

Assignment-1

October 16, 2021

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Chapter 1

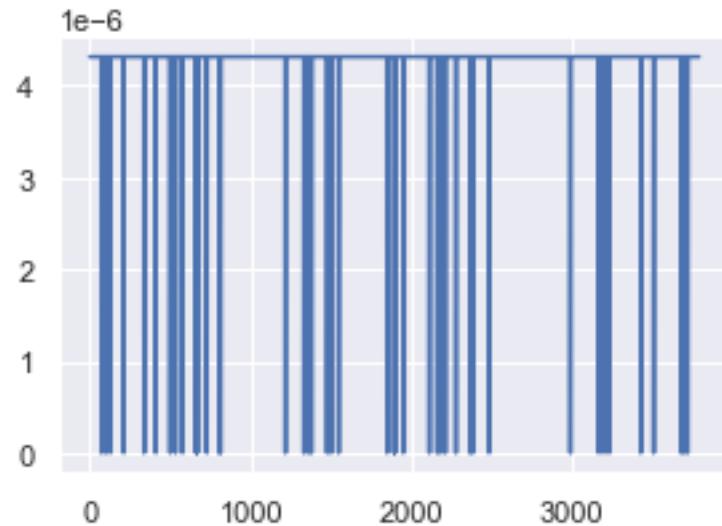
Name and Legi Nr.

David Colonna 18944827

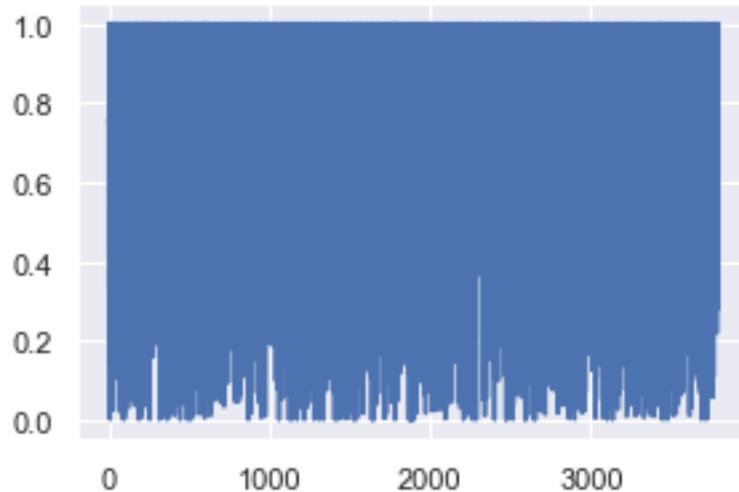
1.1 Imports

1.2 Step 1

1.2.1 First Plotting Questions



[<matplotlib.lines.Line2D at 0x1695df940>]



(3788,)

Regarding the question about its shape, the array resulting from the element-wise multiplication should have the same shape as its components, even if there is a great number of arrays.

Skipping the 2 and 3 optional questions

1.2.2 4.

I used the IEEE Explore Library to find references regarding IEEE 802.11 and the ACM Digital Library to find references for the 5G Cellular. - IEEE 802.11 references: - [1st Paper](#), Cited by: 120 Papers, 8505 Patents - [2nd Paper](#), Cited by: 5923 Papers, 55 Patents - [3rd Paper](#), Cited by: 1410 Patents - 5G references: - [1st Paper](#), cited by 17 papers - [2nd Paper](#), cited by 37 papers - [3rd Paper](#), cited by 29 papers

1.2.3 5.

Primary sources are created closely to the original event, in time as well as in space. Secondary sources are inspired by the primary sources, the authors interpret data from the primary sources. Tertiary sources synthesizes the research from secondary and primary sources. Wikipedia pages can be used as direct sources for academic writing as long there is no copy-pasting, and the primary sources mentioned at the bottom of the page are also cited in the academic document.

1.2.4 6.

Radio Regulations regulates on law radiocommunication services and the utilisation of radio frequencies while Standardization enables competing commercial and industrial players to develop new technology.

