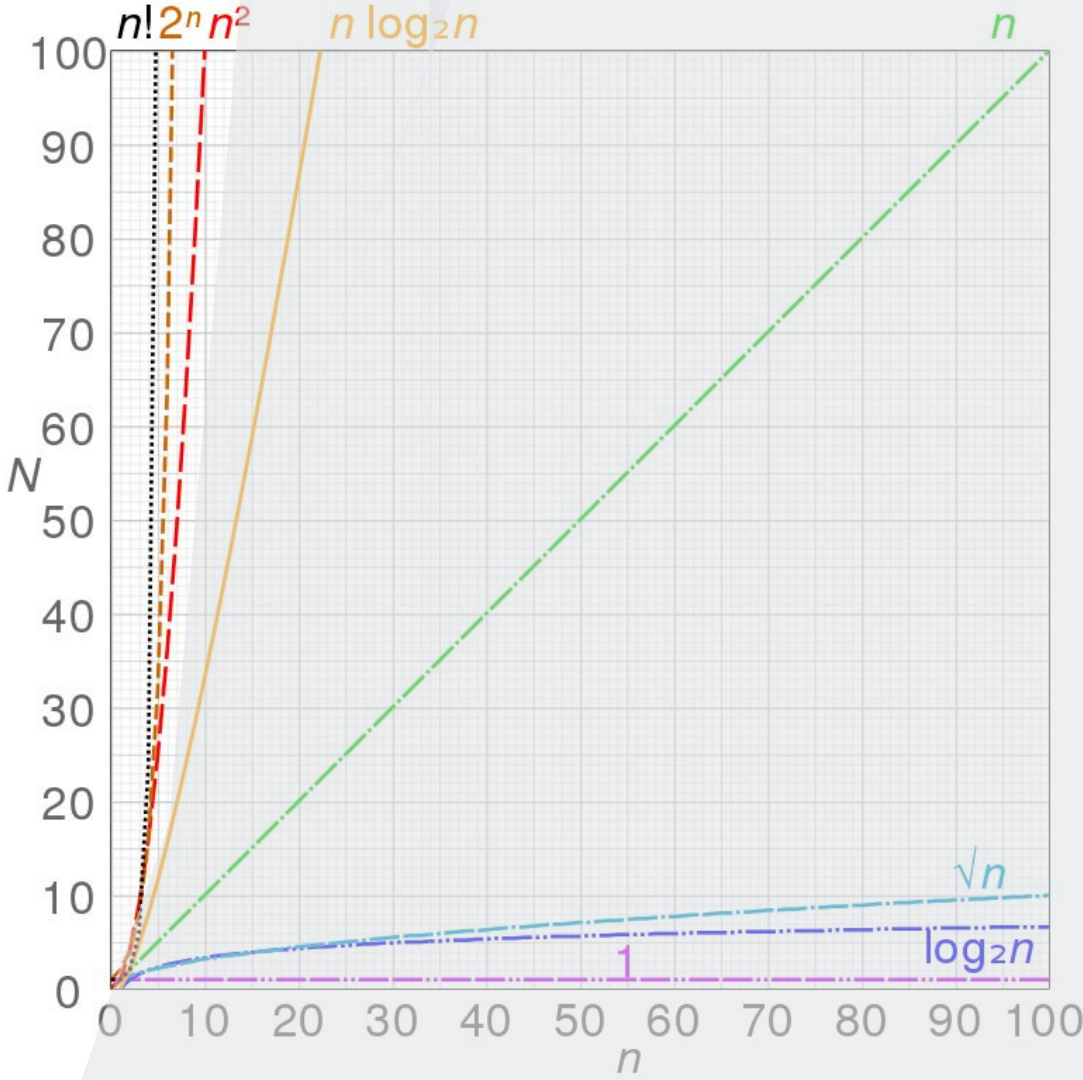
When should we *consider* distributing?



SER 321
Distributed Systems

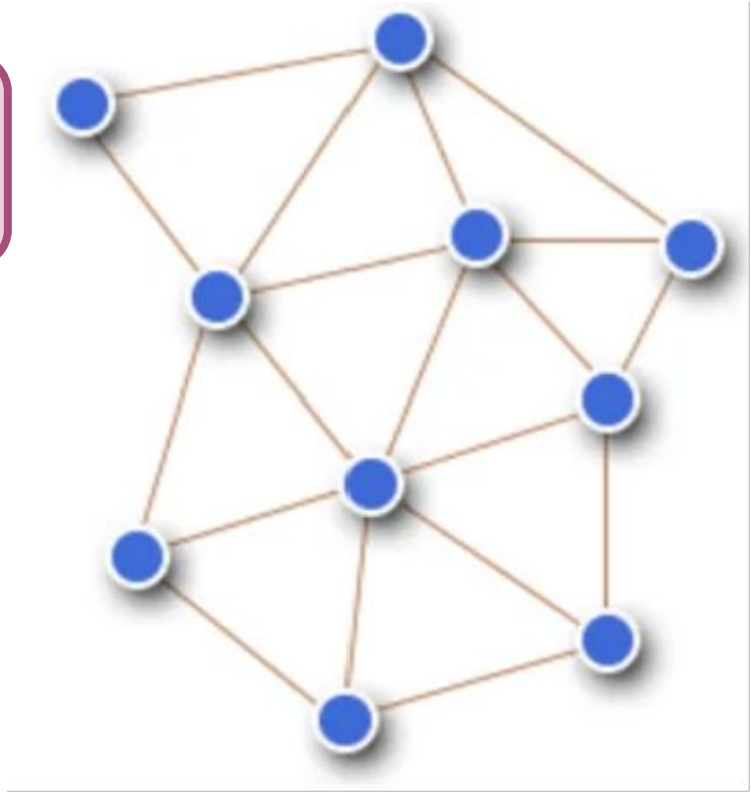
When should we *consider* distributing?

