# Analytic Models

Assignment 3

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Question 1.

For *small packets* we have:

$S_{small} = 0.01ms$, $P_{small} = 0.1$.
$\lambda_{small} = P_{small} * \lambda = (0.1) * (8000\frac{packet}{second} * \frac{1second}{1000ms}) = 0.8\frac{packet}{ms}$
So based on Little's law:
$U_{small} = \lambda_{small} * S_{small} = (0.8\frac{packets}{ms}) * (0.01ms) = 0.008$
$Q_{small} = \lambda_{small} * R_{small} = 0.8R_{small}$
Since we have a deterministic service time distribution for each class, then we have:
$S_{rem_{small}} = \frac{S_{small}}{2} = \frac{0.01ms}{2} = 0.005ms$

For *big packets* we have:

$S_{big} = 0.11ms$, $P_{big} = 0.9$.
$\lambda_{big} = P_{big} * \lambda = (0.9) * (8000\frac{packet}{second} * \frac{1second}{1000ms}) = 7.2\frac{packet}{ms}$
So based on Little's law:
$U_{big} = \lambda_{big} * S_{big} = (7.2\frac{packets}{ms}) * (0.11ms) = 0.792$
$Q_{big} = \lambda_{big} * R_{big} = 7.2R_{big}$
Since we have a deterministic service time distribution for each class, then we have:
$S_{rem_{big}} = \frac{S_{big}}{2} = \frac{0.11ms}{2} = 0.055ms$

Finally for each class based on small class non-preemptive priority we have:

$$R_{small} = S_{small} + S_{small} * (Q_{small} - U_{small}) + U_{small} * S_{rem_{small}} + U_{big} * S_{rem_{big}}$$
$$R_{small} = 0.01 + 0.01 * (0.8R_{small} - 0.008) + 0.008 * 0.005 + 0.792 * 0.055$$

```
Rs = (0.01 - (0.01*0.008) + (0.008*0.005) + (0.792*0.055))/(1 - 0.008)
cat("R small: ", Rs, 'milliseconds')
```

```
## R small:  0.05395161 milliseconds
```

$R_{big} = S_{big} + S_{small} * (Q_{small} - U_{small}) + S_{big} * (Q_{big} - U_{big}) + U_{small} * S_{rem_{small}} + U_{big} * S_{rem_{big}} + (R_{big} - S_{big})\lambda_{small}S_{small}$

$R_{big} = 0.11 + 0.01 * (0.8 * R_{small} - 0.008) + 0.11 * (7.2R_{big} - 0.792) + 0.008 * 0.005 + 0.792 * 0.055 + (R_{big} - 0.11) * 0.8 * 0.01$

```
Rb = (0.11+(0.01*(0.8*Rs-0.008))-(0.11*0.792)+(0.008*0.005)+(0.792*0.055)-(0.11*0.8*0.01))/(1-0.8)
cat("R big: ", Rb, 'milliseconds')
```

```
## R big:  0.3297581 milliseconds
```


Figure 1: rps state-transition model

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Question 2.

*hi*

```
N = 1:30
for(i in N){
  # find max troughput based on MVA

}
```

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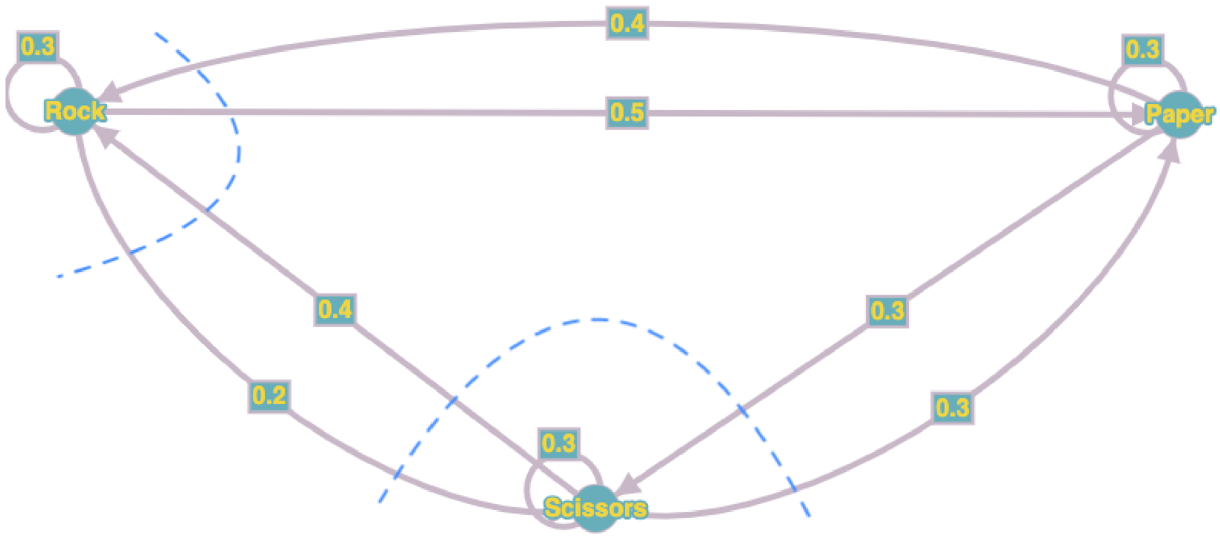
Question 3.