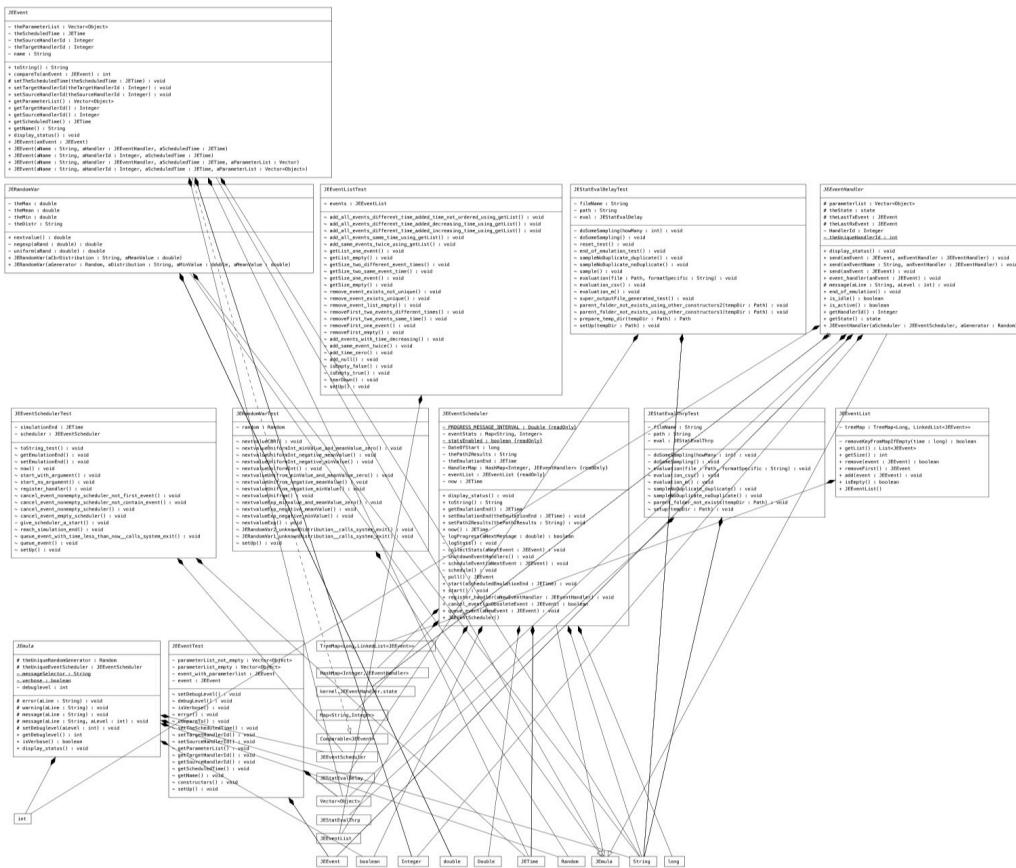
The regulation determines how, where, when radio emissions are permitted and provides spectrum access rights to licensees or unlicensed users.

Standardization enables competing commercial and industrial players to develop new technology together.

It is used to achieve interoperability, which increases value of product. It is also often used to shorten the time-to-market.

Chapter 2

Step 3





2.0.1 Difference between Jemula and Jemula802

Jemula is an event-driven simulation kernel of the program while Jemula802 is the system model. Jemula802 is a tool for simulating IEEE 802.11 wireless networks and it uses Jemula as its simulation kernel.

2.0.2 Description of the kernel classes

- JEmula : the top class of the kernel package. It handles the debugging and logging communication via “messages”, “warnings” and “errors.
 - JEEvent: implements the top class. It describes when something of note happens, with a list of parameters, a name and the scheduled time of its happening.
 - JEEventScheduler : this class is used to construct a schedule of the JEEvent objects and keep track of them through logging.
 - JEEEventHandler : this class is used as an intermediary between the JEEvent objects and a JEEventScheduler object. A handler can either be active or idle, depending on whether it sending a JEEvent to a handler or not.
 - JEEventList : this class is used by the JEEEventHandler and JEEventScheduler classes. It represents an interface to all the available events as queue, where a new event is added at the end and any event can be removed.
 - JETime : this class represents an interface to the actual time, where the time can additionned, multiplied, compared to another time..
 - JETimer : this class is used by the JEEventScheduler as a parameter of a JEEvent object to keep track of when the event starts, stops, the remaining time, pauses..