Super Duper Extra Extra Large Orders of Magnitude!



SER 321
Distributed Systems

Remember that we are operating in ***reality***



- Nodes *will* fail
- Web of nodes *will constantly* change
- Network is not *always* reliable
- Latency is *always present*
- The path traversed *changes*
- Some resources *must be shared*
- *You* need to prevent the pitfalls!
  - No deadlocks
  - No starvation
  - No error states

SER 321

Scratch Space

Upcoming Events

SI Sessions:

- Tuesday, November 19th at 10:00 am MST
- Thursday, November 21st at 7:00 pm MST
- Sunday, November 24th at 7:00 pm MST

Review Sessions:

- Sunday, December 1st at 7:00 pm MST - **2 hour Review Session**
- Tuesday, December 3rd at 10:00 am MST - **Q&A Session**

Questions?

Survey:

https://asuasn.info/ASNSurvey

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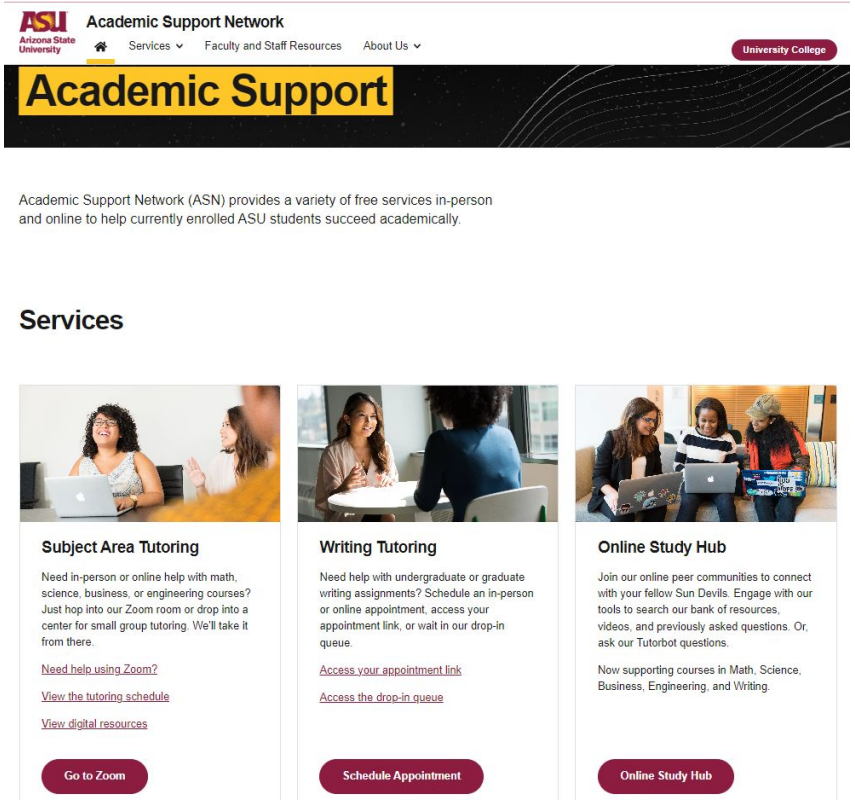
More Questions?

Check out our other resources!