**a)**

This model is provided in figure 1.

**b)**




We can obtain the following equantions by dividing the graph as in figure 2.

$$\begin{cases} P_{rock} + P_{paper} + P_{scissors} = 1 \\ 0.4P_{paper} + 0.4P_{scissors} = 0.5P_{rock} + 0.2P_{rock} \\ 0.2P_{rock} + 0.3P_{paper} = 0.4P_{scissors} + 0.3P_{scissors} \end{cases}$$

The results are $P_{rock} = \frac{4}{11}$, $P_{paper} = \frac{41}{110}$, $P_{scissors} = \frac{29}{110}$

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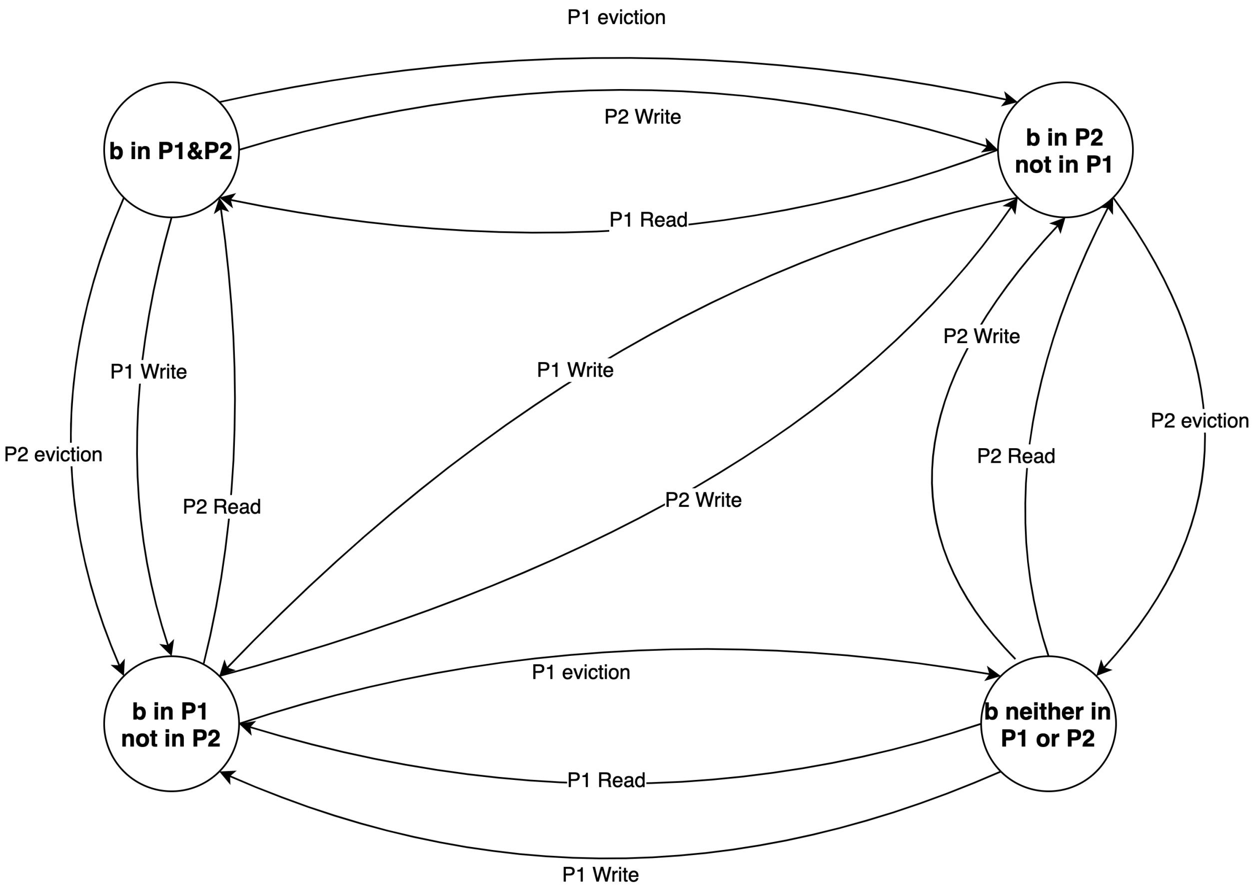
Question 4.

**a)**

This model is provided in figure 3.




**b)**

*hi*

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Question 5.

**a)**

*hi*

**b)**

*hi*

**c)**

*hi*

**d)**

*hi*