2.0.3 event_handler method in the JEEEventHandler Class

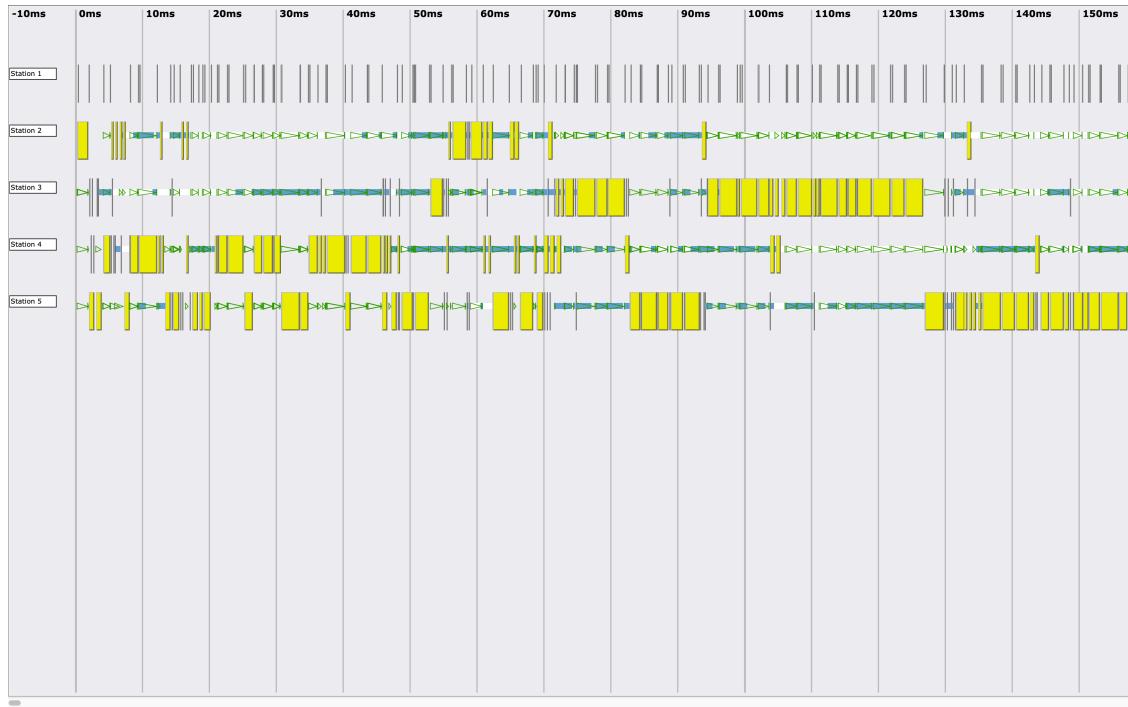
From the message in the first line it seems that the method doesn't do much in this class at least. The only output it produces is an additional message if the JEEEvent given as parameter turns out to be a Test.

2.0.4 Effect of the seed value

The seed value (my immatriculation number) is used in the JE802Control class in the jemula802 package. It is used in line 286 as the seed of a random generator, i.e. the starting point in a long of pseudo-random numbers.

2.0.5 The important concept of a confidence interval in data visualization

Confidence intervals are calculated by multiplying the standard error with small and constant values.