tutoring.asu.edu

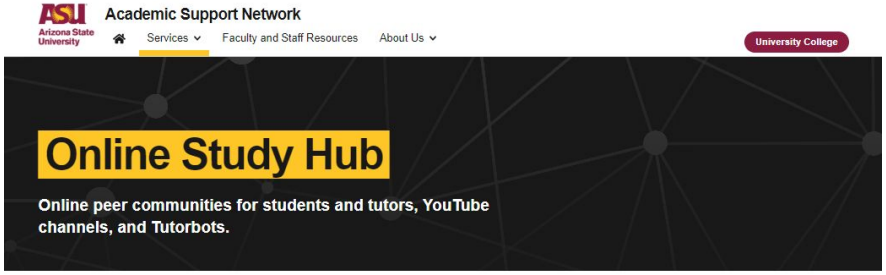


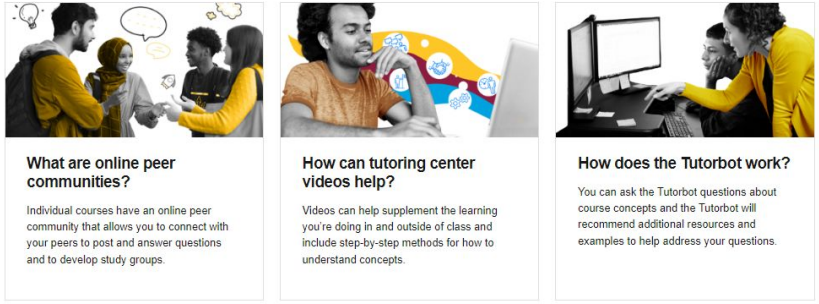
1. **Click on ‘Go to Zoom’ to log onto our Online Tutoring Center.**
2. **Click on ‘View the tutoring schedule’ to see when tutors are available for specific courses.**

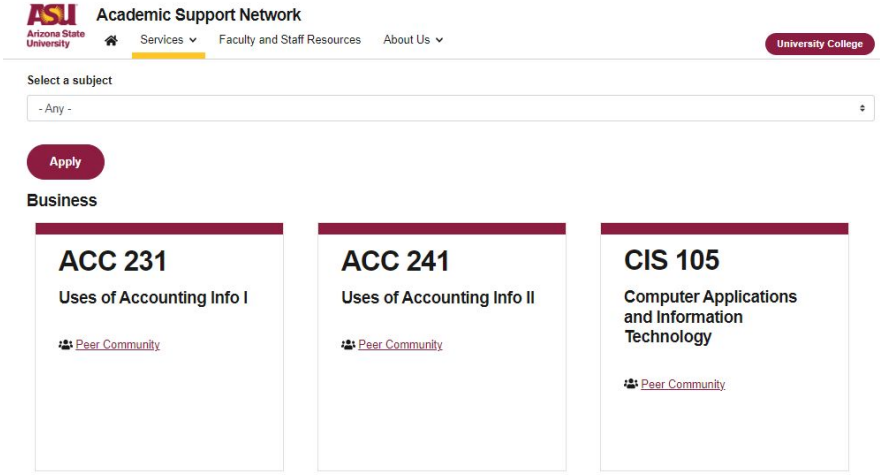
More Questions?

Check out our other resources!

tutoring.asu.edu/online-study-hub



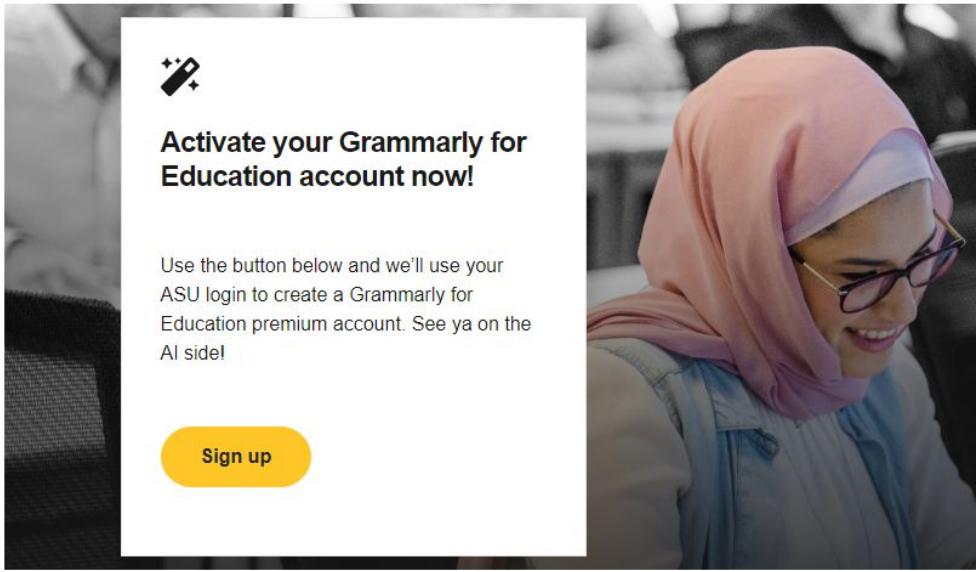




Don't forget to check out the Online Study Hub for additional resources!

Expanded Writing Support Available

Including Grammarly for Education, at no cost!



tutoring.asu.edu/expanded-writing-support

*Available slots for this pilot are limited

Additional Resources

- Course Repo
- Gradle Documentation
- GitHub SSH Help
- Linux Man Pages
- OSI Interactive
- MDN HTTP Docs
  - Requests
  - Responses
- JSON Guide
- org.json Docs
- javax.swing package API
- Swing Tutorials
- Dining Philosophers Interactive
- Austin G Walters Traffic Comparison