Chapter 3

Step 4

```
<?xml version="1.0" encoding="UTF-8"?>
<JE802>
    <JE802Control showGui="true" EmulationDuration_ms="2000">
        <JE802StatEval seed="18944827" EvalThrpPerAC="true"
            EvalDelayPerAC="true" EvalOfferPerAC="true" EvaluationStarttime_ms="0"
            EvaluationInterval_ms="500" Path2Results="results_own_scenario"
            EvalTotalOffer="true" EvalTotalThrp="true" EvalTotalDelay="true"
            HistogramMax_ms="100" HistogramNumOfBins="100">
            <!--JE802StatEval defines the parameters needed for statistical analysis
                and evaluation (for example when measuring the overall throughput etc.) -->
        </JE802StatEval>

        <JE802Animation baseLatitude="48.8725"
            baseLongitude="1.971944" maxDelay="5" maxThrp="5" mbPerBlock="0.5"
            maxTxdBm="-60" minTxdBm="-100" PixelSize_m="100" generateGoogleEarth="true" />
    </JE802Control>

    <JE802RoutingParameters routingEnabled="false"
        channelSwitchingEnabled="false" multiChannelPathMetricEnabled="false"
        activeRouteTimeout_ms="3000" ipHeaderByte="20" brokenLinkAfterLoss="10"
        helloInterval_ms="5000" channelSwitchingDelay_ms="1" />

    <JE802Station>
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            zLocation="0" oldFormat="true" interpolationInterval_ms="10000" />

        <JE802TCP b="1" bufferSizePackets="10" minimumTimeoutMs="50"
            slowStartThreshold="10" />

        <JE802SME>
            <!--not much defined so far -->
        </JE802SME>
        <JE80211MAC dot11MacAddress4_byte="6" dot11MacFCS_byte="4"
            dot11MacHeaderACK_byte="10" dot11MacHeaderCTS_byte="10"
            dot11MacHeaderDATA_byte="24" dot11MacHeaderRTS_byte="16"
            dot11WepEncryption="false">

        <JE802Mlme NameOfAlgorithm="phymode_6Mbps"
            ComputingInterval_ms="100" ShowPlot="false">
    
```

```

<!-- // MLME = MAC Layer Management Entity -->
<!-- // "NameOfAlgorithm" determines the actual algorithm used for dynamically
     adapting the MAC parameters. This string value will be compared to the list
     of existing algorithms by the mobile computing entity. Use "none" for static
     behavior. -->
<!-- // "ComputingInterval_ms" will set the period, i.e., the time interval
     between each computing event, given in milliseconds -->
<!-- // "ShowPlot" set to true will switch on a small plot showing the
     parameters used. For example the value of the parameter AIFSN can be seen -->
</JE802Mlme>

<JE802BackoffEntity AC="2" queuesize="10">
    <MIB802.11e dot11EDCAAIFSN="4" dot11EDCACWmax="1023"
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                  dot11EDCATXOPLimit="3008" />
</JE802BackoffEntity>

<MIB802.11-1999 dot11BroadcastAddress="255"
                  dot11FragmentationThreshold="512" dot11LongRetryLimit="4"
                  dot11MACAddress="1" dot11MaxReceiveLifetime="1000"
                  dot11MaxTransmitMSDULifetime="1000" dot11RTSThreshold="500"
                  dot11ShortRetryLimit="7" />

</JE80211MAC>

<JE80211PHY channelBusyThreshold_dBm="-82" noiseFloor_dB="5.0"
              PLCPHeaderWithoutServiceField_ms="0.004" PLCPPreamble_ms="0.016"
              PLCPServiceField_bit="16" PLCPTail_bit="6" SymbolDuration_ms="0.004">
    <MIB802.11abgn SIFS="0.016" aSlotTime="0.009"
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</JE80211PHY>

</JE802Station>

<JE802Station>
    <JE802TrafficGen AC="2" DA="1" EvalDelay="true"
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                      HistogramNumOfBins="600" isTcpTraffic="false" max_packet_size_byte="2000"
                      mean_load_Mbps="2.2" port="47768196" starttime_ms="0" stoptime_ms="0"
                      type="data" />
    <JE802TCP b="1" bufferSizePackets="10" minimumTimeoutMs="50"
               slowStartThreshold="10" />
    <JE802Mobility isMobile="true" xLocation="10000"
                   yLocation="0" zLocation="0" offsetTime_ms="0.0" oldFormat="true"
                   interpolationInterval_ms="10000" />

    <JE802SME>
        <!--not much defined so far -->
    </JE802SME>
    <JE80211MAC dot11MacAddress4_byte="6" dot11MacFCS_byte="4"
                  dot11MacHeaderACK_byte="10" dot11MacHeaderCTS_byte="10">

```

```

dot11MacHeaderDATA_byte="24" dot11MacHeaderRTS_byte="16"
dot11WepEncryption="false">

<JE802MLme NameOfAlgorithm="phymode_6Mbps"
    ComputingInterval_ms="100" ShowPlot="false">
    <!-- // MLME = MAC Layer Management Entity -->
    <!-- // "NameOfAlgorithm" determines the actual algorithm used for dynamically
        adapting the MAC parameters. This string value will be compared to the list
        of existing algorithms by the mobile computing entity. Use "none" for static
        behavior. -->
    <!-- // "ComputingInterval_ms" will set the period, i.e., the time interval
        between each computing event, given in milliseconds -->
    <!-- // "ShowPlot" set to true will switch on a small plot showing the
        parameters used. For example the value of the parameter AIFSN can be seen -->
</JE802MLme>

<JE802BackoffEntity AC="2" queuesize="10">
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        dot11EDCATXOPLimit="3008" />
</JE802BackoffEntity>
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    dot11FragmentationThreshold="512" dot11LongRetryLimit="4"
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    dot11MaxTransmitMSDULifetime="1000" dot11RTSThreshold="500"
    dot11ShortRetryLimit="7" />
</JE80211MAC>

<JE80211PHY channelBusyThreshold_dBm="-82" noiseFloor_dB="5.0"
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    PLCPServiceField_bit="16" PLCPTail_bit="6" SymbolDuration_ms="0.004">
    <MIB802.11abgn SIFS="0.016" aSlotTime="0.009"
        dot11CurrentChannelNumber="6" dot11CurrentTransmitPowerLevel_dBm="17" />
    <JEAntenna xDirection="-1" yDirection="0" zDirection="0"
        angle_degrees="20" gain_dBi="10" />
</JE80211PHY>

</JE802Station>

<JE802Station>
    <JE802TrafficGen AC="2" DA="1" EvalDelay="true"
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        HistogramNumOfBins="600" isTcpTraffic="false" max_packet_size_byte="2000"
        mean_load_Mbps="2.2" port="47768196" starttime_ms="0" stoptime_ms="0"
        type="data" />
    <JE802TCP b="1" bufferSizePackets="10" minimumTimeoutMs="50"
        slowStartThreshold="10" />
    <JE802Mobility isMobile="true" xLocation="-10000"
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<JE802SME>
    <!--not much defined so far -->

```

```

</JE802SME>
<JE80211MAC dot11MacAddress4_byte="6" dot11MacFCS_byte="4"
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dot11MacHeaderDATA_byte="24" dot11MacHeaderRTS_byte="16"
dot11WepEncryption="false">

<JE802Mlme NameOfAlgorithm="phymode_6Mbps"
ComputingInterval_ms="100" ShowPlot="false">

<!-- // "NameOfAlgorithm" determines the actual algorithm used for dynamically
adapting the MAC parameters. This string value will be compared to the list
of existing algorithms by the mobile computing entity. Use "none" for static
behavior. --&gt;
<!-- // "ComputingInterval_ms" will set the period, i.e., the time interval
between each computing event, given in milliseconds --&gt;
<!-- // "ShowPlot" set to true will switch on a small plot showing the
parameters used. For example the value of the parameter AIFSN can be seen --&gt;
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dot11EDCATXOPLimit="3008" /&gt;
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dot11MACAddress="3" dot11MaxReceiveLifetime="1000"
dot11MaxTransmitMSDULifetime="1000" dot11RTSThreshold="500"
dot11ShortRetryLimit="7" /&gt;

&lt;/JE80211MAC&gt;
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PLCPServiceField_bit="16" PLCPTail_bit="6" SymbolDuration_ms="0.004"&gt;
&lt;MIB802.11abgn SIFS="0.016" aSlotTime="0.009"
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&lt;JEAntenna xDirection="1" yDirection="0" zDirection="0"
angle_degrees="20" gain_dBi="10" /&gt;

&lt;/JE80211PHY&gt;

&lt;/JE802Station&gt;
&lt;JE802Station&gt;
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HistogramNumOfBins="600" isTcpTraffic="false" max_packet_size_byte="2000"
mean_load_Mbps="2.2" port="47768196" starttime_ms="0" stoptime_ms="0"
type="data" /&gt;
&lt;JE802TCP b="1" bufferSizePackets="10" minimumTimeoutMs="50"
slowStartThreshold="10" /&gt;
&lt;JE802Mobility isMobile="true" xLocation="0" yLocation="10000"
zLocation="0" offsetTime_ms="0.0" oldFormat="true"
interpolationInterval_ms="10000" /&gt;
&lt;JE802SME&gt;
</pre>

```

```

    <!--not much defined so far -->
</JE802SME>
<JE80211MAC dot11MacAddress4_byte="6" dot11MacFCS_byte="4"
            dot11MacHeaderACK_byte="10" dot11MacHeaderCTS_byte="10"
            dot11MacHeaderDATA_byte="24" dot11MacHeaderRTS_byte="16"
            dot11WepEncryption="false">

<JE802Mlme NameOfAlgorithm="phymode_6Mbps"
             ComputingInterval_ms="100" ShowPlot="false">
    <!-- // MLME = MAC Layer Management Entity -->
    <!-- // "NameOfAlgorithm" determines the actual algorithm used for dynamically
        adapting the MAC parameters. This string value will be compared to the list
        of existing algorithms by the mobile computing entity. Use "none" for static
        behavior. -->
    <!-- // "ComputingInterval_ms" will set the period, i.e., the time interval
        between each computing event, given in milliseconds -->
    <!-- // "ShowPlot" set to true will switch on a small plot showing the
        parameters used. For example the value of the parameter AIFSN can be seen -->
</JE802Mlme>

<JE802BackoffEntity AC="2" queuesize="10">
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                  dot11EDCATXOPLimit="3008" />
</JE802BackoffEntity>
<MIB802.11-1999 dot11BroadcastAddress="255"
                  dot11FragmentationThreshold="512" dot11LongRetryLimit="4"
                  dot11MACAddress="4" dot11MaxReceiveLifetime="1000"
                  dot11MaxTransmitMSDULifetime="1000" dot11RTSThreshold="500"
                  dot11ShortRetryLimit="7" />
</JE80211MAC>

<JE80211PHY channelBusyThreshold_dBm="-82" noiseFloor_dB="5.0"
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             PLCPServiceField_bit="16" PLCPTail_bit="6" SymbolDuration_ms="0.004">
    <MIB802.11abgn SIFS="0.016" aSlotTime="0.009"
                    dot11CurrentChannelNumber="6" dot11CurrentTransmitPowerLevel_dBm="17" />
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</JE802Station>
<JE802Station>
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                      EvalThrp="true" EvalOffer="true" HistogramMax_ms="60"
                      HistogramNumOfBins="600" isTcpTraffic="false" max_packet_size_byte="2000"
                      mean_load_Mbps="2.2" port="47768196" starttime_ms="0" stoptime_ms="0"
                      type="data" />
    <JE802TCP b="1" bufferSizePackets="10" minimumTimeoutMs="50"
               slowStartThreshold="10" />
    <JE802Mobility isMobile="true" xLocation="0" yLocation="-10000"

```

```

        zLocation="0" offsetTime_ms="0.0" oldFormat="true"
        interpolationInterval_ms="10000" />
<JE802SME>
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</JE802SME>
<JE80211MAC dot11MacAddress4_byte="6" dot11MacFCS_byte="4"
    dot11MacHeaderACK_byte="10" dot11MacHeaderCTS_byte="10"
    dot11MacHeaderDATA_byte="24" dot11MacHeaderRTS_byte="16"
    dot11WepEncryption="false">

<JE802Mlme NameOfAlgorithm="phymode_6Mbps"
    ComputingInterval_ms="100" ShowPlot="false">
    <!-- // MLME = MAC Layer Management Entity -->
    <!-- // "NameOfAlgorithm" determines the actual algorithm used for dynamically
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        behavior. -->
    <!-- // "ComputingInterval_ms" will set the period, i.e., the time interval
        between each computing event, given in milliseconds -->
    <!-- // "ShowPlot" set to true will switch on a small plot showing the
        parameters used. For example the value of the parameter AIFSN can be seen -->
</JE802Mlme>

<JE802BackoffEntity AC="2" queuesize="10">
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        dot11EDCATXOPLimit="3008" />
</JE802BackoffEntity>
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    dot11MaxTransmitMSDULifetime="1000" dot11RTSThreshold="500"
    dot11ShortRetryLimit="7" />

</JE80211MAC>
<JE80211PHY channelBusyThreshold_dBm="-82" noiseFloor_dB="5.0"
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    PLCPServiceField_bit="16" PLCPTail_bit="6" SymbolDuration_ms="0.004">
    <MIB802.11abgn SIFS="0.016" aSlotTime="0.009"
        dot11CurrentChannelNumber="6" dot11CurrentTransmitPowerLevel_dBm="17" />
    <JEAntenna xDirection="0" yDirection="1" zDirection="0"
        angle_degrees="20" gain_dBi="10" />
</JE80211PHY>

</JE802Station>
<JEWirelessChannels AttenuationCoeff="2"
    orthogonalChannelDistance="1" CoverageRange_m="22000">
    <aChannel aChannelNumber="1" dot11FreqBandWidth_MHz="22"
        dot11CenterFreq_MHz="2412" />
    <aChannel aChannelNumber="6" dot11FreqBandWidth_MHz="22.0"
        dot11CenterFreq_MHz="2437" />
    <aChannel aChannelNumber="11" dot11FreqBandWidth_MHz="22.0"

```

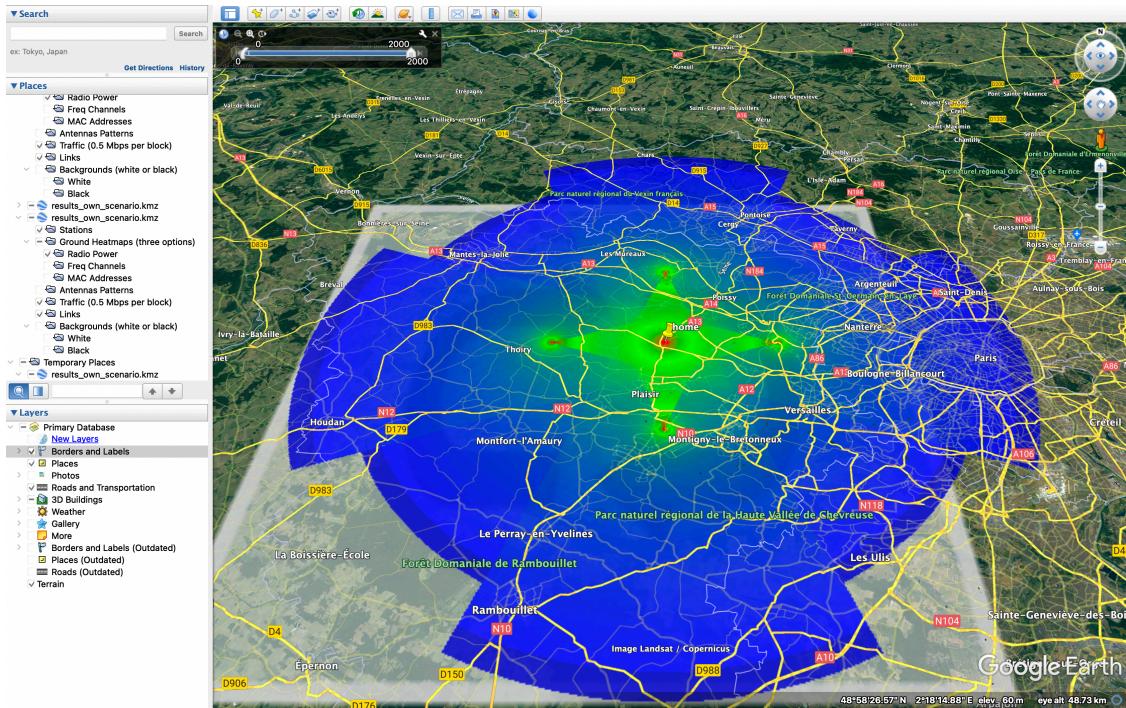
```

        dot11CenterFreq_MHz="2462" />
    </JEWirelessChannels>
    <JE802PhyModes>
        <aPhyMode Mbps="06" Name="BPSK12" basic="true"
            bit_per_symbol="24" id="1"
            bitErrorProbabilitiesPerDb="1,2.26E-1,1.844E-2,1.071E-3,4.854E-5,1.649E-6,3.357E-8,3.1
        <aPhyMode Mbps="09" Name="BPSK34" basic="false"
            bit_per_symbol="36" id="2"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,8.429E-2,1.750E-3,4.702E-5, 1.138E-6,1.51E-8,7.1
        <aPhyMode Mbps="12" Name="QPSK12" basic="true"
            bit_per_symbol="48" id="3"
            bitErrorProbabilitiesPerDb="1,1,1,1,1.712E-1,1.543E-2,9.755E-4,4.694E-5,1.655E-6,3.45
        <aPhyMode Mbps="18" Name="QPSK34" basic="false"
            bit_per_symbol="72" id="4"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,1,1,1,8.465E-2,1.795E-3, 4.859E-5, 1.184E-6, 1
        <aPhyMode Mbps="24" Name="16QAM12" basic="true"
            bit_per_symbol="96" id="5"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,1,1,1,5.64E-1,1.151E-1,1.698E-2,1.806E-3,1.43
        <aPhyMode Mbps="36" Name="16QAM34" basic="false"
            bit_per_symbol="144" id="6"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,5.179E-1,1.61E-2,4.972E-4,1.7
        <aPhyMode Mbps="48" Name="64QAM23" basic="false"
            bit_per_symbol="192" id="7"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,3.771E-1,3.584E-2,2
        <aPhyMode Mbps="54" Name="64QAM34" basic="false"
            bit_per_symbol="216" id="8"
            bitErrorProbabilitiesPerDb="1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,1,2.319E-1,9.428E
    </JE802PhyModes>
</JE802>
```

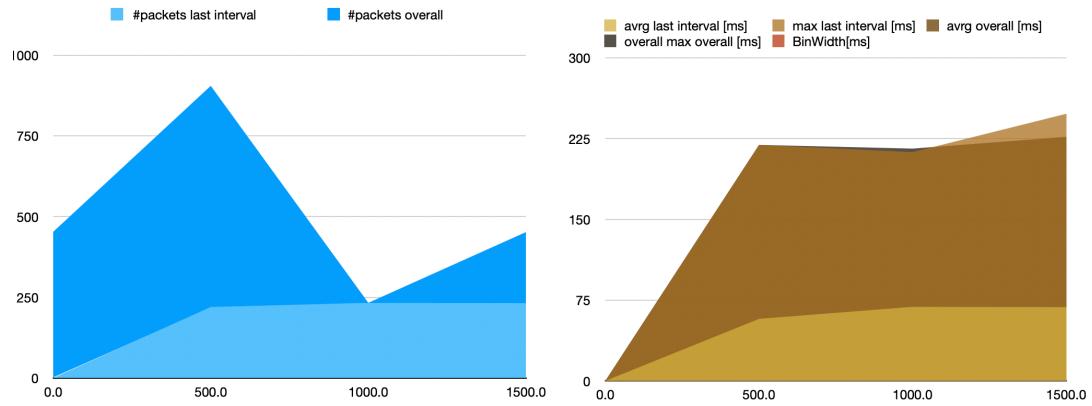
Chapter 4

Step 4

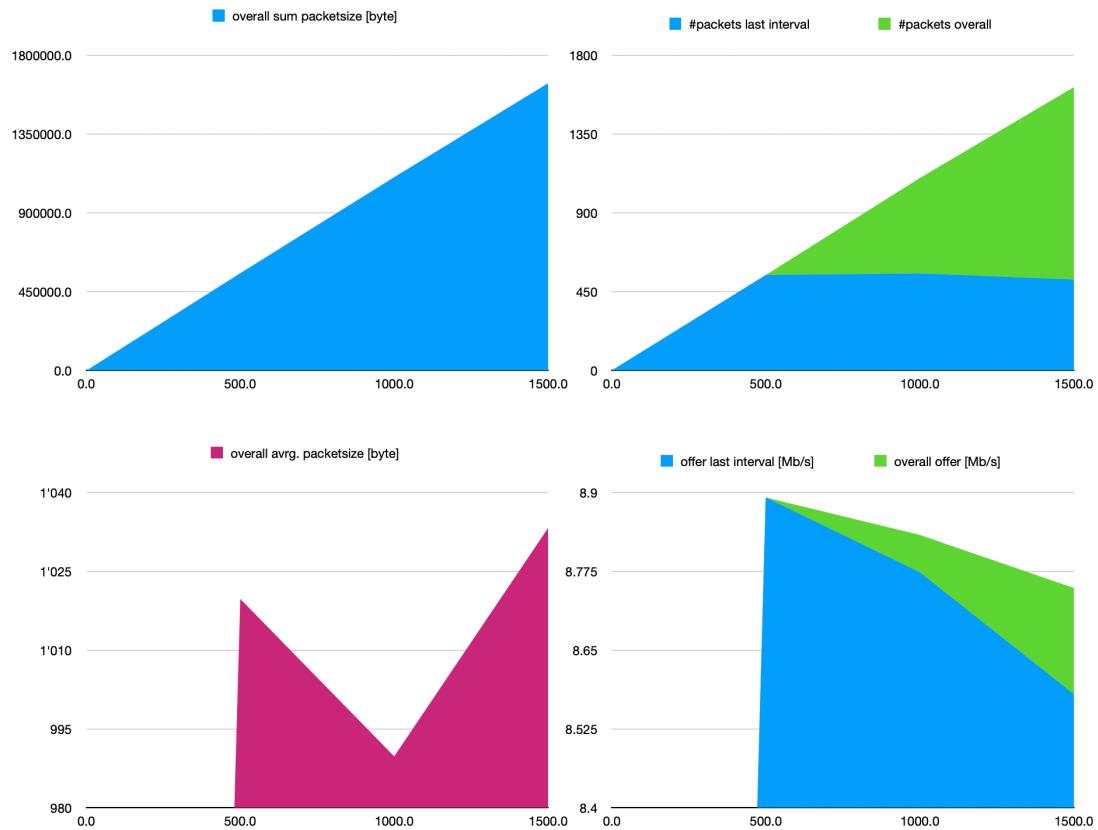
4.0.1 Google Earth Result Image



Total delay graph:



Total offer graph:



Total throughput graph:

